Extended Summaries

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Rainfed Agriculture: Building Pathways for Resilience & Sustainable Livelihoods

29-31 January, 2025

at

ICAR- Central Research Institute for Dryland Agriculture

Organised by

Indian Society of Dryland Agriculture

ICAR- Central Research Institute for Dryland Agriculture

In collaboration with

Indian Council of Agricultural Research, New Delhi

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2nd International Conference of ISDA

on

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Edited by

Rama Rao C. A., Srinivasa Rao M., Shanker A. K., Pratibha G., Rejani R., Suvana S., Kundu S., Josily S., Pushpanjali, Anshida Beevi C. N., Savitha S., Salini K., Kumar R.N., Pankaj P.K., Prasad J.V.N.S., Rao K. V. and Singh V. K.

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Resource Characterization, Conservation, Management and Governance

UID: 1028

Climate Resilience through Inclusive Water Management: A Decade-long Case Study in Karnataka

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Climate change has altered the weather parameters largely in terms of rainfall behavior and temperature anomalies. The varied rainfall behavior due to climate change led to more frequent and intense heavy rainfall events, and extended dry spells in the 21st century (Raghavan *et al.,* 2020), which has a greater impact on the sustainability of fragile rainfed ecosystems than irrigated ecosystem. In India, 60% of the total cultivated area is managed as a rainfed ecosystem, wherein crop production is dependent on rainfall, having no facility for protective or lifesaving irrigation. Agriculture in India, particularly in states like Karnataka, is deeply impacted by climate change, which manifests as shifts in rainfall patterns, rising temperatures, and an uptick in extreme weather events. Karnataka's economy heavily relies on agriculture, yet the sector is vulnerable due to limited irrigation infrastructure, covering only 31.2% of the state's agricultural land, and erratic rainfall. These factors put small-scale farmers in a precarious situation, often leaving their livelihoods at the mercy of environmental conditions. In India the yield loss due to impact of dry spells was about 75–99% in 24% of sorghum, 23% of groundnut and 13% of pearl millet and it was about 50–74% in 44% of cotton, 24% of groundnut, 17% of maize, 16% each of pearl millet & sorghum and 12% of pigeon pea growing rainfed regions (Bal *et.al., 2022*). Recognizing these challenges, the National Initiative on Climate Resilient Agriculture (NICRA) launched a project targeting water management practices aimed at enhancing resilience in agriculture.

Methodology

The network project on National Innovations in Climate Resilient Agriculture implemented in a participatory trial were undertaken on farmers' fields from 2011 to 2024 in each in the village in the district of Tumakuru, Chikkaballapura and Gadag where strategic water conservation interventions led to improved water availability, increase in groundwater levels, and provide much-needed support to farmers in sustaining their livelihoods despite climate challenges. These village received an annual rainfall of 584 mm in Tumakuru, 641mm in Gadag and 590 mm in Chikkaballapura and categorized under high vulnerability as for as drought index in concerned. The NICRA project implemented a variety of water management practices like *in-situ* soil and water conservation, desilting and renovation of community tanks, construction of check cams, excavation of farm and percolation ponds promotion of Rainwater Harvesting and

Recycling to counteract the adverse effects of climate change on agriculture. These practices were chosen based on their potential to enhance water retention, reduce water wastage, and support groundwater recharge. The volume of water in rainwater harvesting structure is calculated using the formula after the top width; bottom width, depth, and side slope are known

$$V = \frac{(A + 4B + C)}{6} \times D$$

Where, V = Volume of the farm pond (m^3), A = Top width = 2 x D + Bottom width, B = Middle width = (Top + Bottom)/ 2, C = Bottom width, D = Depth of water in rainwater harvesting structure

The stored water in the rainwater harvesting structure was lifted by a 1.5 HP pump and used for protective irrigation. The protective irrigation area was documented in ha. The income generated from utilization of harvested water was calculated by multiplying the output (produce) with the prevailed market price at the time of harvest.

Results

The NICRA project's interventions in Tumakuru, Chikkaballapura, and Gadag have led to notable improvements in water availability and storage, positively impacting agriculture in these regions. Tumakuru witnessed substantial gains in water storage capacity because of various water management interventions. A total of 108 farm ponds and 13 percolation ponds were excavated, resulting in a significant increase in water storage. Five check dams, five water storage structures, and 33 community tanks were rejuvenated, leading to a notable improvement in water availability. These interventions collectively increased the water storage capacity by 428,890 cubic meters, providing critical support to rainfed agriculture in village during the dry spells.

In Chikkaballapura, targeted water management interventions were instrumental in enhanced water security. Eight farm ponds and 13 percolation ponds were excavated, contributing to improved water storage. The construction of one nala bund, two check dams, and desilting of community tanks contributed to water retention. Additionally, trench cum bunding was implemented over 45 hectares to conserve soil moisture and reduce erosion. These measures resulted in a total secured water capacity of 39,357 cubic meters, aiding farmers the village in sustaining their crops even in the face of rainfall irregularities.

Water management interventions were implemented in Gadag district viz, thirty-seven farm ponds excavation, and two community tanks rejuvenation increased water retention. Seventeen borewell recharge units and the desilting of a check dam further contributed to water availability in this drought-prone village. A total of 54,636 cubic meters of water was secured through these measures, benefiting the local agricultural community. The cumulative impact of these interventions across the three districts has been significant. By increasing water storage capacity and ensuring consistent availability of water for irrigation, the NICRA project has enabled a 25% increase in the net cultivated area. This expansion is a direct result of supplementary irrigation made possible through the various water management practices, which have reduced the dependency on rainfall.

Additionally, groundwater levels have seen a noticeable improvement due to increased infiltration and groundwater recharge facilitated by check dams, percolation ponds, and borewell recharge units. As a result, 33 open wells and 52 borewells have been successfully recharged, providing farmers with a more reliable and accessible source of water for their crops. This improvement in groundwater levels is crucial for sustaining agriculture during extended dry periods and contributes to long-term water security in the region.

Details of rainwater harvesting structures and water storage in NICRA villages

Water conservation structures	Tumakuru			Chikkaballapura			Gadag			Protective irrigation potential created (ha)
	No. of Units	No. of farmers benefited	Water Storage Capacity (Cu m)	No. of Units	No. of farmers benefited	Water Storage Capacity (Cu m)	No. of Units	No. of farmers benefited	Water Storage Capacity (Cu m)	
Farm pond	108	119	30950	8	8	1120	37	37	48900	58
Percolation pond	13	13	1750	13	18	4420	-	-	-	-
Check dam	05	11	6750	2	10	1950	-	-	-	111
Water storage structure	05	05	1960	-	-	-	-	-	-	03
Rejuvenation of farm pond/	34	106	387480	-	-	-	2	35	3920	45
Desilting of community pond	-	-	-	2	18	17825	1	4	1000	21
Nala bund	-	-	-	1	15	12420				17
Trench cum bund	-	-	-	45 ha	25	1622				
Borewell recharge				68	68	-	17	17	816	
	Total		428890			39357			54636	255

Conclusion

Rainwater harvesting structure has the potential to mitigate the climate change vulnerability of rainfed agriculture to achieve sustainability in terms of production and economic gains. Harvested water will help in providing supplementary irrigations during dry spells as well as pre-sowing irrigations in *rabi* season that helps in augmenting productivity. The runoff water diverted from the catchment area to recharge pits of the defunct / low yielding bore wells resulted in improved water table level in the vicinity and trench cum bunding helped in soil and moisture conservation leading to higher productivity of crops cultivated.

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UID: 1029

Delineation of Constraints in Core Districts/AERS for Enhanced Production of Sesame through Strategic Interventions

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Sesame (*Sesamum indicum* L.) is an oilseed crop, being grown mainly in *kharif* season in different agro-ecological regions (AER) of the country. Crop grows best on medium to light, well-drained soils, prefers pH 5-8 and does not tolerate salinity or standing water. In India, it is being grown in an area of 17.1 lakh ha with average productivity of 477 kg/ha. The productivity of the crop is varying from 100 kg/ha to 1100 kg/ha in different districts of the country. Understanding the constraints related to NRM perspective in low productive districts with considerable area is essential to enhance the sesame production through strategic interventions both in short term and long term basis. Agro-ecological sub-region (AESR) based data analysis is one of the approaches to delineate core districts in each AESR/AER. Therefore, the study was conducted with the objectives of (i) Delineation of core districts in important AESR/AER; (ii) Understanding constraints in core districts of important AESR/AER through GIS approach and (iii) Identification of reference district for target districts in core area of important AESR/AER.

Methodology

Quinquennial averages of district wise area and productivity of sesame crop was computed (2017-18 to 2021-22). AESR specific reference district for a group of target districts were identified for strategic interventions. Strategic interventions were derived for target districts based on the AER specific reference district/s. Based on agro-ecological regions (AER) and agro-ecological sub-regions (AESR) district wise quinquennial data was grouped. The AERs which occupied top 75% of the sesame cropped area were considered. Further from the selected

AERs, the AESRs with more than 2000 ha were included in the study. The districts which were having area more than 1000 ha were considered with respect to each AESR. Yield ranges were worked for group of districts under each AESR/state.

Results

The core AERs for sesame cultivation were AER 4 > 15 > 10 > 5 > 12 where 75% of the sesame area was concentrated. In each AER, important agro-ecological sub-regions were identified (AESR) (Table 2). Finally, core districts under each AESR/AER/State were delineated. Different GIS layers *viz.*, soil type, soil drainage, soil erosion were used to understand constraints in a particular district/AESR/AER. Addressing the constraints on short term/long term basis will pave the way for enhanced sesame production in the country.

Table 1. No. of districts in different AERs/AERs/States considered of imposing GIS layers

AER	AESR	State/s and districts	Total no. of districts
4	4.1	Rajasthan (5), U.P (2)	7
	4.2	Gujarat (4) Rajasthan (8)	12
	4.3	U.P (9)	9
	4.4	M.P (6), U.P (5)	11
5	5.1	Gujarat (5)	5
	5.2	Rajasthan (3)	3
	5.3	Gujarat (3)	3
10	10.1	M.P (2), Rajasthan (1)	3
	10.3	M.P (9), U.P (1)	10
	10.4	M.P (2)	2
12	12.1	Chhattisgarh (3), Maharashtra (1), Odisha (6)	10
	12.2	Odisha (3)	3
	12.3	Odisha (5), W.B (1)	6
15	15.1	Jharkhand (1), W.B (10)	11

The important groups of reference district *vs* target districts in core area of important AESR/AER were presented in Table 1. One of the interventions is conducting field days in reference district to encourage target district farmers for following improved cultivation practices. More Frontline demonstrations (FLD) may be allocated to the target district farmers to show the improved practices impact on sesame production. Need to conduct awareness campaigns before crop season as well as during crop season about best management practices of sesame particularly soil drainage and soil and moisture conservation measures. Another important intervention is improving the access (for the farmers) to seed of improved cultivars of sesame.

Table 2. Important groups of reference district for target districts in different AERs

AER	AESR	References district	No. of target districts	Yield (kg/ha)	
				References district	Target districts (range)
4	4.4	Banda UP)	3	244	116-167
5	5.1	Rajkot (GJ)	4	1124	192-680
	5.3	Gir Somnath (GJ)	3	1133	757-940
10	10.3	Damoh (MP)	6	574	303-466
12	12.1	Bauda (OD)	1	406	284
15	15.1	North 24 Parganas (WB)	8	1077	682-903

Conclusion

- Core districts (94) districts in AERs of 4, 5, 10, 12 and 15 were identified.
- Constraints in core districts were delineated through GIS approach using soil type, soil drainage and soil erosion layers.
- Six groups of reference district for target district/s in core AERs were identified

UID: 1054

Agriculture Drought Risk in Groundnut Crop

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Indian agriculture is impacted by different kinds of droughts in which Agricultural drought is one of the most important of all. It occurs when soil moisture is insufficient to meet the water needs of the crops. It results from uneven rainfall distribution, prolonged dry periods, high temperatures and poor soil management. These conditions leading to reduced crop growth, lower yields, and even crop failure. Studies are there on different kinds of drought Studying drought influences on crops are common but not at stage wise. As drought occurs at flowering stage which is highly sensitive; water stress during this period decreases flower production, increases flower drop, and adversely impacts peg formation. At the pod development stage, drought limits the filling of pods, leading to smaller, lighter, and fewer pods, ultimately reducing yield. During the maturity stage, insufficient moisture affects proper pod drying, reducing quality and making harvesting more challenging. This study aimed at stage wise analysis of Agricultural drought for identifying the critical stages where the agriculture drought risk is more. The cumulative effects of agricultural drought at these stages can severely impact the productivity and profitability of rainfed groundnut farming. Agricultural drought was analyzed for the two blocks Bathalapalli and Chennekothapalli blocks during *kharif* period for the year of 1988-2017 in Anantapur district.

Methodology

Long term rainfall data of two blocks Bathalapalli and Chennekothapalli was analyzed for the occurrence of agricultural drought as per the criteria given by National Commission on Agriculture (NCA), 1976

Results

Observations of Bathalapalli block revealed that frequency of occurring drought in 1989, 1991, 2003, 2006, 2013 and 2014 is double than rest of the year during ground nut crop growing season. Agricultural drought during these years mostly fallen at vegetative stage (27-29 SMW) and pegging stage (36-40). Rest of the years about 66% of drought occurred at emergence to vegetative state (27-33 SMW).

Table 1. Stage wise occurrence of Agricultural Drought in Bathalapalli

Year	Frequency	SMW	Crop stage
1988	1	22 - 30	Sowing/seedling and Vegetative stage
1989	2	23 - 26	Vegetative stage
		30 - 35	Vegetative to flowering stage
1990	1	34 - 38	Flowering to pegging stage
1991	2	33 - 36	Vegetative to pegging stage
		39 - 42	Pegging to pod development
1994	1	29 - 39	Emergence to pod development stage
1997	1	27 - 30	Emergence to Vegetative stage
2002	1	23 - 31	Emergence to Vegetative stage
2003	2	22 - 30	Emergence to Vegetative stage
		33 - 41	Vegetative to pod development stage
2004	1	32 - 35	Vegetative to Pegging stage
2005	1	24 - 28	Emergence stage
2006	2	26 - 29	Emergence stage
		31 - 36	Vegetative to Pegging stage
2007	1	39 - 42	Pegging to Pod development stage
2008	1	39 - 42	Pegging to Pod development stage
2009	1	27 - 31	Emergence to Vegetative stage
2012	1	22 - 25	Vegetative
2013	2	29 - 32	Emergence to Vegetative stage
		39 - 42	Pegging to Pod development stage
2014	2	29 - 33	Emergence to Vegetative stage
		39 - 42	Pegging to Pod development stage
2015	1	25 - 30	Emergence

For analyzing *kharif* agricultural drought at Chennekothapalli block 39 years of data was used (1979 -2017). Out of 39 years only three years viz., 1990, 2002 and 2006 had recorded 2 events of agricultural drought during groundnut crop growing season i.e., at vegetative stage-flowering stage (27-34 SMW) and pegging to pod development stage (38-42 SMW). 30% of times agricultural drought is occurring at flowering stage i.e., at (34-37 SMW). 60% of times agricultural drought occurring at emergence to vegetative stage (27-29 and 30-33 SMW). (Table 2).

Table 2. Stage wise occurrence of Agricultural Drought in Chennekothapalli

Year	Frequency	SMW	Crop stage
1980	1	34 - 37	Flowering to Pegging stage
1984	1	31 - 36	Vegetative to Pegging stage
1985	1	34 - 38	Flowering to Pegging stage
1986	1	33 - 37	Vegetative to Pegging stage
1987	1	34 - 37	Flowering to Pegging
1989	1	39 - 42	Pegging to Pod development
1990	2	28 - 31	Emergence to Vegetative stage
		33 - 38	Vegetative to Pegging stage
1991	1	32 - 36	Vegetative to Pegging stage
1992	1	28 - 39	Sowing to Pegging stage
1993	1	28 - 32	Sowing to Vegetative stage
1994	1	29 - 38	Emergence to Pegging stage
1997	1	28 - 31	Emergence to Vegetative stage
1999	1	34 - 38	Flowering to Pegging stage
2001	1	32 - 37	Vegetative to Pegging stage
2002	2	28 - 31	Emergence to Vegetative stage
		33 - 37	Vegetative to Pegging stage
2003	1	35 - 39	Flowering to Pod development stage
2004	1	32 - 35	Vegetative to Pegging stage
2005	1	37 - 40	Pegging to Pod development stage
2006	2	28 - 36	Sowing to Pegging stage
		38 - 42	Pegging to pod development stage
2009	1	28 - 32	Sowing to vegetative stage
2011	1	35 - 42	Flowering to Pod development
2014	1	29 - 32	Emergence stage
2016	1	33 - 37	Vegetative to Pegging stage

Conclusion

As the rainfall variability is predicted high in the future years, Agricultural droughts are major risk for groundnut crop at different stages. Sensitive stages identified are vegetative and pegging stage. Adaptation of mitigation strategies include timely sowing, using drought-resistant varieties, conserving soil moisture through mulching and intercropping, and adopting rainwater harvesting techniques to support critical growth phases may be necessary to manage the agricultural drought in groundnut.

UID: 1065

Assessment of Drought using Standardized Precipitation Index and Precipitation Decile Index in Aurangabad District of Maharashtra

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The study on assessment of drought using standardized precipitation index and precipitation decile index in Aurangabad District of Maharashtra was carried out during the year 2023**.** The rainfall data for 30 years (1993 to 2022) on a daily basis was processed to study the analysis of the frequency of drought events using standardized precipitation index (SPI), Precipitation Deciles (PD). It was observed that from 2000 to 2018 the frequency of drought increased in all tehsils of Aurangabad district. Also, severe drought conditions were observed for the years 2000, 2012, and 2018. It was observed that there were 13 drought events in the period of 1993-2022 where much below normal (Deciles 1-2) condition was observed for 6 years (1995, 2000, 2007, 2012, 2017, 2018) and much above normal (Deciles 9-10) condition was observed for 7 years (1998, 2006, 2010, 2019, 2020, 2021, 2022). It was observed that the frequency of the drought event was increased during the period (2008-2018). In all other tehsils of Aurangabad district frequency of drought events has increased in recent decades. As the severity of drought has more in recent decades, more efforts are needed for in situ moisture conservation. In Aurangabad tehsil, there are increasing occurrences of moderate to extreme drought conditions, with a notable rise in severity from 2008 to 2018. Similar trend was observed in Paithan, Gangapur, Vaijapur, Kannad, Khultabad, Sillod, Soegaon, and Phulambri tehsils of Aurangabad district.

UID: 1084

Modifications in the Location Specific Constants of Rainfall Intensity-Frequency-Duration Equation for Solapur in Scarcity Zone of Maharashtra

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The location specific rainfall intensity-frequency-duration (IFD) equations are required for estimation of peak rate of runoff which is useful for design of soil and water conservation and runoff disposal structures and planning flood control projects. It is also important from economic considerations as an overdesigned structure involves excessive cost and under

designed structure will be unsafe, involve high recurring expenditure on repair, maintenance and replacement. In order to have optimization in hydraulic design of any structure, the peak rate of runoff expected during the recurrence interval should be correct. This necessitates the knowledge of IFD relationship for a particular location. The rational formula is extensively used empirical formula for estimating runoff. In USA the generalized charts of IFD are being used for obtaining the value of rainfall intensity 'I' in the Rational formula. Since such generalized charts are not available in our country because of insufficient density of automatic raingauge stations, some empirical assumed values of 'I' are used for estimating runoff which needs improvement. Such relationships and nomographs have been developed at few stations scattered over the country. Nemec (1973) developed the most satisfactory general equation is of the form $I = (KT^a) / (t+b)^d$ where, I = rainfall intensity, cm/hr ; T = return period, yr.; K, a, b and d are the location specific constants. The IFD relationship is specific for a particular location and mainly depend upon the physical characteristics of rainfall, the relationship developed for one particular location cannot be superimposed on the other. Hence, it is necessary to determine the values of constants for as many locations as possible with maximum period of data in order that their reliability and applicability will have greater practical significance. Barai (2004) analyzed 17 years rainfall data from daily automatic raingauge charts (1970 to 2003) of Solapur in the scarcity zone of Maharashtra and found the values of constants K, a, b and d as 11.08, 0.1892, 1.01 and 1.1081 respectively. Hence, an effort has been made with an objective to modify these constants for Solapur by analyzing 28 years (1970-2011), 32 years (1970-2015) and 37 years data (1970- 2020 except 1973, 1978, 1983-1988,1992,1993, 1997-2000).

Methodology

The daily automatic rain gauge charts of Solapur obtained from the observatory of NARP, Solapur for the period 1970 to 2020 (except 1973, 1978, 1983-1988,1992,1993, 1997-2000) (total 37 years) were analyzed in the form of annual maximum series of various durations *viz.,* 5, 10, 15, 30 minutes, 1, 3, 6, 12 and 24 hours by using 'Original trace method' (Ram Babu et al. 1979). The plotting positions corresponding to 50, 15.9 and 84.1 per cent of abscissa were obtained by using the 'computing method' suggested by Ogrosky and Mockus (1957). The rainfall intensities were plotted on log-normal probability paper, with rainfall intensities on log scale and per cent chance of occurrence on probability scale (Fig 1). The rainfall intensities for each duration against selected per cent frequencies (1, 2, 4, 10, 25 and 50 per cent) were obtained and frequency converted to return period in years (Table 1). The values of coefficients K, a, b and d were obtained by following the procedure given by Ram Babu et al 1979.

Estimation of constant 'a'

The values of rainfall intensities from table 1 for all durations were plotted on Y-axis and values of return period on X-axis on log-log paper (Fig 2). The geometric mean slope ($\overline{m}$) for the entire set of lines was determined which represents the exponent 'a' in the equation. It was obtained as 0.1992, 0.2313, 0.2890 and 0.1934 for 17, 28, 32 and 37 years data respectively. A line representing the geometric mean slope was drawn at the base through origin. The solid lines parallel to this slope line were drawn by cutting the y-axis against 1-year return period. The rainfall intensities against 1-year return period for the corresponding durations are obtained from the graph.

Estimation of constant 'b'

The values of rainfall intensities of one-year return period on Y-axis and selected durations on X-axis plotted on log-log paper. The points so plotted do not fall in a straight line. To make the points aligned into a straight line, suitable constant 'b' is needed. The estimated value of 'b' was 1.01, 1.00, 0.25 and 0.40 for 17, 28, 32 and 37 years data respectively.

Estimation of constants 'K' and 'd'

The constants 'K' and 'd' are found by solving the equations by least square method.

Results

The values of constants K, a, b and d found by analyzing 17, 28, 32 and 37 years daily automatic raingauge charts from 1970 to 2020 are given in table 2. The constants K, a, b and d in the rainfall intensity-frequency-duration equation developed by analyzing 37 years daily automatic raingauge charts for Solapur are modified as 4.57, 0.1934, 0.40 and 0.9187 respectively.

Table 1. Rainfall intensities for different return period and selected durations at Solapur

Duration, h	Per cent frequency					
	1%	2%	4%	10%	25%	50%
	Return period, year					
	100	50	25	10	4	2
	Rainfall intensity, mm/h					
0.08	230.0	210.0	185.0	150.0	120.0	90.0
0.16	205.0	180.0	162.0	130.0	98.0	72.0
0.25	182.0	165.0	140.0	115.0	88.0	68.0
0.50	130.0	120.0	102.0	84.0	66.0	50.0
1.0	100.0	88.0	78.0	60.0	47.0	35.0
3.0	42.0	38.0	35.0	28.0	22.0	16.0
6.0	23.0	20.0	18.0	15.0	12.0	9.0
12.0	13.0	12.0	10.0	8.4	7.6	5.0
24.0	6.4	5.8	5.0	4.2	3.4	2.6

Table 2. Values of constants K, a, b and d for Solapur

Data Period*	No. of years	K	a	b	d
1970-1996	17	11.08	0.1992	1.01	1.2066
1970-2011	28	6.96	0.2313	1.00	1.1081
1970-2015	32	3.1318	0.2890	0.25	0.8802
1970-2020	37	4.57	0.1934	0.40	0.9178

(Except 1973, 1978, 1983-1988,1992,1993, 1997-2000 : Total 14 years)

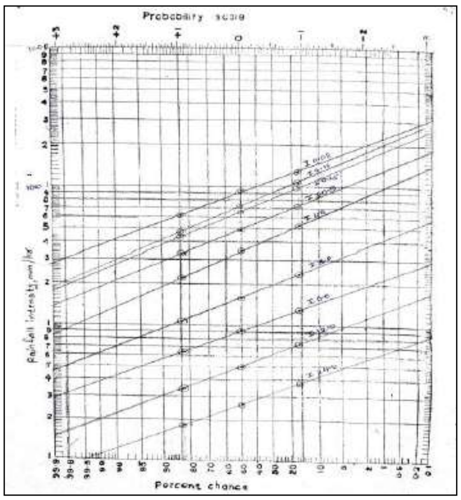

Fig 1. Frequency distribution of rainfall intensities for various durations at Solapur. (log scale = rainfall intensity, mm/hr, (probability scale = percent chance of occurrence)

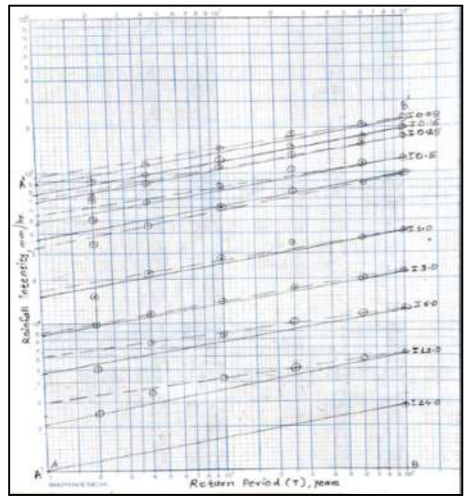

Fig 2. Rainfall intensities for selected durations and return period at Solapur.

Conclusion

The modified constants K, a, b and d in rainfall intensity-frequency-duration equation from 37 years rainfall data for Solapur are recommended as 4.57, 0.1934, 0.40 and 0.9187 respectively. The equation is

$$I = \frac{4.57\ T^{0.1934}}{(t + 0.40)^{0.9187}}\ cm/h$$

Where, I= rainfall intensity, cm/hr; T = return period, year ; t = duration, h

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Land resource inventory, prioritization of micro-watershed for soil, water and land use in northern dry zone of Vijayapura district of Karnataka by using GIS techniques

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Land is a scarce resource and basic unit for any material production. It can support the needs of the growing population, provided they use land in a rational and judicious manner. But what is happening in many areas of the state is a cause for concern to anyone involved in the management of land resources at the grassroots level. In India the geographical area available for agriculture is about 51 per cent of the total area and more than 60 per cent of the people are still relying on agriculture for their livelihood. The limited land area is under severe stress and strain due to increasing population pressure and competing demands of various land uses. Due to this, every year there is a significant diversion of farmlands and water resources for non-agricultural purposes Sehgal *et al.,* (1990). Apart from this, due to lack of interest for farming among the farmers in many areas, large tracts of cultivable lands are turning into fallows and this trend is continuing at an alarming rate.

The watershed management programs are aimed at designing suitable soil and water conservation measures, productivity enhancement of existing crops, crop diversification with horticultural species, greening the wastelands with forestry species of multiple uses and improving the livelihood opportunities for landless people.

The objectives can be met to a great extent when an appropriate Natural Resources Management (NRM) plan is prepared and implemented. It is essential to have site specific Land Resources Inventory (LRI) indicating the potentials and constraints for developing such a site-specific plan. LRI can be obtained by carrying out detailed characterization and mapping of all the existing land resources like soils, climate, water, minerals and rocks, vegetation, crops, land use pattern, socio-economic conditions, infrastructure, marketing facilities and various schemes and developmental works of the government (Naidu *et al.,*2006). From the data collected at farm level, the specific problems and potentials of the area can be identified and highlighted, conservation measures required for the area can be planned on a scientific footing, suitability of the area for various uses can be worked out and finally viable and sustainable land use options suitable for each and every land holding can be prescribed to the farmer and other land users of the area (Katyal*et.al.,*2003).

Methodology

The Atharga Sub-watershed is located in between $17^0$0‘0" to $16^0$57‘30“ North latitudes and $75^0$50‘30" to $75^0$58‘0“East longitudes, covering an area of about 1044.36 ha. Extends over entire Koppal, Vijayapur, and Bellary district and five taluks of Belgaum, six of Bagalkot, two of Raichur, one of Dharwad and Davanagere, four of Gadag. The main cropping season is kharif. sorghum, maize, bajra, red gram groundnut, green gram, cotton, sugarcane, wheat, chickpea, horticultural crop like grape, lime, pomegranate and vegetables like chilli, onion, brinjal and cucurbits are the important crops of the zone.

A comprehensive soil survey of the study area was conducted utilizing data from IRS-LISS IV and Cartosat-1 satellite images (1:8000 scale) and Vijayapura district toposheet as per procedure outlined by Land resource inventory (LRI) for surface study during which the area was intensively traversed, surface characteristics like texture, slope, erosion, gravellines, calcareousness and stoniness were recorded. Surface soil samples were collected at 320m grid intervals and were analysed for macro and micronutrients status, salinity, soil reaction and organic carbon. Soil samples were then collected and analysed for essential physical and physicochemical properties following standard analytical procedures. Following the correlation of these soil properties, classification into four series was carried out according to the guidelines provided in the field guide for LRI Sujala-III project, ICAR-NBBSS & LUP. Subsequently, these soils were mapped into 14 distinct mapping units based on variations in texture, depth, slope and erosion characteristics. The soil-site characteristics of various soil units were determined by calculating the weighted average of each soil property. Which was then interpreted to assess land capability. The properties were compared with the criteria outlined for land capability classification.

In the present study the land capability classification is followed as per category: Land capability refers to group of soils with the same degree of limitations, which escalate from class I to VIII. Classes I to IV are suitable for cultivation, while classes V to VIII are not suitable for cultivation but may be suitable for grazing, forestry, wildlife maintenance, recreation or watershed protection) which is mainly based on the inherent soil characteristics, external land features and environmental factors. The land capability classes and subclasses were determined according to the guidelines provided in the LRI Field Guide, REWARD project, ICAR-NBSS & LUP. With the advancements in remote sensing and Geographic Information System (GIS), thematic layers were generated, integrated, and subjected to spatial analysis to create land capability maps and soil-site suitability maps. This process was conducted using the ArcView Interface within ArcGIS 10.8.2 software.

Results

A soil map is crafted to depict the spatial distribution of various soil types or other mapping units relative to prominent physical and cultural features of the Earth's surface. In the identification of soil mapping units within the study area, input parameters such as soil series, soil texture, soil depth, slope, erosion and gravel content were utilized. Study area is grouped into four series namely, Babaleshwar (BBL), Dadamatti (DMT), Halangeni (HLG), Jumanal (JML), Naihalla (NHL) and Tenihalli(THL) series. Babaleshwar series covers 495 ha (87.39%) of the study area and they are very deep, black soils, vary from clay loam to clay texture. Dadamattiseries which cover 127 ha (12.03%) area and they are shallow clay soil with gentle sloping. Halangeniseries covers 143 ha (13.68%) and are classified as very deep, Jumanal series covers 121 ha (11.58%) and they are deep with gently sloping, Naihalla series covers 56 ha (5.33) and 56 ha (5.35%) of Atharga sub-watershed area belongs to Tenihalli series which is characterized by clay soils which are moderately deep moderately eroded with gravel soils.

These mapping units were delineated into fourteen categories during various phases of soil series using the Arc View Interface of ArcGIS 10.8.2 GIS software. The legend for mapping units is represented as follows: for example, "DMTiB2g1", where the first three capital letters denote the name of the series (e.g., DMT for Dadamatti), followed by a lowercase letter indicating surface texture (i.e., for sandy clay), the subsequent capital letter denotes slope (e.g., B for 1 to 3% slope), the following numerical value signifies erosion status (e.g., 2 for moderately eroded), and finally, "g1" indicates the class of gravellines (e.g., gravelly). The design of the legend and the types of mapping units for the study area were determined according to the procedures outlined in the LRI Field Guide for the REWARD project. Soil depth varied from shallow to very deep, slope grouped under very gently sloping class (1-3%) with moderately eroded with gravelly (15-35%) class.

Land capability classification

Based on the soil-site characteristics of the study area, the soils were classified into two land capability classes. These classes are described as follows:

Class III: Our study indicates that majority of Atharga sub-watershed area i.e,874 ha (83.73% of the study area) were categorized as land capability class III lands. Soils within this class are considered moderately good cultivable lands with limitations that erosion or runoff. These limitations may include one or more of the following factors: 1) soil depth 2) gravellines 3) light or heavy texture 4) salinity or alkalinity. Hence soil conservation practices like ploughing across the slope for field crops, levelling of land, ridges and furrows, providing proper drainage will help to improve the soil properties and land productivity Sharma et al., (15).

Class IV: The result showed that 11.62% (121 ha) of Athargasub watershed area has been categorized into IV class with severe limitation of erosion/runoff. These soils are categorized as fairly good cultivable lands, suitable for occasional cultivation only due to severe limitations.

They are characterized by: 1) severe restrictions on the choice of crops, 2) high susceptibility to erosion, 3) steep slopes, 4) shallow soil depth, 5) low water-holding capacity, 6) poor drainage, and 7) severe alkalinity and salinity. These soils exhibit moderate to rapid permeability and are moderately well-drained, with severe limitations regarding slope, moderate to severe limitations in erosion and depth, profile development, and base saturation. They also have moderate limitations in terms of coarse fragments and organic carbon content. Natarajan et al., (14). To achieve sustainable production of field crops and horticulture on these soils, management practices such as terracing, strip cropping, and contour tillage may be necessary. Reported from their study that in IVthclass soils occasional cultivation is rotated with hay or pasture, or by orchards and should be protected by permanent cover crops for control of intensive erosion Amara et al.,(16).

Grouping of soil-site suitability characteristics of soil mapping units of Atharga sub-watershed according to LCC classification

Sl. No.	Mapping units	Depth (cm)	Texture	Slope (%)	Erosion	Gravels (%)
1.	BBLmB2	>150	c	1-3	Moderate	<15
	LCC class	II	III	II	II	I
2.	BBLmB3	>150	c	1-3	Severe	>60
	LCC class	II	III	II	IV	IV
3.	BBLmB2g1	>150	c	1-3	Moderate	15-35
	LCC class	II	III	II	II	II
4.	DMTmB2	25-50	c	1-3	Moderate	<15
	LCC class	III	III	II	II	I
5.	DMTmB2g1	25-50	c	1-3	Moderate	15-35
	LCC class	III	III	II	II	II
6.	DMTmB2g2	25-50	c	1-3	Moderate	35-60
	LCC class	III	III	II	II	III
7.	HLGmB2	100-150	c	1-3	Moderate	<15
	LCC class	II	III	II	II	I
8.	HLGmB3	100-150	c	1-3	Severe	>60
	LCC class	II	III	II	IV	IV
9.	JMLmB2	100-150	c	1-3	Moderate	<15
	LCC class	II	III	II	II	I
10.	JMLmB2g1	100-150	c	1-3	Moderate	15-35
	LCC class	II	III	II	II	II
11.	NHLmB2g2	50-75	c	1-3	Moderate	35-60
	LCC class	III	III	II	II	III
12.	NHLmC3	50-75	c	3-5	Severe	>60
	LCC class	III	III	II	IV	IV
13.	THLmB2	75-100	c	1-3	Moderate	<15
	LCC class	III	III	II	II	I
14.	THLmB2g1	75-100	c	1-3	Moderate	15-35
	LCC class	III	III	II	II	II

Source: WDPD project, UHS, Bagalkot

Conclusion

Athargasub watershed land capability maps generated from information collected through LRI depicts that all the study area belongs to arable lands and it is fit for cultivation. In the study area, there were no lands categorized as Class I. The majority of the area falls under Class III lands, Soils within this class are considered moderately good cultivable lands, hence soil conservation practices like ploughing across the slope for field crops, levelling of land, ridges and furrows, providing proper drainage will help to improve the soil properties and land productivity. Class IV lands can be utilized for crop cultivation by adopting major soil conservation practices. Suitable soil conservation and management practices like graded bunds, terracing, strip cropping and contour-tillage should be followed to improve the soil physico chemical properties along with enhancing the productivity. Hence site specific LCC study and its interpretation helps to conserve the valuable agricultural resources and to achieve the sustainability. The capability maps generated from information collected through field work and topographical maps for Atharga sub-watershed area shows that all the study area belong to arable lands and fit for cultivation. Thus, the data on crop-land suitability can help farmers and decision makers to develop new crop management systems along with enhancing land productivity. The above studies and information will be helping farmers to go for horticulture cropping system.

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Adaptation to Rainfall Variability: Cropping Pattern Shifts and Enhanced Groundnut area under the NICRA Project in Chhatarpur District

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Chhatarpur, Madhya Pradesh, has witnessed profound changes in rainfall patterns due to climate variability, significantly influencing agriculture. Between 2016 and 2024, rainfall deficits and fewer rainy days have led to a marked increase in groundnut cultivation, from 11,352 ha in 2016 to 109,532 ha in 2024 (Anonymous 2024). Groundnut drought tolerance and ability to adapt to erratic rainfall have made it a preferred choice. This study analysis how climatic trends have driven the adoption of groundnut as a reliable crop to sustain agricultural productivity under changing weather conditions.

Methodology

The study analysis secondary data on annual rainfall, rainy days, and shifting trends in groundnut cultivation in Chhatarpur district from 2016 to 2024 (Anonymous 2024). It focuses on total precipitation and its distribution during key growth stages of groundnut, such as vegetative and pod formation phases. The analysis examines how rainfall variability has influenced the expansion of groundnut cultivation, offering insights into its resilience to climatic challenges.

Results

The groundnut area in Chhatarpur saw a remarkable increase from 2016 to 2024, expanding by 98,180 hectares, resulting in a growth rate of 864.87% (Table). This growth can be attributed to favorable rainfall patterns that supported groundnut adaptability and yield stability. Consistent rainfall during key growth stages in 2019, 2020, and 2021 facilitated increased cultivation, while groundnut drought resilience in years with reduced rainfall (e.g., 2020 and 2022) ensured continued expansion. In 2023, rainfall during the pod filling and maturation stages further bolstered yields, leading to additional area growth (Fig). Groundnut deep root system and drought tolerance helped it maintain stable yields despite fewer rainy days, making it a reliable and viable choice for farmers.

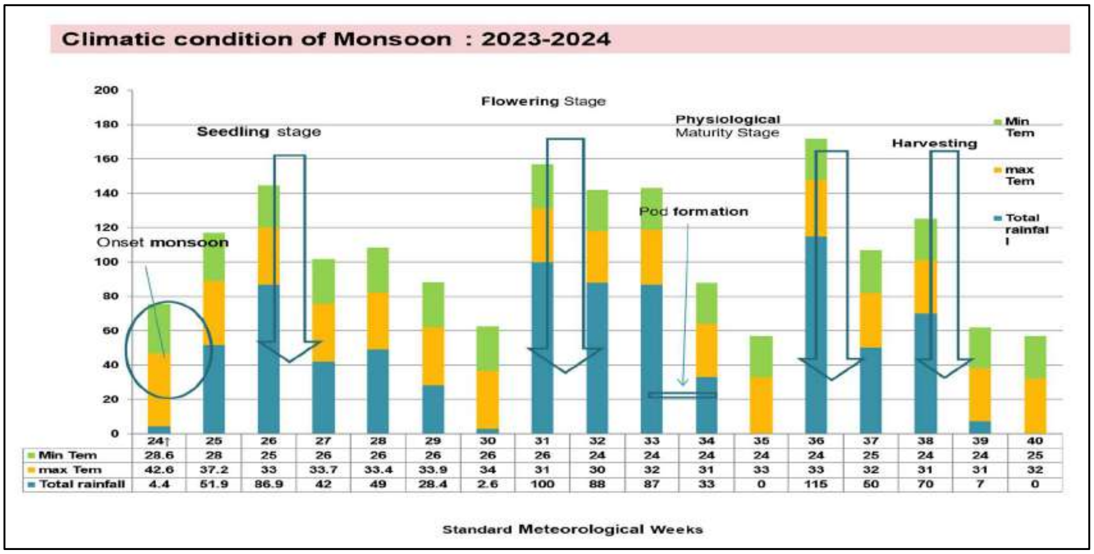
The climatic changes, particularly in Chhatarpur, have proven beneficial for groundnut cultivation due to the region's light, sandy soils. These soils allow groundnut to easily adapt to varying climatic conditions, including both reduced and erratic rainfall. The ability of groundnut to thrive in these soils, even under fluctuating climatic situations, enhances its suitability for this region, making it a resilient crop choice. In contrast, the acreage of other *kharif* crops in Chhatarpur declined in 2024 due to unfavorable climatic conditions. Paddy, sorghum, maize, moong, arhar, and soybean areas decreased significantly, driven by erratic rainfall, heat stress, and changing weather patterns. These crops, less tolerant of water stress and temperature fluctuations, became less viable compared to groundnut.

Year-wise (2016–2024) Groundnut area changes and fluctuations in Chhatarpur district and the role of rainfall trends

Year	Groundnut Area (ha)	Change (ha)	Fluctuation (%)	Role of rainfall trends in area change
2016	11,352	-	-	Consistent rainfall supported stable sowing area.
2017	14,024	+2,672	+23.54%	Increased rainfall in early season enhanced groundnut growth.
2018	11,765	-2,259	-16.11%	Deficit rainfall in mid-season led to reduced area under crop.
2019	20,331	+8,566	+72.79%	Favorable rainfall during crucial growth stages spurred growth.
2020	35,620	+15,289	+75.19%	Drought-resistant groundnut thrived during reduced rainy days.
2021	65,940	+30,320	+85.14%	Improved rainfall distribution led to an area expansion.
2022	75,880	+9,940	+15.08%	Despite rainfall deficit, groundnut maintained stable growth.
2023	99,024	+23,144	+30.49%	Rainfall surpluses during critical stages increased sowing.
2024	109,532	+10,508	+10.61%	Groundnut's drought resilience favored its growth despite erratic rainfall.
Difference (2016–2024) (ha)	+98,180		864.87 %	

Rainfall patterns over this period revealed an 18.63% surplus in 2016, followed by deficits of -46.35% in 2017 and -39.96% in 2022. The number of rainy days also declined, with only 18 in 2016, 29 in 2017, and 30 in 2021. The rainfall distribution showed heavy rains in July-August, followed by dry spells from June-September, which favored drought-resistant crops like groundnut. These trends underscore how groundnut's ability to thrive in Chhatarpur's light, well-drained soils and under changing climatic conditions positions it as a more stable and profitable option for farmers in the region.

This study examines the influence of rainfall variability on the expansion of groundnut cultivation in Chhatarpur, Madhya Pradesh, between 2016 and 2024. Erratic rainfall and fewer rainy days have favored the drought-tolerant groundnut over other crops. Analysis of climatic trends and cultivation data highlights significant growth in groundnut area, increasing from 11,352 ha in 2016 to 109,532 ha. in 2024. The 98,180-ha expansion in groundnut cultivation from 2016 to 2024 highlights its adaptability to climate variability in Chhatarpur. Groundnut's drought tolerance and stable yields under erratic rainfall emphasize the importance of climate-resilient crops in sustaining agriculture. Promoting such crops and improving water management strategies is crucial for mitigating the impacts of climate change on regional agriculture.



Climatic conditions during the 2023-2024 season across key growth stages of groundnut

Conclusion

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Drought and Cyclone vulnerability districts of Andhra Pradesh

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Agriculture in Andhra Pradesh is mostly dependent on rainfall, and nearly 60% area under rainfed farming. The net sown area of Andhra Pradesh is 67.19 lakh ha, net irrigated area is 28.08 lakh ha. Rainfed area is 39.11 lakh ha and it accounts for 58.21% of net sown area with 60% area under red soils and 25% area under black soils. Among all crops rice is the large contributor to Andhra Pradesh's economy, contributing a quarter of agricultural Gross State Domestic Product (GSDP). The level of cropping intensity (126%) moves with the behaviour of the monsoon. The State is prone to drought conditions especially in Rayalaseema region. The East Coast of Andhra Pradesh is one of the most cyclone prone areas of India. Despite their unpredictability, forecast techniques have made it possible to predict their occurrence time and range, which is very important to make the necessary preparations to face the monster (Ashok Kumar *et al.,* 2024).

Methodology

A study has been conducted to assess the vulnerability for drought and cyclones in different districts of Andhra Pradesh, data was analysed from 2002 to 2024 by considering the drought and cyclones. Data on drought in different districts was collected from Directorate of Economics and Statistics, Andhra Pradesh from 2002 to 2024 from Directorate of Economics and Statistics, Government of Andhra Pradesh which is available in the website (https://des.ap.gov.in) and in "Agricultural Statistics at a glance" from 2002 to 2024. Data on cyclones in different districts for the same period were collected from Andhra Pradesh State Disaster Management, Government of Andhra Pradesh (APSDMA -https://apsdma.ap.gov.in/). The data on droughts and cyclones in different districts were analysed and prioritised for vulnerability in Andhra Pradesh.

Results

Mandal wise data on drought affected districts of Andhra Pradesh out of 22 years from 2002-03 to 2024-2025 indicated that during *kharif* 15 years were drought years and seven years has no drought. During *Kharif*, Kadapa, Chittoor and Ananthapuramu recorded all the years of drought (17 Years), Kurnool 16 years, Prakasam 14 years, Nellore 12 years, Vizianagaram 11 years, Srikakulam and Guntur 10 years, Visakhapatnam 7 years, east and west Godavari 6 years of drought. During *rabi* season only two years were declared as drought. During Out of thirteen districts during *rabi*, 10 districts except Krishna, East and west Godavari during 2018-19, five districts *i.e* Vizianagaram, Prakasam, Nellore, Kadapa and Ananthapuramu during 2017-18 were declared as drought. Entire district of Ananthapuramu (9 years), Prakasam (5 years), Kurnool and YSR Kadapa (3 years) were declared as drought. Ananthapuramu district has high drought vulnerability index at 1.0, followed by Chittoor at 0.96, Kadapa at 0.71, Prakasam at 0.70, and Kurnool at 0.67. According to an estimate by the Department of Disaster Management, Government of Andhra Pradesh, about 44 percent of the State is vulnerable to tropical storms and related hazards. Out of 22 years, Srikakulam, Vizianagaram, Krishna, Visakhapatnam, Prakasam and Nellore were affected 10-11years of cyclones. In East and West Godavari districts 5 to 6 years of cyclones were recorded. The coastal Andhra Pradesh is highly vulnerable to cyclones with varying intensities. Consequently, the study has identified that most of the cyclones cross the state during the Northeast monsoon. Andhra Pradesh is a vulnerable coastal zone, experiencing 11 cyclonic turbulences, 5 depressions were documented during the years 2007, 2008, 2010, 2013 and 2018; although 2 cyclonic storms occurred during years 2006 and 2018, and 4 severe cyclonic storms (SCS) were measured in 2010, 2013, 2014 and 2020 (Komali Kantamaneni *et al.,* 2022).

Conclusion

Periodicity of and number of mandals affected by drought were more in Rayalaseema region *i.e* Ananthapuramu, Chittor, Kadapa, Kurnool and Prakasam districts compared to other districts. The coastal Andhra Pradesh districts *i.e.,* Srikakulam, Vizianagaram, Krishna, Visakhapatnam, Prakasam, Nellore, East and West Godavari were highly vulnerable for cyclones.

Drought and Cyclone vulnerability districts of Andhra Pradesh

Sl. No	District	No. of years of drought	No. of cyclones	Priority Rank for drought	Priority Rank for cyclones
1	Srikakulam	10	11	8	1
2	Vizianagaram	11	11	7	2
3	Visakhapatnam	7	10	11	4
4	East Godavari	6	5	13	9
5	West Godavari	6	6	12	8
6	Krishna	8	11	10	3
7	Guntur	10	7	9	7
8	Prakasam	14	10	5	6
9	Nellore	12	10	6	5
10	Kadapa	17	2	2	12
11	Kurnool	16	1	4	10
12	Ananthapuram	17	3	1	13
13	Chittoor	17	3	3	11

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Spatial Estimation of Soil Loss in Northern Karnataka Using Geospatial Techniques

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Nearly 49.0% of Karnataka is severely affected by soil erosion with a rate of more than 10.0 t $ha^{-1}yr^{-1}$ and the mean annual soil loss in the state ranges from <5.0 to >10.0 t $ha^{-1}yr^{-1}$ (Biswas et al., 2019). Earlier studies reported that Koppal, Bagalkote, Bellary and Dharwad requires soil loss mitigation in phased manner whereas Belgavi and Vijayapura are worst affected and needs immediate conservation. The most commonly used methodologies for gauging soil erosion includes runoff plots and gauging devices. Also, soil loss can be estimated using geospatial techniques and other modelling techniques. In case of ungauged catchments and areas with limited number of gauging stations, estimation of the soil loss is needed. Among different approaches, RUSLE has been widely adopted for soil loss estimation at watershed level as well as regional scale because of its convenience, accuracy and simplicity. This study aims to estimate soil loss spatially and temporally using RUSLE and geospatial techniques.

Methodology

The selected study area, Vijayapura district lies in northern dry zone of Karnataka, in Krishna basin, located between 16^0 8' to 17^0 29' N and 75^0 20' to 76^0 28' E with an elevation ranging from 273 m to 708 m above the MSL. It is a dry semi-arid region in Northern Karnataka and the average rainfall varies spatially from 560 to 700 mm. The study was also carried out for the entire Northern dry zone of Karnataka covering districts nemely, Belgavi, Bagalkot, Vijayapura, Gadag, Koppal, Bellary, Davengere, Raichur and Dharwad districts.

Soil erosion estimation using Revised Universal Soil Loss Equation (RUSLE)

In this study, Revised Universal Soil Loss Equation (RUSLE) and GIS was used for the estimation of soil erosion spatially and temporally using equation *(Eqn. 1)* considering rainfall, soil, land use and topographic datasets. The different thematic layers were prepared and intersected in ARCGIS and soil loss was estimated.

$$A= R\ K\ L\ S\ C\ P \quad \ldots\ldots\ldots.(1)$$

where A= average annual soil loss (t ha^{-1} y^{-1}); *R* is the rainfall-runoff erosivity factor (MJ mm ha^{-1} h^{-1} y^{-1}); *K* is the soil erodability factor (t ha h ha^{-1} MJ^{-1} mm^{-1}); *LS* is the slope length – steepness factor (dimensionless); *C* is the cover management factor (dimensionless); and *P* is the conservation practices factor (dimensionless). The equation for R-factor for daily soil loss was developed at ICAR-CRIDA, Hyderabad and was used in the study (Rejani et al., 2022). In this study, the value of K factor for the selected area was 0.015. The *LS* factor was estimated based on flow accumulation and slope steepness. C factor was derived from MODIS NDVI and P factor was adopted based on the LULC and the conservation practices followed in the area. The different thematic layers generated were intersected in ARCGIS and soil loss was estimated spatially and temporally using RUSLE for a period of 70 years from 1951 to 2020.

Prioritization of vulnerable areas

The spatial soil loss map generated was intersected with the catchments generated using GIS and dissolved so as to obtain the catchment wise soil loss. The areas producing more sediment would need special priority for the implementation of soil and water erosion control measures. The catchments affected with annual soil loss of more than 15.0 t ha^{-1} y^{-1} needs top priority for erosion control followed by areas with less soil loss.

Results

Rainfall, erosivity and soil loss

Rainfall and erosivity maps were generated using daily rainfall grid data of IMD from 1951 to 2020. The mean annual rainfall varied spatially from 560 to 700 mm and R factor varied from 3340 to >5530 MJ mm ha^{-1} h^{-1} yr^{-1} in the selected area. C factor derived spatially from MODIS NDVI. Soil loss was estimated spatially and the mean annual soil loss varied from less than 2.5 t $ha^{-1}y^{-1}$ to more than 15.0 t $ha^{-1}y^{-1}$ with 92% area having soil loss of less than 10.0 t $ha^{-1}y^{-1}$. Similarly, soil loss was also estimated from the other districts nemely, Belgavi, Bagalkot, Gadag, Koppal, Bellary, Davengere, Raichur and Dharwad districts of Northern dry zone of Karnataka

Prioritization of vulnerable areas

The soil loss map was intersected with the catchments generated in GIS. The catchments affected with soil loss of more than 15.0 t ha^{-1} y^{-1} needs special priority for the implementation of erosion control measures. Around 4.0% area in Vijayapura with soil loss more than 15.0 t $ha^{-1}y^{-1}$ was categorized under Priority 1 and 4.0% area with soil loss 10.0 to 15.0 t ha^{-1} y^{-1} under Priority 2 followed by 50.0% of the area with 5.0 to 10.0 t ha^{-1} y^{-1} under Priority 3. It was found that 42% area has slight erosion with soil loss less than 5.0 t ha^{-1} y^{-1} also needs interventions for controlling erosion under Priority 4 in Vijayapura district. In case of Northern dry zone of Karnataka, mean annual rainfall varied spatially from 420 to 3700 mm and R factor varied from 2606 to >15000 MJ mm ha^{-1} h^{-1} yr^{-1}. More than 81.0% of the area is having soil loss of less than 10.0 t $ha^{-1}y^{-1}$ (Rejani et al., 2022).

Conclusion

In this study, spatial soil loss was estimated using RUSLE and GIS. The mean annual soil loss ranged from less than 2.5 to more than 15.0 t ha^{-1} y^{-1}. For most of the study area, the mean annual soil loss was less than 10.0 t ha^{-1} y^{-1}. The spatial soil loss was estimated catchment wise and prioritized to determine the vulnerable areas.

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UID: 1137

Open Well: Resilient Technology of Rainwater Harvesting for Efficient Use in Agriculture

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Nature gives us our life in the form of rainfall through monsoon but little beat of it is stored in the soil, dams, lakes etc. and remaining water wasted or unutilized. Rainfall is often erratic resulting in runoff leading to unavailability of irrigation water during the crop season and prolonged dry spell in NICRA district of Raigarh. Rainwater harvesting, storage and efficient utilization is important for preparedness for supplemental pre-sowing irrigation as well as lifesaving irrigation to rainfed crops to mitigate dry spells and also important for timely sowing for rabi crops. Hence under the NICRA project, construction & renovation worked of open well in farmer's field with convergence of allied departments of C.G. Government during 2023-25 and enhanced the availability of water in the NICRA village of Raigarh. During the period 10 open well renovated and constructed, whereas 14 farmers have benefited. The total volume of water harvested was 43080.8 cubic foot in each year. The volume of water harvested was used to provide critical irrigation for 10.56 hac area during the kharif season which has significantly minimized the impact of dry spells and enhanced yield as well as productivity. The surplus water was used to irrigate during the rabi and farmers benefitted 10, contributed to double cropping in the NICRA village and enhancing productivity & income significantly. This resilient technology also improved recharge augments the groundwater to ensure long term sustainability.

UID: 1140

Application of Resource Conservation Technologies (RCTs) for Rainfed Rice-Toria Cropping System in Medium Land Situations of Assam

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The rice-toria cropping system is predominant in some pockets of Assam where double cropping is practised. While the rice-toria cropping system offers numerous benefits, intensive tillage practices associated with it can negatively impact soil health and natural resources. Traditional tillage methods, such as ploughing and harrowing, can lead to soil erosion, loss of organic matter, and reduced water-holding capacity. These practices also contribute to increased greenhouse gas emissions. Therefore, to ensure long-term sustainability, it is essential to adopt conservation tillage techniques like reduced tillage (RT), zero tillage (ZT), minimum tillage (MT) and mulching. These practices can help maintain soil structure, reduce erosion, and improve water retention, leading to higher crop yields and environmental benefits. RCT like Zero tillage eliminates soil disturbance by directly sowing seeds into undisturbed soil while leaving crop residues on the surface, which conserves moisture, suppresses weeds, and enhances soil organic matter. In contrast, minimum tillage involves shallow soil disturbance to prepare a seedbed, balancing moisture conservation with better seed-soil contact and reduced labour compared to conventional methods. Reduced tillage allows slightly deeper soil loosening and moderate incorporation of crop residues, improving water infiltration and reducing erosion. Together, these RCT practices enhance resilience, soil health, and yield stability in rainfed systems while lowering input costs and environmental impact. Moreover, conventional transplanted rice has a high labour cost for manual transplanting. RCTs like Direct Seeded Rice (DSR) may be an alternate option to overcome this problem (Borah et al., 2024). However, no systematic study on these RCTs was earlier carried out in Assam in the dominant cropping systems under rainfed conditions. Considering all these in view, an experiment was set up with the following objectives in Rice-toria cropping system in rainfed medium land situations of Assam. (a) To find out the best RCT practices for tillage in rainfed rice-toria production systems (b) Assess the impact of RCT on productivity and profitability in the rice-toria system under medium-land situations (c) Quantify energy efficiency and their soil physico-chemical properties.

Methodology

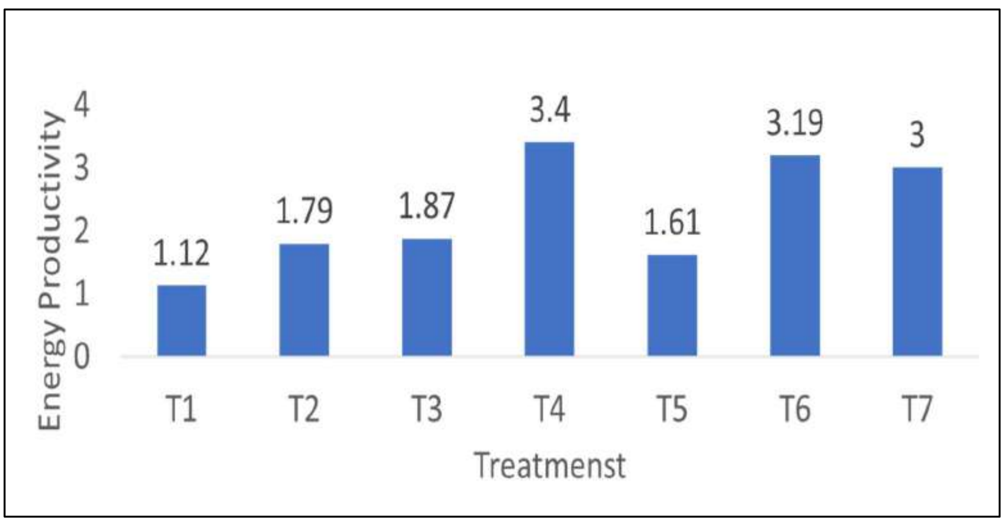
The experiment was conducted at KVK, Sonitpur farm (26^0 41' 55''N 92^0 49'35''E, 95 m above mean sea level) for four years from 2020-21 to 2023-24 in Randomized Block Design (RBD) with the following treatments in 3 replications: T_1: ZT Dry Direct Seed Rice (DSR) Sali- ZT toria with 20-30 cm rice stubble retention, T_2: RT Dry DSR Sali- ZT toria with 20-30 com rice stubble retention,T_3: MT wet DSR-ZT toria with 20-30 cm rice stubble retention, T_4: Conventional Tillage (CT) transplanted Sali-ZT toria with 20-30 cm rice stubble retention.T_5: CT Dry DSR-ZT toria with 20-30 cm rice stubble retention, T_6: CT wet DSR Sali- ZT toria with 20-30 cm of rice stubble retention, T_7: CT transplanted Sali- CT toria with no residue retention. ZT Toria seeds were sown with a seed-cum-fertilizer drill mixing with dry sand at a sand-to-seed ratio of 1:4.6 to 1:4.8 at a seeding depth of 1.3 to 2.5 cm into the untilled soil. In minimum tillage shallow harrowing was performed up to 5-15 cm depth. While in reduced tillage slightly deeper harrowing was performed (15-30 cm) than the minimum tillage operations. Rice variety Ranjit and Toria variety TS 67 were used in the study. Wet and Dry DSR were sown in the first week of June. Transplanting was done in the first week of July. Harvesting of the paddy was done in the last part of November. DSR rice matured 7-10 days earlier due to the escape of transplanting shock. Toria seeds were sown 10-12 days after harvesting of paddy. Immediately after harvesting of rice, Glyphosate was applied in the paddy field to make the soil weed-free for ZT toria. Soil samples were collected from 0–15 cm and 15–30 cm depths to analyse organic carbon, bulk density, Soil reaction, NPK content, and carbon fractionations using standard protocols before sowing (single composite sample) and treatment-wise replicated samples after completion of crop sequence. The effect of treatments on soil properties after the 4th-year sequence along with initial soil data is presented in Table. Energy productivity was calculated (Fig), and the benefit-cost (B:C) ratio was also assessed for each treatment.

Results

The study compared different cropping sequences and tillage practices to evaluate the system yield in the rice-toria cropping system, benefit-cost ratio (B: C), and energy productivity. The highest mean system yield (7371 kg/ha) was observed in the CT sali-zero tillage toria with 20-30 cm rice stubble retention, achieving a B: C ratio of 2.31 with Rainwater use efficiency (RWUE) 6.50 kg/ha/mm. However, the highest B: C ratio of 2.64 was recorded in the CT wet DSR sali-zero tillage toria with 20-30 cm rice stubble retention, indicating the best return on investment for this system (Table). In terms of energy productivity, the highest value of 3.40 kg/MJ was observed in the CT transplanted rice-ZT toria sequence. The CT wet DSR sali -ZT toria sequence followed it with energy productivity of 3.19 kg/MJ, while the lowest energy productivity of 1.61 kg/MJ was found in the CT dry DSR sali -ZT toria sequence. These results suggest that CT wet DSR sali-ZT toria with 20-30 cm rice stubble retention not only provides the highest benefit-cost ratio but also demonstrates favourable energy productivity, while the dry DSR sequence results in lower energy productivity (Fig). Proper tillage and stubble retention are key to optimizing both yield and cost-effectiveness in these systems. The effects of treatments on soil reactions and soil bulk density in both the top and sub-soil were found to be non-significant. Significantly highest organic C, Av. N,P,K were observed in ZT Dry DSR Sali- ZT toria with 20-30 cm rice stubble retention and the lowest was in CT transplanted Sali-CT toria with no residue retention . A fractional study of organic C reveals that treatments T_1 and T_2 exhibit relatively higher Less Labile Carbon (LLC) values, indicating a better potential for long-term carbon storage. This is because LLC is more resistant to decomposition, ensuring that carbon remains locked in the soil for extended periods. On the other hand, treatments T_6 and T_7 show lower LLC values, suggesting a lower potential for long-term carbon sequestration. Lower LLC implies a higher risk of carbon loss through decomposition.

Mean system yield (kg/ha)

Treatment	Mean system yield (kg/ha)						
	2020-21	2021-22	2022-23	2023-24	Pooled	Mean B:C ratio	RWUE (kg/ha/mm)
T_1	3156	3110	3459	3317	3261	1.29	2.8
T_2	3688	3630	4212	5153	4171	1.61	3.6
T_3	6035	5350	5406	5946	5684	2.24	5.0
T_4	7906	7050	7386	7223	7391	2.31	6.5
T_5	5160	5020	4625	5241	5012	1.56	4.4
T_6	7423	6620	6600	7028	6918	2.64	6.0
T_7	8078	7060	7133	7190	7365	2.16	6.4
CD (0.05)	730.1	766.6	618.9	658.8	1,510.7		



Effect of treatments on energy productivity

Conclusion

The study underscores the effectiveness of Resource Conservation Technologies (RCTs) in enhancing productivity, profitability, energy efficiency, and soil health in the rice-toria system under rainfed conditions in Assam. CT Wet DSR Sali-ZT Toria with 20-30 cm stubble retention delivered the highest benefit-cost ratio (2.64) and strong energy productivity (3.19 kg/MJ), while CT Sali-ZT Toria achieved the highest yield (7371 kg/ha). Zero Tillage and residue retention improved soil organic carbon and long-term carbon storage, reinforcing their role in sustainability. The findings advocate adopting RCTs like Wet-DSR followed by ZT toria and residue retention to balance productivity, cost-effectiveness, and environmental benefits in rainfed rice-toria systems in medium land situations of Assam.

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UID: 1161

Agro-Morphological Characterization and SSR Profiling of Barnyard Millet germplasm for their Potentiality in Bundelkhand Region

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Barnyard millet (*Echinochloa* spp.), is an annual, short-day, C_4 grass with a chromosome number of 6x=54 and comes under the family *Poaceae*. Barnyard millet has enormous potential to provide nutrition and food security because it has high nutritional value and is rich in antioxidant components, and can be grown in areas where major cereals cannot be cultivated due to harsh climatic conditions. Minor millets, including Barnyard millet, have been traditionally cultivated by certain farmers and tribes of the Bundelkhand region. Despite this, Barnyard millet is one of the most under-researched crops with respect to the characterization of genetic resources and genetic enhancement. Its potential for climate adaptation, particularly in harsh climatic regions like Bundelkhand, makes it a critical subject for study.

Methodology

A total of 180 germplasm lines were evaluated in augmented design along with 3 checks (Co (KV)-2, DHBM 93-3, and VL-207) in *Kharif* 2021 at the University research farm, Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh, these lines consist of a global panel of germplasm consisting of accessions from 7 different geographical origin including India. China, Japan, Malawi, Pakistan, Cameroon and Russia. These lines were characterized for eight traits like days to flowering, plant height, number of tillers, panicle length, flag leaf length, flag leaf width, fodder yield and grain yield.

Results

Analysis of variance indicates sufficient genetic variability in the germplasm for all the traits except panicle length and flag leaf length. Phenotypic and Genotypic Coefficient of Variation (PCV and GCV) indicated substantial genetic variability with minimal environmental influence for key traits such as grain yield (GY) with high PCV (41.21%) and GCV (39.64%) as well as fodder yield and number of tillers per plant. High broad-sense heritability (H^2) was observed for most traits, such as grain yield (92.52%), plant height (PH) (92.16%), fodder yield (96.72%), and number of tillers per plant (82.32%), indicating that these traits are predominantly controlled by genetic factors. Genetic Advance as Percentage of Mean (GAM) was high for key traits, suggesting their potential for improvement through selection. Principal Component Analysis (PCA) demonstrated significant genetic variability, with PC1 and PC2 accounting for 32.7% and 19.3% of the total variability, respectively, highlighting the importance of grain yield and panicle length in determining diversity.

On the basis of genetic divergence-based clustering of genotypes in first year, twenty accessions of diverse origins, along with two national checks CO (KV)-2 and DHBM 93-3, were again characterized for 14 quantitative characters using cluster and principal component analysis in randomized block design with three replications at the University research farm, Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh during *Kharif* 2022. The cluster analysis grouped the 22 *Echinochloa* spp. accessions into six groups, revealing significant genetic diversity. The principal component analysis revealed that the sum of the main components produced a maximum variability of 77.2% among the genotypes. Furthermore, 26 simple sequence repeats (SSR) markers showed a high degree of polymorphism among the germplasm, with the primer UGEP 8 having the highest PIC value of 0.71. The dendrogram generated based on these markers distinctly demarcated most of the *Echinochloa* spp. into different clusters, indicating vast genetic diversity in the population.

Conclusion

Overall, the high degree of genetic variability described by morphological traits and molecular markers in *Echinochloa* spp. can be used as a foundational tool for genetic improvement programs. These findings are particularly valuable for developing climate-resilient varieties suitable for the challenging agro-climatic conditions of the Bundelkhand region, thereby enhancing food security and sustainable agriculture.

UID: 1167

Effect of Rainfall Intensity on Splash Erosion under Simulated Rainfall

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Splash erosion is recognized as the first stage in a soil erosion process. Quantification of splash erosion for various combinations of land slopes and rainfall intensities with the help of rainfall simulation system and modified Morgan's splash cup was tried in this study. The clay soil was used to study the splash erosion. The directional splash soil loss rate (kg ha^{-1}), i.e. upslope and down slope were found increasing with increase in rainfall intensity and land slope. The rate of increase in down slope splash was comparatively more than upslope. The highest soil splash i.e. 16369 kg ha^{-1} was observed for combination of 10 percent land slope and 7.75 cm h^{-1} rainfall intensity in clay soil. The results obtained showed that maximum average vertical movement of splashed material was 83 cm in clay soil, for the combination of rainfall intensity 7.75 cm h^{-1} and land slope 10 %. The maximum average horizontal movement of splashed material was found 100.5 cm for the combination of rainfall intensity 7.75 cm h^{-1} and land slope 10 %. The Splashed soil material was spread near about 100.5 cm in the down slope direction and 69.0 cm in the upslope direction which highlights the need to modify the size of splash cup to study the realistic soil movement during splash erosion.

UID: 1194

Temporal analysis of soil erosion using remote sensing and GIS technique

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Soil is a complex mixture of minerals, organic matter and living organisms on the earth's surface. Soil erosion is one of the key considerations for planning the development of watershed. Erosion models, such as the Universal Soil Loss Equation (USLE), are widely used around the world to estimate erosion rates by relating different variables or factors with mathematical expressions. The USLE equation consists of five major factors such as Rainfall erosivity factor (R), Soil erodibility factor (K), Topographic factor (LS), Crop management factor (C) and Conservation practice factor (P). Construction of different soil and water conservation structures plays important role in reducing rate of soil erosion. Change in land use land cover with time is also one of the influencing factors in soil erosion estimation. Remote sensing and Geographical Information System (GIS) plays crucial role in generation of different spatial and temporal information related to land resources. Considering all above facts, the present study was conducted at central MPKV campus watershed with the aim to

estimate soil erosion using Universal Soil Loss Equation (USLE) and to compare soil erosion for different temporal periods. The study area is the central MPKV campus watershed located in Rahuri taluka in Ahmednagar district of Maharashtra, India which is located between latitudes from 19° 21.77' N to 19° 18.73' N and longitudes from 74° 37.79' E to 74° 36.49' E having total geographical area 13.83 km^2 (1383 ha). The mean annual precipitation in study area is 592 mm. The study was conducted for five years i.e. 2000, 2005, 2010, 2015 and 2020. The area under slight erosion class has increased by 3.36%, 23.47%, 21.5% and 63.39% for year 2005, 2010, 2015 and 2020 as compared to 2000. Similarly, the area under very severe erosion class has decreased by 20.70%, 53.83%, 41.97% and 73.34% for year 2005, 2010, 2015 and 2020 as compared to 2000. The construction of SWC structures also plays key role in reducing intensity of soil erosion. Overall study suggests that the areas with very severe erosion class needs immediate soil erosion control measures.

UID: 1201

Sustainable Dryland Agriculture through Resource Conservation Techniques in Vidarbha Region of Maharashtra

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In dryland agriculture, scarcity of water is the main problem. Apart from the low and erratic behavior of rainfall, high evaporative demand and limited water holding capacity of the soil constitute the principle constraint in the crop production in dryland area. Yield fluctuations are high mainly due to vagaries of weather, often much behind the risk bearing capacity of the farmers. It is surprising to a layman that even humid areas with 2000 mm of annual rainfall not only suffer from moisture stress, but also face drinking water scarcity. Monsoon starts in the month of June and ends in last week of September or sometimes in the first week of October. Most of the rainfall is received during this period. With undulating topography and low moisture retention capacity of the soil, major portion of the rain water is lost through runoff, causing erosion and adding to the water logging of low-lying areas. After the rain stops, very little moisture is left in the profile to support plant growth and grain production. In dryland area deficiency and uncertainty in rainfall of high intensity causes excessive loss of soil through erosion which leaves the soil infertile. Owing to erratic behavior and improper distribution of rainfall, agriculture is risky, farmers lack resources, tools become inefficient and ultimately productivity is low. In order to have solution to these problems research was conducted and results are given below.

Results

1. Continuous Contour Trenches for resource conservation and perennial plantations

As per requirement contour lines are demarcated on selected plot and lines are drawn parallel to these guide lines with 5-6m row spacing of desired plantation. On these lines a continuous contour trenches of 60 x 30cm are excavated such that the upper fertile soil is collected on upstream side and below murum is spread at downstream side in the form of bund with suitable berm. Then the fertile soil is used to fill mound in the trench on desired distance as per plant to plant spacing. The mound is used for plantation and remaining trench is left for rainwater conservation.

Performance

- There was no surface runoff in the CCT treated catchment as compared to untreated catchment *i.e.* the runoff in CCT treated catchment (100%) was recharged in the soil.
- The highest yield of pod and grain of green gram was observed in the treatment of CCT treated catchment (271.75 and 170.48kg ha^{-1}) as against untreated catchment (162.45 and 106.84kg ha^{-1}).
- The soil moisture status in CCT treated catchment was observed to be better as compared to the untreated catchment at 0-15, 15-30 and 30-45cm depth in every recorded month.
- On an average the ground water recharge in the CCT treated catchment was more by 17.74 % compared to the non-treated catchment.

The CCTs are useful in order to increase infiltration into soil, to control damaging excess runoff and to manage and utilize runoff for groundwater recharge. The *in-situ* conservation of rainfall takes place in CCT treated catchment. The prolonged moisture in the CCT treated catchment will enhance the growth of perennial plantation. The groundwater recharge in the CCT treated catchment was more.

2. Tillage and nutrient management for resource conservation and improving soil quality

In rainfed condition for sorghum crop, minimum tillage (one hoeing followed by one hand weeding) with 20kg nitrogen through inorganic fertilizer+20kg N through FYM (3.8t ha^{-1}), 40kg P_2O_5 and 40kg K_2O as basal dose and remaining 20kg nitrogen through inorganic fertilizer + 20kg through gliricidia (3t ha^{-1}, at 30 DAS) is recommended for higher rainwater use efficiency, higher grain yield and enhanced soil fertility.

Productivity

The tillage treatments were found statistically significant for grain yield and observed to be non-significant in case of fodder yield. The treatment 50% of conventional tillage and hand weeding has recorded significantly highest grain yield (3843kg ha^{-1}) over conventional tillage

(2987kg ha^{-1}) and it was at par with 50% of conventional tillage and herbicide (3501kg ha^{-1}). The treatment 50% recommended dose through organic and inorganic recorded statistically significant grain yield (3664kg ha^{-1}) over the treatment recommended dose through inorganic and at par with treatment recommended dose through organic (FYM/Glyricidia). Significantly highest fodder yield (10155kg ha^{-1}) was recorded in the treatment recommended dose through organic and inorganic. Interaction effect of tillage and nutrient management in case of grain yield was found statistically significant and for fodder yield it was non-significant.

Energy

Equivalent input energy required for different operations undertaken in the different treatments was estimated, using the procedure given in Research Manual on Energy requirement in Agricultural sector. The equivalent energy requirement for sorghum crop was observed to be higher in the treatment combination of conventional tillage and application of inorganic fertilizer as the energy input through fertilizer is high as compared to organics but the energy required for application of fertilizer is also high.

Conclusion

Due to adoption and proper implementation of these dryland practices/techniques the yield maximization is possible due to soil and water conservation which will lead to development of natural resources and ultimately sustainability in Dryland Agriculture.

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UID: 1203

Long-Term Effect of Crop Residue Application on Soil Properties and Crop Performance in Sorghum-Cowpea System under No-Tillage

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Conservation agriculture implies three important interlinked principles viz., minimum or no tillage, permanent residue cover and crop diversification. Some of the studies conducted earlier have given indication that the long-term practice of no-tillage with crop residue application have significantly influenced soil physical, chemical, and biological properties (Indoria et al., 2017). In this context, the long influence of practices like no-tillage and use of adequate levels of crop residue as surface cover was studied in rainfed Alfisols. The objective of the study was to assess the effect of crop residue on soil physical, chemical and biological properties and its effect on yield of sorghum-cowpea crop.

Methodology

Long-term experiment started during 2005 with cowpea sorghum yearly rotation at HRF, ICAR-CRIDA, Hyderabad. The treatment comprised of T_1 - No crop residue application (control), T_2 – 2 t dry crop residue ha^{-1} + 35 cm sorghum crop stubble retention/ full cowpea residue retention, T3 – 4 t dry crop residue ha^{-1} + 35 cm sorghum crop stubble retention/ full cowpea residue retention and T4 – 6 t dry crop residue ha^{-1} + 35 cm sorghum crop stubble retention/ full cowpea residue retention. Experiment was laid down in the randomized plot design and standard procedures were used for the estimation of the soil properties.

Results

Crops Yield

The pooled yield of sorghum and cowpea crops significantly increased with the increase in the level of crop residue application. Significantly higher sorghum pooled yield was observed with the surface application of crop residue @ 2 t ha^{-1} (1726 kg ha^{-1}), 4t ha^{-1} (1905 kg ha^{-1}) and 6 t ha^{-1} (2036 kg ha^{-1}) compared to no residue application (1584 kg ha^{-1}). The increase in pooled yield of sorghum due to application of sorghum residue @ 2, 4 and 6 t ha^{-1} was to the extent of 9, 20 and 28%, respectively over no residue application. Significantly higher cowpea pooled yield was observed with the surface application of crop residue @ 2 t ha^{-1} (588 kg ha^{-1}), 4 t ha^{-1} (677 kg ha^{-1}) and 6 t ha^{-1} (718 kg ha^{-1}) compared to no residue application (439 kg ha^{-1}). The increase in pooled yield of cowpea due to application of sorghum residue @ 2, 4 and 6 t ha^{-1} was to the extent of 34, 45and 64 %, respectively over no residue application.

Mineral Nitrogen

Ammonical N in these soils varied from 19.4 to 29.9 mg kg^{-1}across the treatments. Significantly higher ammonical N (29.9 mg kg^{-1}) was observed with the application of sorghum residue @ 6 t ha^{-1} compared to control (19.4 mg kg^{-1}) at flowering stage of the sorghum crop. Nitrate nitrogen in the soil varied from 24.7 to 45.4 mg kg^{-1} across the treatments. Significantly higher (45.4 mg kg^{-1}) nitrate N was observed with the application of sorghum residue @ 6 t ha^{-1} followed by @ 4 t ha^{-1} (36.6 mg kg^{-1}) compared to control (24.7 mg kg^{-1}).

Soil moisture content

On an average, the increase in soil moisture at 0-10 cm depth was 18%, 25%, 49% in 2, 4 and 6 t ha^{-1} crop residue treatments respectively over no crop residue application during sorghum crop growing season during 2021. At 10-20 cm soil depths, the crop residue treated plots stored 9%, 18% and 26% higher moisture content compared to no crop residue application during sorghum crop growing season.

Soil temperature, soil infiltration rate and RWUE

Surface application of crop residues @ 2, 4 and 6 t ha^{-1} recorded lower soil temperatures of 27.4, 27.0 and 26.3^{0}C at 9:00 AM and 31.8, 30.7 and 30.2^{0}C respectively at 2:00 PM over the control (27.8 and 33.6^{0}C). Similarly, the application of crop residue increased the soil infiltration rate by 21 to 58% in different residue treatments as compared to the control. The application of crop residue @ 6 t ha^{-1} recorded higher RWUE (3.32 kg ha^{-1} mm^{-1}) in sorghum and cowpea (1.09 kg ha^{-1} mm^{-1}) as compared to the rest of the treatments.

Effect of surface crop residue application on pooled yield of sorghum and cowpea crops, NH_4^+-N, NO_3^--N and soil moisture under no-tillage

Treatments	Cowpea pooled yield (kg ha^{-1})	Sorghum pooled yield (kg ha^{-1})	NH_4^+-N (mg kg^{-1})	NO_3^--N (mg kg^{-1})	Soil Moisture (%) in 0-10 cm
Control	798	192	19.43	24.68	11.2
2 t crop residue ha^{-1}	1027	277	21.22	29.65	13.2
4 t crop residue ha^{-1}	1166	392	24.26	36.58	13.9
6 t crop residue ha^{-1}	1327	557	29.88	45.44	16.9

Earthworm castings and soil enzymes activity

Significantly higher earthworm castings were observed in 6 t ha^{-1} (136/m^2) followed by @ 4 t ha-1 (117/m^2) and @ 2t ha^{-1} (97/m^2) and control (85/m^2). The added levels of the crop residue increased the dehydrogenase, acid and alkaline phosphatase enzymes activities. The significantly higher enzymes activity recorded with the application of 6 t ha^{-1}.

Conclusions

The results of the present study clearly indicated that the levels of surface crop residue application under no-tillage increased the yield of crops (sorghum and cowpea) significantly over the control. The reported results are in close conformity with the earlier findings by Sharma et al., 2024. The mineral-N, soil moisture content, RWUE, infiltration rate, earthworm casting and soil enzymes activity increased significantly, and it is emphasizing the importance of recycling the crop residues which can reduce the dependence on the synthetic fertilizers besides protecting the long-term soil health and sustainable of crop production.

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Long-Term Effect of Crop Management Practices on Crop Yields and Soil Properties in Sorghum-Castor Cropping Systems under Rainfed Alfisols

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To ensure desired targets of productivity, it is of paramount importance to improve soil quality through effective soil management practices such as conservation tillage, residue recycling and adequate amount of nitrogen fertilization. Sharma et al., 2016 have reported that conservation tillage practices coupled with proper residue management and optimum dose of nitrogen application can maintain or improve soil properties and has the potential to substantially increase long-term crop production in semi-arid rain fed regions. The present study was conducted with the objectives of: (i) To study the long-term influence of tillage, crop residues and N levels on crop response in sorghum-castor system in rainfed Alfisols. (ii) To study the long-term influence of tillage, crop residues and levels of N on crop yields and soil properties in sorghum-castor system under rainfed Alfisols.

Methodology

A long-term field experiment was started during 1995 and conducted at HRF, ICAR, CRIDA, Hyderabad. Treatments comprising of two tillage practices (conventional tillage, CT and minimum tillage, MT); three residue residues levels (2 t ha^{-1} dry sorghum stover (SS), 2 t ha^{-1} fresh gliricidia loppings (GL) and no residue (NR) and four nitrogen levels (0 (N0), 30 (N30), 60 (N60) and 90 (N90) kg N ha^{-1}) under sorghum (*Sorghum vulgare* L.) and castor (*ricinus communis* l.) system. experiment was initiated in a strip split-split plot design. standard methodology was used for the estimation of the crop and soil parameters.

Results

Effect on crop yields

Conventional tillage (CT) performed significantly well in terms of maintaining higher sorghum grain and castor pooled yield compared to minimum tillage. Application of GL and SS significantly increased the sorghum grain and castor seed pooled yield. The increase in sorghum grain pooled yield with N applied @ 30 kg, 60 kg and a 90 kg ha^{-1} level of nitrogen over control was tune of extent of 54, 81, and 98%, respectively. The increase in castor pooled yield with N applied @ 30 kg ha^{-1}, 60 kg ha^{-1} and 90 kg ha^{-1} level of nitrogen over control was tune of extent of 46, 70 and 91 % percent respectively. CT recorded the higher SYI of sorghum and castor as compared to MT. GL and SS maintained almost similar SYI in both the crops. The added levels of N increased the SYI in both the crops.

Effect of crop management practices on crop yields and SYI in sorghum-castor systems under rainfed Alfisols

Treatments	Sorghum pooled yield (kg ha^{-1})	SYI	Castor pooled yield (kg ha^{-1})	SYI
Conventional tillage (CT)	1221	0.24	795	0.21
Minimum tillage (MT)	1127	0.19	676	0.15
Dry sorghum stover @ 2 t ha^{-1} (SS)	1187	0.21	755	0.16
Fresh gliricidia loppings @ 2 t ha^{-1} (GL)	1282	0.23	798	0.21
No residue (NR)	1054	0.21	654	0.17
No- nitrogen (N0)	741	0.15	484	0.14
30 kg ha^{-1} (N30)	1144	0.21	709	0.16
60 kg N ha^{-1} (N60)	1343	0.25	824	0.19
90 kg N ha^{-1} (N90)	1469	0.26	926	0.24

Effect on soil properties

Significantly higher ammonical-N and nitrate-N was observed in minimum tillage as compare to the CT. Both GL and SS significantly increased the ammonical-N and nitrate-N as compared to the no residue application. The carbon pools content (very labile carbon, VLC; labile carbon, LC; less labile carbon, LLC) recorded significantly higher under MT as compared to the CT, while CT recorded the higher non-labile carbon (NLC) as compared to the MT. Application of GL and SS significantly increased the VLC, LC, LLC and NLC content as compared to no residue application. Among the N levels, the application of N @ 90 kg ha^{-1} recorded significantly higher VLC, LC and LLC (3.08, 1.71 and 1.12 g kg^{-1}) in soils followed by N @ 60 kg ha^{-1} (2.47, 1.48 and 0.98 g kg^{-1}), 30 kg ha^{-1} (1.98, 1.25 and 0.77 g kg^{-1}) and no nitrogen application (1.61, 1.06 and 0.64 g kg^{-1}). MT recorded the 7% higher soil available N as compared to the CT. Increase in available N under SS, and 2 t GL over NR was to the extent of 10.2 and 16.2% respectively. The increase available N under with 30, 60 and 90 kg N ha^{-1} was to the tune of 7.76%, 15.51% and 24.23% respectively over the control at 0-15 cm depth. Dehydrogenase activities (DHA), acid phosphatase, alkaline phosphatase, L-glutaminase, L-asparginase, urease, amidase and protease activity followed the order: MT>CT; GL>SS>NR; N90>N60>N30>N0. The activity of these enzymes decreased with increasing the soil depths. The soil moisture content at different crops growth periods and depths followed the trend as: MT>CT, GLI=SS>NR & 90>60>30>0 N kg ha^{-1}.

Conclusion

The present study has clearly indicated that the long-term use minimum tillage coupled with 2 t GL and 90 kg N ha^{-1} in sorghum–castor system significantly improved the crop yields and different soil properties. The reported results are in close conformity with earlier findings of Sharma et al., 2016 and Indoria et al., 2017.

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Addressing the Drought Induced Yield Variability in Karnataka Using Dry Spell Index (DSI)

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Indian agriculture is highly susceptible to adverse effects of climate and related extreme weather events (Charate *et al.,* 2017), as most of its cultivable land is under rainfed agriculture. Besides this, the burgeoning population, industrialization etc., have resulted in increased water demand in India (Dharminder *et al*., 2019). Karnataka, the second-largest state in India in terms of rainfed agriculture, accounting for nearly 66 percent of the cultivated area, relies heavily on southwest monsoon rains, which are of uneven and erratic distribution, both spatially and temporally, due to climate change and posing significant challenges to its food production. Deficit or no rainfall for consecutive days causes dry spell conditions which is highly related to the failure of crops and hence crop failure and water scarcity are viewed with great concern. Based on this, the present study is to examine the dry spells and drought condition in Karnataka by using Dry Spell Index (DSI), which is essential to developing strategies for drought mitigation, improved water management practices, and the development of drought-resistant crops.

Methodology

Karnataka, located in the southwest of India, consists of 30 districts. Geographically, it lies between 11.40° and 18.27° N latitude and 74.25° and 78.50° E longitude, covering an area of 191,791 square km, which constitutes 5.83% of the total area of India. Daily rainfall data for the 30 districts of Karnataka, spanning a 41-year period (1980-2020), was collected from the India Meteorological Department (IMD) for analysis.

Dry Spell Index

The Dry Spell Index (DSI) is a simple and effective drought index, offers advantage of easy calculation and flexibility in the scale of assessment. It's based on average daily reference evapotranspiration, soil texture, rooting depth, and total available water in the root zone; moisture stress may begin after 5 consecutive dry days for shallow-rooted crops (e.g., groundnut) in light-textured soils, whereas 10 consecutive dry days for deep-rooted crops (e.g., pigeon pea, cotton) in heavy-textured soils (Bal *et al*., 2022). In order to make the study simple and uniform as well as to estimate the response of crop productivity towards the dry spells, a common scale of 7 consecutive dry days is considered, receiving less than 2.5 mm of rainfall as a dry day.

DSI is calculated using the following equation

$$\text{DSI} = \frac{1}{LP}\sum_{i=1}^{NDD} W_i$$

Where LP is the dry spell scale, NDD is the number of consecutive dry days and Wi is the weighting factor assigned to each dry day within dry spell that linearly increases as the dry spell's duration.

Results

Dry Spell Index (DSI) was computed for the districts of Karnataka during the period 1980–2020 (Table 1). More number of years falls under <4 and > 12 average DSI for kharif, and under >12 average DSI for rabi season.

During Kharif season, Chitradurga and Tumkur districts experienced more than 84 consecutive dry days out of 122 days for 35 years out of 41 years with >12 DSI, led to severe water stress to the crops, which increases the rate of leaf senescence and drooping, scorching, leaf rolling and brittleness, closed flowers and flower sagging, etiolation, wilting, turgidity, premature fall, senescence and yellowing of leaves and ultimately, failure of crops (Khan *et al*., 2018). During rabi season, most of the years (37 – 41 years) in all the districts showed more than 84 consecutive dry days out of 92 days (>12 DSI category), led to drop in soil moisture can be attributed to the increase in the temperature which may have significant consequences on crop yields, and irrigation requirements

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Number of years under different categories of average DSI-7 of *kharif* and *rabi* season across different districts of Karnataka.

District	*Kharif*						*Rabi*					
	0-4	4.1 - 6	6.1 - 8	8.1 - 10	10.1-12	>12	0-4	4.1-6	6.1 - 8	8.1 - 10	10.1 - 12	>12
Bagalkote	5	2	5	3	2	24	0	0	0	0	0	41
Belgaum	33	4	3	1	0	0	0	0	0	0	0	41
Bellary	3	6	2	4	4	22	0	0	0	0	0	41
Bidar	23	4	3	4	2	5	0	0	0	0	0	41
Bijapur	6	1	3	4	5	22	0	0	0	0	0	41
Bangalore Rural	2	2	1	3	3	30	0	0	1	1	1	38
Bangalore Urban	3	0	5	2	6	25	0	0	2	0	0	39
Chamarajanagar	13	7	4	5	7	5	1	0	1	1	1	37
Chikkaballapur	1	1	2	3	2	32	0	0	0	1	2	38
Chikkamagalur	39	1	1	0	0	0	0	0	0	0	2	39
Chitradurga	1	2	1	0	2	35	0	0	0	0	0	41
Davanagere	8	5	4	7	6	11	0	0	0	0	0	41
Dharwad	30	5	1	3	1	1	0	0	0	0	0	41
Dakshina Kannada	40	1	0	0	0	0	0	0	0	1	1	39
Gadag	5	6	7	1	4	18	0	0	0	0	0	41
Gulbarga	16	7	4	2	3	9	0	0	0	0	0	41
Hassan	31	4	2	3	0	1	0	0	0	1	0	40
Haveri	15	5	8	7	0	6	0	0	0	0	0	41
Kodagu	15	5	8	7	0	6	0	0	0	1	0	40
Kolar	1	1	1	3	4	31	0	1	1	1	2	36
Koppal	1	8	2	3	3	24	0	0	0	0	0	41
Mandya	2	2	1	3	5	28	0	0	1	0	1	39
Mysore	30	5	4	2	0	0	1	0	0	0	3	37
Raichur	5	5	6	7	3	15	0	0	0	0	0	41
Ramanagara	3	2	1	3	4	28	0	1	0	0	3	37
Shimoga	40	1	0	0	0	0	0	0	0	0	0	41
Tumkur	1	1	0	1	3	35	0	0	0	0	0	41
Udupi	39	1	1	0	0	0	0	0	1	0	1	39
Uttara Kannada	40	0	1	0	0	0	0	0	0	0	0	41
Yadgiri	8	7	5	6	2	13	0	0	0	0	0	41

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Study of vulnerability in Agriculture of NICRA village and its mitigation through resilient technology

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In view of changing climatic variables such as rainfall, temperature and humidity the agriculture has become very hazardous due to occurrence of Flood, drought like situation and extreme level of temperature (max & min). Moreover, farming is a challenging activity depends upon various factors such as financial, knowledge, visible technology, lack of expertise, etc. Considering these points, a study was conducted in the adopted village of KVK Dhemaji under TDC-NICRA programme to study the vulnerability and performance of resilient technology. Climate resilient technologies are promising tool to guard a farming system from climatic variations (VK, 2017).

Methodology

The study was carried out in Magurmari village of Dhemaji district. To explore the problems faced by the farmers and to study the impact of climate resilent technology the study was carried out in 109 farm families of Magurmari village. Primary data were collected from 109 farmers by the personal interview method using standardized structured interview schedule. Data with respect to problems faced by the respondents and the yield of the climate resilient technology were collected. To prioritize the major constraints faced by the farmers a set of common problems were prepared after studying, consulting available literature and discussion with experts. Simple ranking technique was applied to measure the constraints faced by farmers. Each farmer was asked to responses the problems in four-point continuum as 'most serious', 'moderately serious', 'less serious' and 'not serious' and scores were assigned as 3, 2, 1 and 0. Then from the mean value ranking of problems were done as i, ii, iii etc. The constraint with highest mean value was considered as the most serious one and the others followed in that order. And for study of the economics of the resilient technology yield are compared with their respective check variety.

Results:

It is cleared from the table that majority (75%) of the respondents termed ' flood ' as the most serious problem followed by 70% respondents termed 'financial problem' as 2nd most serious problem. Accordingly, 57% respondents termed 'moisture stress' as the third most serious problem of the village. Agriculture is the primary source of livelihood for the farmers of magurmari village. Every year the village experienced flash flood during the monsoon season at least twice a year, causes a major loss in paddy cultivation. They also face financial problem to established agriculture as an enterprise and from time to time they were not able to buy hybrid seeds, equipments etc is in the study area. After that respondents didn't get quality seeds in proper time for cultivation. They practiced agriculture in a traditional way as they are not familiar with the use of hybrid varieties, submergence tolerant paddy varieties, scientific and advanced technologies since they didn't get any proper training on it, which is also a major problem. With the advent of new technologies and increasing competition in the global market, this traditional way of agriculture proved to be less profitable to the farmers. To address these entire problems some climate resilient technology were demonstrated in NICRA village.

Table 1: Distribution of respondents and ranking of problems according to their frequency of constrains faced by the farmers of NICRA village

Sl. No	Constraints	Frequency of Respondents				Mean	Rank
		Most serious	Serious	Less serious	Not serious		
1	Temperature	12 (11 %)	18 (17%)	66 (61%)	13 (12%)	**1.27**	14
2	Moisture stress	62 (57%)	47 (43%)	0 (00%)	0 (0%)	**2.57**	3
3	Quality inputs	52 (48%)	46 (42%)	6 (06%)	5 (05%)	**2.33**	7
4	Flood	82 (75%)	27 (25%)	0 (00%)	0 (00%)	**2.75**	1
5	Financial	76 (70%)	33 (0.30%)	0 (00%)	0 (00%)	**2.70**	2
6	Knowledge	42 (39%)	48 (48%)	10 (09%)	9 (08%)	**2.13**	9
7	Customs	32 (29%)	56 (51%)	9 (08%)	12 (11%)	**1.99**	11
8	No proper storage facility	28 (26%)	52 (48%)	22 (20%)	7 (06%)	**1.93**	13
9	Lack of training	53 (49%)	38 (35%)	15 (14%)	3 (03%)	**2.29**	8
10	Lack of skill	58 (53%)	42 (39%)	6 (06%)	3 (03%)	**2.42**	4
11	Lack of formal education	39 (36%)	52 (48%)	13 (0.12%)	5 (05%)	**2.15**	12
12	Lack of capital	64 (59%)	31 (28%)	8 (07%)	6 (06%)	**2.40**	5
13	Lack of available technology	56 (51%)	43 (39%)	6 (06%)	4 (04%)	**2.39**	6
14	Lack of expertise	53 (49%)	27 (25%)	8 (07%)	22 (20%)	**1.99**	10

The table showed better yield performance than farmer's variety in all attributes. The demonstrated technology Ranjit sub 1 performed well in stressful flooded situation as well as during the time of moderate drought. It was also found from the demonstration that the Benefit Cost Ratio (BCR) of the demonstration unit was better than the farmers cultivation practice. Farmers have come forward to adopt all the technology and have exchanged 4.5 q of submergence tolerant variety Ranjit sub1 seeds in their village leading to a horizontal spread of the technology. An additional area of 10 hectare has been covered by cultivation of Ranijit Sub 1.

Table 2: Economics of climate resilient technology demonstrated on NICRA village

Intervention	Crop/ enterprise	Variety	Production	GR	GC	NR	BC
Demonstration on submergence tolerant rice variety 'Ranjit sub-1'	Sali-paddy	Ranjit sub 1	48	93,120	38,000	55,120	2.45
		Jahingia (check)	39	54,660	31,500	23,160	1.73
Demonstration on medium duration rice variety Numoli	Sali-paddy	Numoli	46	89,240	38,000	51,240	2.34
		Bas dhan (check)	31	60,140	36,684	23,456	1.63
Cultivation of Rabi vegetables using organic mulching	Rabi vegetables	Tomato (hybrid)	210	2,10,000	52,000	1,58,000	4.03
		Local variety (check)	176	1,76,000	50,000	1,26,000	3.52
Cultivation of potato using organic mulching for moisture conservation	Tuber crop	Pusa pukhraj	215	3,22,500	68,550	2,54,500	4.7
		Local variety (check)	170	2,55,000	65,500	1,89,500	3.8

Mitigating with the nature and adoption of new technology including the climate resilient technologies have brought about new avenues in resource conservation. It can be concluded from the above study that NICRA project was a successful project in Dhemaji district and has been able to accomplish the prime objective of the project which was the adoption of new technology with changing of agro-climatic condition to establish resilient agriculture system.

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Agrometeorological indices influenced by varying Planting Windows and Varieties of Brinjal (*solanum melongena* L.) in Maharashtra

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Brinjal or eggplant (*Solanum melongena* Linnaeus) is from Solanaceae family belonging to genus *Solanum* and known as "King of vegetables". It is a native of India. It is an important vegetable crop grown throughout the country all the year round. Brinjal crop requires a long warm climate for its growth. Temperatures ranging between 25-32^{0}C are suitable for its cultivation. It does not prefer cool or frosty weather and requires silt loam to clay loam soil. Determination of optimum planting windows is considered an important effort to have optimum yields and keep insect pest damage below economic threshold level (ETL) both quantitative and qualitative traits of crops depend on planting on the proper windows and growing season. In India higher brinjal quality Prolonged periods of low or high temperatures or sudden change in them adversely affect the insect development. Different levels of humidity and rainfall, likewise, increase or reduce the population of certain insect pest species.

Methodology

The field experiment was conducted at Department of Agricultural Meteorology Farm, College of Agriculture, Pune during kharif seasons of 2014 and 2015. The experiment was conducted in a split plot design with three replications. The treatments were allotted randomly to each replication by keeping the gross plot size 4.5m x 3.75 m2 and net plot size 2.7 m x 2.7 m2with 90 x 75 cm spacing. There were twelve treatment combinations. The experiment was laid out in split plot design with three replications. The treatment comprised of three brinjal hybrids viz., V1: Phule Arjun V2: Krishna, V3:Panchganga as main plot and four planting windows viz., P1: 31MW (30 July- 3Aug), P2:32nd MW (6 Aug- 12 Aug),P3: 33rd MW (13Aug- 19 Aug) P4: 34th MW (20 Aug- 26 Aug) as sub plot treatments.

Growing degree days (GDD)

Temperature is a major environmental factor that determines the rate of plant development. The temperature requirement and range of optimum temperature varied with species and genotype. The thermal response of genotype can be quantified by using the heat unit or thermal time concept. There is high probability of successfully predicting the development of brinjal by heat unit. Thermal time or growing degree days were calculated according to the equation.

$$GDD = [(T_{max.} + T_{min.})/2 – Tb]$$

Photo-thermal units (PTU)

Photo-thermal units were determined by GDD multiplying with maximum possible sunshine hours (N).

Determination of maximum possible sunshine hours:

N=COS(RADIANS((COS(RADIANS(((A91172)*2*180)/365)))*23.5))

Helio thermal units (HTU)

Heliothermal units for various growth stages are calculated by the formula given. HTU = GDD x Bright sunshine hours.

Results

Determination of Growing Degree Days (GDD)

Effect of hybrids

The GDD in different hybrids varied from 35.41 to 72.3^{0}C for emergence, 444.48 to 481.76^{0}C days for vegetative growth, 512 to 575^{0}C for 50 % flowering, 568.65 to 681.66^{0}C days for first fruit setting and 1154.11^{0}C to 1183.7^{0}C days for final harvest. The highest values of GDD were recorded in hybrids Phule Arjun and the lowest values of GDD were recorded in hybrids Panchganaga.

Effect of planting windows

The GDD in different planting windows varied from 37.85 to 61^{0}C for emergence, 452.2 to 484.6^{0}C days for vegetative growth, 512.45 to 597.55^{0}C for 50 % flowering, 611.05 to 658.66^{0}C days for first fruit setting and 1128.85^{0}C to 1183.2^{0}C days for final harvest. The highest values of GDD were recorded in 31st MW planting windows and the lowest values of GDD were recorded in 34th MW planting windows. (Parthasarathi and Jeyakumar 2013)

Determination of Heliothermal Units (HTU)

Effect of hybrids

The HTU in different hybrids varies from (151.88 to 351.86) units for emergence, (1450.24 to 3539.83) units for vegetative growth, (1698.43 to 4357) units for 50 % flowering, (1893.69 to 4993.37) units for first fruit setting and (5282.36 to 9286.87) units for final harvest. The highest values of HTU were recorded in hybrids Phule Arjun and the lowest values of HTU were recorded in hybrids Panchganaga.

Effect of planting windows

The HTU in different planting windows varies from (93.96 to 411.98) for emergence, (1277.85 to 4044.66) units for vegetative growth, (1673.78 to 4770.45) units for 50 % flowering, (1852.04 to 3223.48) units for first fruit setting and (4899.03 to 10154.52) units for final harvest. The highest values of HTU were recorded at 31st MW planting window and the lowest values of HTU were recorded at 34thMW planting window. This might be due to delayed planting completed each phenophases earlier than the late planted crop (Pennington and Heatherly 1989).

Conclusion

Heat unit requirement or GDD has been used for characterizing the thermal response in brinjal crop. GDD for entire crop growing period decreased with subsequent delay in planting. HTU and PTU were also decreased during later planting windows condition. GDD in different stages in that emergence (59.6 and 72.3), vegetative growth (481 and 478), 50% flowering (575 and 568), first harvesting (681 and 645), last harvesting (1178 and 1183) was observed in hybrid Phule Arjun during 2014 and 2015, respectively. Lower GDD was observed in hy.Panchaganaga during 2014 and 2015, respectively. The highest HTU observed in 31st MW planting windows in hybrids Phule Arjun (5376 and 9190.4).This was followed by hy.krishna and Panchganaga (5370 and 9086) during 2014 and 2015, respectively. Highest HTU was observed in 31st MW in hybrids Phule Arjun followed by hy.krishna and lower in panchganga.

Table 1. Cumulative growing degree days (GDD) of brinjal as influenced stage wise different by treatments in 2014 and 2015

Treatment	EM		VG		50% FL		First FR		At final harvest	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A) Hybrids(H)										
V_1 :Phule Arjun	59.6	72.3	481.7	478.3	575.5	568.6	681.6	645.7	1178.4	1183.7
V_2: Krishna	47.5	47.6	470.2	467.4	552.1	535.0	623.3	602.5	1166.2	1170.4
V_3: Panchganga	35.4	46.1	447.2	444.4	540.2	512.5	599.1	568.6	1154.1	1157.2
B) Planting Windows(D)										
P_1:31 MW (30 July– 5 August)	53.7	61	46.45	484.6	525.5	597.5	631.8	658.6	1135.5	1183.2
P_2:32 MW (6August 12August)	45.2	59.4	453.3	464.9	530.8	554.5	624.3	641.3	1143.2	1161.8
P_3:33MW (13August –19 August)	39.1	50.4	457.5	471.8	526.4	543.2	616.4	621	1128.9	1152.1
P_4:34M (20-26August)	37.8	38.6	452.2	469.6	512.4	539.0	611.0	611.4	1129.6	1143.4
General mean	45.5	53.6	401.2	468.7	537.6	550.0	626.8	621.3	1148.0	1164.5

Table 2. Cumulative Heliothermal units (HTU) of brinjal as influenced stage wise by different treatments in 2014 and 2015

Treatment	EM		VG		50% FL		First FR		At final harvest	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
A) Hybrids(H)										
V_1 :Phule Arjun	249.9	351.8	1544.4	3539.8	1893.6	4357.6	2142.1	4993.3	5376.9	9190.09
V_2: Krishna	161.4	195.8	1450.2	3247.2	1698.4	4047.6	1893.69	4555.5	5282.3	9286.87
V_3: Panchganga	15188.	271.31	1508.3	3435.5	1763.8	4164.8	2014.88	4902.3	5370.9	9086.14
B) Planting Windows										
P_1:31 MW (30 July– 5 August)	251.24	34.785	1628.5	1982.2	1930.7	2767.4	2333.6	4904.2	4899.0	9970.4
P_2:32 MW (6August 12August)	145.0	344.27	1277.8	3927.9	1673.7	4770.4	1852.0	5303.4	5027.5	10154.5
P_3:33MW (13August –19 August)	93.96	411.98	1553.6	4044.6	1684.6	4629.4	1915.6	5318.7	5587.8	10145.4
P_4:34M (20August-26August)	184.6	100.255	1353.01	3658.41	1695.25	4177.76	2058.23	3223.48	5989.48	6877.1
General mean	178.26	244.33	1473.73	3405.13	1762.91	4130.75	2030.05	4743.02	5362.02	9244.37

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Effect of Conservation Agriculture and Fertilizer Doses on Yield and Soil Carbon Pools under Cotton-Pigeonpea Rotation in Semi-Arid Alfisols

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Human efforts globally to produce ever increasing amounts of food to meet their demands through persistent use of conventional farming practices like extensive tillage, alone or combined with removal or in situ burning of crop residues, has magnified soil erosion losses, and as a result the soil resource has been steadily degraded (Montgomery 2007; Singh et al.

2020). Conservation agriculture (CA) has been proposed as a widely adapted set of management principles that can assure more sustainable agricultural production (Hobbs, 2007). The CA is aimed to conserve, improve, and/or make more efficient use of natural resources through integrated management of available soil, water, and biological resources combined with external inputs. It contributes to environmental conservation in addition to the economically, ecologically, and socially sustainable agricultural production (FAO, 2014). Conservation agriculture (CA) is gaining huge attention in Indian agriculture, especially in semiarid Alfisols which are poor in natural resources, due to its potential to enhance soil health and productivity while mitigating environmental impacts. In this context, conservation agriculture practices like conservation tillage practices were studied with the following objective of studying the impact of CA and fertilizer doses on the crop yields and soil carbon pools.

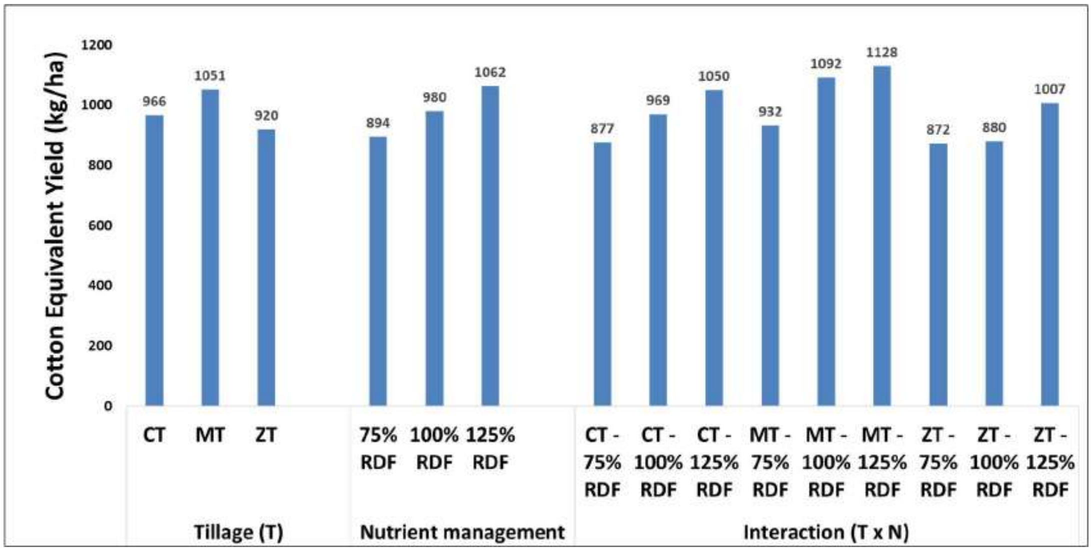
Methodology

A field experiment was conducted since 2016, in sandy loam soil of Gunegal Research Farm at ICAR-Central Research Institute for Dryland Agriculture (ICAR-CRIDA), Hyderabad with different treatments: Zero tillage (ZT - no till, direct seeded with residue retention), Minimum tillage (MT - One ploughing, sowing with residue retention) and Conventional tillage (CT - two ploughings with disk plough, one harrowing and sowing) as main plots and 75% RDF, 100% RDF (RDF for cotton: 120-60-60 kg N, P_2O_5, K_2O ha^{-1}; for pigeon pea: 20-50-0 kg N, P_2O_5, K_2O ha^{-1}) and 125% RDF as subplots, to study the effect of tillage practices and different doses of fertilizers on performance of cotton (ADB 542) - pigeon pea (WRGE 93) rotation. A spacing of 75 × 20 cm for pigeonpea and Cotton were followed.

Results

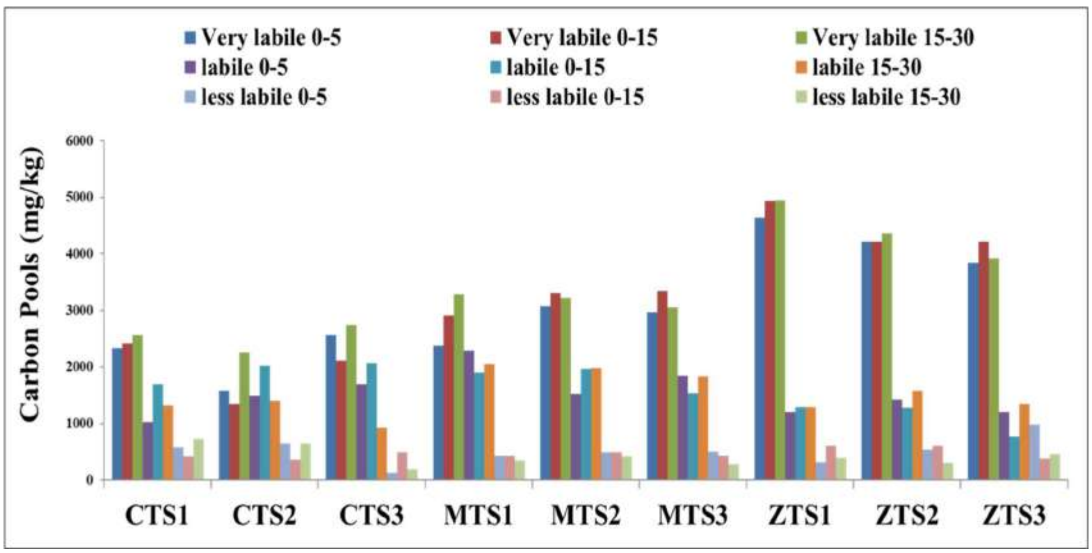
Cotton Equivalent Yield

The mean cotton equivalent yield (CEY) was highest in the MT treatment (1051 kg/ha) followed by the CT, while it was highest under 125% RDF (1062 kg/ha) followed by the 100% RDF. However, among the interaction of tillage and fertilizer application, MT with 125% RDF was found to record highest CEY (1128 kg/ha) followed by MT with 125% RDF and CT with 125% RDF treatments. The lowest CEY was recorded under CT with 75% RDF treatment. Over all, the mean very labile soil carbon pools in three depths were found to be maximum in the ZT treatments followed by the MT treatments and were minimum under CT treatments. Very labile carbon pool was recorded to be highest with ZT with 75% RDF at 15-30 cm (4945 mg/kg) followed by ZT with 75% RDF at 5-15 cm (4939 mg/kg). The labile pool was found to be maximum under MT with 75% RDF at 0-5 cm (2294 mg/kg) followed by CT with 100% RDF at 5-15 cm (2074 mg/kg). The less labile soil carbon pool was highest under ZT with 125% RDF at 0-5 cm (986 mg/kg) followed by CT with 75% RDF at 15-30 cm (725 mg/kg).



Effect of conservation agriculture and fertilizer doses on cotton equivalent yield under cotton-pigeonpea system

Soil Carbon Pools



Impact of conservation agriculture and fertilizer doses on soil carbon pools under cotton-pigeonpea system

Conclusion

The present study revealed that conservation agriculture practices like minimum and zero tillage in combination with chemical fertilizer application can not only increase the over all yield of the system but also improve the soil health and helps in maintaining and improving the soil productivity which was evident in the soil carbon pools. Hence, reduced and zero tillage combined with fertilizer application can be a viable option for sustaining the health and productivity of semi-arid Alfisols.

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Rainwater Harvesting and Supplemental Irrigation for Improved Crop and Water Productivity in Lower Shivaliks of Northwest India

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Rainfed agriculture is being practised in around 80% of the world's arable land which contributes to about 60% of the global food (Rao et al. 2015). In India, rainfed agriculture occupy about 50% of net cultivated area, practiced in diverse agro-ecologies and contributes 40% of country's food basket and dominant producer of oilseeds, cotton, jute and allied fibres (NRAA 2022). Rainfed agriculture is always is always under threat due to changes in rainfall behaviour. Therefore, there is need to developed some relevant strategies to make the rainfed agriculture sustainable. The *Shivaliks* foothills of the northwest India, local known as *Kandi* area, covers an area of about 2.14 million hectare (m ha) extending five states of India. This region is characterised by uneven distribution of rainfall, lack of irrigation facilities, undulating topography, severe soil erosion and lack of vegetative cover (Yousuf et al., 2017). Water scarcity is extremely severe in the *Shivaliks* foothills where agriculture is almost entirely contingent upon rainfall. Climate change results in weather anomalies like delayed and or deficit monsoons, high intensity downpour causing greater runoff/erosion and lengthy dry spells which leads to crop failure. Due to these water resource limitations and potential expansion of the area under cultivation, it is imperative to develop an alternate supplementary water source. Rainwater harvesting has been used in various regions of the world as a viable solution for reducing water scarcity and improving water quality. Besides, it is a measure to explore how climate change impacts precipitation variability (Ndiritu et al. 2018). Rainwater harvesting is commonly practised in areas where the rainfall is insufficient for crop growing. The most widespread use is that of supplementary irrigation, complementing rainfall during periods of water scarcity or stress during the growth stages of plants. The principal objective of RWH as supplementary irrigation is to collect run-off from outlying areas or from areas where it is not used, store it, and make it available where and when there is a scarcity of water. Therefore, due to the intermittent nature of run-off events, it is necessary to store the maximum possible amount of rainwater during the rainy season so that it may be used for irrigation during the critical stages.

Methodology

Study area

The study was conducted at All India Coordinated Research Project on Dryland Agriculture (AICRPDA), Research Centre, Ballowal Saunkhri. The experimental site is geographically located between 31° 6’05”N latitude, 76̊30’26”E longitude, and at an altitude of 346 m. The climate of the region is sub-humid with hot and dry summer and extremely cold winter. The average annual rainfall of the study area is about 1050 mm, about 80% of which is received during the monsoon season (July to September). The soil characteristics of the study are low in available nitrogen, with available phosphorous and available potassium in medium range. The maximum and minimum temperature of the study area is about 45℃ (in May) and 2℃ (in December). The cumulative potential evapotranspiration (PET) is 1666.5 mm, which indicates that available rainfall is insufficient to meet the water demand of crops.

A farm pond having capacity of 696 m^3 was constructed at the AICRPDA centre Ballowal Saunkhri in 2015. The catchment area of farm pond is about 1.8 ha. The pond was constructed with trapezoidal cross section with dimensions 23 × 14 m at the top, 8 × 6 m at the bottom, depth of about 2.5 m and side slope of 1:1. The pond was lined on sides using the cement and sand mixture (1:8) concrete laid in the boxes of 1.0 m × 1.5 m. The solar pump of 1 hp was installed to use the harvested water. The staff gauge was installed at the centre of the pond to measure the runoff collected after each rainfall event. The rainfall and evaporation was measured using the self-recording rain gauge and evaporimeter, respectively in the nearby agro-meteorological observatory.

Rainfall

The rainfall received during *kharif* and *rabi* seasons during the study years is given in Fig 1. Although rainfall received is high during the kharif season, however, the distribution of rainfall is uneven, which often results in occurrence of dry spells during the *kharif* season. The rain water harvested in farm pond was used to apply the supplemental or life-saving irrigation to crops, viz. maize, okra during kharif and wheat, pea during the *rabi* season. The irrigation was applied to maize and okra through furrow irrigation with depth of one irrigation being 50 mm. Similarly, sprinkler irrigation was applied to wheat with depth of each irrigation as 40 mm.

The irrigation to pea was done using drip irrigation at 50% ET, with depth of irrigation as 50 mm. The control treatment for each crop was no irrigation, i.e. rainfed. The sowing of *kharif* crops (maize and okra) was done on the onset of monsoon, preferably in the last week of June or first week of July, while as the sowing of *rabi* crops was done in the first fort night of November, on the residual soil moisture after the *kharif* crop.

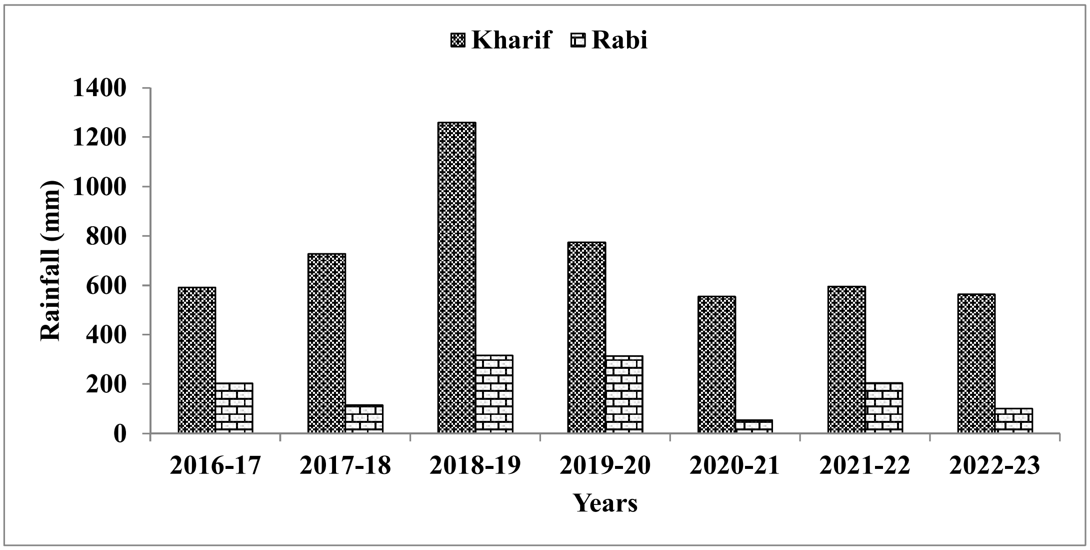

Fig 1. Rainfall received during the study years

Grain yield/pod yield of crops

The crops were harvested manually and grain yield was calculated on 14% moisture basis. The yield was determined by harvesting 19.2 m^2 for maize and 24 m^2 for wheat in each plot. The benefit: cost ratio for different treatments was computed by dividing the net returns with cost of cultivation of that treatment.

Water use efficiency

Water use efficiency was calculated by the following equation (1) and consumptive use of water for the crops under different treatments was calculated by theformula given by (Singh et al., and Raheja 1960)

$$WUE = \frac{Economic\ yield\ (kg\ ha^{-1})}{Consumptive\ use\ (mm)}$$

Results

Rainfall-runoff relationships

The average annual rainfall and *kharif* rainfall over the study period was 1022 mm and 559.5 mm, respectively. The runoff generated from each rainfall and the corresponding rainfall is given in Fig 2. The highest rainfall received during the study area is about 150 mm which resulted in runoff about 50 mm. The total rainfall received was about 3913mm, which resulted in total runoff of 1190.9 mm, accounting for about 30.4%.

Effect of supplement irrigation on yield, economics and water use efficiency of crops

The effect of supplemental irrigation (SI) on grain yield is given in Table. The supplemental irrigation resulted in increased yield of both *kharif* and *rabi* crops. The mean of seven years showed that the maize yield increased by about 57.1%. Similarly, the wheat yield increases by about 63.6% due to the supplemental irrigation. The yield of okra and pea also increased due to the application of the supplemental irrigation. The supplemental irrigation also resulted in increased water use efficiency and B:C ratio.

Conclusions

The rainwater harvesting is an important climate resilient technology to mitigate the impact of changing climate in Shivaliks of northwest India. The rainfall received during the monsoon season may be efficiently stored in the farm ponds and can be used to irrigate the crops during the dry spells. The supplemental irrigation results in better crop growth, economics and water use efficiency in rainfed regions.

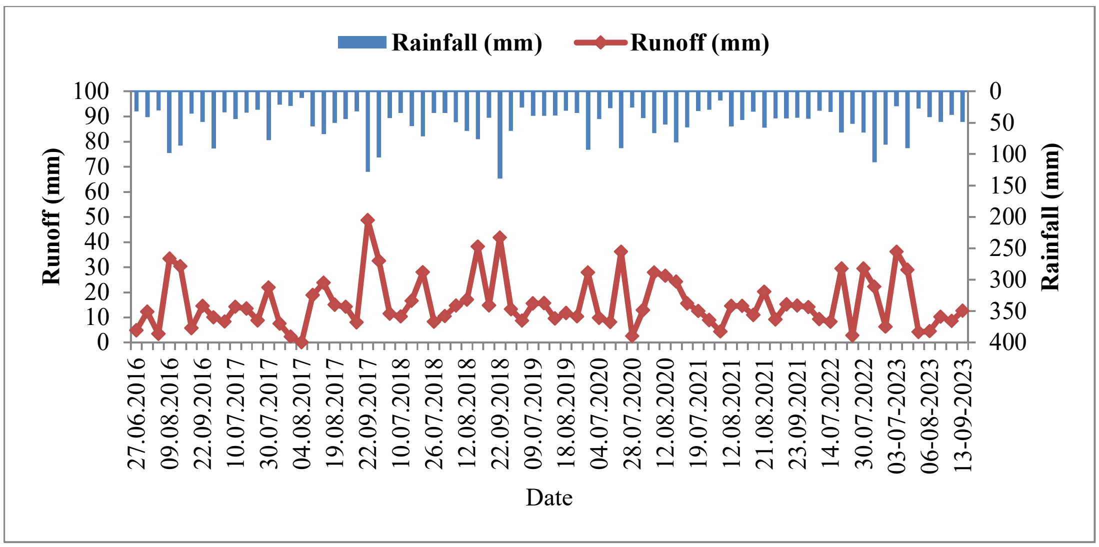

Fig 2. Rainfall-runoff relationship

Effect of supplement irrigation on yield, economics and water use efficiency of crops

Crops	Grain yield (kg ha^{-1})		B:C ratio		Water use efficiency (Kg ha^{-1} mm^{-1})	
	WSI	SI	WSI	SI	WSI	SI
Maize	2425	3811	1.50	2.13	3.80	5.29
Okra	8100	12608	1.86	2.53	13.16	18.33
Wheat	2131	3466	1.83	2.71	11.64	16.56
Pea	1656	3377	1.37	1.95	12.58	19.53

*WSI: Without supplemental irrigation; SI: Supplemental irrigation

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UID: 1326

Contribution of Production Factors on Productivity of Pearl Millet (*Pennisetum glaucum L.*)

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Pearl millet is the fourth most widely grown food crop in India after rice, wheat, and maize. In 2023–24, pearl millet area in India was 7.36 million ha, with an average production of 10.67 million tons and 1449 kg ha^{-1} productivity (Anonymous, 2024). Maharashtra occupies 16.00 lakh ha area with an annual production of 14.04 lakh tonnes and productivity of 888 kg ha^{-1} as the 2023–2024 farming year (Anonymous, 2024). Marathwada region occupies 1.37 lakh ha area with an annual production 1.22 lakh tonnes and productivity of 994 kg ha^{-1} (Anonymous, 2021). Productivity of any crop depends on many management factors such as fertilizer, thinning, gap filling, weeding, hoeing and irrigation management and every factor has its towards productivity. Therefore, it is necessary to find out the contribution of individual or combinations of full package of practices to the yield of pearl millet. But very less information is available regarding role of individual factor towards the productivity of pearl millet. Keeping the above points in view, the present study was conducted with an objective to study contribution of different production factors on productivity of pearlmillet.

Methodology

An experiment was carried out during *kharif* 2023 at experimental field of National agricultural Research Project, Chh. Sambhajinagar. The experimental design was RBD with eight treatments. The experimental plot, characterized by its levelled and well-drained conditions, with clay texture. The chemical composition of experimental plot soil was as follows: medium organic carbon content (0.63%), low available nitrogen(144.0 kg ha^{-1}), medium available phosphorus(20.16 kg ha^{-1}), very high available potassium(405 kg ha^{-1}) and alkaline pH (8.29) in reaction. Additionally, the concentrations of zinc, iron, manganese, copper, and boron in the soil were 0.39, 4.23, 4.89, 1.98, and 0.31 ppm, respectively. The pearl millet was sown on 28th June 2023 by dibbling method and harvested at 25th September 2023. The experiment consisted of eight treatments as detailed below (T1) Full package and practices of location RDF+ZnSO4 @25kg ha^{-1}+FeSO4 F@ 0.5-0.75 % at 20 - 25DAS+ bioinoculant seed treatment- *Azospirillum*) + thinning & gap filling + weeding & hoeing (3&5 weeks after sowing) +Irrigation, (T_2) T_1 – RDF, (T_3) T_1 – $ZnSO_4$ @ 25kg ha^{-1}, (T_4) T_1 – $FeSO_4$ F @0.5 - 0.75 % at 20-25 DAS, e) T_5 = T_1 – Bioinoculant Seed Treatment [*Azospirillum*], (T_6) T_1 – Thinning & gap filling, (T_7) T_1 – Weeding & hoeing (3& 5 weeks after sowing), (T_8) T_1 – Irrigation. The gross and net plot sizes were 5.0 x 4.5 m^2 and 4.0 x 3.6 m^2 respectively.

Results

A) Growth studies

The plant height of pearl millet is significantly affected at all growth stages with the different levels of treatment . Among all the treatment, the treatment T_1 recorded the highest plant height at 30,45,60,75DAS and at harvest. Number of leaves $plant^{-1}$, leaf area $plant^{-1,}$ and dry matter $plant^{-1}$ (g) recorded similar trend on the contrary, treatment (T_2) I.e. T_1 – RDF reported lowest values for these growth attributes. Similar results were recorded by Ray *et al*. (2021), and Kumavat and Shekawat (2017).

B) Yield studies

Treatment T_1 (Full package and practices) recorded significantly highest number of tillers $plant^{-1}$ (4.93), number of effective tillers $plant^{-1}$(3.87) grain weight $earhead^{-1}$ (35.39g) , grain weight $plant^{-1}$ (75.45g) in treatment T_1 (Full package and practices) and test weight (16.7g) .Treatment T_1 receiving full package and practices of the location recorded significantly higher grain yield (2644 kg ha^{-1}) of pearl millet than rest of the treatments, however, it was on par with treatments receiving full package and practices of the location – (T_3) $ZnSO_4$ @ 25 kg ha^{-1}, (T_4) $FeSO_4$ F@ 0.5- 0.75 % at 20-25DAS and (T_5) Bioinoculant seed treatment *(Azospirillum*) and found to be significantly superior over treatments such as T_6 (1863 kg ha^{-1}), T_8 (1766 kg ha^{-1}) and T_7 (1681 kg ha^{-1}) which was significantly reduced by not caring out the important management operations. The perusal of the data in the resulted that maximum reduction of 36.94% was observed without RDF operation which was followed by without weeding & hoeing (36.42%) and thinning & gap filling (29.55%) treatments. The reduction was between 10.89-13.68 % when ZnSO4, FeSO4, irrigation, biofertilizers were not applied. Similar findings have also been published by Yalamati *et al.* (2019) and Vinay *et al.* (2019).

Conclusion

The study demonstrates that adopting the full package of agronomic practices significantly enhances both growth character and yield character of pearl millet. Eliminating critical elements like RDF or proper weeding practices results in significant yield losses, highlighting the importance of comprehensive and integrated management practices for maximizing production. Therefore, it is recommended to implement the complete package of practices to achieve the best yields in pearl millet cultivation.

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Enhancing Climate Resilience with Resource Conservation through Rice Fallow Management with Black Gram in North Eastern Coastal Plain Zone of Odisha

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Rice is the principal crop during the kharif season in eastern India, covering 26.8 million hectares, which accounts for 63.3 percent of the total rice-growing areas in the country (Mohapatra *et al.,* 2022). In Bhadrak district of Odisha, the area under rice cultivation is 164.97 thousand hectares, which constitutes 82% of the total cultivable area of the district (District Strategy Bhadrak, 2022). Rice fallow refers to uncultivated land in a monocrop-based rice agroecosystem, left fallow after the rice harvest. About 11.7 million ha area in rice production system remains fallow during the succeeding winter season due to several limitations in Eastern India (Kumar *et al*.,2018). In Odisha alone, rice-fallows spread over 1.6 m ha covering 21 percent of rice-fallow areas in eastern India (Gumma *et al.* 2016). So far as Odisha state is concerned, the Odisha University of Agriculture and Technology (OUAT) team, in their report "OUAT strategies for pulse production in rice-fallows of Odisha" has pointed out some constraints under different categories. Physical constraints include (1) nearly 94% of pulse area is rainfed (33% in kharif as rainfed and 61% in rabi under residual soil moisture), (2) suffer from moisture stress during rabi season due to low winter rainfall, (3) plant growth is affected due to waterlogging in coastal tracts, (4) about 70% of cultivated area in the state is acidic, which reduces the yield, (5) a sizeable area in coastal districts is salinity affected, (6) canal irrigated lands are gradually becoming unsuitable for pulse cultivation, (7) rain at maturity for kharif, the cold Climate during winter sowing and heat stress at reproductive stage of summer crops cause low productivity, (8) stray cattle menace restricts the horizontal expansion. The technological constraints include (1) lack of varieties resistant to various biotic and abiotic stresses in general such as YMV and cold, (2) non-availability of suitable varieties with better yield advantage and desirable characteristics suitable for varied agro-climatic conditions and multiple adversities, (3) lack of varieties responsive to high impacts, e.g., irrigation, fertilizers, etc., (4) most of the improved varieties are lacking preferred consumption quality as compared to the local varieties, (5) lack of commercial exploitation of hybrid vigour, (6) non-adoption of improved production technology because of more instability and poor crop performance under adverse condition. The service-related constraints are (1) a wide gap between the requirement of certified/ quality seeds and their distribution and low SRR, (2) no or very less use of Rhizobium inoculants because of no visible yield advantage, (3) poor storability and lack of storage facility leading to post-harvest losses to the extent of 23-30% (OUAT, 2016). Efficient utilization of fallow lands has the potential to enhance productivity and sustainability in the region. Soil characteristics indicate that short-duration pulses, such as Black gram, can be successfully cultivated in rice-fallows with supplementary lifesaving irrigation. This will increase cropping intensity, thereby improving system productivity and profitability, which will boost farm income and ensure food and nutritional security for all. The primary objective of this study is to improve the socioeconomic conditions of farmers through effective rice-fallow management with Black gram, utilizing the climate-resilient local variety (Kadua Biri) from Dhamnagar block of Bhadrak district of Odisha.

Methodology

Fatepur is selected as KVK adopted village under NICRA, situated at Dhamnagar block of Bhadrak district. The village is frequently affected by flood resulting in complete damage of main crop rice in Kharif. During August 2023, 80% of rice crop damaged by unfortunate flood. To meet this damage a contingent crop plan has been made for rice fallow management. Under the rice fallow management plan, a cluster demonstration on pulses (black gram) has been conducted in 40ha area involving 100 farmers and farm women. For the demonstration programme local variety of black gram (Kadua Biri) seeds have been used. The main objective of the study is to increase the socioeconomic condition of farmers through rice fallow management. The seeds have been treated with Rhizobium culture and broadcasted in residual soil moisture. Soil test-based fertilizer and need based plant protection measures has been taken.

Results

The yield and economic parameters have been studied. The yield gap was observed due to climate resilient black gram variety (Kadua biri), seed treatment with Rhizobium culture, integrated nutrient and pest management practices. In farmer practice they used to cultivate black gram without any scientific management practices. By this practice farmers got an average yield of 6.28q/ha. With an average investment of Rs. 10,160.00/ha farmers got an average net return of Rs. 33,800.00 per ha which have been proved as a successful climate resilient intervention under NICRA.

Conclusion

Rice–fallows offer a great opportunity to maximize area of pulses with adoption of improved agro-techniques. Soil-moisture conservation and mitigation of abiotic stresses are two major strategies required for successful trapping of rice–fallows. for better use and understanding, intensive research is needed to understand the rice–fallows ecology for strategic crop management. Location-specific, extra early duration, drought-tolerant varieties of pulses are vital. BY using this rice fallow management with black gram adopting scientific method of technology farmer got an average yield of 6.28q/ha (28.16% higher than farmers practice). Farmers have given positive feedback and hopeful for area expansion using this technology in subsequent years.

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Assessment of Land Suitability for Selected Horticultural Crops in Kuruvanaka-1 Micro-Watershed, Arsikere Taluk, Hassan District, Karnataka by Using Geospatial Techniques

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Land evaluation is concerned with the assessment of land performance when used for specific purposes. It involves the execution and interpretation of basic surveys of climate, soils, vegetation and other aspects in terms of the requirements for alternative forms of land use. The main purpose of land use planning is to guide decisions on land use towards efficiency and sustainability that is utilizing environmental resources to the maximum while conserving those resources for the future. A detailed land suitability assessment was carried out for five selected horticultural crops, *viz*. Coconut (*Cocosnucifera*), Mango (*Magniferaindica*), Arecanut (*Areca catechu*), Guava (*Psidiumguajava*) and Sapota(*Manilkarazapota*) in Kuruvanka-1micro-watershed of Arasikere taluk, Hassan District. The study identified 14 soil series and 20 mapping units based on soil morphological, physical and chemical properties. Out of the total geographical area of 804 ha, 169.7 ha (21.1 %) were occupied by hill, rock out, habitation (settlements) and water bodies. By the land resource inventory it was clear that the area had considerable variation with respect to soil texture, topography and depth. The majority of the area (369.6 ha) was highly suitable, 111.6 ha moderately suitable with topography and depth limitations, 123.3 ha marginally suitable with depth and texture limitations and 29.8 ha was not suitable for coconut, arecanut, guava and sapota crops. For mango crop, majority of the area (248.0 ha) was highly suitable, 186.8 ha moderately suitable with topography and depth limitations, 99.1 ha marginally suitable with depth and texture limitations and 100.4 ha was not suitable in Kuruvanka-1 micro-watershed area. Thus, the data on land suitability showed that with some corrective measures to texture, depth and topography for these horticultural crop selections may be decided for higher production and productivity.

UID: 1357

Effect of Raising Bund Height in Rice Field on Yield, Economics and Water Productivity of rice

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Rice is both a major staple food for much of the world's population and the largest consumer of water in the agricultural sector. The standard system for growing irrigated rice around the world is to flood paddy fields and maintain standing water on them. This uses a large amount of water because of high water losses through evaporation, seepage, and percolation (Thakur *et al*., 2014). The productivity of rainfed rice ecosystem is quite lower than that of the irrigated rice ecosystem, which emphasizes that assured irrigation water supply plays a crucial role in determining rice production. In rainfed rice ecosystem, conservation of rainwater to maximum extent can reduce the supplemental irrigation water requirement of the crop and drainage need of the catchment(Mishra *et.al* 1998). Pre monsoon, monsoon and post monsoon precipitation during rainy season causes sub surface soil erosion ,nutrient depletion by runoff and sometimes flood situation and crop damage resulting which reduces production and productivity of soil. Raising bund height of rice field conserve rain water, reduces the runoff, maintain soil moist and increase ground water level. Keeping these views a demonstration was conducted in NICRA adopted villages to enhance the rice productivity and saving the rain water in the field.

Methodology

The field study was conducted under National Innovation on Climate Resilient Agriculture Project, NICRA-TDC at KVK ,Buxar ,in adopted village-Kukurah ,Suroundha and Bhitihara at 60 farmers field during 2020 to 2023.The benchmark survey and participatory rural appraisal (PRA) technique were used for selection of participants and capacity building of farmers wasup skilled through training and experienced learning on conservation of rain water harvesting in rice field. The soil was loamy clay andhave deep percolation rate. In selected field Technology demonstration Component "Raising Bund Height (dimension 60x45x45 cm)have been demonstrated in 85.2 ha area of rice field at 65 farmers field of village and the rainfall were stored up to 35 cm height plots, the existing farmers practice was symbolic field bunds (unshaped, zigzag shape lump sum<30x30x20 cm),the rainfall used to be stored maximum up to 20 cm. Rice crop variety BPT 5204 was transplanted in line 20 x 10 cm. The metrological data like rainfall, Wind speed, soil temperature and Temperature were recorded from Small weather station of Village Kukurha. The yield, economics and water productivity related parameter were taken in crop season.

Results

The results of 3 years of experimental study showed that raising bund height of rice field save the more rain water, moist the rice field during the crop growth period and enhanced the rice yield. Rice plots with bund height were store 87% rain water in the field whereas 29% in farmer practice of the total precipitation. An exponential relationship has been observed between the rainfall excess values (as percentage of rainfall) and weir heights. Conservation of rainwater in rice fields with weir heights created significant impact on grain yield differences (Tapsoba *et al.,* 2018). The yield of the rice crop was recorded 49.40 q/ha which was 11.76% higher over farmer practice (4420 q/ha).The economics of demonstrated plot reveals net return of Rs 53780 per ha and benefit cost ratio is 2.64.The area brought under Rabi season was from 19.1 to 59.6 ha in rabi 2020-21, 25.30 to 67.6 ha in 2022-23 and 27.65 to 120.1 ha in 2022-23 by using residual moisture. The rain water productivity of demonstration field was recorded 1.37 kg/m3. Keeping in view the aspects of conserving rainwater, sediment and nutrient and minimizing irrigation requirement, 30–45 cm of bund height is considered to be suitable for rice fields.

Conclusions

On the basis of three year of study raising bund height with the dimension of (dimension 60x45x45 cm) found effective for conservation of rain water, maintain the field moist, reduced the irrigation requirement of crop, improving the rice production, reduced the cost of irrigation, increased economic returns and provide the residual moisture for rabi season crops.

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Enhancing Agricultural Resilience with Raised Bed Technology in Cotton: Insights from Adilabad District, Telangana

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Cotton is the main crop cultivating about three-fourth cropped area of Adilabad district of Telangana. The district received 1574.7 mm, 1635.03 mm, and 1383.81 mm of rainfall annually in 2021-2022; 2022-2023; and 2023-2024, respectively. Farmers using traditional flatbed methods to cultivate cotton crop, but excessive rainfall in July and August months causes water logging, runoff and an increased the incidence of insect pests and diseases. Flat bed cultivated cotton was yielded lower than cotton planted on raised beds (Boquet, 2005). The planting method is crucial for cotton growth and yield, as it ensures optimal crop stand establishment and balances plant competition for light and water leading to maximum yield (Ali et al., 2012)

The climate-smart resilience technology of raised bed cultivation in cotton has become a game-changing technique that greatly improves crop quality and productivity. By directing water straight to the root zone, these elevated beds improve water retention and lessen surface runoff. The plants gain from a steadier supply of moisture. In areas like Adilabad, where rainfall patterns are frequently unpredictable and excessive during specific months, causing problems like waterlogging and nutrient leaching, hence this method is very useful for getting better growth and yield. Raised bed cultivation yields higher than conventional flat sowing and offers benefits such as water savings, runoff and waterlogging (Sahu et al., 2024).

Methodology

Under NICRA Krishi Vigyan Kendra (KVK) Adilabad has conducted demonstrations in three NICRA villages like Palsi K, Sakinapur, and Lachampur since 2021. The raised bed method of cotton cultivation was widely disseminated across the district and state through print and electronic media to create awareness. Recognizing its potential benefits, the technology was introduced in farmers' fields with varying land configurations in the district during the period from 2017-18 to 2021-22 at the instructional farm. From 2021 to 2024 demonstrations were conducted across the villages of Palsi K, Sakinapur, and Lachampur in the Talamadugu mandal of Adilabad district.

Tractor mounted bed maker was used for preparation of raised beds in the farmer’s field. Currently two types of bed makers are available with two tyne and three tyne. This bed maker enables us to make beds with a height of 30 to 45 cm, a furrow width of 30 cm, and configurable adjustable bed distance of 90, 120, 150, and 180 cm, based on the crop and the type of soil. Using a tractor-mounted bed maker, laying beds on an acre of land generally takes 45 to 60 minutes.

Results

The area covered under raised bed cultivation in cotton increased from 4 ha. in 2021-2022 to 27.2 ha. in 2023-2024. The raised bed system in cotton under NICRA resulted in a yield of 21.5 q/ha, a cost of cultivation of Rs. 53,500, and net returns of Rs. 90,410. In Non-NICRA, the yield was 16.75 q/ha, the cost of cultivation was Rs. 49,750, and net returns were Rs. 67,835.

Details of demonstrations

Year	Total number of demonstrations	Total area under demonstrations (ha)
2021-22	10	4
2022-23	25	10
2023-24	33	13.2
Total	68	27.2

Outcome

Raised bed technology			Flat bed cultivation		
Yield (q/ha)	Cost of Cultivation (Rs.)	Net Returns (Rs.)	Yield (q/ha)	Cost of Cultivation (Rs.)	Net Returns (Rs.)
21.5	53500	90410	16.75	49750	67835

The raised bed system under NICRA increased yield by 28.4% and net returns by 33.3% compared to Non-NICRA. The slightly higher cost of cultivation in NICRA was offset by better water management, root aeration, and overall plant health associated with the raised bed system. This technology appears to be particularly beneficial in regions where water management is a critical factor for cotton cultivation. The higher cotton yields on raised bed cultivation may be attributed to increased root length, radius, dry weight, enhancing nutrient and moisture uptake. This improved root system supports better plant growth and development. Consequently, more photosynthates are synthesized and efficiently translocated to the sink, boosting yield.

Conclusion

The raised bed system proves to be a highly effective climate smart technology for improving cotton yield and profitability under rainfed situations. This technology promotion can enhance agricultural resilience and farmer income.

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Climate Change Impacts on Water Footprints of Rainfed Crops in Semi-Arid Watershed of Lower Krishna Basin

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Natural resources, particularly water and food supply, are at tremendous pressure due to global population rise and dynamic changes in the consumption pattern of society, and India, which is projected to be the world's most populated country by 2027, will be one of the most impacted countries [1]. This will have a direct impact on water and land resource availability vis-à-vis agriculture. It is predicted that severe water scarcity is affecting one billion population in India at least for one month of the year which stresses the need for efficient water resource development and management [2]. Rainfed (green water) farming systems in Semi-Arid Tropical (SAT) regions provide diverse food supplies from 51% of net sown area (139.4 mha) in India [3]. SAT regions contribute 60% of nutritive food grains, although is suffering with 20 to 35% undernourished population [4]. As per IPCC report (AR5), the climate change impacts would lead to global warming by increased temperature from 2 to 5 ◦C by the end of the century with increased extreme weather events [5]. Indian agriculture is also affected by changes in the rainfall pattern, high intense rainfall, floods, and droughts contributing to the overall reduction in the crop productivity, soil quality, and accelerated land degradation due to erosion, availability of both blue and green water, etc., in the SAT regions. SAT regions contribute 60% of nutritive food grains. Water Footprint (WF) assessment for rainfed crops on watershed scale is critical for water resource planning, development, efficient crop planning and better water use efficiency.

Methodology

The present study was conducted in a watershed consisting of 8 tribal villages of Padara Mandal, Nagarkurnool district of Telangana state (Fig 1). The area lies between 16°27′ N and 79°1′ E. The watershed has its automatic weather station in Padara Mandal. The watershed having an area of 4700 ha was delineated into several sub watersheds with different land use, soil characteristics and slopes. According to the 20 years observation data, the average annual rainfall in the watershed is 734 mm, of which the average south west seasonal rainfall accounts for 86%. Two-thirds of the rainfall occurs during the period of July to October. Agriculture in the watershed mainly consists of seasonal rainfed crops like maize, cotton, redgram, groundnut, and sorghum. The watershed has a rolling topography having slopes from 1–11% on average.

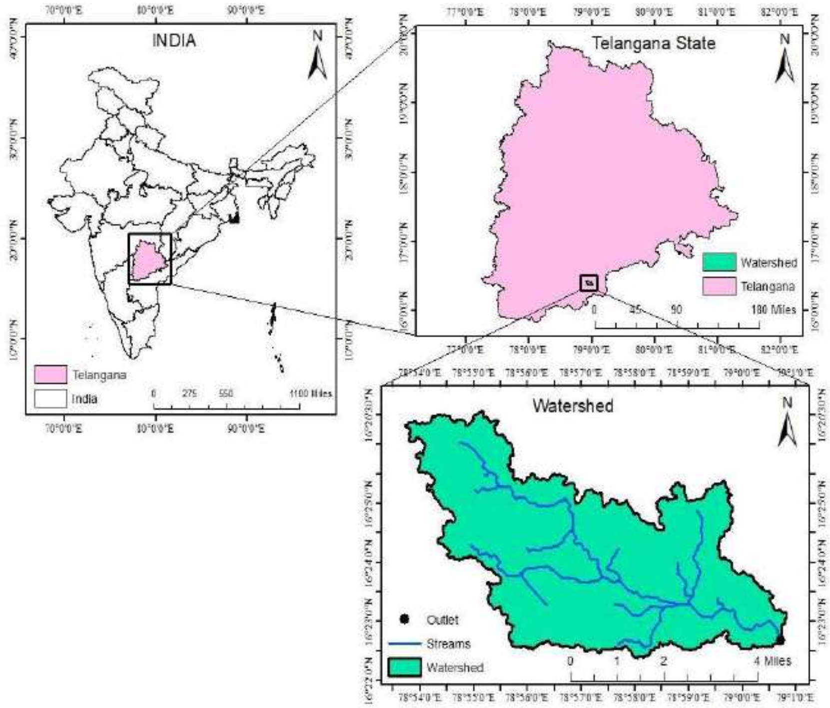

Fig 1. Location map of the watershed

Results

The green WF under rainfed condition over different RCPs and time periods had decreasing trend for all crops (Fig 2). The study suggested that in the rainfed agro-ecosystems, the blue WF can significantly reduce the total WF by enhancing the productivity through critical irrigation management using on farm water resources developed through rainwater harvesting structures. The maximum significant reduction 13–16% under rainfed, 30–32% with 30 mm CI and 40–42% in WF over the base period was bserved with 50 mm CI by 2080. Development of crop varieties particularly in oilseeds and pulses which have less WF and higher yields for unit of water consumed could be a solution for improving overall WF in the watersheds of SAT regions.

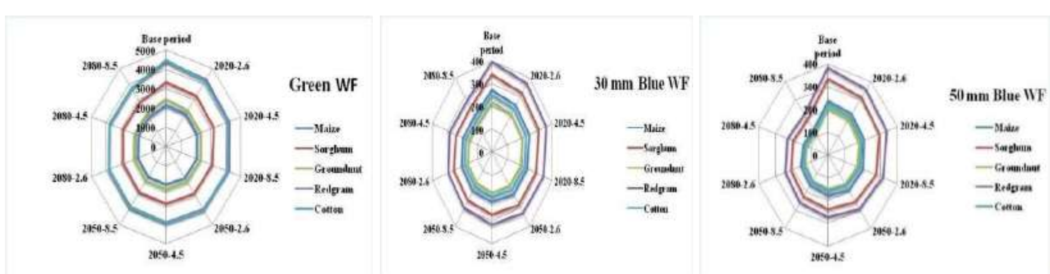

Fig 2. Water Footprint (m^3/t) of rainfed crops with critical irrigation and different RCPs with time periods (a) Green WF (b) Blue WF CI: 30 mm (c) Blue WF CI: 50 mm

Conclusion

Water footprint assessment on watershed basis is required to select the most efficient cropping system per unit of water consumed, which ultimately results in not only con- serving water but also economic benefits to the farmers through proper water resource development and use management, particularly in SAT regions. The analysis of water footprints for rainfed crops on a watershed basis indicated that the lowest water footprint was observed in maize under the 50 mm CI strategy followed by groundnut, sorghum, redgram, and cotton. The strategy of 50 mm CI during two critical stages of the crops resulted in maximum reduction in the blue WF which is 6.6–37%, 12–40%, and 18–44% for RCP 2.6, 4.5, and 8.5, respectively among the selected crops. In the rainfed system with a green water footprint also resulted in the reduction of green water footprint across the RCP and the time period of 2020 to 2080 which is less than blue water footprint of the crops. It would help to bring a policy framework from governments to effectively use water and develop water-efficient crop plans for enhancing productivity in rainfed SAT regions.

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Soil Suitability Assessment for Sustainable Production of Cereals in Ganjigatti Sub-Watershed

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To evaluate the potential and limitations of a specific land parcel for agricultural uses, a scientific method of land evaluation is necessary. In developed nations, intensive agriculture has been associated with issues like declining soil fertility, stagnant yield levels, and uncontrolled soil erosion, whereas in developing nations, intensive agriculture is linked to issues like overuse of natural resources and a lack of inputs like chemical fertilizers. In this context, there is a more emphasis on the land evaluation for better land use options. The sustainability of agriculture is maintained via efficient land usage. According to FAO (1976), evaluating a land involves "the process of assessment of land performance when used for specified purposes." It entails carrying out and interpreting surveys and studies on landform, soils, vegetation, climate, and other relevant land factors for a comparison between prospective land use and/or specific land use. The potential of the integrated approach to using GIS and RS data for quantitative land evaluation has been demonstrated earlier by several researchers. This research was conducted to show how remote sensing (RS) and geographic information system (GIS) data may be used together to evaluate soil-site suitability for the most common cereal crops farmed in the Ganjigatti sub-watershed of Karnataka, viz., rice, wheat, maize, sorghum and pearlmillet.

Methodology

The study was conducted in 2021–2022, in the Ganjigatti sub-watershed (5B1A4F) of Dharwad district in Karnataka, situated between 15° 10′ 10.114″ to 15° 17′ 1.147″ N latitudes and 75° 0′ 57.672″ to 75° 4' 50.525″ E longitudes, with the highest elevation of 610 m above mean sea level. The total geographical area of the watershed is about 4323.84 ha. The annual temperature ranges from 24.68 to 26.67 °C. The average rainfall in the watershed was 917.00 mm. The length of growing period (LGP) for crops is 150 days. After preliminary traversing of the entire watershed using a 1:7,920 scale base map and satellite imagery, based on geology, drainage pattern, surface features, slope characteristics, land use, landforms and physiographic divisions, twenty-seven (27) soil profiles were selected and studied and their morphometric characteristics were recorded. Physical and chemical properties were estimated using standard procedures. A detailed soil resource inventory of the Ganjigatti sub-watershed was carried out and 21 series mapped into sixty-one (61) mapping units based on surface soil properties. Their suitability was assessed using the limitation method regarding the number and intensity of limitations (Naidu *et al.,* 2006). This evaluation procedure consists of three phases.

Result

Rice is primarily a tropical and subtropical crop. It is grown in a wide variety of climate-soil-hydrological regimes. Based on the criteria and degree of limitation, the soil-site suitability of soil mapping units for rice has been worked out. The overall suitability class for rice showed that 26.35, 56.43 and 9% of TGA, were moderately, marginally suitable and currently not suitable respectively, due to having moderate to very severe limitations of climate, soil physical properties and land form characteristics. The suitability of soil phases of Ganjigatti sub-watershed for growing wheat indicated that all the mapping units were categorized into moderately, marginally suitable and currently not suitable, having moderate to very severe limitations of climate, soil physical properties and land form characteristics. The areas of moderately (S2), marginally (S3) and currently not suitable class (N) for wheat were 2324 (53.75% of TGA), 1429 (33.05% of TGA) and 215 ha (4.97% of TGA), respectively. The suitability of soil phases for growing maize indicated that all the mapping units were highly suitable to currently not suitable (N), having none to slight, moderate, severe and very severe limitations of soil drainage, soil physical properties and limitations of land form characteristics. Areas of highly (S1), moderately (S2), marginally (S3) and currently not suitable (N) classes for maize were 254 (5.88% of TGA), 2071 (47.85% of TGA), 1429 (33.04% of TGA) and 215 ha (4.97% of TGA), respectively. The suitability of soil phases in the Ganjigatti sub-watershed for growing sorghum indicated that all the mapping units were with moderately, marginally suitable and currently not suitable category, having moderate to very severe limitations of climate, soil physical properties and land form characteristics. The areas of moderately (S2), marginally (S3) and currently not suitable classes (N) for sorghum were 2394 (55.34% of TGA), 1048 (24.23% of TGA) and 528 ha (12.20% of TGA), respectively. The suitability of soil phases for growing pearlmillet indicated that all the mapping units were moderately, marginally suitable and currently not suitable, having moderate to very severe limitations of climate, soil physical properties and land form characteristics. The areas of moderately (S2), marginally (S3) and currently not suitable (N) classes for pearlmillet were 1093 (25.27% of TGA), 2661 (61.53% of TGA) and 215 ha (4.97% of TGA), respectively.

UID: 1429

Conservation and Carbon Emission Reductions with Future Prospects for Carbon Credits: Interventions in NICRA Villages of Siwan District, Bihar

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The research highlights significant advancements in conservation, and carbon emission reductions achieved in NICRA villages from 2022 to the present. Various interventions have been implemented to enhance resource efficiency, promote sustainable agriculture, and mitigate climate change impacts. Adoption of resilient technologies, such as zero tillage for wheat and direct-seeded rice (DSR), has led to substantial reductions in carbon emissions by minimizing fuel consumption, water usage, and chemical inputs. Demonstrations of flood-tolerant crop varieties like Swarna Sub-1 and DBW 187, along with moisture conservation techniques, have improved productivity while lowering emissions. Livestock management practices, including the use of mineral mixtures and improved shelters, have reduced methane emissions and enhanced manure management, thereby contributing to carbon footprint reductions. The transition to clean energy sources, such as LPG, in over 90% of households and decreased dependence on fuelwood in NICRA villages further highlight successful emission reduction efforts. Conservation initiatives like organic manuring, residue recycling, and water harvesting structures have improved soil carbon sequestration while enhancing crop yields and economic returns. The results demonstrate that integrating climate-resilient technologies yields dual benefits mitigating carbon emissions and improving farmers' livelihoods. Future efforts to link these interventions with carbon credit mechanisms will further enhance their impact. Continued efforts in scaling these interventions across NICRA villages are crucial to addressing climate change while ensuring sustainable agricultural growth.

UID: 1454

Influence of Weather Parameters on Pod Yield of Groundnut in Scarce Rainfall Zone of Andhra Pradesh

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Crop growth and yield are influenced by multiple factors, including management practices, cultivar selection, and environmental conditions under changing climate scenario. Among the climatic parameters, solar radiation, temperature, humidity, and rainfall are critical in determining crop performance. Oilseed crops like groundnut are particularly sensitive to changes in climatic factors such as radiation and temperature (Prathima *et al*., 2022). The interaction between genotype and environmental conditions directly affects seed maturity and overall crop performance as weather variations influence the duration of growth phases. A decline in minimum temperatures, especially with delayed sowing, can slow pod formation, while high temperatures may impair crop physiology by promoting partial stomatal closure, limiting photosynthesis. The time of sowing plays a crucial role in aligning crop phenology with favorable weather conditions. Patel *et al*. (2013) reported that groundnut yields may decline by 19–31% when sown at the onset of monsoon and by 21–38% if delayed by 15 days.

In the context of climate change, this study was undertaken to analyze the effect of weather variables on yield of groundnut in the Scarce Rainfall Zone of Andhra Pradesh.

Methodology

A field experiment was conducted from 2016 to 2023 at the Agricultural Research Station (ARS), Ananthapuramu, to study the crop-weather relationship of groundnut in the Scarce Rainfall Zone of Andhra Pradesh. The experiment was arranged in a split-plot design with three replications. The main treatments consisted of three sowing dates: the first fortnight of July, the second fortnight of July, and the first fortnight of August. Sub-treatments included four groundnut varieties. The plot size was 5.4 m × 4 m, with plants spaced 30 cm apart between rows and 10 cm within rows. A uniform fertilizer dose of 20:40:50 kg/ha of N, P_2O_5, and K_2O was applied at sowing, and all other crop management practices were consistently followed across treatments. Both biotic and abiotic factors were effectively managed throughout the crop growth period to ensure unbiased results. Weather data were collected from the Class B meteorological observatory located at ARS, Ananthapuramu. Statistical analysis, including correlation coefficients, was used to determine relationships between weather parameters and dry matter production.

Results

Pod yield of groundnut

The data pertaining to pod yield of groundnut for different dates of sowing and varieties are presented in Table 1. The results revealed that sowing of groundnut at 2nd fortnight of July (D2) produced higher pod yield in almost all years except 2021, 2022 & 2023. On an average, 2nd fortnight of July (D2) produced pod yield of 1152 kg ha^{-1} and it was on par with 1st fortnight of July (D1) (1136 kg ha^{-1}). Lower yield was recorded with 1st fortnight (FN) August (D3) (744 kg ha^{-1}). Thus, 34% higher yield was recorded in D1 & D2 treatment as compared with D3. The higher yield at optimum sowing time made maximum utilization of rainfall, whereas late sown crop yielded lesser due to dry weather conditions for considerable period after cessation of monsoon rains in middle of September. Among the cultivars, on an average, all varieties performed better. Groundnut is a tropical crop and requires long warm growing season. The favourable climate for rainfed groundnut is well-distributed rainfall of at least 500 mm during crop-growing season, and abundant sunshine and relatively warm temperature. Temperature in the range of 25 to 30ºC is optimum for plant development (Prathima et al, 2022).

The correlation coefficients between weather variables and dry matter production during pod development phase indicated that rainfall, relative humidity morning and afternoon have positive correlation with dry matter production. The temperature maximum and evaporation prevailed during this corresponding phase showed negative correlation with dry matter production.

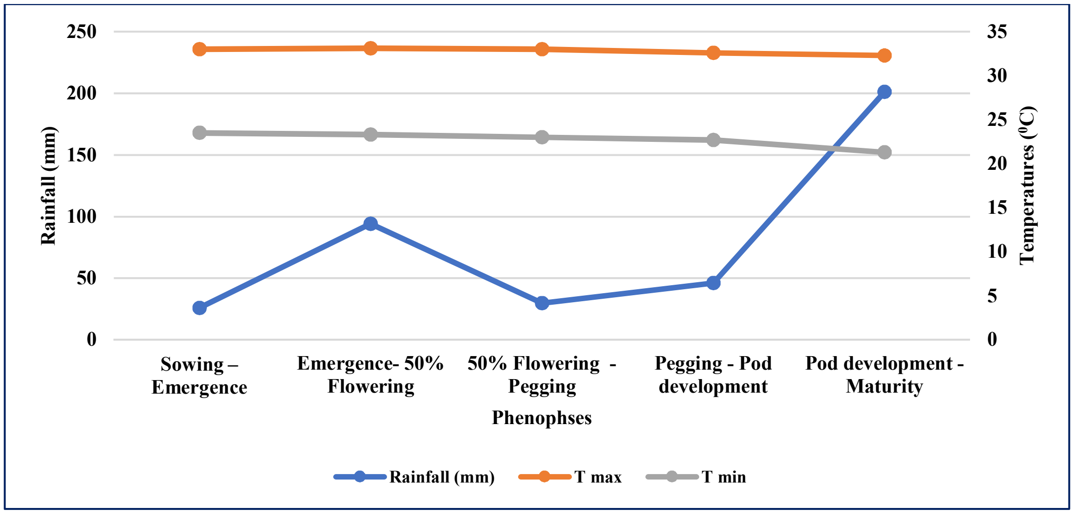

Fig 1. Weather parameters during the crop growth stages at ARS, Anantapuramu (2016-2023)

Table 1. Pod yield (kg ha^{-1}) of groundnut as affected by dates of sowing and varieties

Treatments	Pod yield (kg/ha)								
	2016	2017	2018	2019	2020	2021	2022	2023	Pooled
Dates of sowing									
D1 – I FN July	566	2200	233	1432	584	1025	1703	1350	1136
D2 – II FN July	728	2528	231	1997	643	987	1581	525	1152
D3 – I FN August	376	1726	194	1740	272	787	633	227	744
Sem (±)	19.7	67.6	24.6	68.3	26.3	24.3	67.8	25.3	21.9
CD (5%)	79.3	272.6	NS	257.6	106.1	98.2	273.5	105.1	88.5
Varieties									
K6	598	1987	202	1537	497	969	1042	692	940
KH	507	2373	249	1809	515	943	1166	459	1003
Dharani	546	2156	188	1872	569	1009	1150	801	1036
Kadiri Anantha	576	2091	237	1674	417	812	1863	850	1065
Sem (±)	18.8	70.3	16.4	91.1	42.0	29.1	114.8	20.7	20.3
CD (5%)	56.4	210.5	NS	NS	NS	87.1	343.7	62.0	60.7

Relationship of dry matter production and weather parameters

Table 2. Correlation coefficients between weather parameters and dry matter production of groundnut during different phenophases.

Weather parameters/Phenophase	Sowing – Emergence	Emergence- 50% Flowering	50% Flowering – Pegging	Pegging – Pod initiation	Pod initiation – Maturity
Rainfall (mm)	-0.600**	0.307	0.023	-0.552*	0.545*
T_{max} (^{0}C)	0.325	-0.305	-0.420	-0.078	-0.498*
T_{min} (^{0}C)	0.224	-0.173	-0.264	-0.003	0.246
RH1(%)	-0.509*	0.229	0.443*	0.402	0.733**
RH2 (%)	-0.566*	0.382	0.353	0.240	0.577*
WS (kmph)	-0.054	-0.178	-0.206	-0.124	-0.490
SS (hr)	0.103	-0.387	-0.007	-0.247	-0.235
EVP (mm)	0.254	-0.463*	-0.377	-0.071	-0.560*

Conclusion

It can be concluded that the recommended optimum time sowing for scarce rainfall zone of Anantapuramu i.e., 1st fortnight (FN) of July to 2nd FN of July still holds good even during the erratic rainfall situation as experienced during kharif 2016 to 2023.

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UID: 1460

Characterization of Extreme Rainfall Events in East and South Eastern Coastal Plain Zone of Odisha

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An extreme weather event is defined as 'an event that is rare at a particular place and time of year' (IPCC, 2021). Global warming, the driver of climate change, theoretically increases the convection energy, which is likely to increase the rainfall extremes. The occurrence of these weather aberrations inflicts huge damage to crops, livestock, humans & properties (Bal and Minhas, 2017). Odisha state, which lies on the east coast of the Indian peninsula, is one of the most disaster-prone states in India with frequent occurrences of natural disasters like droughts, floods, cyclones, dry spells, heat waves, and other climate extremes occurring alone or in combination in the same year. The documentation of extreme weather events will be a vital data source for understanding present and future climate risks. The East & South Eastern Coastal Plain Zone covers seven districts of the state namely Cuttack, Ganjam, Jagatsinghpur, Kendrapara, Khordha, Nayagarh and Puri. Considering the vulnerability of the zone to climate change, natural calamities and livelihood security of people dependent on agriculture, this study was made to document the occurrence of extreme rainfall events, their frequencies and trend in the region.

Methodology

The analyses was done using daily observed rainfall data from 81 stations (located at the block headquarters) spread across seven districts for 32 years (1991-2022) obtained from the SRC, Govt. of Odisha. The IMD classification of 24-hour accumulated rainfall viz. Heavy Rain: 64.5 to 115.5 mm, Very-Heavy Rain: 115.6 to 204.4 mm, and Extremely Heavy-Rain: >204.4 mm, were used for analysis of extreme rainfall in the present study. The block-wise number of very heavy and extremely heavy rainfall events, i.e. rainfall greater than 115.5 mm were calculated for annual, monsoon (June to September), and non-monsoon (January to May & October to December) months. District average was obtained by dividing the total number of events by the number of blocks for the respective district (Table). The non-parametric Mann-Kendall test (Kendall, M.G., 1948 & Mann, H.B., 1945) was used to detect the trends of rainfall extremes.

Results

The annual incidence of the average number of events was maximum in Puri (50.7) followed by Kendrapara district (44.0). Ganjam district received the minimum number of events (20.1) followed by Nayagarh (25.0). Events were maximum in 1991-2000 (1st decade) in the zone and then decreased. The monsoon period analysis revealed that Puri district experienced the maximum number of events (37.4) followed by Jagatsinghpur (30.1) and minimum rainfall events occurred in Ganjam (8.0) followed by Nayagarh (17.8). Decade-wise analysis for monsoon months revealed that the zone received maximum events during the 2001-2010 period. During non-monsoon months, the events were maximum in Kendrapara (14.4) followed by other coastal districts namely Puri (13.4), Ganjam (12.2), Jagatsinghpur (12.9), and events were minimum in Nayagarh (7.3). The recent decadal period (2011-2020) experienced the maximum extreme rainfall events during non-monsoon months in the zone as compared to the previous two decades.

Conclusion

This study revealed that Puri district is more vulnerable to the extreme rainfall (≥ 115.5 mm) events during annual and monsoon period. However, Kendrapara is more vulnerable during non-monsoon period. Ganjam district showed a significant increasing trend of Heavy-Rainfall events during annual and monsoon, whereas Cuttack and Jagatsinghpur showed increasing trends during non-monsoon period. Kendrapara showed a decreasing trend of Very-Heavy Rainfall events during monsoon period whereas increasing trend was found in Jagatsinghpur and Puri during non-monsoon period. A significant decreasing trend in Extremely-Heavy Rainfall was found only in Puri during monsoon period. These rainfall extremes when occur during November and 1st fortnight of December coincide with the ripening stage of *kharif* rice and cause crop loss. However, the rainfall during October helps rainfed *kharif* rice at the grain filling stage and rainfed *rabi* non-paddy crops for sowing and establishment.

District-wise extreme rainfall (≥ 115.5 mm) events (number) during annual, monsoon and non-monsoon period

Sl. No.	District	No. of Blocks	1991-2000 (1st decade)		2001-2010 (2nd decade)		2011-2020 (3rd decade)		1991-2022 (32 yrs)	
			Average	Total	Average	Total	Average	Total	Average	Total
	Annual									
1	Cuttack	13	9.5	123	17.0	221	10.8	141	39.4	512
2	Ganjam	22	6.8	149	4.3	94	7.9	173	20.1	443
3	Jagatsinghpur	8	15.4	123	12.3	98	12.0	96	43.0	344
4	Kendrapara	9	17.1	154	13.7	123	10.7	96	44.0	396
5	Khordha	10	8.8	88	9.2	92	8.7	87	28.3	283
6	Nayagarh	8	7.0	56	8.8	70	7.4	59	25.0	200
7	Puri	11	17.2	189	17.2	189	13.8	152	50.7	558
	Monsoon									
1	Cuttack	13	6.2	81	14.5	189	6.7	87	29.5	383
2	Ganjam	22	2.6	58	2.9	63	2.0	44	8.0	175
3	Jagatsinghpur	8	11.4	91	9.5	76	7.3	58	30.1	241
4	Kendrapara	9	11.0	99	10.6	95	6.9	62	29.6	266
5	Khordha	10	5.1	51	8.4	84	3.6	36	18.7	187
6	Nayagarh	8	4.0	32	8.4	67	3.5	28	17.8	142
7	Puri	11	12.1	133	15.5	170	7.6	84	37.4	411
	Non-Monsoon									
1	Cuttack	13	3.2	42	2.5	32	4.2	54	9.9	129
2	Ganjam	22	4.1	91	1.4	31	5.9	129	12.2	268
3	Jagatsinghpur	8	4.0	32	2.8	22	4.8	38	12.9	103
4	Kendrapara	9	6.1	55	3.1	28	3.8	34	14.4	130
5	Khordha	10	3.7	37	0.8	8	5.1	51	9.6	96
6	Nayagarh	8	3.0	24	0.4	3	3.9	31	7.3	58
7	Puri	11	5.1	56	1.7	19	6.2	68	13.4	147

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Drought Vulnerability and Resilient Crops and Cropping Systems for Andhra Pradesh

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Rainfed agriculture is likely to be more vulnerable in view of its high dependency on monsoon and the likelihood of increased extreme weather events due to aberrant behaviour of South-West (SW) monsoon. Climate resilience involves adapting to the changing climate patterns, reducing vulnerabilities, and ensuring sustainable development. The risk of crop failure and poor yields always influence farmers' decision on investing on new technologies and level of input use. Andhra Pradesh is one of the prominent agricultural States in India facing the vagaries of climate change effects such as droughts and dry spells in Rayalaseema region. The choice of the crops and cropping systems for an agro-ecosystem could further be narrowed down by matching crop requirements with prevailing location specific climatic and soil information. The analysis of long-term climatic data on drought vulnerable mandals serve as a good guide to select climate resilient crops and cropping systems.

Methodology

A study has been conducted to assess the drought vulnerable mandals in different districts of Andhra Pradesh based on the data collected from Directorate of Economics and Statistics (https://des.ap.gov.in), Andhra Pradesh from 1996 to 2023. Based on Normal rainfall data of different districts (Ananthapuramu, Sri Sathya Sai, Kurnool, Nandyala, YSR Kadapa, Annamayya, Chittoor, Tirupati and SPSR Nellore) of Andhra Pradesh, the mandals are divided in to rainfall of less than 500 mm, 500 – 750 mm, 750 to 1000 and more than 1000 mm.

Results

The Southern region of Andhra Pradesh, comprising districts such as Ananthapuramu, Sri Sathya Sai, Kurnool, Nandyala, YSR Kadapa, Annamayya, Chittoor, Tirupati and Prakasam is vulnerable districts for drought. Among the 335 mandals in these predominantly rainfed districts, 16 mandals receive less than 500 mm of annual rainfall, 172 mandals receive rainfall between 500 and 750 mm, 106 mandals receive between 750 and 1000 mm, and 41 mandals received over 1000 mm (Table 1).

The major crops grown are Groundnut, Redgram, Castor, Cotton and Chickpea in these areas. As a general rule, rainfed crops are sown early with the onset of monsoon to realize higher yields. Beyond the sowing window, choice of alternate crops or cultivars depends on the farming situation, soil, rainfall and cropping pattern in the location and extent of delay in the onset of monsoon (Sahadeva Reddy *et al.*, 2021). For example, pulses and oilseeds are preferred over cereals with respect to water requirement and for delayed kharif sowing. Clusterbean and horsegram are better choice for low rainfall areas as compared to other kharif season pulses. For cultivation on conserved soil moisture during rabi season, chickpea and safflower are preferred. Similarly, among oilseeds, groundnut, castor, sesame and niger perform well under rainfed conditions during kharif season. Among the kharif cereals, coarse cereals (millets, ragi and sorghum) are better choice over maize and rice. Among the millets, setaria is most suited for late sown condition without any serious effect on productivity. A good intercropping system gives optimum productivity and higher LER in normal/good season, while brings reasonable yield for either of the crop in poor seasons as an insurance against weather aberrations. In general, intercropping with additive series was found better than replacement series under most of drought situations. However, intercropping systems were more favourable in kharif than rabi season in Indian rainfed regions. Traditionally, double cropping including relay cropping is practiced in rainfed regions with sufficient rains (usually >750 mm) and good soil moisture holding capacity (>150 mm). However, some more areas could bring under double cropping through use of available dryland technologies viz. rainwater management, choices of crops, short duration varieties and agronomic practices. Out of the two crops, one could be short durations (usually legumes) and another, medium duration (usually cereals) for optimum use of available growing season (Ravindra Chary *et al*., 2020).

Table 1: Drought Vulnerability of mandals based on normal rainfall

District	Average rainfall (mm)	< 500	500 – 750	750 – 1000	> 1000	Total
Srisatyasai	596	3	29	--	--	32
Ananthapuramu	525	11	20	--	--	31
Kurnool	627		25	--	--	25
Nandyal	747		18	11	--	29
Prakasam	781	1	16	19	2	38
Bapatla	928	-	2	15	8	25
Palnadu	805	-	9	18	1	28
Chittoor	856	0	4	22	4	30
Tirupati	1044	0	2	7	24	33
YSR Kadapa	659	1	29	3	1	34
Annamayya	727	0	18	11	1	30
Total		16	172	106	41	335

Conclusion

The adoption of drought management and climate-resilient agricultural technologies in Andhra Pradesh has shown significant potential to mitigate drought impacts. These practices not only enhance agricultural productivity and resource use efficiency but also strengthen the livelihoods of farming communities. Expanding these interventions with government support and community participation can make Andhra Pradesh's agriculture more resilient to future climate challenges.

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UID: 1480

Long Term Analysis of Western Disturbance, Characteristics and its Statistical Frequencies in the Haryana

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This study was performed based on actual observation from Agromet observatory, CCS HAU, Hisar (Latitude: 26° 10'N; Longitude: 75° 46' E & Altitude: 215 mts) from 2012-13 to 2022-23. The objective of this works to known the statistical characteristics and frequencies of dry and wet western disturbance, The state influenced the variable weather conditions which includes favourable that mean to optimum influenced the growth and development of crops) and unfavourable, abrupt/abnormal (not favour in the positive influence always damage or losses ours in field of agriculture) weather as influencing in the state such as Western disturbance (WD) influenced the from October to May month. Under our state two type of WD influenced i.e. dry WD (not rainfall happen only cloudy weather, lightning & thundering associated with moderate westerly wind) and wet WD (associated amount of rainfall, sometime event associated with hailstorm specially during month of Jan, Feb and first fortnight of March). Hailstorm, an average was resulted two to three activity noticed in winter season during study period. Dry periods, its frequent weather event happened during monsoon season

(South West Monsoon) which were influenced from July to September month in the state. One of the severe weather event as high temperature (day temperature) in the May & June and low night temperature or frosting night/frost, cold wave etc. (events occurred during December to January month). Dew night (November to March) i.e. also act as the micro irrigation in the pulses crop, foggy weather (moderate in month of November & February, Denser Dec and January month). Western and Eastern Agroclimatic zone influenced & noticed the smog events-in last week of October to first fortnight of November (this period was notice as peak period of Harvesting & threshing of paddy crops in the state). As per the meteorological event data analyzed. The results reveal that the variation in frequencies occurred as western disturbance either dry and wet WD was observed among the different month of study period. Over all resulted the 37 percentage of the wet western disturbance (WWD) and 46 percentage of dry western disturbance (DWD) analyzed period under which considered the month Oct, Nov, Dec, Jan, Feb, March, April and May in the state. These months are under actual observed the events at agromet observatory, CCS HAU Hisar and resulted, it was occurred either dry and wet western disturbance in the state of Haryana.

UID: 1481

Role of Weather Based Technology for Climate Resilient Crop Production in Haryana, India

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Weather-based technology is crucial in crop production because it enables farmers to optimize their operations, mitigate risks, and increase efficiency. The weather-based technology in the form of Agromet Advisories provided to the farmers of Ludas and Arya Nagar villages adopted under AICRPAM–NICRA project during the year 2021-22 and 2022-23. The village Shahpur was taken as control where no AAS was provided and the farmers were considered as non-AAS adopted. A comparison was made between AAS-adopted farmers and non-AAS-adopted farmers. The AAS bulletins were prepared and disseminated through mobile massages, calls and personal contacts during both the crop seasons. The feedback was collected from the AAS as well as non-AAS farmers on the crop condition, agricultural operations undertaken, input used etc. after each advisory and finally the crop yield outputs. The economic impact assessment of AAS for cotton crop shows that B:C ratio of AAS adopted farmers were higher (1.20 and 1.24) as compared to the non-AAS farmers (1.07) during kharif 2021 and similar impact was observed during kharif 2022. The net return of AAS adopted farmers of Ludas and Aryanagar is Rs. 16465 ha^{-1} and Rs. 21431 ha^{-1}, which is Rs. 9408 and Rs. 14374 ha^{-1} more than the Non-AAS farmers, respectively during kharif 2021 and Rs. 17001 ha^{-1} and Rs. 17026

ha^{-1}, respectively, higher over non-adopter farmers during kharif 2022. In case of wheat AAS farmers received higher net benefit of Rs 9408 ha^{-1} and 14374 ha^{-1}during 2021-22 and Rs 18604 ha^{-1} and Rs 22742 ha^{-1} during 2022-23 over the Non-AAS farmers, respectively.

UID: 1483

Performance of Climate Resilient Technologies for Resource Conservation in Wheat Cultivation in Northern Bihar: A Comparative Analysis with Conventional Practices

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Agriculture in Bihar is predominantly rainfed. So, it faces a host of challenges due to climate variability, water scarcity, and inefficient resource management. Wheat, a major crop in the state, is highly sensitive to these climatic fluctuations, impacting its yield and productivity. With increasing climate stress, there is a growing need for sustainable agricultural practices that can enhance productivity, conserve natural resources, and improve farmer livelihoods. In this context, climate-resilient agricultural (CRA) technologies have emerged as promising solutions. These technologies, including zero tillage, community irrigation, raised bed planting, and Green Seeker-based nutrient management, are designed to optimize resource use and increase agricultural resilience. This study evaluates the performance of these CRA technologies in wheat production across different regions of northern Bihar, comparing them with conventional farming practices in terms of yield, resource efficiency, and economic outcomes.

Methodology

The study was carried out in multiple districts of northern Bihar under Climate Resilient Agriculture (CRA) Programme, where wheat is a major crop. Four CRA interventions were taken into consideration for the study:

1. **Zero Tillage (ZT):** No soil tilling before sowing to reduce soil erosion and water evaporation.
2. **Community Irrigation (CI):** A collective irrigation management system that optimizes the distribution and use of water resources.
3. **Raised Bed Planting (RBP):** Elevated planting beds to improve water drainage and enhance soil fertility.
4. **Green Seeker-based Nutrient Management (GS):** Precision agriculture technology using sensors to optimize the application of fertilizers based on crop needs.

Conventional practices involved traditional tillage, individual farmer-managed irrigation, and standard fertilization methods. Data on wheat yields were collected from plots under both CRA and conventional practices across several regions in Bihar. The following parameters were measured:

1. **Wheat Yield (q/ha):** Yield data were recorded at harvest from both CRA and conventional plots.
2. **Water Use Efficiency (WUE):** Water consumption was compared between CRA and conventional methods, with water savings calculated.
3. **Cost Savings:** A detailed comparison of input costs, including labor, seed, water, and fertilizers.
4. **Income Increment:** The difference in total income per hectare under CRA versus conventional practices.

Statistical analyses, including analysis of variance (ANOVA), were conducted to determine the significance of differences in yield and other parameters between the two sets of practices.

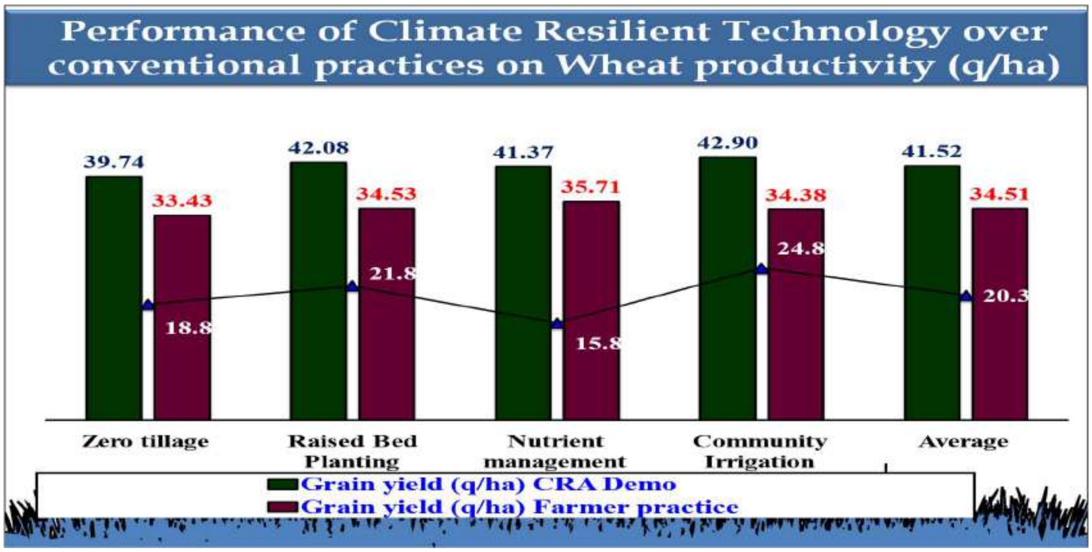
Results

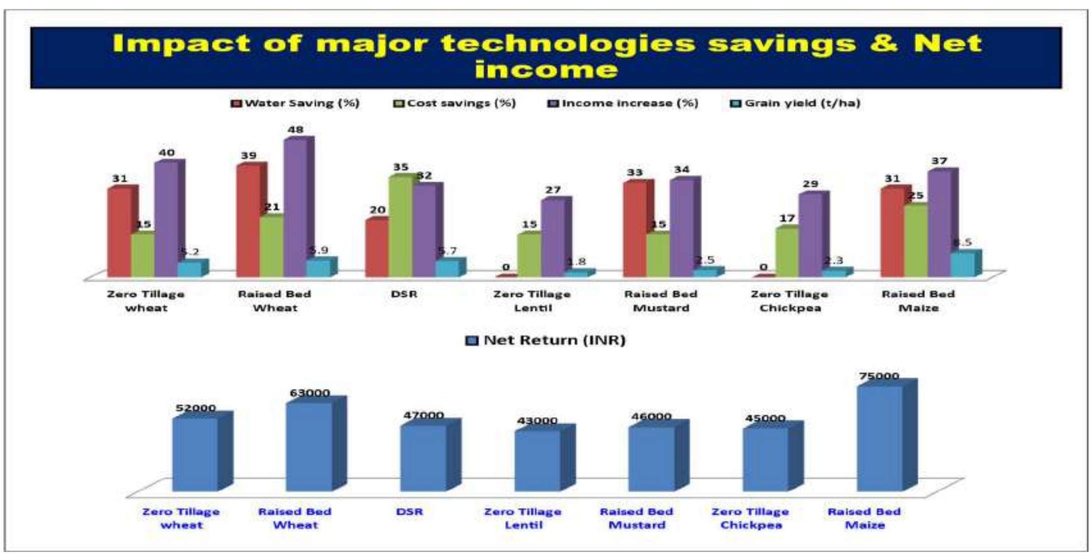
The results indicated that all CRA interventions significantly improved wheat yields in comparison to conventional practices across the study regions. The average wheat yields under CRA interventions were 39.74 q/ha for zero tillage, 42.90 q/ha for community irrigation, 42.08 q/ha for raised bed planting, and 41.37 q/ha for Green Seeker-based nutrient management. In contrast, conventional practices yielded 33.43 q/ha, 34.38 q/ha, 34.53 q/ha, and 35.71 q/ha, respectively. The yield increases across the CRA interventions ranged from 15.8% to 24.8%, with an average increase of 20.3%. These results demonstrate that CRA technologies can substantially enhance wheat productivity in Bihar, where crop yields are often constrained by climatic and resource limitations.

Regarding water use, CRA interventions resulted in significant water savings. Water use efficiency increased by 31-39% under CRA technologies compared to conventional practices. This water conservation is critical for rainfed regions of Bihar, where irrigation resources are scarce and unevenly distributed. Community irrigation, in particular, proved to be effective in optimizing water distribution, ensuring that more farmers had access to water for their crops.

In terms of cost efficiency, CRA interventions led to significant cost savings. The reduction in input costs ranged from 15% to 21%, primarily due to decreased water usage, reduced fertilizer application with Green Seeker technology, and more efficient management of labor. These cost savings, combined with higher yields, resulted in an income increase ranging from 40% to 48%. The economic benefits of CRA technologies are particularly significant in Bihar, where many farmers struggle with low and uncertain incomes.

The findings of this study highlight the potential of CRA technologies to address the challenges faced by farmers in Bihar's rainfed regions. By improving wheat yields, conserving water, reducing costs, and increasing income, these technologies can contribute to both the economic and environmental sustainability of farming systems. Additionally, the success of community irrigation and precision nutrient management demonstrates the importance of collective action and technological innovation in enhancing resource use efficiency and building climate resilience.





Conclusion

In conclusion, this study underscores the importance of scaling up CRA technologies in Bihar, particularly in rainfed areas. By improving wheat productivity and promoting sustainable agricultural practices, CRA technologies can play a vital role in enhancing food security, promoting climate resilience, and improving the livelihoods of farmers. The findings also highlight the need for supportive policies, training, and infrastructure development to facilitate the adoption of these technologies, ensuring their widespread impact in Bihar's agricultural landscape.

UID: 1488

Impact of Borewell Recharge Structures on Groundwater Quality and Quantity in North-Eastern Dry Region of Karnataka

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Groundwater, which is the source for more than 85 percent of rural domestic water requirements, 50 percent of urban water requirement and more than 50 percent of irrigation requirement of the country, is depleting fast in many areas due to its large-scale withdrawal for various sector. The rapid development of groundwater resources for varied usage has contributed in expansion of irrigated agriculture, overall economic development and improving the quality of life in India. Management of natural resources needs long term planning to match demand and supply. The ground water development with time has changed the hydrogeological regime and as a result natural recharge component have altered to a greater extent. Augmentation of the depleting groundwater water resources and maintaining its quality is very essential for preservation of this resource. Harvesting of excess monsoon runoff, otherwise being lost to the sea, is one of the best options to achieve the objective of groundwater augmentation. In India, the groundwater in most of the areas is fresh and it is brackish in the arid zones of Rajasthan, close to coastal tracts like Saurashtra and Kutch, and in some zones in the east coast and certain parts of Punjab, Haryana, Western Uttar Pradesh, etc., which are under extensive surface water irrigation. Pollution due to human and animal wastes and fertilizer application has resulted in high levels of nitrate and potassium in ground water in some parts of the country. Groundwater recharge is very much essential in these areas due to depleting water resource day by day. In India, the groundwater quality is also deteriorating in many parts of the country. Hence, the groundwater pollution can be minimized through recharging as it dilutes the groundwater by rain water addition. The runoff generated from rainfall can be harvested and diverted to the defunct or lesser yield bore wells so as to increase the quantity and this recharged water could be used as supplemental irrigation during the dry spells. Therefore, the artificial recharge techniques can also be utilized in improving the quality of groundwater by diluting the groundwater with rainwater. Owing to the above problems and causes of the present scenarios, the project was being operated on augmenting groundwater quality and quantity by demonstrating artificial ground water recharge techniques in three districts of Karnataka North-Eastern Dry zone of Karnataka where there is huge problem of groundwater quantity as well as quality.

Methodology

Groundwater recharge is essential in this area because of depleting water resource day by day in the region due to uncertainty in the rainfall. The ground water quality is also deteriorating. The parts of Bidar and Kalaburagi districts have already been identified as fluoride contaminated regions. The salt content in the bore wells of almost all the talukas of Kalyana Karnataka surveyed were shown higher saline water. Hence, to diluting the groundwater with recharged water is very mush essential. In ground water recharging, there are number of techniques for recharging. Here, in this project, the normal method i.e. artificial recharge technique was followed by excavating and making the defunct bore wells and tube wells as working. The regions were identified as safe groundwater potential zones in the region where the ground water is under exploited.

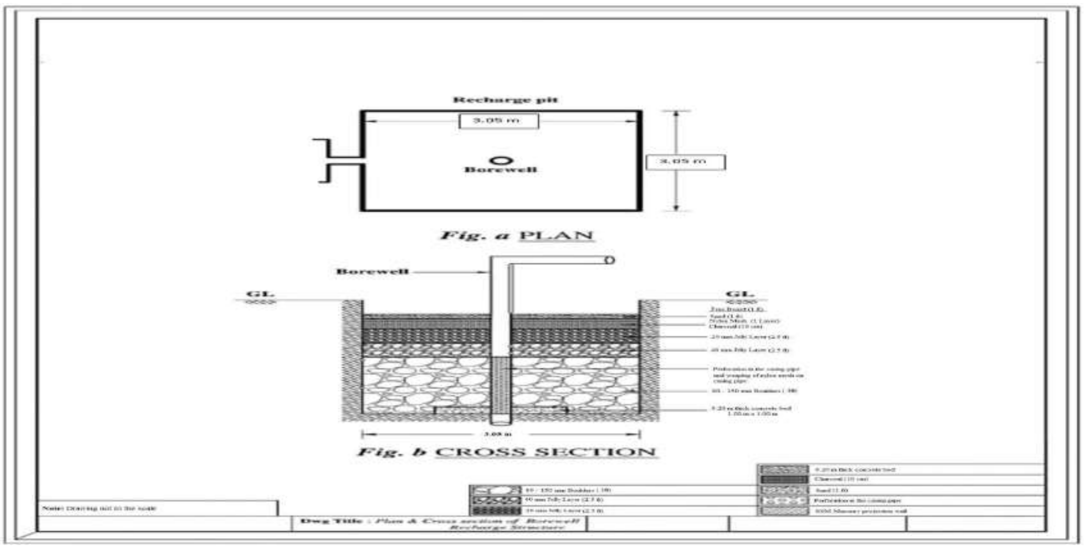
The artificial ground water recharge technique was implemented in hobli wise, one step maller unit than tehsil or taluka. In each hobli of Raichur, Yadgiri and Kalaburagi districts, two bore wells were selected from different farmer's fields and borewell recharge structures were installed. Total 170 problematic borewells were selected from these selected districts through each Raitha Samparka Kendra (RSK). These recharged borewells structure were also used for demonstrating and exposure visits to the farmers of the different regions of Kalyana Karnataka. The farmers and stakeholders are the major beneficiaries of this technology in efficient management of rain water/ runoff water by enhancing the ground water levels of the bore wells.

Procedure for construction of borewell recharge pits

The beneficiaries who are having defunct borewells and kept idle due to poor quality and lesser yields were identified based on the guidelines prepared for three districts of semi-arid region i.e. Kalaburagi, Yadgiri and Raichur. In all 170 (One hundred seventy) defunct borewells 64 are in Kalaburagi, 34 in Yadgiri and 72 borewells in Raichur districts, and recharge pits were installed in these borewells. With through survey, the necessary areas of rehabilitation works are to be taken up, identified and selected the defunct borewells which are in the low areas. It was also ascertained that whether the runoff water can flow through these boreholes. In some cases, diversion channels were constructed to divert the runoff water to the borewells.

A pit measuring 3.05 x 3.05 x 3.05 m was constructed around the casing pipe of a suitable borehole at all the farmers' field (Fig). Small hole of 3-4 mm diameter were drilled with the help of drilling machine at 6 feet middle section of the casing pipe allowing maximum 2 inch water into the casing. Then two layers of geotextile filter material was wrapped up around the casing pipe then 8 to 10 layers of plastic screen / nylon (waterproof) screen was tightly wrapped around the perforated casing pipes.

Boulders with 120-150 mm size were laid 0.61 m at the bottom of the dug pit as first layer. Then in second layer, 40 mm granite stones were set for 0.61 feet depth. 20 mm gravel stones were filled as third layer upto 0.61 feet and 10 mm jelly (aggregates) was also filled in 0.61 feet as a forth layer. In between the entire (five) layers, one layer of nylon mesh was covered. 15 cm coarse sand has been filled and then 30 cm charcoal was spread on the layers. Above these, 0.45 cm thick coarse sand was filled and the remaining space was kept as empty to collect and store the rainwater.



Plan and cross section of borewell recharge pit

A 1.0 m high embankment/ brick wall was built around this pothole with inlet and outlet provision. It was ensured that the fallen rainwater first flows through the silt trap and then enters to this pit. The flowing water should be stopped and was stored in silt trap and detention time was given to settle the silt. Only over flowed water was reached to the recharge pit. The silt trap was constructed with the size of 1.5 x 1.5 x 1.5 m with brick and should be plastered. The water table depths below ground level during before onset of monsoon and after the season were measured in selected farmer's field with sensor-based water level indicators. The quality parameters for the collected samples during before onset of monsoon and after the season were measured with Hanna multi parameter analyzers, Flame photometer, Single Beam Visible spectrophotometer etc.

Results

Artificial recharge is important for groundwater management as it provides storage space free of cost and avoids evaporation losses and allows the use of stored water in dry seasons. To demonstrate artificial groundwater recharge techniques in Kalyana Karnataka region, the experiment was initiated during 2021-22 and continued for 2023-24. The farmers details and initial data's on borewell details like total depth of borewells, present and past water level through water level indicator, discharge, pump details and suitability were recorded. The water samples were also collected to know the initial water quality of the borewells before installation of the pits. The water quality of borewells such as EC, pH, TDS, Ca^{2+}, Mg^{2+}, Potassium (K), K_2O, Cl^- , SO_4^{2-}, PO_4^{3-}, P, P_2O_5 and fluoride were collected before and after installation of recharge pit in all the three districts. The water levels before installation of recharge pit were 8.20 m to 30.06 m bgl and after installation the levels were, 7.10 m to 28.35 m bgl. The EC and TDS of the water ranged from 0.435 dS m^{-1} to 8.37 dS m^{-1} and from 217 ppm to 7324 ppm respectively before installation i.e. during pre-monsoon. After installation i.e. post-monsoon the EC and TDS were ranging from 0.392 dS m^{-1} to 7.45 dS m^{-1} and 190 ppm to 6523 ppm respectively in one season. The advantages observed from these borewell recharge pits were harvested runoff water had increased the groundwater level, the water quality also slightly improved towards favorable conditions. Due to the poor water quality and quantity, the ideal and left out defunct borewells were made to reuse again. With this technique, farmers could be able to give one or two supplemental irrigations to their crops during prolonged dry spells. Finally, the water table in the borewell and quality had improved slightly in one season after the installation of recharge pits at farmer's field.

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UID: 1489

Impact of Residue Management Practices on Cotton Crop Yield and Yield Attributes in Dry Farming Condition

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Cotton (Gossypium spp.) is a key global fibre crop, essential for the textile industry. India is the second-largest cotton producer and grower, after China. Cotton is grown on 130.49 lakh hectares in India, with a production and productivity of 337.27 lakh bales and 439 kg/ha, respectively. In Gujarat state, it is grown on 25.49 lakh hectares with a production and productivity of 87.12 lakh bales and 581 kg/ha, respectively, DES, (2022). In India, around 30 million tonnes of cotton stalks are produced annually mostly treated as waste. Only 5-6% is used commercially and 15-20% as fuel. The rest is burned in fields, causing significant environmental pollution. Burning cotton residues helps with stalk management and field preparation but negatively impacts soil properties. Recycling residues is crucial for improving soil fertility and crop productivity. Proper management and decomposition of cotton stalks can enhance soil health and support plant growth, ultimately boosting crop yields.

Methodology

A study on the recycling Cotton stalks and its effect on yield and yield attributes was carried out at Main Dry Farming Research Station, Junagadh Agricultural University, Targhadia (Rajkot) during the *kharif* 2015-16 to 2022-23. The experiment was laid out in a strip plot design, replicated thrice, comprising fifteen treatment combinations. The main plot treatments, namely S_1(Removal of cotton stalks from plot), S_2(Surface burning of cotton stalks), S_3(Incorporation of cotton stalks using rotavator), S_4(Incorporation of cotton stalks using mobile chopper) and S_5(Ex-situ composting of cotton stalks using shredder), were combined with subplots consisting of three fertigation schedules: D_1(One irrigation for decomposing), D_2(One irrigation + addition of N @10kg/ha through urea + compost culture @5kg/ha) and D_3(Addition of N @10kg/ha through urea + compost culture @5kg/ha at sowing). The cotton variety G.cot. Hy.-8 BGII was grown using standard package of practices. Irrigation was applied after ploughing to facilitate the decomposition of stalk residues. The Gross and net plot size was 10.8 m X 6.0 m and 9.6 m X 3.6 m, respectively. Cotton was sown at the distance of 120 cm X 30 cm on 26 June 2018, 24 June 2019, 08 June 2020, 19 June 2021 and 28 June 2022 under conserved soil moisture. Data on growth, yield performance and economic of cotton was pooled over 5 years.

Results

Effect on yield attributes

The results in Table revealed that the stalks management practice S_5(ex-situ composting of cotton stalks using shredder) recorded significantly higher plant height (93.11cm), number of sympodia/plant4.41/plant and number of balls/plant (30.32/plant), while number of monopodia/plant was found non-significant. The effect of different de-composting practices on plant height, numbers of monopodia and number of bolls per plant of cotton were found non-significant. Significantly higher number of sympodia/plant 4.31 was recorded under stalk management practices D_2 (One irrigation+addition of N @10kg/ha through urea + compost culture @5kg/ha). Interaction effect of stalk management and de-composting practices (SxD) were found non-significant in respect of growth and yield attributes parameters.

Effect on yield

The results revealed that significantly higher seed cotton yield (1770 kg/ha) was recorded under S_5 (ex-situ composting of cotton stalks using shredder). Whereas, effect of de-composting practices on seed cotton yield was found non-significant. However, the maximum seed cotton yield (1631kg/ha) was recorded under de-composting practice D_2 (One irrigation + addition of N @ 10kg/ha through urea + compost culture @ 5kg/ha). While in seed cotton yield interaction effect of stalk management and de-composting practices (SxD) were found significant in pooled result Table. Significantly higher seed cotton yield was recorded under treatment combination of *Ex-situ* composting of cotton stalk using shredder and addition of 10 kg N/ha through urea + compost culture @ 5kg/ha at sowing (S_5D_3) in pooled result. Similar results have been reported by Vora *et al*. (2019) in cotton and Kumari *et al.* (2018) in rice-wheat cropping system.

Effect of stalk management and de-composting practices on yield attributes and seed cotton yield of *Bt.* cotton (pooled mean of five years)

Treatment	Plant height/cm	No. of Monopodia/ pl	No. of sympodia/pl	No. of balls/pl	Seed cotton yield (kg/ha)
Stalks management practices(S)					
S_1	85.17	1.31 (1.72)	4.18 (17.48)	22.93	1477
S_2	85.59	1.33 (1.77)	4.13 (17.04)	25.26	1580
S_3	89.36	1.32 (1.74)	4.33 (18.74)	26.48	1651
S_4	89.51	1.35 (1.83)	4.31 (18.61)	27.22	1642
S_5	93.11	1.36 (1.86)	4.41 (19.41)	30.32	1770
S.Em. ±	1.36	0.02	0.05	0.86	28
C.D. at 5 %	4.08	NS	0.13	2.58	79
C.V. %	6.45	11.04	7.40	12.77	11.44
De-composting practices(D)					
D_1	87.66	1.31 (1.73)	4.21 (17.69)	26.06	1624
D_2	89.29	1.34 (1.79)	4.31 (18.60)	26.58	1631
D_3	88.70	1.35 (1.84)	4.29 (18.45)	26.68	1617
S.Em. ±	0.63	0.02	0.03	0.33	21
C.D. at 5 %	NS	NS	0.08	NS	NS
C.V. %	6.20	11.0	5.63	10.85	11.12
Interactions					
Interaction SXD					
S.Em.±	1.50	0.04	0.08	1.14	51
C.D. at 5 %	NS	NS	NS	NS	148
C.V. %	6.56	10.86	7.06	12.79	9.13

Conclusion

Maximum seed cotton yield was recorded under Ex-situ composting of cotton stalks using shredder and adding 10kg N/ha through urea + compost culture @ 5kg/ha at sowing. **OR** incorporating cotton stalks using a mobile chopper and one irrigation for decomposting along with 80kg N+40kg P_2O_5+250kg gypsum/ha for obtaining higher yield and net monetary return as well as sustaining soil health under rainfed conditions.

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Sustainable Agricultural Management Practices to Mitigate Climate Change in Sorghum

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Sorghum is increasingly valued for its diverse uses in food, feed, and bioenergy (Stamenković et al., 2020; Rao et al., 2019). Its adaptability to drought tolerance, high productivity, and low nutrient requirements make it a cost-effective crop, particularly in Africa and Asia (Maina et al., 2022). Bibliometric analysis serves as a powerful tool for assessing research trends, examining journal citations, and identifying emerging themes in publications. This quantitative method, endorsed by leading scholars (Donthu et al., 2021), provides a systematic approach to understanding the evolving research landscape, particularly in areas such as sorghum and sustainable agriculture**.**

Methodology

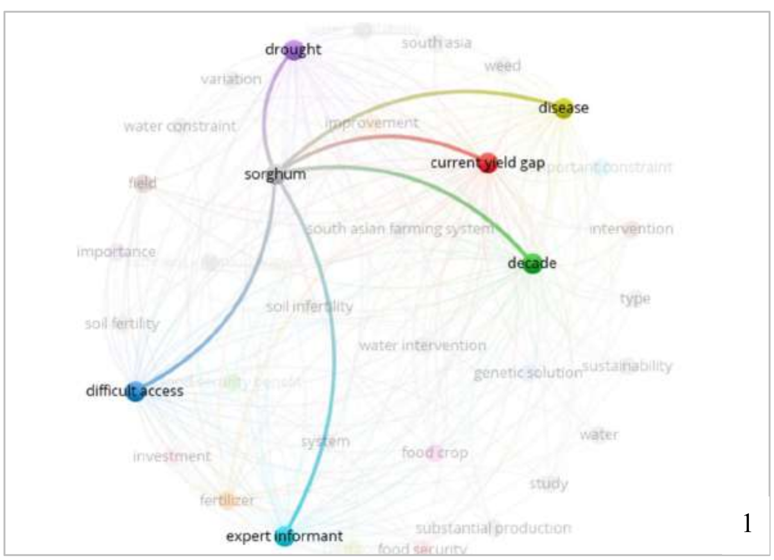
Strategic search terms covered sorghum's agricultural sustainability and crop yield to ensure diverse scholarly inclusion. The search spanned titles, abstracts, and keywords for comprehensive data collection. A five-year temporal restriction (2020-2024) was applied to capture recent, relevant literature, ensuring the analysis reflects current research trends and contributions. Bibliometric and content analysis was done using PRISMA. This comprehensive approach aimed to address key research inquiries concerning sorghum studies. By leveraging the combined power of VOS viewer and Bibliometrics, this study sought to provide an extensive and nuanced understanding of sorghum research in contemporary and future directions.

The bibliometric and content analysis followed a structured approach, using Bibliometrics and co-occurrence analysis via VOS viewer. This process identifies thematic relationships by examining keyword co-occurrence frequency. Frequently co-occurring keywords indicate closer thematic links, visualized through network maps or clusters. A minimum occurrence threshold was applied to ensure reliability, identify significant keywords, and provide insights into literature themes. This method allows for a systematic exploration of relationships within the research, enhancing understanding of key topics and emerging trends.

Results

The findings emphasize intercropping as an effective strategy to increase sorghum yields and enhance resilience in crop production. Stress-tolerant varieties resistant to drought and floods align with sustainable agriculture principles, addressing climate change-induced economic impacts on yields and informing adaptive strategies. This study provides valuable insights for future research.

The cluster investigates the tolerance and plant stress response which is committed to advancing sorghum research within the domain of cereal crops and yield. The cluster is involved in research related to sorghum's utilization for biomass and productivity, and simultaneously, it specializes in exploring metabolism and genetic expression. Investigating the link between extreme climate indices and sorghum yields across various climatic zones will provide insights into enhancing sorghum resilience to climate change (Sanaou et al., 2023). This study contributes valuable insights into global sorghum research patterns and emerging trends, encouraging further multidisciplinary research and promoting sustainable agricultural practices.



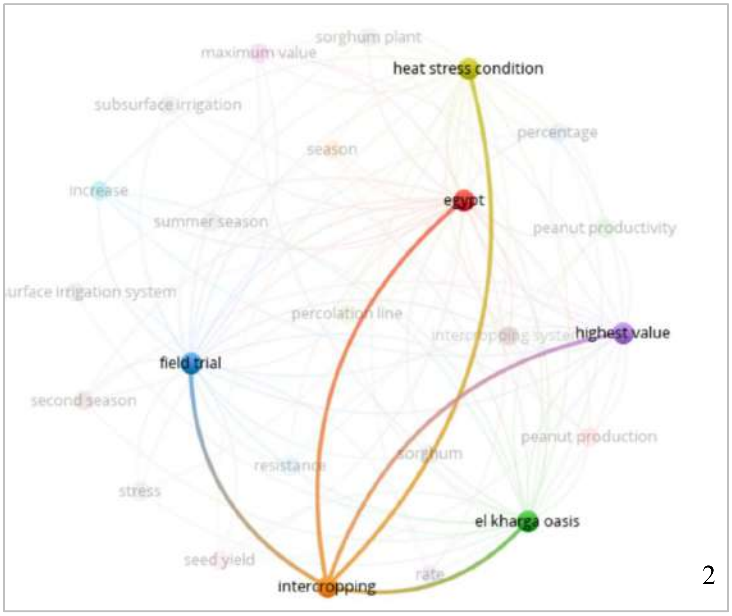


Fig 1 and 2: Co-occurrence network diagrams for certain keywords

Conclusion

This study used bibliometric and content analysis to examine research patterns, emerging topics, and future trends in sorghum. It highlights significant improvements in sorghum yields through adaptation strategies. The findings emphasize integrated approaches to enhance agricultural productivity and resilience, particularly in changing climates, with sorghum's role in food security under drought conditions as a potential future focus**.**

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Rainfall Runoff Relation for Sustainable Fingermillet Production System in Rainfed Areas

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Rainwater harvesting is important to get better crop yields by utilizing rainfall under rainfed ecosystems. Rainfall runoff relation facilitates to harvesting runoff and provides supplemental irrigation to obtain sustainable yields. Rainfed area over 55% of the net cultivated area in the country is contributing 40% of the food grains, supporting 60% livestock and 80% of the pulses and oilseeds (Anon., 2011). Fingermillet in India is 1.38 M ha with a production of 2.13 M t and the productivity 1552 kg/ha. Largest area under fingermillet (0.84 M ha) in India is in Karnataka followed by Uttarakhand (0.14 M ha). Most important districts in Karnataka include Bangalore, Kolar, Tumkur and Hassan. In fingermillet production system dry spells occurs frequently during months of September, October and sometimes November coinciding with flowering and pod filling stages. Runoff collection into rainwater harvesting structures like farm ponds and use as supplemental irrigation can increase and stabilize crop production (Krishna et al., 1987). There is an abundant scope and opportunity for harvesting excess runoff in the rainfed region in different states of the country. An experiment on rainfall – runoff relationship was conducted to obtain sustainable yield of fingermillet under the present weather aberrations in rainfed conditions.

Methodology

A field study was conducted based on the concept of harvesting of rainwater from a defined agricultural catchment and establishing a rainfall-runoff relation to obtain sustainable production in rainfed agriculture at All India Coordinated Research Project on Dryland Agriculture, Bengaluru center representing the domain districts of Central eastern and southern dry zone in Karnataka, India (Fig 1). The soils in the regions are alfisols with semi-arid (Hot-moist climate) with average rainfall of 928 mm out of which 60% received in the monsoon season (June–September) in kharif and in rabi 35% as winter and rest as summer rainfall and the soils are lateritic and sandy loam in texture with low water holding capacity and higher seepage rate.

Fig 1. Study area

Catchment area for the water harvesting structure was demarcated (165 m x 34 m, 5610 m^2), at the lower side constructed a water harvesting farm pond with capacity 180 m^3 (10.5 m x 4.5 m x 3m with slope 1:1) and bottom and sides lined with brick pointing and brick compartment at 1 m2 with soil + cement (8:1) overlaying to a depth of 5 cm. Crops grown in catchment area were Fingermillet+Pigeonpea (8:2), Field bean, greengram, blackgame and sesame including vegetables. Conservation furrows were made 30 DAS in the crop rows. Observations on rainfall, runoff using a staff in structure, yield attributes recorded from 2012 to 2022 expect in 2016 as it was a severe drought year and crops were vitiated. Water harvested for each runoff event was worked out by calculating the difference in the volume of water before and after the runoff event. Since the catchment is an agricultural micro watershed, some of rainwater was conserved due to land configuration and crop cover etc., Runoff generated beyond these *in-situ* conservation measures was enroute to the FP. Runoff data was used to establish rainfall–runoff relationship.

Results

A. Rainfall Runoff Relation

The runoff volume harvested from different runoff yielding storms from 2012 to 2022 was recorded with in monsoon season from June to December. The maximum runoff volume (573.5 m^3) was recorded in 2021, which is mainly a wet year with 1121 mm (excess 22% average). The minimum runoff volume (17.11 m^3) recorded in 2013, which was mainly due to drought conditions with more than 50% deficit rainfall. A relation between rainfall and runoff was established by plotting runoff-producing rainfall in mm on the x-axis and total seasonal runoff in mm on the y-axis with a linear trend line and a coefficient correlation of 0.77 (Fig 2);

B. Design of threshold storage

From Fig 2 it can be inferred that an average seasonal runoff-producing rainfall received in a season is 700 mm, which is able to produce a runoff of 55 mm. For 1.0 ha catchment the volume of runoff can be harvested is 550 m3. Assuming at least two fillings in a crops season. Therefore, threshold design capacity of the farm pond is 275 m3 with dimensions of Farm pond (12.0 m x 6.0 m and depth 3.0 m with slope 1:1) occupies 1.5% of the catchment area. Assuming a supplemental irrigation of 5 cm to be provided at the time of dry spells/critical stages in kharif for fingermillet and at critical stages during rabi season, so that command can cover up to a maximum of 0.55 ha.

These results are on par with earlier studies too (Patode et. al. 2020), in vertisols for crops like cotton and soybean. Efficient utilization of harvested water can also be profitable by using farm pond with HDPE polythene lining, as reported by earlier researchers for this region to reduce the cost of lining material when compared to cement, brick, and concrete lining (*Anon., 2019-20*).

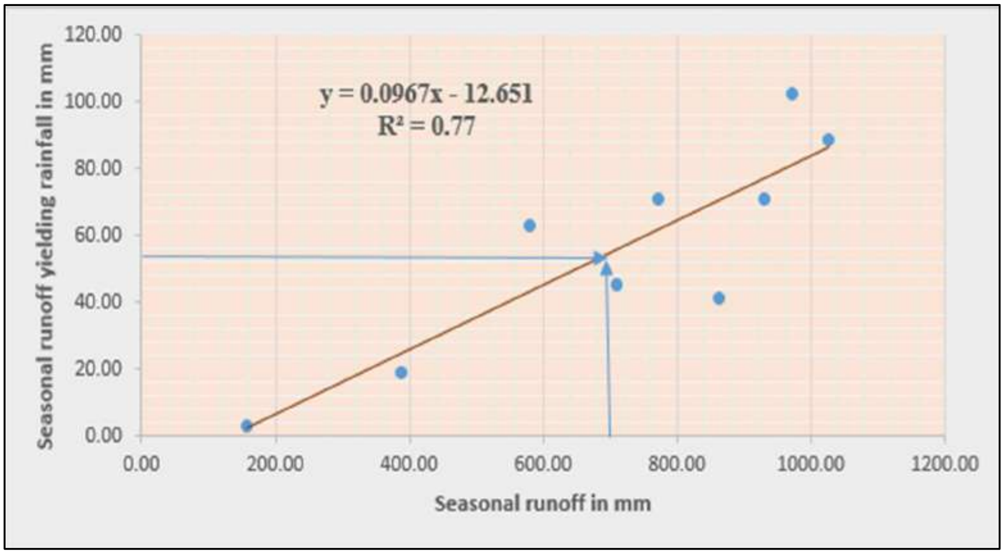

Fig 2. Rainfall runoff relationship in an agricultural watershed for the period 2012–2022

Conclusions

For the domain districts of Central eastern and southern dry zone in Karnataka, India. A threshold storage of 275 m3 was designed with an assumption of two fillings occurring in a crop season from an agricultural catchment of 1.0 ha with land configurations and crop cover. The dimensions of farm pond are top 12.0 m × 12.0 m, bottom 6.0 m x 6.0 m with depth 3.0 m and side slope of 1:1. Assuming a supplemental irrigation of 5 cm to be provided at the time of dry spells/critical stages in kharif for fingermillet and at critical stages during rabi season, so that this can cover up to a maximum of 0.55 ha.

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Effect of *In-situ* Moisture Conservation Practices on Growth and Yield of Castor

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Two thirds of cultivated area in India is under rainfed farming which is often influenced by aberrant weather conditions, by which the poor rainfed farmer suffers with low productivity and low net returns. The main aim of extension in dryland areas is to increase net returns of the dryland farmer by improving the economic returns and by reducing the cost of production with minimum risk of crop failures, besides sustaining natural resources (Reddy *et al* 2022). Castor (*Ricinus communis* L.) is the premier non-edible oilseed crop, mostly grown under rainfed situation during *kharif* season in Ananthapur district. Though the state of Andhra Pradesh stands second in area (1.86 l ha) and third in production (1.20 l t), the productivity levels of castor are very low (645 kg/ha) as compared to Gujarat (1,978 kg/ha), Haryana (1,600 kg/ha) and Rajasthan (1,417 kg/ha). The major reasons being growing castor under rainfed conditions in marginal and sub-marginal soils with low input management, occurrence of prolonged dry spell during mid/ terminal stages at flowering/capsule development stage during *kharif* season. Further, neither effective drought proofing mechanisms are available. Consequently, the realized productivity is only 25 to 30% of actual potential yield. Thus, castor cultivation during *kharif* season has become non-remunerative. Rainwater conservation is a critical factor in stabilizing and stepping up of crop yields in drylands. To increase the soil moisture availability to the agricultural crops and to increase the infiltration and percolation of rain water into the root profile, the in-situ moisture conservation techniques are recommended. As moisture is the key limiting factor in the rainfed farming and rainfall is the only source of water for this vast stretch of lands. It is necessary to harvest maximum rain water and to adopt methods to maximize the retention of the available moisture. Hence in rainfed areas, the in-situ rainwater harvesting through Deep ploughing and making conservation furrows assumes greater priority. Considering the above facts, attempt was made to study the effect of chisel ploughing and conservation furrows on the growth, yield and economics of castor under rainfed conditions.

Methodology

Front Line Demonstrations (FLDs) were conducted for two years from 2023-24 to 2024-25 at KVK operated mandals of Kalyandurg area of Ananthapur district. Average rainfall during the crop growing period was 287.4mm and 584.8 mm during the year 2023-24 to 2024-25 respectively. The demonstration practice comprised of *in-situ* soil moisture conservation practices viz., Chisel ploughing and conservation furrow. Deep ploughing (40-55 cm) was done with Chisel plough which is used for breaking hard pans with less disturbance to the top layers. Its body is thin with replaceable cutting edge so as to have minimum disturbance to the top layers. It contains a replaceable share to shatter the lower layers. Conservation furrows are made with bullock drawn country plough near the row zone of castor leaving 20 cm apart on one side of the row. In case of farmers practice no such *in-situ* moisture conservation practices were followed. Sowing of castor was taken up in the month of June during both the years. Seeds of Castor hybrid ICH 66 was used for the study in both demonstration and farmer's practice. Line sowing was done with a seed rate of 5 kg ha^{-1}. All other agronomic practices like fertilizer application and weed management was done uniformly in both demonstration and farmer's practice. Five randomly selected plants from all the farmers field were used for biometrical observations and yield data were recorded at the time of harvest in 5X5 m^2 plot.

Results

Two years pooled analysis data in Table reveals that chiseling and *in-situ* moisture conservation furrow was responsible for significantly increase in various growth and yield characters of castor. Chiseling followed by *in-situ* moisture conservation furrow produced higher primary spike length, more number of spikes per plant, more capsules in primary spike and yield/ha. The castor bean yield recorded under demonstrated practice was 634 kg/ha in 2023-24, 986 kg/ha in 2024-25 and 810 kg/ha when pooled over the years. This was about 17.6% higher in 2023-24 and 15.45% higher in 2024-25 over farmer's practice. The increase in yield is attributable to more spikes per plant and more capsules per spike. From the pooled data demonstrated practice of Chiseling followed by *in-situ* moisture conservation furrow produced 16.52% additional yield as compared to farmers practice of conventional tillage. The results clearly showed the need of Chiseling and in-*situ* moisture conservation practice for higher yield attributing characters that ultimately helped in increasing the castor productivity. Biradar *et al.* (2020) also reported more differences in yield attributes and yield in-situ moisture conservation methods in redgram. The cost of cultivation was higher in demo practice over the farmers practice during both the years and on mean data. Farmers adopting Chiseling and in-*situ* moisture conservation practice (Rs. 32,185/-) recorded 13.7% additional cost than farmers practice over the pooled data (Rs.28,295/-). Year-to-year variability in cultivation costs can be explained by differences in the local social and economic conditions. The average gross returns from the pooled data recorded was Rs. 46,029/ha as compared to Rs. 39,469 in farmer's practice. The demo practice registered an increase of 16.6% gross returns over farmer's practice. The pooled data on net returns also showed the superiority of demo practices over farmer's practice. It was also noticed that net returns recorded under Chiseling followed by *in-situ* moisture conservation furrow (Rs.13,844/-) was 23.8% higher than farmers practice (Rs.11,174/-). Economic analysis of the yield performance revealed that benefit cost ratio of demonstration plots was observed to be higher than control plot of farmer practice.

Effect of *in-situ* moisture conservation practices on growth and yield of castor during kharif 2023-24 to 2024-25 in farmers field at Ananthapuramu district.

Parameters	2023-24*		2024-25*		Mean	
	I.P	F.P	I.P	F.P	I.P	F.P
Primary Spike length (cm)	38.6	37.8	45.2	44	41.9	40.9
spikes per plant (No)	3.82	3.65	5.6	5.15	4.71	4.4
Maturity period for the first picking (days)	92	90	86	82	89	86
Capsules in primary spike (No)	54	50	62	56	58	53
Bean Yield (kg/ha)	**634**	**539**	**986**	**853**	**810**	**696**
Cost of cultivation (Rs/ha)	31570	27570	32800	29020	32185	28295
Gross Returns (Rs/ha)	34870	29464	57188	49474	46029	39469
Net Returns (Rs/ha)	3300	2075	24388	20454	13844	11174
B:C Ratio	1.11	1.08	1.74	1.7	1.43	1.39
% Yield Increase	17.6		15.45		16.52	
C.D (P=0.05) for bean yield	32.64		46.22		38.95	

** Anantapur, Area-08 ha, No. of farmers-20, IP-Improved Practice, FP-Farmers Practice*

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Spatio-temporal Variation of Precipitation based Extreme Indices over Upper Brahmaputra Valley (UBV) zone of Assam

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An investigation has been carried out to study the variation in annual and seasonal distribution of daily precipitation based extreme indices for the period 1991 to 2021 in Upper Brahmaputra Valley (UBV) zone of Assam, India. Initially, twelve numbers of extreme precipitation indies *viz*., CDD, CWD, R10mm, R20mm, PRCPTOT, r95p, r95pTOT, r99p, r99pTOT, SDII, Rx1day and Rx2day which were based on the ETCCDI and ET-SCI classification systems were derived using Climpact v3.1.6 web-based software. Mann-Kendall trend test and Sen's slope estimator techniques were applied for identifying shifts in extreme climatic indices. To further analyse the spatial pattern, the trend surface was interpolated in a GIS platform using Inverse Distance Weighted (IDW) interpolation technique over the 5 districts (i.e., Golaghat, Jorhat, Sivasagar, Dibrugarh and Tinsukia) of UBV zone of Assam. Mean climatology of the indices revealed that highest value of CDD (i.e., 46 days) and the lowest CWD (i.e., 14 days) were observed in Golaghat district while Tinsukia district observed the highest value of CWD (i.e., 35 days). Rainfall frequency indices (R10mm and R20mm) showed peaked values in Dibrugarh (i.e., 77 days) and in Tinsukia (i.e., 41 days) respectively. Annual rainfall (PRCPTOT) values varied between 1636.5 mm in Golaghat and 2377.3 mm in Tinsukia with a zone-wide mean of 2056 ± 321 mm. Very wet days (r95p) and extremely wet days (r99p) showed maximum intensities in Tinsukia while Golaghat and Sivasagar reported lower values. Precipitation intensity indices (Rx1day, Rx2day, and SDII) followed similar patterns with Tinsukia consistently recording the highest values. Amongst the five districts, Golaghat, Jorhat and Tinsukia showed sharp declines in total wet-day precipitation (PRCPTOT) of 2.93 mm/year, 14.48 mm/year and 12.95 mm/year respectively indicating potential meteorological drought in near future. Tinsukia experienced significant increases in consecutive dry days (CDD) by 0.72 days/year and decreases in consecutive wet days (CWD) by 0.23 days/year. Sivasagar and Dibrugarh districts showed positive trends in heavy precipitation indices (R10mm, R20mm) and maximum 5-day precipitation (Rx5day) increased significantly in Dibrugarh by 1.96 mm/year. Rainfall intensity (SDII) rose across most districts except Jorhat which showed a decrease of 0.17 mm/day. In addition, correlation matrix of the indices revealed that PRCPTOT was positively correlated with most extreme precipitation indices, except in Golaghat district, where it showed a negative correlation with r99pTOT (-0.22) and Rx1day (-0.11). CDD exhibited an inverse relationship with PRCPTOT across the UBV zone. A strong negative correlation was observed between CDD and CWD, while indices like r95p and r95pTOT (r = 0.92) and r99p and r99pTOT (r = 0.96) demonstrated strong positive correlations in Golaghat. Similarly, indices related to one-day and five-day maximum precipitation and wet-day fractions showed high positive correlations (>0.8) in Jorhat. SDII exhibited strong positive correlations (r ≥ 0.7) with most indices but was poorly or negatively correlated with CWD in several districts. The study highlighted a robust relationship between PRCPTOT and the frequency of heavy precipitation days (r = 0.8 to 0.9), emphasizing potential for informing regional contingency crop planning including crop insurance schemes, adjustment of transplanting and sowing windows, improvement of suitable agronomic practices and sustainable utilization and management of natural resources in the zone.

UID: 1566

An Overview of Ground Water Quality of Villages Adopted Under NICRA in Sirsa District

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Groundwater is a vital natural resource that plays a crucial role in supporting agricultural activities. The NICRA project is currently being implemented in three villages of the Nathusari Chopta block in Sirsa District, Haryana, where groundwater serves as a significant source of irrigation. Due to the insufficiency of canal water to meet the irrigation needs of the crops grown, reliance on groundwater has increased. The exploitation and contamination of surface water sources have exerted immense pressure on groundwater resources. The suitability of groundwater for various uses largely depends on its quality, making the evaluation of groundwater a critical concern (Packia Lakshmi et al., 2011; Vishwanath et al., 2016). In this semi-arid region, mapping groundwater quality for irrigation is essential to ensure its safe use and to guide the selection of crops that can thrive under the available water conditions. This study was undertaken to assess groundwater quality parameters and provide farmers with practical advice on its safe and effective use.

Methodology

60 water samples were collected from three villages (Rupana Khurd, Nirban and Ludesar) adopted under NICRA project in Nathusari Chopta block of Sirsa District. These samples were then analyzed for hydrochemical parameters viz. calcium (Ca^{++}), magnesium (Mg^{++}) and sodium (Na^{+}). The physical parameters like pH and electrical conductivity were also measured by using respective measuring devices. All chemical parameters are expressed in milli equivalent per liter except EC. To categorise quality of ground water, SAR and RSC were calculated using suitable formula. For ease of understanding these samples were categorized in various categories using ACRIP classification.

Results

From the table 1 it is clear that electrical conductivity (EC) varied widely, indicating salinity levels from low (0.4 dS m^{-1}) to very high (24.0 dS m^{-1}), with a mean of 5.02. Carbonates (CO_3^{2-}) and bicarbonates (HCO_3^{-}) are present at low to moderate levels, averaging 1.10 and 4.22 me L^{-1}, respectively. Chlorides (Cl^{-}) and calcium-magnesium ($Ca^{++} + Mg^{++}$) levels are variable, with high means of 19.31 and 12.90 me L^{-1}. Residual sodium carbonate (RSC), sodium (Na^{+}), and sodium adsorption ratio (SAR) indicate low sodium hazard, averaging 0.70, 3.81, and 3.99, respectively.

Table 1. Geometric Mean and Range of different quality parameters (analysis of 60 samples)

Quality Parameters	Range	Mean
EC (dS m^{-1})	0.4 – 24.0	5.02
CO_3^{2-}(me L^{-1})	0.1- 4.4	1.10
HCO_3^-(me L^{-1})	0.5 - 4.9	04.22
Cl^-(me L^{-1})	1.2 - 111.3	19.31
$Ca^{++} + Mg^{++}$ (me L^{-1})	0.3 - 43.0	12.90
RSC (me L^{-1})	0.01 - 2.7	0.70
Na^+ (me L^{-1})	1.2 - 48	3.81
SAR (m mol L^{-1}) $^{1/2}$	0.73 – 12.53	03.99

Categorisation of water according to AICRP classification: The classification of water quality samples indicates that 45% are good, 16.6% are marginally saline, and 25% are saline. High SAR saline water accounts for 6.6%, while marginally alkali and alkali waters represent 5% and 1.6%, respectively. No samples were categorized as high alkali. These proportions highlight the dominance of good-quality water but such water exists near the canal banks. Shahid *et al* (2008) also reported similar results in Julana block of Jind district and Kumar *et al* (2012) in Rohtak block of Rohtak district and Ram Prakash *et al* (2016) in Hodal block of Palwal district.

Sl. No.	Water Class	No of Samples	Percent of water samples
1.	Good	27	45
2.	Marginally saline	10	16.6
3.	Saline	15	25
4	High SAR saline	4	6.6
5.	Marginally alkali	3	5
6.	Alkali	1	1.6
7.	High alkali	0	0

Conclusion

Groundwater quality analysis in NICRA villages in Nathusari Chopta block revealed significant variability among samples. While 45% of the water samples were classified as good, salinity issues were evident, with 16.6% marginally saline and 25% saline. High SAR saline, marginally alkali, and alkali waters accounted for smaller proportions (6.6%, 5%, and 1.6%, respectively). No high-alkali samples were found. The results highlight the dominance of good-quality water, especially near canal banks, but emphasize the need for careful management of saline and marginally alkali waters to ensure sustainable use. Hence it is suggested that farmers should get their waters checked in nearby laboratory to use the water under prescriptions where salinity is detected.

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Bund Farming of Pigeonpea for Mitigating Climate Change

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Agriculture is one of the most vulnerable sectors to the impacts of climate change, with unpredictable weather patterns, rising temperatures, and depleting water resources posing severe challenges to food security and livelihoods. Bund farming of pigeonpea emerges as a climate-smart agricultural practice that offers resilience and sustainability in the face of these challenges. By combining traditional methods with ecological principles, this approach aligns with the need for adaptive strategies in a changing climate. It is a practical solution for maximizing land use, improving soil health, and managing water efficiently, especially in rainfed areas. It is the fifth most important pulse crop in the world and in in Chhattisgarh Pigeonpea is cultivated in an area of 89.96('000 ha.) (Anon,2024).The districts where pigeonpea is mostly grown in Chhattisgarh include Surguja, Raigarh, Jashpur, Jagdalpur, Mahasamund, Kanker, Rajnandgaon, and Korba. Among these district sarguja has the highest productivity.

Climate Change Impacts on Agriculture

1. **Unpredictable Rainfall:** Erratic monsoon patterns result in droughts and floods, severely affecting crop yields.
2. **Soil Degradation:** Increased soil erosion due to intense rains and overuse of chemical inputs threatens agricultural productivity.
3. **Water Scarcity:** Prolonged dry spells reduce water availability for irrigation.
4. **Biodiversity Loss:** Monoculture practices and climate pressures harm soil organisms and beneficial insects critical for agriculture.

Bund farming of pigeonpea offers an integrated solution to mitigate these impacts while fostering agricultural resilience.

Why Pigeonpea is Climate-Smart

1. **Drought Tolerance:** Pigeon pea's deep-root system allows it to access water from deeper soil layers, making it resilient to water scarcity.
2. **Carbon Sequestration:** Pigeonpea captures atmospheric carbon and stores it in the soil, contributing to climate mitigation.
3. **Nitrogen Fixation:** As a legume, it improves soil fertility by fixing atmospheric nitrogen, reducing the need for synthetic fertilizers that contribute to greenhouse gas emissions.
4. **Versatility:** It adapts to a wide range of agro-climatic conditions, making it a reliable crop under climate variability.

Role of Bund Farming in Climate Adaptation

Bund farming of pigeonpea amplifies the benefits of this crop by integrating it into a landscape management system. The method directly addresses climate challenges:

1. **Soil Conservation:** Bunds reinforced with pigeonpea reduce soil erosion, a common problem under intense rainfall conditions. The plant's root system stabilizes the bund structure, preventing runoff and nutrient loss.
2. **Water Management:** Bunds act as barriers to water flow, enhancing water retention in the fields. This is particularly crucial in areas experiencing erratic rainfall or prolonged dry spells. Pigeonpea thrives with minimal water, ensuring productivity even in water-limited scenarios.
3. **Crop Diversification:** Bund farming supports mixed cropping systems, reducing the risks associated with monoculture. This enhances biodiversity, which is vital for ecosystem resilience under climate stress.
4. **Climate-Resilient Yield:** Pigeon pea's ability to withstand high temperatures and variable precipitation ensures consistent yields, providing food and income security to farmers.

Mitigating Climate Change through Bund Farming

1. **Reduction in Carbon Footprint:** By minimizing the need for chemical inputs and optimizing land use, bund farming reduces greenhouse gas emissions.
2. **Promotion of Agro forestry:** Pigeonpea on bunds can complement other agroforestry practices, enhancing carbon sequestration and creating microclimates favorable for other crops.

3. **Sustainable Land Use:** This method maximizes land productivity without expanding agricultural footprints, preventing deforestation and habitat loss.

Methodology

The KVK Mahasamund has introduced and demonstrated the Bund Farming of Pigeon Pea in NICRA adopted village "Paraswani". The KVK has made a demonstration on pigeonpea variety "CG Arhar-2". Before sowing, the seeds were treated with Carbendazium as well as with Rhizobium. Seed requirement was calculated considering seed rate as 20kg/ha. and the planting distance was to be 80 cm between two rows and plant to plant distance was maintained at 20 cm however the planting distance varies due to size of the bund. The crop was harvested at 175 days after sowing.

Results

The demonstrated field has a yield of 15q/ha against the 12q/ha in farmers field. In terms of monetary benefits the Farmers were getting a net return of Rs 35000/- /hectare while demonstration field gives a monetary return of Rs 50000/ ha. Formation of conservation furrows is one of the important in-situ moisture conservation measures which facilitate rainwater to infiltrate by reducing the velocity of runoff flow and thus providing more opportune time for the rainwater to infiltrate where it falls.(Reddy et. al,2022)

Rao et al. (2018) reported that, in-situ moisture conservation practice of paired row planting with conservation furrow treatment realized higher net monetary returns (40540 ha) and BCR (8.5) as compared to farmers' practice in Pigeonpea. There is scope to grow Pigeonpea in mid rabi season also which would not only help to increase pulse production in the state as well as country but also possible to increase productivity per unit area. It was also noticed that maturity period reduced by 25 day in Rabi sowing as compared to Kharif sowing (Chandrakar et.al, 2015) flow and thus providing more opportune time for the rainwater to infiltrate where it falls. Low hp tractor drawn two row intercultivator cum conservation furrow opened.

Challenges and Opportunities

Challenges:

- Limited awareness of bund farming benefits among farmers.
- Initial labour investment for bund construction.
- Access to quality pigeonpea seeds.

Opportunities:

- Government and NGO programs promoting climate-smart agriculture can integrate bund farming as a key component.
- Research and development can enhance pigeonpea varieties for greater climate resilience.

- Digital platforms and farmer cooperatives can facilitate knowledge-sharing and market access.

Conclusion

Bund farming of pigeonpea is a beacon of hope in the era of climate change. The results observed in village "Paraswani" shows that the Bund Farming of Pigeonpea" is a very productive and useful technology that can be further propagated for mitigating climate change. It embodies the principles of climate-smart agriculture by addressing soil health, water conservation, and sustainable livelihoods. This method not only mitigates the adverse effects of climate change but also equips farmers with the tools to adapt and thrive in uncertain conditions. By scaling up this practice, agricultural systems can transition toward greater resilience and sustainability, ensuring food security and ecological harmony for future generations.

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Precipitation Patterns and Extreme Rainfall Events in Telangana: A Current and Future Scenario

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Rainfed agriculture, which covers 51% of India's net sown area and contributes 40% of the country's food supply, is highly vulnerable to unpredictable monsoon patterns, climate change, and water scarcity. These challenges lead to variable crop yields and food insecurity in semi-arid states like Telangana. Successful crop production these regions largely depends on quantum and distribution of rainfall. High variability in rainfall, especially during critical crop growth stages, often results in water stress, significant yield losses, and reduced food production in dryland regions (Bal et al., 2022). Despite these challenges, proper management can unlock the potential of these areas. Analysing the spatiotemporal patterns of rainfall is essential for planning effective adaptation strategies to safeguard the livelihoods of vulnerable farming communities. This study examines high-resolution rainfall data (1980–2014) and future projections under the SSP245 scenario, emphasising critical rainfall thresholds that impact major crop-growing seasons in Telangana.

Methodology

This study utilised baseline data (1980–2014) from the India Meteorological Department and CMIP6-based climate projections from Climate Hazard Center. The indicators are annual rainfall, June rainfall, July rainfall, drought incidence, dry spell events, number of rainy days, and extremes (>100mm for three consecutive days). These indicators were calculated yearly and averaged for baseline and 2050s. Annual rainfall was computed as the period average, while June and July rainfall were averaged specifically for these months. Dryspell is a period of dry weather with no rainfall for at least 14 days. Dry spells shorter than 14 days were assumed to have minimal crop impact, whereas those exceeding 42 days were considered significantly detrimental. Values were truncated at these limits. The dry spell was calculated using the following formula (Rama Rao et al., 2019).

Score = $\sum[Exp\{(length\ of\ dryspell/14) - 1\}]$

Drought was calculated as

Drought = (Annual rainfall/Average rainfall over the period) * 100

Drought was categorised as low (>75%), moderate (50–75%), or severe (<50%). Final drought proneness was derived by combining severe and moderate drought probabilities with weights of 2:1 and expressed as a percentage. Indicators were calculated at the grid level and aggregated to the block level using weighted averages based on Thiessen polygon areas. MATLAB was used for data analysis, and ArcGIS was employed for visual representation.

Results and Discussion

The analysis of annual rainfall revealed that, during the baseline period, the state's south-western region receives less than 1000 mm of rainfall, the central and eastern areas receive between 1000–1300 mm, and the north-eastern region receives more than 1300 mm. Future projections indicate a more uniform rainfall distribution across the state. Most areas are expected to receive over 1300 mm, while the central and southern regions are likely to receive between 1000–1300 mm. Additionally, the projections highlight a notable northward shift in rainfall patterns. In case of June rainfall, future projections indicate a significant decline with most mandals receiving less than 100 mm. For July, future projections suggest increased rainfall across the state. The study also highlights a potential delay in the monsoon onset, which may require adjustments to crop planting schedules. The results indicate a possible reduction in incidence of drought and dry spells. These findings highlight the need to adjust cropping patterns and agricultural planning in alignment with future projections. Such adjustments could enhance crop yields, improve economic returns, and optimise the use of climatic conditions, contributing to sustainable livelihoods in the region (Lal, 2013; IPCC, 2022). However, it is to be noted that the uncertainties associated with downscaling climate projections and interpolating historical climate data are to be borne in mind while taking decisions.

Conclusion

The analysis of historical rainfall data and future projections reveals significant shifts in the spatial distribution of rainfall, with a tendency towards more uniform rainfall patterns across the state. However, these changes, including reduced rainfall in June and a potential delay in the monsoon onset, may pose challenges for agriculture. The study's findings on drought proneness and dry spell events indicate a possible reduction in drought risk, which could benefit agricultural productivity. Due to the susceptibility of rain-fed agriculture in Telangana, implementing proactive strategies, including adopting climate-resilient cropping patterns and effective water management practices, will be crucial for alleviating the effects of climate change. However, it is to be noted that the uncertainties associated with downscaling climate projections and interpolating historical climate data are to be borne in mind while taking decisions.

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Impact of Watershed Development Projects on Natural Resources and Rural Livelihood in Western India – Case Study of *Dhuwala* Watershed in Bhilwara District

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The Watershed Development Fund (WDF) of NABARD is a financial mechanism established to support and promote watershed development projects in India. The primary objective of the WDF is to provide financial assistance for integrated watershed development projects across the country to enhance rural livelihoods, improve natural resource management, and promote sustainable agricultural practices through watershed-based interventions. One such WDF project was implemented at *Dhuwala* watershed, located in Mandal block of Bhilwara district, Rajasthan between 25^{O}35’ and 25^{O}35’ north latitude and 74^{O}07’ and 74^{O}08’ East longitude. Average maximum temperature of this region is 32.94^{O}C and minimum temperature is 16.27^{O}C. Annual average rainfall received in the region is 570.3 mm out of which 531.0 mm received from Southwest monsoon which contributes to 93%. Total area of the watershed is 1180 ha comprising of 488 households. The watershed development activities in Dhuwala watershed was initiated during March, 2016 and completed by March, 2021 with major a aim to achieve climate proofing in terms of improved adaptation to climate variability specific to agriculture by maintaining soil and moisture regime, promotion of climate resilience farming system and diversification of livelihood specific to small and marginal farmers.

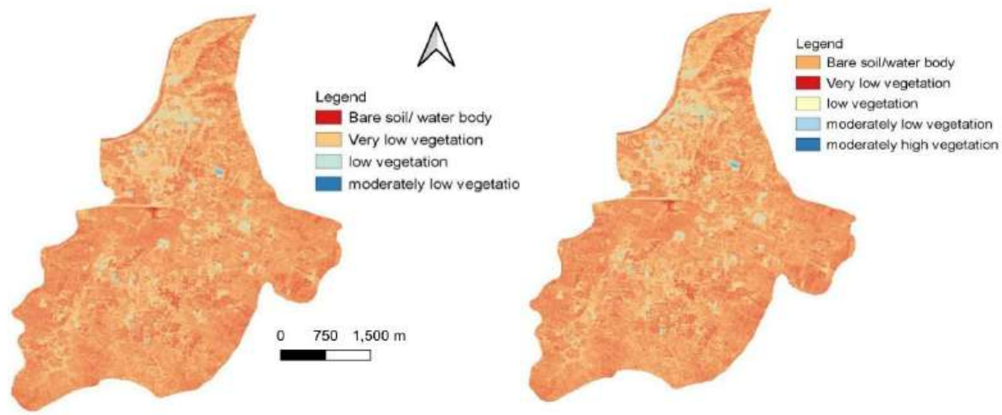
In case of soil fertility analysis, available N was found to be optimal whereas available potassium was very high which can significantly reduce the nutrient use efficiency. Also. In most of samples, soil pH and organic carbon was found to beyond optimal limit. There was no significant improvement in fertility of soil from watershed project compared to field without any treatment (Table 1). Improvement were observed in ground water recharge of well. The average ground water level improved to 9.84 meter after watershed from 12.24 meter before watershed project. This could be achieved through intensive water resource development in the watershed. Significant area now had water availably. Fairly good improvement in vegetative cover was observed. The NDVI values before the start of the project was extremely low to 0.232 during December specifying virtually no vegetation. The same has been improved to 0.352. However, it may take more time to reach NDVI value for optimal vegetation (Table 2).

Table 1. Chemical characteristics of soil samples collected from the farmers field in the watershed

Sample No	PH	EC dS/m	OC %	Avail N Kg/ha	Avail P Kg/ha	Avai K Kg/ha	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
1	5.95	0.05	1.15	188	19.7	1195	2.26	111.36	102.42	0.70
2	8.16	0.2	0.52	213	90.2	527	0.98	10.46	8.29	0.54
3	7.44	0.12	1.12	176	37.4	381	0.58	8.19	13.36	1.15
4	8.01	0.46	0.83	213	75.1	336	0.59	3.50	11.84	0.66
5	7.11	0.1	0.63	226	27.2	630	0.88	5.45	14.84	0.54
6	6.83	0.05	0.55	201	22.4	405	0.87	7.55	16.24	0.50
7	7.74	0.23	0.54	176	17.0	282	0.37	2.10	13.71	0.36
8	8.18	0.23	0.55	163	62.7	659	1.52	7.42	12.82	0.31
9	8.35	0.35	1.07	201	187.5	1309	1.04	7.71	17.58	0.92
10	7.35	0.08	0.92	213	63.3	560	0.65	7.16	8.58	1.00
11	6.80	0.06	0.41	163	20.8	211	1.69	8.00	8.80	0.32
12	8.27	0.66	1.47	263	211.7	810	2.18	10.02	26.12	1.41
13	8.36	0.19	1.36	238	118.7	415	1.02	13.24	18.21	1.40
14	6.81	0.05	0.47	176	37.4	334	1.48	16.47	13.42	0.47
15	6.79	0.28	0.96	226	27.8	335	0.93	5.63	12.39	1.44
Normal range	5.5 -7.5	1.1-5.7	0.5-0.8	240-280	11-22	110-280	0.3-1.0	6.0-8.0	1.0-2.0	0.5-1.0

Table 2. Change in vegetation index after completion of the project

S No	NDVI class	Before project Area (Ha)	After project Area (Ha)	Weighted mean of NDVI	Weighted mean of NDVI
1	0-0.2	1003.88	2.46		
2	0.2-0.4	186.67	351.56		
3	0.4-0.6	3.26	770.69	0.232	0.352
4	0.6-0.8	nil	68.93		
5	>0.8	nil	0.18		



Spatial distribution of NDVI values before and after watershed program

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UID: 1609

Resilient Rainfed Agro-Ecosystem Rainfall Pattern in Dindori District

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With an estimated 1.386 billion km³ of water, rainfall is an essential natural phenomenon that keeps life on Earth going. The global distribution is unequal, with an annual average of about 1000mm. The study focuses on the temporal and spatial variability of rainfall patterns in Madhya Pradesh state's Dindori districts. From 2019 to 2024, the Department of soil & Water conservation Research Centre Dindori (M.P.), provided long-term weather data. The yearly rainfall in the dindori district decreased significantly, trending at 1.9 mm annually, a 9% decline. With a wetter season during the south-west monsoon, the district received fewer than three months of rainfall annually. With a moderate concentration during the previous years, the Precipitation Concentration Index (PCI) revealed a very erratic rainfall distribution.

One of the major natural occurrences that provides us with water, which is necessary for life on Earth, is rainfall. One estimate places the total volume of water on Earth at around 1.386 billion km³.Rainfall is the main source of water for all living things and contributes the most to the total amount of water. The average annual rainfall worldwide is roughly 1000 mm, however the distribution varies widely. Rainfall patterns are typically divided into two categories: temporal rainfall patterns, which are characterized by time, and spatial rainfall patterns, which are characterized by space and region. The current study, "Spatial and temporal variability of rainfall pattern in the parental districts," is based on the rainfall pattern.

Methodology

Long-term weather data for each district from 2019 to 2024 was gathered from the Department of soil & Water conservation Research Centre Dindori (M.P.), Long-term daily data (from 2019 to 2024) was used to meet the goals of the current study. This data was averaged monthly, annually, and seasonally in accordance with the requirements of the Mann-Kendall test and the Ms-Excel linear graph method. Using the formulas provided by Walsh and Lawler (1981) and Oliver (1980), the "Seasonality Index" and the "Precipitation Concentration Index" were calculated on a seasonal and annual basis in order to quantify the rainfall distribution pattern and the rainfall concentration throughout the state district-wise.

Results

The findings of a trend analysis of the Dindori district's rainfall showed a notable decline of 5% in yearly rainfall at a rate of 1.9 mm annually. The outcome of annual rainfall Seasonality Index of long term data of rainfall recorded for Dindori district found an average values of SI for the last 5 years for Dindori district reported that the rainfall happens in less than 3 months in a year. The result of rainfall during the southwest monsoon, average values of the Seasonality Index (SI) for the south-west monsoon for the previous 8 years for Dindori district were 0.36, indicating that the rainfall was distributed throughout the season but had a wetter season. This was based on long-term data (June-September) of rainfall recorded for the district. Dindori district's average Precipitation Concentration Index (PCI) values during the previous 8 years were 22.8, indicating a highly concentrated and very erratic rainfall distribution. Over the previous 8 years, the district's precipitation concentration was modest.

UID: 1626

Real-Time Monitoring and Management of Agricultural Drought in Pigeonpea

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Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is the second most important pulse crop in India after chickpea, primarily cultivated under rainfed conditions. It is grown in almost all the states, with a larger portion of the cultivated area in Karnataka, Maharashtra, Uttar Pradesh, and Madhya Pradesh. Among the different pulses grown in Karnataka, pigeonpea holds first place in both area and production. It is largely grown in the northern parts of Karnataka, particularly in the Kalaburgi, Vijayapura, Bidar and Raichur districts. Pigeonpea is a staple food grain that contribute to nutritional security due to its high protein (21%), with essential amino acid such as methionine, lysine and tryptophan along with mineral supplementation *viz.,* iron and iodine. The abscission of leaves from plants and symbiotic nitrogen fixation improves soil fertility, while its deep, strong root system makes it to recognize as a "biological plough". It is vital to increase pulse crop yield and productivity to fulfill the demands of an ever-increasing population. Boosting productivity by maximizing the use of existing resources is the only viable solution (Saritha *et al.,* 2012).

Strategies such as moisture conservation practices, foliar nutrient sprays, supplemental irrigation, and the use of drought-resistant varieties can significantly enhance the crop's resilience. By integrating drought monitoring systems with actionable management practices including both preparedness and real-time contingency plan, farmers can reduce yield losses and ensure better productivity in pigeonpea grown under rainfed conditions. Proactive drought management is not merely an option but a necessity to sustain pigeonpea cultivation in the face of climate variability. The real-time monitoring and adoption of mitigation measures during long dry spells may help in overcoming the effect of moisture stress during crop growth stages.

Methodology

A field experiment was conducted during the kharif season from 2019 to 2022 at the Regional Agricultural Research Station, Vijayapura, Karnataka, on vertisol soil. The experimental site was located at a latitude of 16˚77' North, a longitude of 75˚74' East, and an altitude of 516.29 meters above mean sea level in the Northern Dry Zone of Karnataka (Zone 3). The soil characteristics included a pH of 8.12 and an EC of 0.39 dSm^{-1}. It was low in organic carbon content (0.54%), low in available nitrogen (242.1 kg N ha^{-1}), medium in available phosphorus (15.2 kg P_2O_5 ha^{-1}), and high in available potassium (364.2 kg K_2O ha^{-1}).

The experiment was non-replicated and focused on real-time agricultural drought management using proven contingency measures to mitigate water stress during the cropping period. These measures were compared against a control representing farmers' conventional practices. The study aimed to address the impacts of early, midseason, and terminal drought conditions, which are common challenges in rainfed agriculture.

The contingency plan included several timely interventions. Sowing across the slope was implemented to reduce runoff and improve water retention. Thinning was carried out to minimize plant competition for soil moisture. Conservation furrows were opened to enhance in-situ moisture conservation, and repeated intercultivation was performed to control weeds and improve soil aeration. Additionally, foliar application of potassium nitrate (KNO_3) at 0.5% concentration was applied at the flowering and podding stages to mitigate moisture stress and support reproductive growth. This real-time drought management approach was designed to evaluate the effectiveness of these interventions in overcoming the adverse effects of water stress. The findings highlight the potential of integrated and timely strategies in ensuring sustainable pigeonpea production under rainfed conditions.

Results

The four-year mean data demonstrated that the adoption of real-time contingency plan (RTCP) interventions during early, mid-season, and terminal drought significantly improved growth attributes, yields, and economic returns compared to farmers' practices, which involved no interventions (Table 1). RTCP interventions, including sowing across the slope, thinning, opening conservation furrows, repeated intercultivation, and foliar application of KNO_3 at 0.5% during flowering and podding stages, effectively managed moisture stress at critical growth stages of pigeonpea. As a result, RTCP treatments achieved 16.25% and 19.24% higher grain and stalk yields, respectively (1278 and 4319 kg/ha), compared to farmers' practices (1099 and 3622 kg/ha). This significant yield improvement can be attributed to enhancements in growth and yield parameters, such as a 4.79% increase in plant height, 9.57% more branches per plant, 9.22% more pods per plant, an 11.06% increase in seed weight per plant, and a 3.88% higher 100-seed weight. Furthermore, the RTCP interventions resulted in a 16.69% improvement in rainwater use efficiency and an 8.9% increase in the benefit-cost (B:C) ratio compared to farmers' practices. These findings align with the observations of Ramachandrappa *et al.* (2016), who reported that implementing real-time contingency techniques effectively enhances crop productivity. The study highlights the critical role of timely drought management practices in sustaining pigeonpea yields and improving the profitability of rainfed agriculture.

Effect of real time agricultural drought management on growth, yield and economics of pigeonpea (Mean of 4 years)

Treatments	Seed yield (kg/ha)	Stalk yield (kg/ha)	Net Returns (Rs/ha)	B:C Ratio	RWUE (kg/ha-mm)	Plant height (cm)	No. of branches /plant	No. of pods /plant	Seed weight/plant (g)	100-seed weight (g)
T1: RTCP*	1278	4319	59905	3.5	2.33	170.70	8.30	196.03	178.25	11.91
T2: Farmers practice (Control)	1099	3622	50931	3.2	2.00	162.90	7.58	179.48	160.50	11.47
% change over control	16.25	19.24	17.62	8.9	16.69	4.79	9.57	9.22	11.06	3.88

*RTCP: real-time contingency plan

Conclusion

The real-time management of agricultural drought is vital for sustaining productivity and improving the livelihoods of farmers in the northern dry zone of Karnataka, a key pigeonpea-growing region. The implementation of timely mitigation measures, such as sowing across the slope, thinning, opening conservation furrows, repeated intercultivation, and foliar application of KNO_3 at 0.5% during flowering and podding stages, proves effective in addressing moisture stress during critical crop growth stages. These practices not only mitigate the adverse effects of long dry spells but also enhance productivity, improve rainwater use efficiency, and boost the economic returns of pigeonpea cultivation under rainfed conditions.

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Impact of CRT: Water Harvesting Structures for supplemental irrigation on Rabi crops during dry spell in Western Himalayan Region of India

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Agriculture in the hills of Uttarakhand is characterized by fragmented land ownership, limited irrigation facilities, soil and water erosion and various other eco-physical challenges. Farmers in the region only achieve about 60% of the potential yield of the crop varieties they use (Bhattacharyya *et al*., 2016). Low productivity in many rainfed agricultural systems is often attributed to reduced soil fertility and inadequate water and nutrient supply during critical plant growth phases (Qin *et al*., 2015). Crop success and failure, especially in rainfed areas, are closely related to rainfall distribution (Bal and Minhas, 2017). Understanding the effects of drought on soil moisture availability and crop performance is critical in dryland agriculture. In view of this, present study was conducted to demonstrate the climate resilient agriculture technology of providing supplemental irrigation through water harvesting structures during the period of dry spells to enhance climate resiliency and methods of farming on farmer field.

Methodology

The demonstration was conducted at farmer fields in the Kaleth village (30.4327 °N, 78.4004 °E at 1350 m above sea level) of Thauldhar Block in Tehri Garhwal district of Uttarakhand, India. The climate of the region is sub-tropical to sub-temperate, characterized by moderate summer, chilling winter and general dryness, except during the south-west monsoon season. The mean rainfall of crop growth period during 2021 was ~935 mm. Wheat (VL- 907), Onion (AFLR), and Vegetable pea (PSM-3) were demonstrated at the farmers field along with climate resilient technology of supplementary irrigation through water harvesting structures during the dry spell. Total 40 farmers were selected for the study. Economics was evaluated using the information collected on the field. Impact of the intervention was observed and analyzed.

Results

Supplementary irrigation has improved the productivity of wheat, onion, and vegetable pea over fully rainfed conditions. Wheat productivity increased from 8.00 to 13.24 q ha^{-1}, a rise of 39.57%, while onion yields went up from 166.00 to 245.00 q ha^{-1}, showing an increase of 24.64%. Similarly, vegetable pea productivity improved from 68.00 to 90.24 q ha^{-1} with a 32.24 % increase. These findings highlight the critical role of supplementary irrigation in improving crop yields, particularly in rainfed agricultural systems. The increase in production can be attributed to the application of supplemental irrigation, which alleviated moisture stress during the dry period in the growing season and provided sufficient moisture during the active vegetative growth and flowering phases, thereby significantly increasing crop yield compared to rainfed conditions.

Table 1. Productivity of Wheat, Onion and Vegetable Pea (q ha^{-1}) under rainfed and supplementary irrigation

Crop	Fully Rainfed (Mean±SD)	Supplementary Irrigation (Mean±SD)	% increase	t-value
Wheat	8.00±2.47	13.24±1.2	39.57	3.815*
Onion	166.00±10.00	245.00±8.87	24.64	11.82*
Vegetable Pea	68.00±7.07	90.24±6.48	32.24	4.636*

*** Significant at 5 % level of significance**

Economic analysis revealed that supplemental irrigation significantly improved the profitability and benefit-cost ratio (BCR) of all three crops except for BCR of Wheat. For wheat, supplementary irrigation increased net return from ₹12,600 to ₹22,896 and improved BCR from 1.4 to 1.69, indicating moderate economic gains. Onion showed the highest economic benefit with net return increased from ₹112,500 to ₹192,000 and BCR increased from 2.1 to 3.6, highlighting its superior profitability. Vegetable peas also showed notable improvements with net return increasing from ₹88,000 to ₹123,980 and BCR improving from 1.83 to 2.19. Overall, onion was found to be the most economically viable crop under supplemental irrigation, followed by peas and wheat, highlighting the significant role of irrigation in increasing economic yields, especially for high-value crops such as onion.

Conclusion

The result highlights the significant benefits of supplemental irrigation significantly increasing the yields with wheat recording an increase of 39.57 %, vegetable pea increasing by 32.24 % and onion increasing by 24.64 %. The economic analysis further highlighted the benefits, with onions emerging as the most economically viable crop, showing the highest net yields and BCR improvements, followed by vegetable pea and wheat. These results support adoption of supplementary irrigation in regions that rely on rain-fed agriculture to ensure sustainable crop production and economic returns.

Table 2. Economics of Wheat, Onion and Vegetable Pea (Rs ha^{-1}) under rainfed and supplementary irrigation

Crop	Net Return			Benefit-Cost Ratio		
	Fully Rainfed (Mean±SD)	Supplementary Irrigation (Mean±SD)	t-value	Fully Rainfed (Mean±SD)	Supplementary Irrigation (Mean±SD)	t-value
Wheat	12600±3892	22896±2075	4.67*	1.4±0.43	1.69±0.16	1.26^{NS}
Onion	112500±6777	192000±6950	16.38*	2.1±0.12	3.6±0.13	16.75*
Vegetable Pea	88000±9151	123980±8910	5.63*	1.83±0.19	2.19±0.16	2.93*

* Significant at 5 % level of significance; ^{NS} Non-Significant

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Tillage and Crop Residue Effects on Productivity, Profitability and Soil Health under Pigeonpea-Wheat and Maize-Mustard Systems

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Deteriorating natural resources-bases and alarming contribution to the carbon footprints accelerating global warming emerges as the prime cause for concern from conventional agriculture for sustainable crop production in future. Conservation Agriculture (CA) with three interrelated principles of minimum soil disturbance, permanent soil cover with crop residue mulch and diversified crop rotations offers a plethora of benefits (Das *et al*. 2020). It has potential to achieve higher crop yields with concurrent improvement /restoration in soil health and environmental quality. Judicious tillage, crop residue management, and crop diversification are the paramount practices among diverse array of agro-techniques under the aegis of CA even though paradoxical views on *pros and cons* of maneuvering tillage and residue management impede successful adoption of the CA technology. Thus, a pragmatic understanding on these issues insisted upon the need of generating cognitive information from field studies addressing different tillage management with or without crop residues retention under CA. The predominant rice-wheat cropping system in the Indo-Gangetic plains (IGPs) has encountered a host of problems. A remunerative non-rice crop is required to diversify this system. Thus, a study was carried out involving two major non-rice cropping systems, viz., pigeon pea-wheat and maize-mustard with suitable CA practices. The objectives of the study were i) to evaluate tillage, residue and cropping sequence effects on productivity, profitability and resource use efficiency and ii) to find out impacts of CA and cropping sequence on soil physico-chemical and microbiological parameters.

Methodology

The field experiments were carried during 2022-23 and 2023-24 at ICAR-Indian Agriculture Research Institute New Delhi during. The four tillage and crop residue treatments namely, zero-tillage (ZT) maize+25 MdR (mustard residue)-ZT mustard+25MzR (maize residue), ZT maize + 50 MdR-ZT mustard+50MzR, ZT maize + 75 MdR-ZT mustard+75MzR and conventional tillage (CT) maize-CT mustard were adopted in maize-mustard cropping system. Whereas, in pigeonpea-wheat system tillage and crop residue treatments were ZT pigeonpea+25 WR (wheat residue)-ZT wheat+25 PR (Pigeonpea residue), ZT pigeonpea+ 50 WR-ZT wheat+50PR, ZT pigeonpea+ 75 WR-ZT wheat+75PR and CT pigeonpea-CT wheat. The experiments were conducted in randomized complete bock design with five replications.

Results

Results of the study revealed that zero-tillage pigeonpea with 50% wheat residue (ZTP+50WR) followed by zero-tillage wheat with 50% pigeon pea residue (ZTW+50PR) resulted in significantly higher yield of pigeonpea (1.42 t/ha), wheat (5.53 t/ha) and system in terms of pigeonpea equivalent yield (3.20 t/ha) as compared to conventional tillage pigeonpea-conventional tillage wheat (CTP-CTW) system (Table 1). In maize-mustard cropping system, the yield of maize (7.03 t/ha), mustard (2.98 t/ha) and system (in terms of maize equivalent yield) (15.30 t/ha) were significantly higher in zero-tillage maize with 50% mustard residue (ZTMz+50MdR) followed by zero-tillage mustard with 50% maize residue (ZTMd+50MzR) as compared to CTMz-CTMd treatment (Table 2). We also performed the combined analysis to compare the performance of these cropping systems (i.e., pigeonpea-wheat and maize-mustard) for system productivity (in terms of maize equivalent yield) across the tillage and crop residue treatments. A result revealed that maize-mustard cropping system resulted in 44.5% higher system productivity (MEY) over pigeonpea-wheat cropping system (Fig).

Conclusion

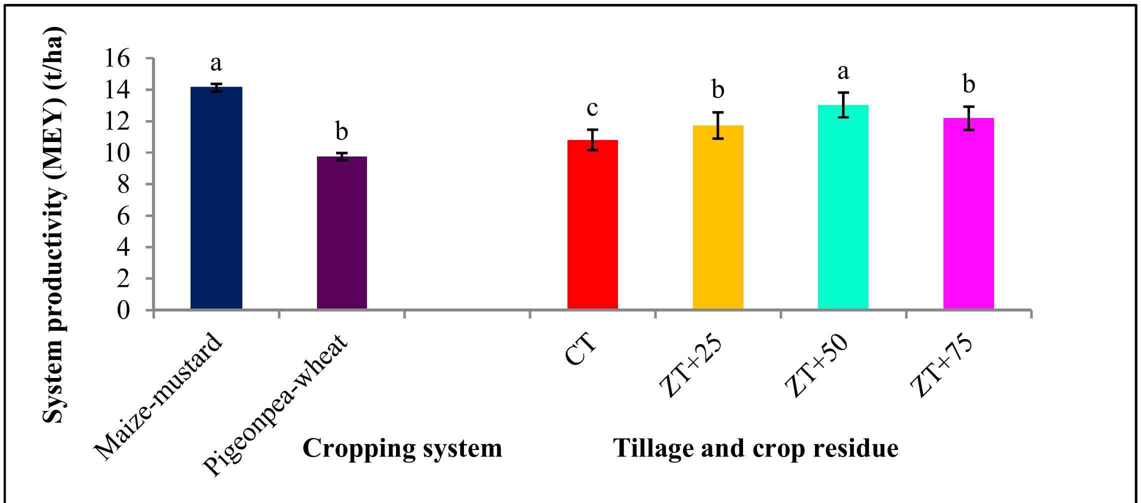
From this study, it can be concluded that application of zero-tillage in combination of 50% crop residue in both pigeonpea-wheat and maize-mustard cropping systems may be recommended for higher yield and system productivity in north western plains zone of India.

Table 1. Effect of tillage and crop residues on grain yield of pigeonpea, wheat and system under pigeonpea-wheat system

Treatment	Pigeonpea yield (t/ha)	Wheat yield (t/ha)	SP (PEY) (t/ha)
CT pigeonpea-CT wheat	1.17[b]	4.46[c]	2.60[c]
ZT pigeonpea + 25 WR (wheat residue)-ZT wheat + 25 PR (pigeonpea residue)	1.33[a]	4.61[bc]	2.81[bc]
ZT pigeonpea + 50 WR-ZT wheat + 50PR	1.42[a]	5.53[a]	3.20[a]
ZT pigeonpea + 75 WR-ZT wheat + 75PR	1.35[a]	5.08[ab]	2.99[ab]

Table 2. Effect of tillage and crop residues on grain yield of maize, mustard and system under maize-mustard cropping system

Treatment	Maize yield (t/ha)	Mustard yield (t/ha)	SP(MEY) (t/ha)
CT maize-CT mustard	5.94[c]	2.44[c]	12.70[C]
ZT maize+25% MdR (mustard residue)-ZT mustard+25%MzR (maize residue)	6.46[b]	2.77[AB]	14.16[B]
ZT maize + 50% MdR-ZT mustard+50%MzR	7.03[a]	2.98[A]	15.30[A]
ZT maize + 75% MdR-ZT mustard+75%MzR	6.81[ab]	2.70[B]	14.32[B]



Cropping systems, tillage and crop residues effects on system productivity (maize equi. yield)

Reference

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Residue Management in Tillage Systems: Pathways to Carbon Stabilization

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Intensive conventional agriculture, while boosting food production, has created environmental problems like soil erosion, nutrient depletion, and biodiversity loss, threatening sustainability, especially for small-scale farmers. Conservation agriculture (CA) offers a solution by minimizing soil disturbance, maintaining soil cover, and diversifying crops. These practices enhance biodiversity, improve resource use efficiency, boost productivity, and mitigate climate change by increasing soil carbon sequestration and improving soil quality (Georgiou *et al*., 2022). A key mechanism is the reduction of the carbon mineralization decay rate constant. Zero tillage, central to CA, increases soil organic carbon compared to conventional tillage due to reduced disturbance and decomposition (Naresh *et al*., 2017). Reduced disturbance protects soil aggregates and their organic matter from rapid decomposition. Permanent soil cover further insulates the soil, reducing temperature and moisture fluctuations that accelerate decomposition. Increased carbon inputs from cover crops and residues create a favourable environment for soil microbial activity (Marinari *et al*., 2000), which shifts towards forming stable soil organic matter under CA. This shift in microbial activity, coupled with the physical protection afforded by reduced tillage and soil cover, contributes to a lower Kc, meaning that carbon is mineralized and released back into the atmosphere at a slower rate (Singh *et al*., 2018). Consequently, CA systems experience greater accumulation and stabilization of SOC over time, leading to improved soil health and contributing to climate change mitigation.

Methodology

A field study exploring the effects of conservation agriculture on soil organic carbon stocks was conducted at ICAR-IARI, New Delhi, from 2010-11 to 2021-22. The study site has a sub-tropical semi-arid climate. Initial soil analysis in June 2010 revealed a sandy clay loam texture with pH 7.9, and specific organic carbon, phosphorus, and potassium levels. The study employed a randomized block design with seven treatments in triplicates, comparing various double and triple cropping zero-tillage systems with and without residue retention against conventional tillage controls. Cropping systems evolved over the study period due to environmental factors and allelopathic effects. Initially, a rice-maize rotation was used (2010-11 to 2012-13), followed by rice-mustard (2013-14 to 2017-18), and finally maize-mustard from 2018-19 onwards. Conservation agriculture treatments adhered to principles of minimal soil disturbance, residue retention, and crop rotation. Specific residue retention percentages were implemented for each cropping system. The study aimed to evaluate the impact of these practices on SOC sequestration by influencing the carbon decay rate.

Results

1. Decay rate (Kc) of soil organic carbon mineralization

The decay rates (Kc) of SOC in bulk soils significantly varied according to tillage and residue management under conservation agriculture practices. At 27 °C, T_7 treatment had highest Kc value which was 94.5 % higher than Kc of T_5 treatment (Table 1). While at higher temperature (37 °C), decay rate was higher than 27 ºC temperature. CTMz–CTM had highest decay rate at 37 ºC, which was 110 and 134 % higher than T_4 and T_5 treatments, respectively. The T_6 treatment had similar Kc to T7 treatment at 27 and 37 °C temperatures. The conventional tillage plots always had higher values of Kc compared with the zero tillage plots.

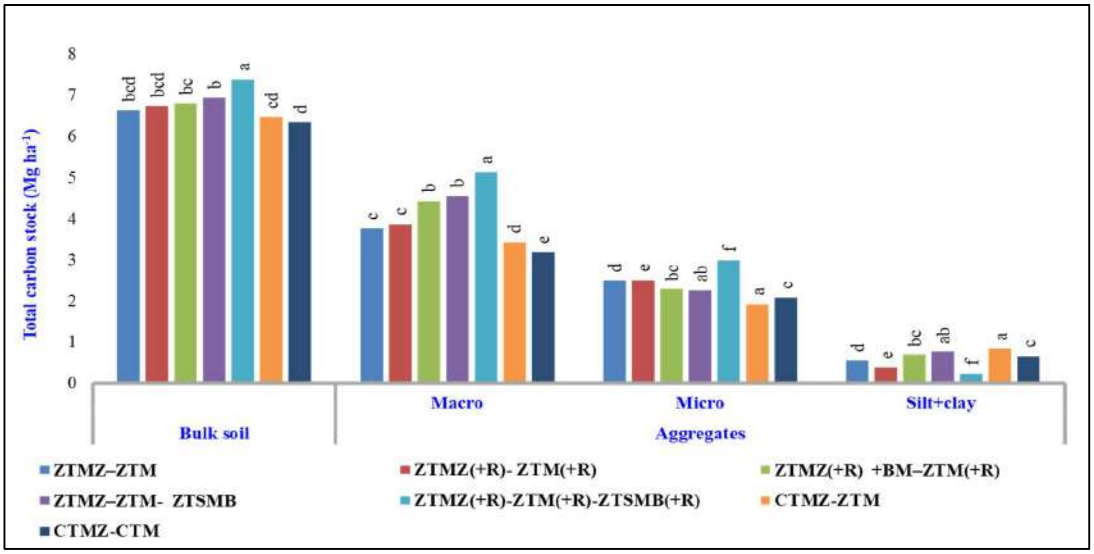
Table 1: Rate of carbon mineralization (Kc) as affected by 11-years of conservation agriculture under a maize-mustard system in an Inceptisol in the 0-5 cm soil layer

Treatment	Rate of carbon mineralization ($Kc*10^{-3}$) day^{-1}	
	27 °C	37 °C
T_1 : ZTMz(-R)–ZTM(-R)	1.11^b	1.38^b
T_2 : ZTMz+R–ZTM+R	1.05^b	1.40^b
T_3 : ZTMz+R+BM–ZTM+R	1.13^b	1.31^b
T_4 : ZTMz(-R)–ZTM(-R)–ZTMB(-R)	0.85^c	1.01^c
T_5 : ZTMz+R–ZTM+R–ZTMB+R	0.73^c	0.91^c
T_6 : CTMz(-R)–ZTM(-R)	1.42^a	2.03^a
T_7 : CTMz–CTM	1.42^a	2.13^a
LSD (<0.05)	0.13	0.18

*Bars with similar lowercase letters are not significantly different at $p < 0.05$ according to Tukey's HSD test

2. Total carbon (TC) stock (Mg ha^{-1}) content in bulk soils and soil aggregates

Fig contains the results of total carbon (TC) stock (Mg ha^{-1}). After 11-years of CA practices, the ZT plots had significantly higher TC content than CT, irrespective of crop residue addition in the topsoil (0-5 cm) (Table 1). The T_5 treatment resulted highest TC stock (7.39 Mg ha^{-1}) in bulk soil. This was 16.64 % higher than T_7 treatment at surface soil layer. The lowest carbon stock was found in T_7 (6.35 Mg ha^{-1}). The TC stock within macro and micro-aggregates were 60.81 and 55.72 % higher in the T_5 treatment compared with T_7, respectively (table 4.20). The silt + clay associated-C content was not improved by ZT. In general, it was observed that higher TC stock content was associated with macro-aggregates followed by micro-aggregates and silt + clay.



*Bars with similar lowercase letters are not significantly different at $p < 0.05$ according to Tukey's HSD test

Fig 1. Total carbon (TC) stock (Mg ha^{-1}) in bulk soil, macro-aggregates, micro-aggregates and silt + clay as influenced by 11-years of tillage and residue management under a maize-mustard system in an Inceptisol

Discussion

The rate of carbon mineralization (Ct) is lower in residue retention plots due to enhanced soil protection provided by minimal disturbances. This promotes better aggregate stability, which reduces microbial access to soil organic carbon (SOC). Additionally, residue retention influences external factors such as temperature, moisture, aeration, pH, and nutrient supply, all of which regulate SOC decomposition. Elevated thermal regimes, such as a temperature of 37°C, increase the physiological reaction rates of organisms and microbial activity (Verma, 2010), resulting in higher carbon mineralization under such conditions. However, in zero-tillage (ZT) treatments, crop residue retention fosters SOC accumulation through physical protection mechanisms (Six *et al*., 2002; Jat *et al*., 2019). This leads to greater SOC stabilization, characterized by lower decay rates and reduced temperature sensitivity compared to conventional tillage (CT) systems. As a result, conservation tillage plots exhibit lower decay rate constants and reduced carbon mineralization rates, culminating in higher SOC stocks compared to CT systems.

Conclusion

Conservation agriculture practices, through reduced soil disturbance and increased organic matter inputs, enhance soil carbon stocks by lowering the decay rate constant. This, in turn, reduces temperature sensitivity of soil carbon and decreases carbon dioxide emissions. Therefore, conservation agriculture offers a sustainable approach to climate change mitigation.

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UID: 1641

Impact of Concurrent Dry Spells and Heatwaves on Kharif Crops in India

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The simultaneous occurrence of two or more extreme events could be more disastrous than their occurrence in isolation. Dry spells significantly affect crop productivity within the crop growing season; however, the impact of dry spells is amplified with the concurrence of heat waves. Although the impacts of dry spells and heatwaves are widely studied individually in Indian agricultural regions, the impacts of their simultaneous occurrence on crop yields have not yet been explored in India. This study investigates the concurrence of dry spells and heatwaves using India Meteorological Department (IMD) high-resolution gridded rainfall and temperature data. Dry Spell Index (DSI) is used to quantify the impact of dry spells on Kharif crops and heatwaves as the period of consecutive days with conditions hotter than normal. The study's results highlight the impact of climate change on crop productivity in India. Changing

characteristics of dry spells and heatwaves in the warming climate could be detrimental to crop yields, creating acute water stress and heat stress at the same time during crop growth stages.

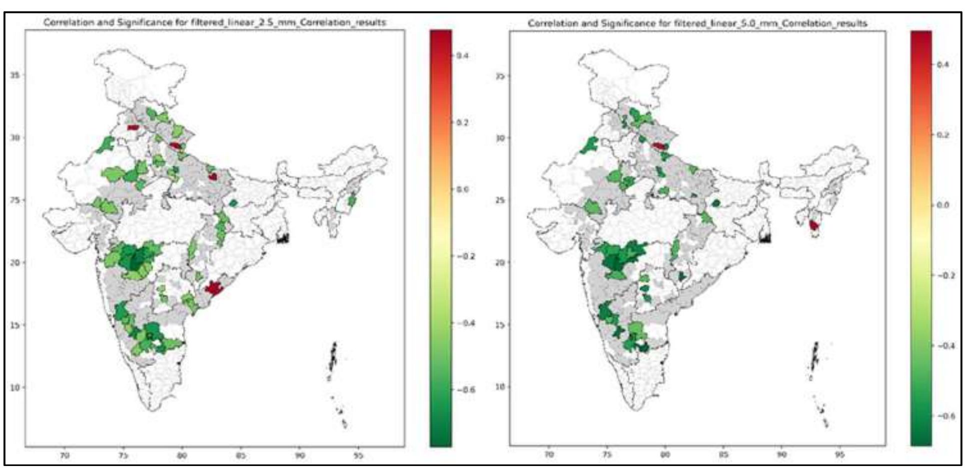
Methodology

In this study, the focus is on identifying and investigating the strength and relationship between yield productivity and rainfall during South West Monsoon (SWM). Maize yield productivity data during the period (2000-2020) is collected from the web portal of the Ministry of Agriculture & Farmers Welfare, Government of India (Economics, Statistics & Evaluation Division) (http://www.aps.dac.gov.in), for the Kharif season (June-September). The daily gridded rainfall with spatial resolution (0.25^o x 0.25^o) (Pai et al., 2014) and temperature (Srivastava et al., 2009) data (1^o x 1^o) is collected from the India Meteorological Department (IMD). The temperature data is re-gridded to the spatial scale of rainfall data using bilinear interpolation. The gridded data is rescaled to the district level using the area-weighted average of grid values falling inside each district shapefile.

A day with rainfall less than the specific thresholds is considered a dry day during the SWM season. Different spell lengths (i.e. 6, 7, 8, 9, 10) with the thresholds 2.5 mm, 5.0 mm, and 10.0 mm are used to extract the dry spell index. Dry Spell Index (DSI) is calculated as the number of dry days below a specific threshold rainfall divided by the spell length. The impact of the dry spell index on maize yield is investigated using Pearson's correlation coefficient at the district scale. In addition, the districts are segregated based on the statistical significance levels to explicitly describe the impacts.

Results

The association of dry spells and crop yields is investigated using Pearson's correlation coefficient. The spatial variation of correlation is shown in Fig. The colored districts show a statistically significant association and the grey color is used to represent a statistically insignificant association of dry spells with maize.



Correlation between DSI (rainfall thresholds as <2.5mm and <5.0mm) and maize yield

Conclusions

The changing characteristics of extreme events can severely influence crop yield in a warming climate. Our results emphasize studying the concurrence of dry spells and heatwaves for improving agricultural productivity in India.

UID: 1642

Assessment of Temperature-Based Climate Indicators for Telangana: Historical Patterns and Future Projections

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Rainfed agriculture is pivotal in India's economy and food security. It covers 55% of the net sown area and supports 61% of the rural population. It contributes approximately 40% of the country's food grain production, and 80% of small and marginal farmers are directly impacted by rainfed agriculture (NRAA, 2022). Rainfed agriculture dominates Telangana's agricultural production, with over 54% of the cultivated area dependent on seasonal rainfall. The state primarily cultivates cotton, pulses, maize, and oilseeds under rainfed conditions, with their cropping patterns closely tied to the monsoon cycle and temperature regimes. The increasing frequency of temperature extremes poses significant challenges to these crops. It affects crop phenology, yield stability, and farmer livelihoods. It is essential to understand the spatiotemporal dynamics of temperature indicators, which is crucial for developing targeted adaptation strategies for these vulnerable farming communities. This study analyses high-resolution temperature data (1980-2014) and future projections under the SSP245 scenario, focusing on critical temperature thresholds that influence major crop-growing seasons in Telangana.

Methodology

The study utilised baseline data (1980–2014) from the India Meteorological Department (IMD) and climate projections for SSP 245 scenario obtained from Climate Hazard Centre. The indicators included Annual Maximum Temperature (Tmax), Minimum Temperature (Tmin), the number of hot days (March to May), and the number of cold days (December to February). These indicators were calculated annually and averaged over the period. Tmax and Tmin were derived as averages over the study period. Hot days were identified when the daily temperature exceeded the average temperature over the years by 4°C or more, while cold days were determined for December to February when the daily temperature was at least 4°C below the average. The indicators were computed at the grid level and then aggregated to the block/

mandal level by taking the weighted average with the areas of the Thiessen polygons in a block. Data analysis was performed using MATLAB, and visual representations were generated using ArcGIS.

Results and Discussion

Maximum Temperature

During the baseline period, the maximum temperature across the state has ranged between 30 to 33 °C, with the western and northern sides having a higher temperature (> 33 °C). The future projections (SSP245) showed that the Tmax is expected to increase across the state (figure 1). It could pose a significant challenge for the crops in the sensitive growth stage. Crops like cotton and maize yield might be reduced by 5- 8% for a 1 °C rise in the optimal temperature (Kumar et al., 2019; Rao et al., 2021). Red gram may face reduced pod formation and seed filling, leading to overall yield losses.

Minimum Temperature

During the baseline period, minimum temperatures exhibited a west-east gradient, ranging from 18 to 21°C in the western regions and 21 to 24°C in the central and eastern areas. However, future projections indicate a significant increase in temperature. The east and central regions are projected to experience temperatures exceeding 24°C, while the western areas are expected to fall within the 21 to 24°C range. This warming trend negatively impacts crop yield and quality, mainly maize and sorghum. It reduces flowering and pod-setting efficiency for pulses, especially in pigeon peas, highly sensitive to elevated minimum temperatures (Sreejith et al., 2020). Additionally, the warming trends suggest a shift in the duration of favourable conditions for these crops.

Hot Days & Cold Days: The state had less than two hot days yearly in the baseline period from March to May. Cold days showed a gradient in the northern (>3 days), southern (<2 days), and central regions (2-3 days). However, in the future scenario, there will be no change in the hot days as there will be a slight increase in the maximum temperature. However, the cold days nearly disappeared due to the increase in the minimum temperature. This change will cause heat stress on Kharif crops like maize and pulses and harm rabi crops like chickpeas and wheat, necessitating adaptive crop management strategies (Sreejith et al., 2020; IPCC, 2021).

Conclusion

Rainfed agriculture is crucial to Telangana's economy, with a significant portion of the cultivated area dependent on seasonal rainfall. However, the study highlighted that the rising temperatures, as projected under the SSP245 scenario, threaten crop productivity, especially for rainfed crops like cotton, maize, and pulses. The projected increase in temperature and the reduction of cold days would exacerbate heat stress during critical growth stages and disrupt the reproductive phases of rabi crops. Adaptation strategies such as heat-tolerant varieties, adjusted crop calendars, and climate-smart practices are essential for building resilience in Telangana's rainfed agriculture to safeguard crop yields and ensure sustainable farming.

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UID: 1654

Weather-Based Decision Support System for Management of Major Pod Borer Pests of Pigeonpea

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Pigeon pea (Cajanus cajan), is an important legume and staple food crop in many tropical and subtropical regions due to its high nutritional value, drought tolerance, and soil-enriching properties. However, in the recent past, pigeon pea production has faced significant challenges from various pest species, such as the Spotted pod borer, (*Maruca vitrata* Geyer), pod borer, (*Helicoverpa armigera* Hub), and pod fly, (*Melangromyza obtusa*) causing substantial yield losses (Sharma, 2016). Traditional pest management strategies, including chemical pesticides, incur higher input costs and have proven ineffective and environmentally unsafe, leading to an urgent need for sustainable alternatives.

One promising solution to combat pest infestations is weather-based pest management. This approach relies on the understanding that weather conditions, such as temperature, humidity, and rainfall, significantly influence the behaviour, biology, growth and development, and proliferation of pest populations. Farmers can receive timely forewarnings about pest outbreaks by integrating weather forecasts, allowing them to take preventive or corrective actions before pest populations reach damaging levels. Weather-based forewarning systems offer several benefits. They enable more precise and timely interventions, reducing the dependency on chemical pesticides and promoting eco-friendly pest control measures (Srinivasa et al., 2023). Furthermore, this method enhances the efficiency of pest management by targeting interventions when they are most needed, improving crop yield and farmer profitability while safeguarding the environment.

In this context, integrating weather data with pest management strategies for pigeon pea can potentially revolutionize crop protection. By providing farmers with advanced knowledge about potential pest outbreaks linked to specific weather patterns, it becomes possible to optimize pest control measures, reduce losses, and promote sustainable agricultural practices. This approach not only benefits farmers economically but also contribute to the broader goals of food security and environmental conservation.

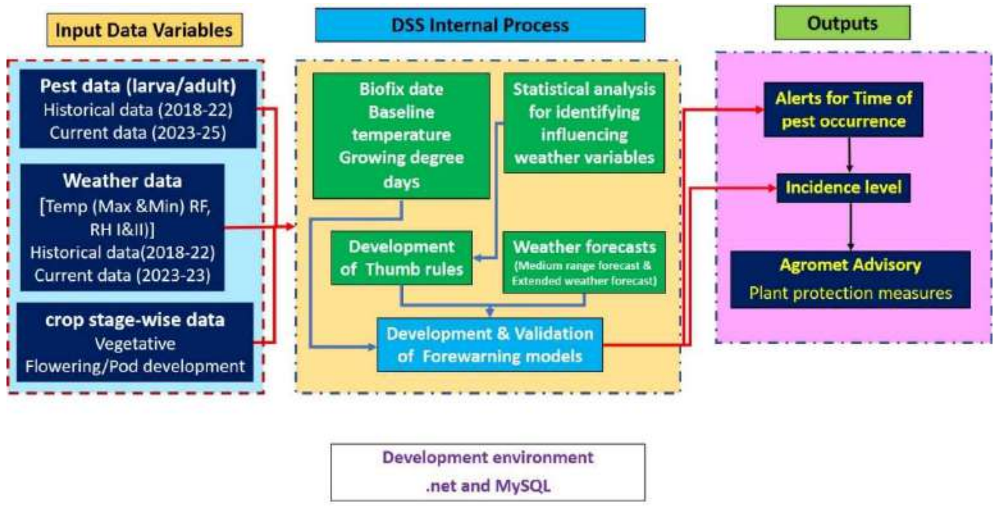
Methodology

The study has been formulated to develop a decision support system for the real-time pest management of pigeon pea in selected agro-climatic zones of India with three objectives *viz*., the impact of climatic variability on the occurrence of major pod borers of pigeon pea (Helicoverpa, Maruca, Pod fly), to develop weather-based thumb rules and forewarning models. The weekly data on pests and their natural enemies along with prevailing weather parameters of the last five years (2018-2022) was recorded from the four major pigeonpea (cv PRG 176) growing locations of India *viz*., Anantapur, Raichur, Parbhani, and Bengaluru. The data was subjected to statistical analysis, and the outcome would be used for the Designing and development of a Decision support system (Fig. 1)

Results

The results revealed that, all three pests are pod-infesting pests, their incidence started from pre-flowering to the pod development stage, the biofix dates were identified (first-time pest appearance), spotted pod borer:45-48 DAS (Days after sowing), *Helicoverpa*, and pod fly:50-55 DAS, and the infestation level of three pests recorded, spotted pod borer (20-35%), *Helicoverpa* (13-20%), Pod fly (10-30%).

The stepwise regression equations were developed, the evening relative humidity, minimum temperature, and rainfall exhibited more influence on the occurrence of all three pod borers, across four locations. The web-enabled DSS platform design and development is under progress. The developed stepwise regression equations will be validated with the ongoing cropping season data, then thumb rules will be developed, and further data of different components will be loaded to a web-enabled decision support system.



Flow chart for the development of a Decision support system for pigeon pea pests

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Broad Bed cum Trench System as a Climate Resilient Farming Model for the Marginal Farmers of Sundarbans

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The Sundarban region of the coastal West Bengal is highly vulnerable to tropical cyclones, tidal surges and erratic distribution of rainfall, leading to intensive rain spells and dry spells (Mandal *et al.,* 2013). High storm surge often breaches the river embankment, forcing saline river water to inundate the inland. Intensive rainfall within short period of time leads to prolonged submergence of the ill drained and low-lying crop fields where long duration and low yielding traditional rice varieties are the only option. The winter and summer seasons witness acute dearth of freshwater for irrigation, rendering huge areas to remain fallow. Such climatic vagaries add anguish to the livelihood of the 4.5 million people residing in the coastal Sundarbans, who primarily depend on agriculture and forest resources for their sustenance. Poor economic return from farming forces the population to migrate to the nearby towns, in search of alternate livelihood. To safeguard agriculture against such climatic vulnerabilities, a project titled "National Innovations on Climate Resilient Agriculture" (NICRA) is being implemented by Ramkrishna Ashram Krishi Vigyan Kendra (RAKVK), in collaboration with ICAR-CRIDA, Hyderabad and ICAR-ATARI, Kolkata, since 2012, in cyclone prone villages of Sundarbans (NICRA News, 2011). The present study was aimed at comparing the performance of the broad bed cum trench technology in the coastal Sundarbans situation, both during climate stress and normal weather condition, against the traditional farming practice.

Methodology

Study Area

The study was conducted in Bongheri village under the Kultali block of the South 24 Parganas district in West Bengal (Latitude: 22°2'3" N to 22°3'11" N; Longitude: 88 °37'5" E to 88 °38'11" E).

Farmers practice

Long duration rice (var. Sabita) was grown on 0.13 ha plot under low land situation (>1.5 ft water stagnation), during July to December. Greengram was grown during February to April as second crop.

Broad bed cum trench technology (BBT) and crop planning

Low-lying fields of 0.13 ha area were selected where series of trenches of 3 ft depth and 4-6 ft width were dug parallelly at 4-6 ft interval. The strips of land, in between the trenches, were raised up to 3 ft height and 3-4 ft width at the top. Various vegetable crops were grown on the raised broad beds, in a relay system (Pic. 1). The rainwater, collected in the trenches, was used for irrigation and culturing fish for 6-8 months. During winter, vegetables are also grown in the trenches with the help of residual moisture.

Data collection

2019 was considered as "stress year" as it encountered two cyclones (*Fani* in May and *Bulbul* in November), intensive rainfall (120 mm and 94 mm), prolonged submergence after transplantation of rice (August), dry spells of more than 10 days (June and July), untimely rain (February and November) and 39% rainfall deficiency in *kharif*. The data of 2023 was taken as "normal year". Both the practices (farmers practice and BBT) were implemented in 20 farmers' field of 0.13 ha size, separately.

Results

The BBT system offered scope of multiple cropping to the farmers as the cropping intensity increased to 238%. The elevated broad beds became suitable for growing multiple vegetables that were saved from prolonged water stagnation during intensive rainfall. The rainwater collected in the trenches was used for irrigation during dry spells in 2019 and sustaining fishery throughout the rainy season. The residual soil moisture in the trenches also allowed to grow vegetables in winter and summer season. The net income from the BBT plots were 10 times more than the farmers' plots (Table).

Both during a normal year and stressful weather, the average net income was significantly higher from the BBT plot in comparison to farmer's practice. Even after heavy submergence due to cyclone Bulbul (November, 2019), the BBT farmers suffered a minimum crop loss due to improved drainage from the raised beds. The excess water collected in the trenches helped to increase the duration of fish cultivation (from 6 to 8 months) and extended irrigation to the winter vegetables, whereas there was 25-30% loss of rice under farmers' practice. Land development have been reported to maximize farm income, even during climatic hazards in Sundarbans (Rahman *et al*., 2016).

Comparison of broad bed cum trench plot over farmers' practice (Rs./ 0.13 ha/ year)

	Crop	Area (ha)	Yield (q)	Gross return	Cost of cultivation	Net return	BCR
Broad bed cum trench (0.13 ha plot)							
Normal year (2023)	Bittergourd	0.05	15.9	44520	12500	32020	3.56
	Brinjal	0.05	15.4	33880	7600	26280	4.46
	Cow pea	0.05	8.25	20625	6780	13845	3.04
	Snake gourd	0.05	10.2	22440	6350	16090	3.53
	Pumpkin	0.05	16.35	14715	4625	10090	3.18
	Fish (trench)	0.06	0.9	10800	3072	7728	3.52
			Total			**106053**	
Stress year (2019)	Bittergourd	0.05	14.6	40880	12500	28380	3.27
	Brinjal	0.05	15.2	33440	7600	25840	4.40
	Cow pea	0.05	7.25	18125	6780	11345	2.67
	Snake gourd	0.05	9.75	21450	6350	15100	3.38
	Pumpkin	0.05	15.95	14355	4625	9730	3.10
	Fish (trench)	0.06	1.08	12960	3072	9888	4.22
			Total			**100283**	
Farmers' practice (0.13 ha plot)							
Normal year (2023)	Rice	0.12	3.48	7656	3840	3816	1.99
	Greengram	0.12	1.2	9000	3600	5400	2.50
			Total			**9216**	
Stress year (2019)	Rice	0.12	2.52	5544	3840	1704	1.44
	Greengram	0.12	0.888	6660	3600	3060	1.85
			Total			**4764**	

Crops in a broad bed cum trench system

Conclusions

BBT technology is an effective climate resilient technology for the coastal Sundarbans farming situation. It not only provides additional income to the marginal farmers but also engages the family members in farming, throughout the year, thus reducing chance of migration.

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UID: 1661

Declining Rainfall and Increasing Variability: Implications for Rainfed Hill Agriculture in Northeastern India from 124 years of climate datasets

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Rainfall variability driven by climate change poses significant risks to rainfed hill agriculture, which forms the backbone of rural livelihoods in the northeastern region of India (NEI). Understanding spatiotemporal rainfall trends and their implications is crucial for developing sustainable farming practices and mitigating climate-induced risks (Saha et al. 2018).

Methodology

This study analyzed the high-resolution gridded (0.25° X 0.25°) daily rainfall data of the India Meteorological Department (IMD) from 1901-2023 to unveil the long-term patterns (Pai et al. 2014). The analysis was confined to all the northeastern states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura.

Results

The spatial analysis of annual rainfall and its coefficient of variation (CV) over the NEI provides critical insights into the changing precipitation patterns and their variability over time.

Results reveal distinct trends in both rainfall magnitude and variability across the region (Fig 1). The figure illustrates (a) the spatial distribution of annual rainfall across different time periods: 1901–1930, 1931–1960, 1961–1990, and 1991–2023. During the early period (1901–1930), large portions of the region experienced rainfall exceeding 2,300 mm annually, with certain pockets receiving over 3,500 mm. These trends were relatively stable in the subsequent period (1931–1960), though slight spatial shifts in the areas of higher rainfall were observed. From 1961–1990, the distribution of rainfall began to show a decline in the areas receiving higher rainfall, with a noticeable reduction in regions exceeding 3,500 mm. In the most recent period (1991–2023), a further contraction in high-rainfall zones (≥3,500 mm) is evident, with a greater prevalence of moderate rainfall zones (1,700–2,600 mm) dominating the landscape. This pattern suggests an overall declining trend in annual rainfall across the NEI, particularly in high-precipitation zones. Further, the CV of annual rainfall (b), reflects the extent of variability in rainfall distribution. During the early period (1901–1930), most of the region exhibited relatively low CV values (≤14%), indicating a consistent rainfall pattern. However, over subsequent decades, CV values increased significantly in many parts of the region. By 1961–1990, areas with moderate CV (22–30%) began to emerge, particularly in the southern and western parts of NEI. This trend further intensified during 1991–2023, with regions exhibiting high CV values (30–38%) becoming more widespread. Notably, regions with extremely high variability (>38%) have also emerged, signifying an alarming trend of increased unpredictability in rainfall patterns.

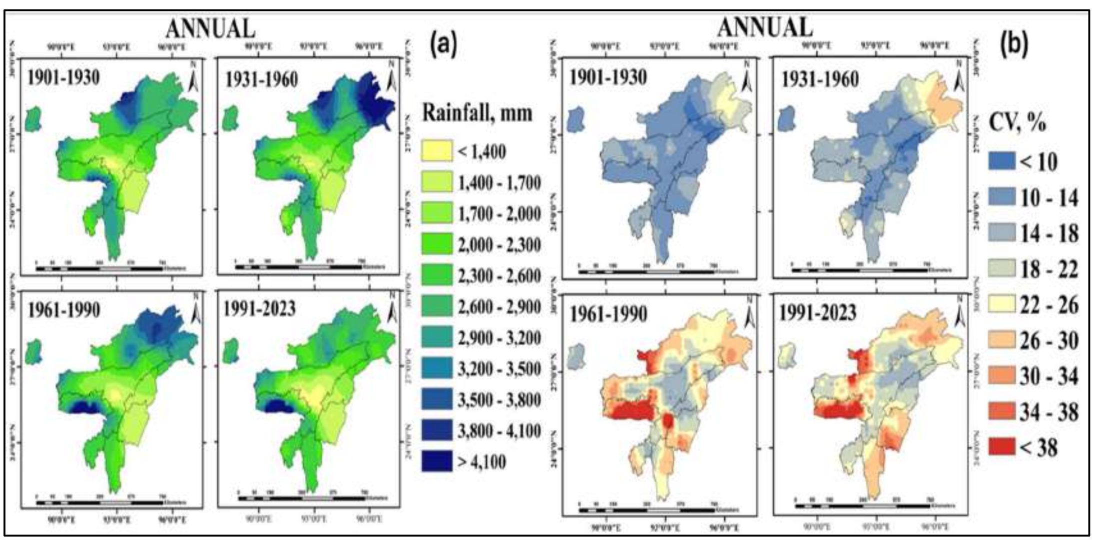

Fig 1. Spatial changes in the annual rainfall (a) and its coefficient of variation (CV) over the northeastern region of India (1901 – 2023).

The trend analysis results clearly revealed a predominance of negative rainfall trends across the northeastern region, particularly in southern and central areas, with declines exceeding -50 mm/decade in red-highlighted zones (Fig 2). These trends are statistically significant ($p \leq 0.01$), emphasizing potential long-term rainfall reductions. Conversely, a few scattered regions, especially in the western and southeastern parts, display positive trends with increases of >10 mm/decade (in blue).

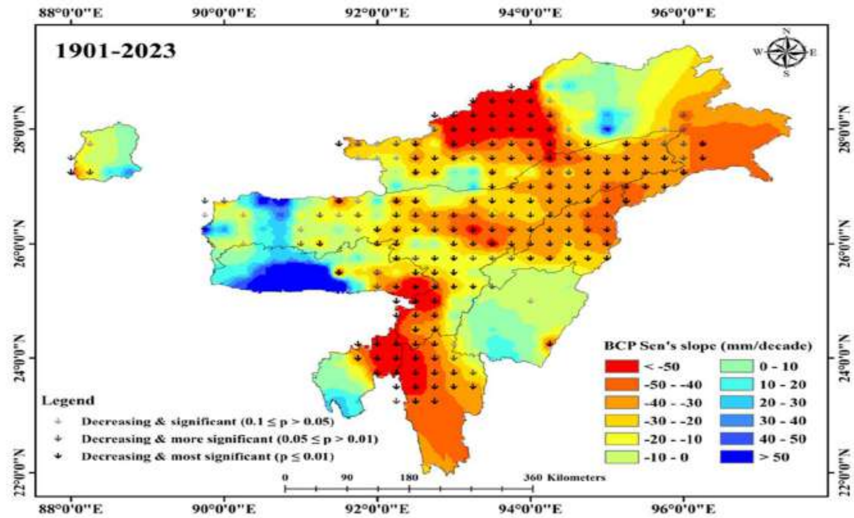

Fig 2: Trends in the annual rainfall over the northeastern region of India (1901 – 2023)

Conclusion

The implications of these findings are profound for agricultural practices and water resource management in the NEI. Rainfed agriculture, which dominates the region, is highly sensitive to changes in both rainfall magnitude and variability. The declining trend in annual rainfall, coupled with increased CV values, poses a dual challenge for farmers—ensuring adequate water supply during critical growing periods and mitigating the risks of extreme events such as droughts or floods. The increasing spatial heterogeneity in rainfall patterns further complicates regional adaptation strategies, underscoring the need for localized interventions tailored to specific sub-regions within NEI. Moreover, the reduction in annual rainfall, particularly during the monsoon season, threatens the availability of surface and groundwater resources essential for irrigation and drinking water. Increased variability exacerbates these challenges by intensifying periods of water surplus and deficit. Innovative water management strategies, including rainwater harvesting, efficient irrigation systems, and crop diversification, are imperative to enhance resilience in the agricultural sector. Overall, the observed spatial changes in annual rainfall and its variability across NEI highlight the urgency for region-specific climate adaptation measures. Sustainable water resource management and climate-resilient agricultural practices are essential to mitigate the adverse impacts of changing rainfall patterns and ensure the livelihoods of millions dependent on agriculture in this vulnerable region. Further research focusing on high-resolution climate modeling and region-specific adaptation strategies will be crucial for informed decision-making in the face of evolving climatic challenges.

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UID: 1693

Climate Vulnerability in Meghalaya: A Comprehensive Assessment at District and Block Level

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Climate change is a critical global challenge with profound implications for agro-ecosystems, economies, and societies. It poses significant threats to agriculture, water resources, and economic stability (Economic Survey of India, 2023). North-East India, comprising eight mountain bound states like Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, is particularly susceptible to changing climate due to its diverse ecology and predominantly agrarian driven economy. The region has experiencing erratic rainfall patterns, rising temperatures, and increased soil erosion, which have adversely affected agricultural productivity. Agriculture in North-East India is especially vulnerable to climate change impacts, given its complete dependence on monsoon rains, sensitivity to temperature variations, and exposure to extreme weather events. Existing studies on vulnerability in the region have largely focused on localized areas, leaving broader patterns unexplored. This study aims to address this gap by assessing climate change vulnerability at district and block levels, employing the IPCC 2014 framework and targeted to deliver a detailed analysis of vulnerability across Meghalaya.

Methodology

Spatial secondary data from 2020 were sourced from the Ministry of Rural Development, Government of India, encompassing approximately 180 village-level parameters. Using exploratory factor analysis, relevant sub-indicators associated with adaptive capacity and sensitivity were identified. These sub-indicators underwent data cleaning and descriptive statistical testing to ensure readiness for further analysis. The vulnerability index was constructed following the IPCC 2014 framework (Sharma and Ravindranath, 2019) and categorized into five levels: Very Low, Low, Medium, High, and Very High. Classification ranges at the district level were derived from the overall vulnerability index values of all districts, while block-level ranges were calculated based on individual block indices.

Results

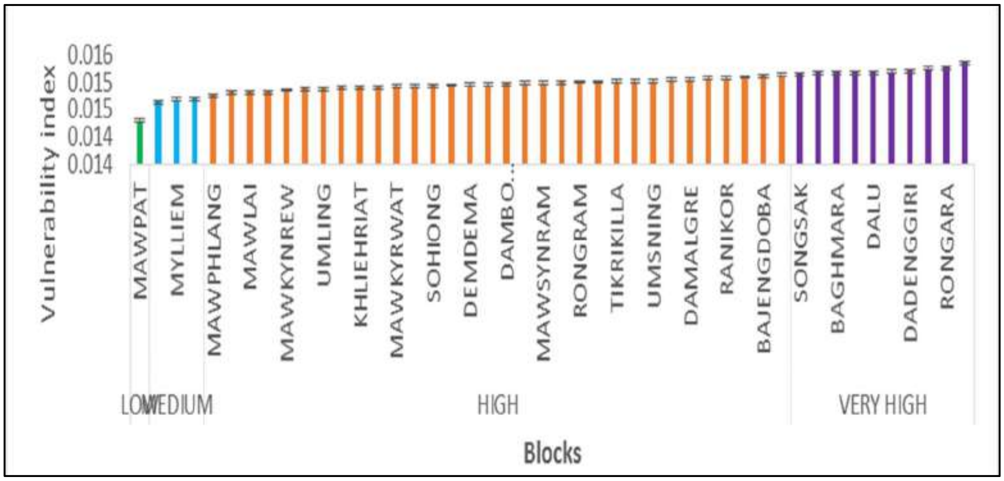
Key Drivers o Vulnerability: In Meghalaya, health and nutrition factors significantly contribute to vulnerability, with Total Anemic Pregnant Women (11.49%) emerging as a major concern, highlighting maternal health challenges. Economic vulnerability, underscored by the contribution of Self-Help Groups (9.24%), and agricultural sensitivity, as indicated by Drip/Sprinkler Irrigation (9.10%), are also critical drivers. Additionally, the role of child nutrition and maternal care services is evident through parameters like Registered Anganwadi Children (8.93%) and beneficiaries of the Pradhan MantriMatruVandanaYojana (PMMVY) (8.90%).

District-Level Vulnerability Patterns: Among Meghalaya's 11 districts, 72.73% (8 districts) fall under the high vulnerability category, including East Khasi Hills, South West Garo Hills, and East Jaintia Hills. West Jaintia Hills (9.09%) exhibits medium vulnerability, while South Garo Hills and West Khasi Hills (18.18%) are classified as very high vulnerability areas. These districts face significant challenges in health, nutrition, and socio-economic resilience (Table).

District level vulnerability profile in Meghalaya

State	Very low % (0.0140-0.0143)	Low % (0.0143-0.0146)	Medium % (0.0146-0.0149)	High % (0.0149-0.0151)	Very high % (0.0151-0.0154)
ML (11)	-	-	9.09 (1) West Jaintia Hills	72.73 (8) East Khasi Hills, South West Garo Hills, East Jaintia Hills, Ri Bhoi, South West Khasi Hills, North Garo Hills, West Garo Hills, East Garo Hills	18.18 (2) South Garo Hills, West Khasi Hills

Block-Level Vulnerability Analysis:The block-level analysis provides a more granular perspective, highlighting localized disparities within Meghalaya (Fig). Blocks were categorized into five vulnerability levels—very low to very high—enabling precise identification of critical areas for targeted interventions. The analysis reveals that 69.57% (32 blocks) and 21.74% (10 blocks) are categorized as high and very high vulnerability, respectively. The remaining blocks include 6.52% (Mawryngkneng, Mylliem, and Amlarem) under medium vulnerability and 2.17% (Mawpat) under low vulnerability.The most vulnerable blocks include Mawshynrut, Rongara, Jirang, Dadenggiri, Nongstoin, Dalu, Gambegre, Baghmara, Chokpot, and Songsak. Notably, Mawshynrut, Dadenggiri, Nongstoin, Dalu, and Gambegre are in the West Khasi Hills district, while Rongara, Baghmara, and Chokpot are in the South Garo Hills district. This highlights these two districts as the most vulnerable regions in Meghalaya. The mapping of climate change vulnerability in Meghalaya underscores the critical need for a comprehensive, integrated, and participatory approach to policy-making. Prioritizing community involvement, bolstering agricultural resilience, and enhancing governance and institutional capacities are essential steps to mitigate climate-related risks and foster sustainable development for the region's diverse populations. Achieving these policy objectives will require dedicated commitment, collaborative efforts, and innovative strategies from all stakeholders invested in shaping the region's future.



Block level vulnerability profile of Meghalaya

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UID: 1700

Impact Assessment of Climatic Resilient Practices on *In-situ* Moisture Conservation through Direct Seeded Rice under farmer's field

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Production of conventional puddled transplanted rice is facing severe constraints because of water and labor scarcity and climatic changes. Direct-seeded rice (DSR) is a feasible alternative to conventional puddled transplanted rice with good potential to save water, reduce labor requirement, mitigate green-house gas (GHG) emission and adapt to climatic risks. In the traditional transplanting system (TPR), puddling creates a hard pan below the plough-zone and reduces soil permeability. It leads to high losses of water through puddling, surface evaporation and percolation. Water resources, both surface and underground, are shrinking and water has become a limiting factor in rice production with the help of DSR technology all those constraints can be mitigated. The yields and cost of cultivation are comparable with transplanted rice if crop is properly managed. In this view efforts have been made in promoting the DSR technology at NICRA village Karga by KVK, Durg II (C.G.) in kharif season under NICRA Project. Here, we observed Plant height, Tillers, Panicle length and yield of rice sowed under DSR technology. Rice verity Swarna, dry seeds has been directly sowed with seed drill machine @ of 75 kg per ha farmer's field at NICRA village. The row-to-row distance in rice field has been maintained 22.5 c.m. under DSR technology. Our observations of Plant height of swarna were 122.8 c.m. found. The Panicle length of DSR fields Rice was recorded 25.3 cm for Swarna also Tillers found on an average 9.6 for Swarna. Also, it found feasible for water inputs, labor costs and labor requirements.

UID: 1731

Conservation Agriculture for Improving Resource Use Efficiency in Rainfed Conditions

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Over half (around 51%) of India's cultivated land relies solely on rainfall, contributing nearly 40% of the nation's food grains (MoA & FW). Farming in these rainfed regions faces significant challenges due to unpredictable rainfall patterns, leading to low productivity, water scarcity and unstable yields. Climate change further exacerbate these problems. However, Conservation Agriculture (CA) offers a promising solution. This sustainable farming approach emphasizes minimal soil disturbance (zero tillage preferred), diverse crop rotations, and permanent soil cover. By adopting CA practices, farmers can cultivate rainfed lands more sustainably, leading to improved soil health (both physical and chemical properties), and enhanced yields with moisture conservation practices. CA has been recognized as an environmentally friendly tool for improving resource use efficiency, sustainability and productivity. The benefits of CA are realized only when all the three principles of CA are adopted and applied simultaneously. Moreover, CA requires lower energy inputs, reducing cultivation costs and making it an attractive option for resource-constrained farmers.

1. We have reviewed and synthesize existing literature on the impacts of conservation agriculture practices on water use efficiency (WUE) and energy use efficiency (EUE) in rainfed agricultural systems.

2. Comprehensive review was conducted to examine the effectiveness of conservation agriculture practices in enhancing system productivity and yield stability on rainfed crop production.

Methodology

A comprehensive search was conducted in Google Scholar, Research gate, J-Gate and the CeRA database using keywords related to CA, rainfed systems, and key performance indicators (energy use efficiency, water use efficiency, system productivity, and yield stability). Peer-reviewed journal articles meeting specific addition criteria (e.g., rainfed systems, explicit CA practices) were included. Exclusion criteria included reviews and grey literature. The risk of bias in included studies was assessed using appropriate tools. A narrative synthesis approach was used to integrate and summarize findings. The search may not have captured all relevant studies, and the heterogeneity of study methodologies could introduce some bias.

Key Findings

1. Water use efficiency (WUE)

Pratibha et al. (2021) reported a significant enhancement in rainwater use efficiency (RWUE) in Alfisols of southern India. Under zero tillage (ZT) with residue retention, pigeon pea exhibited a 26% higher RWUE compared to conventional tillage (CT). Residue retention consistently boosted rainwater productivity and RWUE across various crops. Corroborating this finding, *Handiso et al. (2023)* observed that conventional tillage resulted in lower soil moisture content (SMC) at 13.73%, compared to 15.08% and 15.11% SMC under zero tillage and reduced tillage, respectively. These findings strongly suggest that conservation agriculture (CA) practices effectively conserve soil moisture and enhance water use efficiency compared to conventional tillage.

2. Energy use efficiency (EUE)

The results (table-1) highlight the significant impact of different agricultural practices on energy use efficiency as reported by *G. Pratibha et al., 2021*. ZT and CA consistently showed higher EUE compared to CT, mainly due to lower energy inputs associated with reduced tillage and efficient soil management. Similarly, *Gozubuyuk et al., 2020* reveal that the NT practice in rainfed was very advantageous compared to the CT practice in terms of saving both diesel fuel (3.2 times less) and working time (4.5 times less).

3. Sustainable yield index (SYI)

As depicted in fig-1 the increase in SYI (0.72) within the ZT-RB (Zero Tillage-Raised Bed) system researched by *Shivanand et al., 2021* with crop residue is likely a result of synergistic effect of CA practices and Raised bed. The combined effect of these factors appears to be driving the observed increase in SYI, indicating a more sustainable and productively agricultural system.

Conclusion

This review demonstrates that Conservation Agriculture practices, by concurrently implementing three core principles, offer significant potential to improve resource use efficiency and enhance agricultural sustainability in rainfed environments relative to conventional farming methods.

Table 1: Impact of conservation agriculture practices on energy use efficiency (EUE) observed between CT and CA in different cropping systems *(G. Pratibha et al., 2021)*

Cropping Systems	Crops	CT	CA	% increase in CA over CT
Pigeon pea-Castor system	Pigeon pea	4.94	9.81	49.64
	Castor	2.28	2.87	20.5
Maize-Pigeon pea system	Maize	3.49	5.52	36.7
	Pigeon pea	1.72	1.9	9.47
Finger millet + Pigeon pea		7.2	21.7	66.8
Soybean-Chickpea		5.66	6.11	7.36

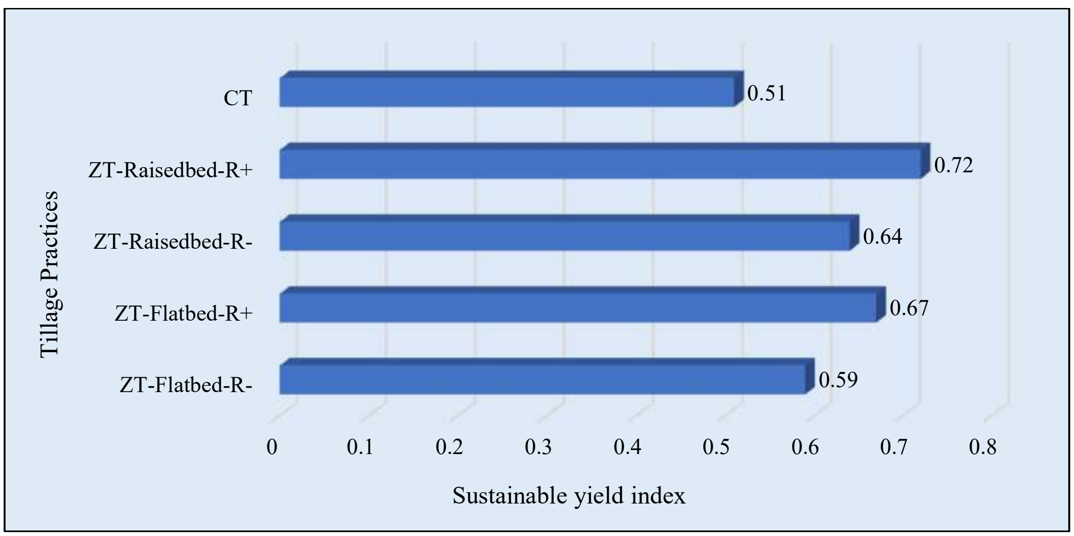

Fig 1. Effect of conservation agriculture practices on sustainable yield index (*Shivanand et al., 2021)*

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UID: 1753

Sustainable Agriculture through Organic Farming in India

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Organic farming is the practice that relies more on using sustainable methods to cultivate crops and it avoids chemical inputs that do not belong to the natural eco system. Organic agriculture can contribute to meaningful socioeconomic and ecologically sustainable development, especially in developing countries. This is due to the application of organic principles, which advocates the application of local resources viz., indigenous seed varieties, manure, etc. and therefore cost effectiveness. Organic farming is one of the several approaches found to meet the objectives of sustainable agriculture. Ecological friendly Organic farming is the answer to the problems being faced by agriculture in India today. It will also keep agriculture more sustainable. This form of agriculture conserves our soil and water resources, protects our climate, improves agro-diversity, ensures biodiversity, meets the demand for food and safeguards livelihoods. In brief, it ensures that the environment blooms, the farm is productive, the farmers makes a net profit and society has adequate nutritious food. The impact of organic farming on biodiversity and soil fertility is discussed in comparison with conventional systems. A significant barrier for wide application and future development of organic farming is the existing diversity of national and international policy instruments in this sector. Special attention is paid to up-to-date research techniques that could help solve a number of the problems typically faced in plant organic farming. It is argued that organic farming is still not productive enough to be considered fully sustainable. This underlines the necessity of strong support for more effective implementation of scientific research innovations and improvement of the networking between all stakeholders – organic producers, scientists and corresponding policy makers at the national and international level.

UID: 1776

Utilizing Smoke for Frost Protection: A Sustainable Approach to Mitigating Cold Stress

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Frost, a significant abiotic stressor, notably impacts agricultural productivity and quality, posing substantial challenges in tree and native plant nurseries globally. The severity of frost stress is influenced by a myriad of environmental conditions, making timely and precise frost detection, and forecasting critical for effective management and mitigation. The frost detection and prevention techniques focus on the array of strategies employed in agriculture to modify the microclimate, thereby improving the physical environment for crops. Various field techniques are employed in valuable crops and generally involve interfering with the freezing environment by the use of turbines to mix cold and warm layers of air or by smoke blankets to prevent the crop losing long wave radiation (Kalma et al., 1992). Creating a cloud of smoke in the orchard by burning waste material on a night when frost is expected helps to minimize its effects in two ways. Firstly, the smoke forms a sort of screen over the plants thus warding off the frost. Secondly it raises the temperature of the orchard to some extent thereby decreasing the incidence of frost.

Materials and Methods

The present study was conducted at the College of Temperate Sericulture (CoTS), Mirgund SKUAST-Kashmir. The study was conducted during 2022-23 & 2023-2024. The cuttings of two mulberry varieties viz., Goshoerami and Kokuso-21, obtained from 8–9 month old branches of mulberry were used for raising the mulberry saplings in the polyhouse. Cuttings of the length of 13-15 cm and of pencil thickness with 3-4 active buds were taken and planted in the rooting medium contained in small polytubes of size 4 × 12 inch. The rooting medium comprised of sand, soil and farm yard manure (FYM) in the ratio of 6:3:1. The cuttings were treated with 0.1% carbendazim to ensure their surface disinfection and one cutting was inserted in each polytube. The polytubes with the cuttings were placed in zero energy polyhouse. The saplings were allowed to grow for three months approximately from March to May. Then the mulberry saplings of uniform size raised under polyhouse were selected and transplanted to main nursery during mid-June. The treatment like, modification of micro-climate in nursery through smoke were started with the onset of freezing temperature. The frost damage of saplings was observed and the extent of damage was measured weekly till March, and various growth parameters were recorded during spring. It was recorded by measuring the total height of sapling and the height damaged by winter frost as:

$$\text{Frost damage (\%)} = \frac{\text{Length damaged}}{\text{Total length of sapling}} \times 100$$

Results

The data presented in Table 1 reveals that the variety Goshoerami experienced the highest level of frost damage compared to Kokusu-21. However, despite the notable damage in Goshoerami, both varieties exhibited a significantly lower degree of frost-induced harm when compared to the control group, demonstrating their relative resilience under frost conditions.

Further insights are provided by Table 2, which highlights several growth parameters including the number of leaves per sapling, leaf area (cm²), shoot length (cm), fresh shoot weight per sapling (g), dry shoot weight per sapling (g), and shoot diameter (cm). Across all these indicators, both Goshoerami and Kokusu-21 outperformed their respective controls. This suggests a marked improvement in plant vigor and growth characteristics despite exposure to frost conditions, emphasizing the potential adaptability and robustness of these varieties when compared to the control group under challenging environmental stresses.

Table 1. Influence of smoke on frost damage (cm) of mulberry saplings under nursery conditions

Date / Variety	15/12	01/01	15/01	01/02	15/02	01/03
Goshoerami	18.018	26.666	34.054	37.958	38.750	38.900
Goshoerami (control)	30	42.6	49.8	54.8	57.1	57.8
Kokusu-21	17.171	25.959	27.939	28.959	29.618	29.871
Kokusu-21 (Control)	24.444	33	39.888	42.111	44.222	44.555

Table 2. Influence of smoke on growth parameters of mulberry saplings under nursery conditions during spring

Mulberry Variety / Growth Parameter	Goshoerami	Goshoerami (control)	Kokusu-21	Kokusu-21 (Control)
No. of leaves per sapling	23.81	20.02	22.93	19.42
Leaf area (cm^2)	224.46	198.75	194.28	168.85
Shoot length (cm)	110.84	92.58	98.64	78.98
Fresh shoot weight per sapling (g)	122.12	110.8	118.02	105.81
Dry shoot weight per sapling (g)	28.38	26.23	26.68	24.53
Shoot Dia (cm)	1.52	1.12	1.49	1.09

Conclusion

The study demonstrated the potential benefits of microclimate modification through smoke in reducing frost damage and enhancing growth parameters in mulberry saplings. Although Goshoerami experienced greater frost damage than Kokuso-21, both varieties showed improved performance over their respective controls. These findings highlight the efficacy of smoke-based interventions and the adaptability of selected mulberry varieties to frost stress conditions, paving the way for improved nursery management strategies in frost-prone regions.

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UID: 1777

Study of Crop Residue Management of Sugarcane Trash Through Rotary Mulcher on Yield of Wheat

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Uttar Pradesh is the largest producer of sugarcane in India followed by Maharashtra and Karnataka. Sugarcane is the major cash crop grown in the Gonda district. The area under sugarcane is 105645 ha in sandy loam soil with productivity 83.5 t/ha. Trash burning of sugarcane is the major problem in the area. An experiment was conducted at the farmers field under NICRA Village during the year 2021-22 & 2022-23 under the Scientific technical guidance of LBS Krishi Vigyan Kendra Gonda (U.P.) under north east plain zone. The treatments comprising studies regarding the trash management of sugarcane crop on yield of wheat and also to stop the burning of sugarcane crop residue and incorporation of trash in the soil for increasing organic matter content which retain the in- situ moisture conservation in soil. In this experiment treatment T1 (sowing of wheat after burning of sugarcane trash) and treatment T2 (sowing of wheat after crop residue management of sugarcane trash through rotary mulcher). Due to mulching of sugarcane trash and incorporation of sugarcane crop residue in the soil that enhances the biomass in the soil. The experiment results showed that the yield of wheat due to incorporation of trash in the soil enhanced by 12.78% and the net return of Rs. 44825/ha. It also enhanced the biomass in the soil so that organic carbon percentage increased from 0.27 to 0.35% and the saving of water throughout the crop period upto 25% due to in-situ moisture conservation under the treatment T2 (sowing of wheat after crop residue management of sugarcane trash through rotary mulcher). Due to this reason farmers were accepted this technology of crop residue management of sugarcane instead of burning of sugarcane trash.

UID: 21404

Climate Variability Over Southern Agroclimatic Zone of Tamil Nadu, India

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Climate variability describes the natural changes in the climate system that occur over a range of timescales, spanning months to decades or even centuries. Trend analysis is a technique used to assess spatial variations and temporal changes in various climate-related parameters by Arun *et.al.,* (2012). Climate change is expected to improve agricultural land suitability in high-latitude regions of the Northern Hemisphere while decreasing it in tropical areas (Ramankutty *et al.*, 2002). Climate variability led to changes in spatial and temporal variation in vegetation and water distribution, we could see more epidemics as the vector moves to new areas (McMichael *et al.,* 2006). Expected changes in rainfall and temperature variability in the future, there is high uncertainty: IPCC (2012). The impact of yield anomalies on production can be intensified by a reduction in cropping frequency and a smaller harvested area as a result of climate variability (Cohn *et al.,* 2016). In India, the distribution of land area based on rainfall patterns is classified as follows: 15 million hectares receive less than 500 mm of rainfall, 15 million hectares receive between 500–750 mm, 42 million hectares receive 750–1150 mm, and 25 million hectares receive more than 1150 mm. Tamil Nadu experiences tropical, subtropical, and temperate climates, with average annual rainfall ranging from 650 mm in Thoothukudi district to 1460 mm in Kanyakumari district. The southern regions of Tamil Nadu are predominantly classified as drylands, comprising districts with the lowest annual rainfall. The cropping period in these regions aligns with the rabi season, coinciding with the Northeast Monsoon. Crops such as pulses, maize, sorghum, minor millets, sesame, and sunflower are raised during a 70-90 day growing period, receiving approximately 400 mm of seasonal rainfall. In dryland agriculture, a comprehensive understanding of rainfall climatology is essential, as it is a key factor affecting the success of farming in semi-arid regions. Therefore, this study aimed to critically analyze historical rainfall data from selected districts in the southern agroclimatic zones of Tamil Nadu, namely Virudhunagar, Thoothukudi, and Madurai, where dryland areas are extensively distributed.

Methodology

The southern agroclimatic zone of Tamil Nadu comprises the districts of Madurai, Sivagangai, Ramanathapuram, Virudhunagar, Tirunelveli, Tenkasi, and Thoothukudi. Geographically, it is located between 8°9' and 10°50' North latitude and 77°10' and 79°25' East longitude.. The region has a mean annual rainfall of approximately 857 mm. Major crops cultivated in this area include rice, maize, cucumber, sorghum, ragi, black gram, green gram, groundnut, fodder crops, gingelly, castor, cotton, chillies, banana, jasmine, coriander, onion, lime, cashew, and amla. Spanning an area of 36,655 sq. km, this zone is highly prone to frequent droughts. Rainfall is a crucial factor in determining crop productivity, the choice of crops, and the length of the growing period. Daily rainfall data accumulated during the cropping period (September–December) over 73 years for Thoothukudi district, 40 years for Virudhunagar district, and 53 years for Madurai district were collected from the TNAU research station/Institute and analyzed to assess deviations from normal rainfall patterns over time. This analysis aimed to assess rainfall trends to guide cropping patterns and crop selection.

Results

During the cropping period, the percentage change in rainfall per decade at Thoothukudi showed an increasing trend in September (3.1%), October (1.4%), and December (0.8%), while November exhibited a decreasing trend (-1.7%). The predominant soil type in the district is black cotton soil. Farmers typically practice in pre-monsoon sowing during the second fortnight of September. However, increased rainfall during this period can disrupt pre-cultivation practices and delay sowing activities. In November, when crops are in the vegetative to flowering stage, deficient rainfall can adversely affect crop yields. In Virudhunagar district, the percentage change in rainfall per decade showed a decreasing trend in September (-2.5%) and October (-9.2%). In contrast, November (0.2%) and December (8.2%) exhibited an increasing trend. The predominant soil type in the district is black cotton soil. A decrease in rainfall during September and November can impact sowing and affect all dry land crops at the vegetative stage, subjecting them to moisture stress and initial drought conditions. For Madurai district, percent change over decade for the month of September (-1.7%), November (-1.6%) and December (-3.9%) it was decreasing trends. Whereas October (6.1%) was in increasing trends. The predominant soil type in the district consists of red alluvial soils, followed by black soil. A decrease in rainfall during September impacts cotton crops at the vegetative stage, while reduced rainfall during November and December affects other rainfed crops sown in October, leading to initial drought conditions. Even paddy grown under irrigation faces challenges, ultimately resulting in a decline in crop yields.

Conclusion

Based on the rainfall analysis on decade wise and the results obtained it can be concluded that the rainfall showed in all the three districts rainfed crops under moisture at maximum vegetative stage which affects the source sink relationship. Hence, farmers to be planned the crops based on the forecast of each year need to be further. The study showed that all three districts were most prone to moderate drought.

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UID: 21404

Effect of different drought mitigation technologies on the growth and yield of blackgram under rainfed conditions

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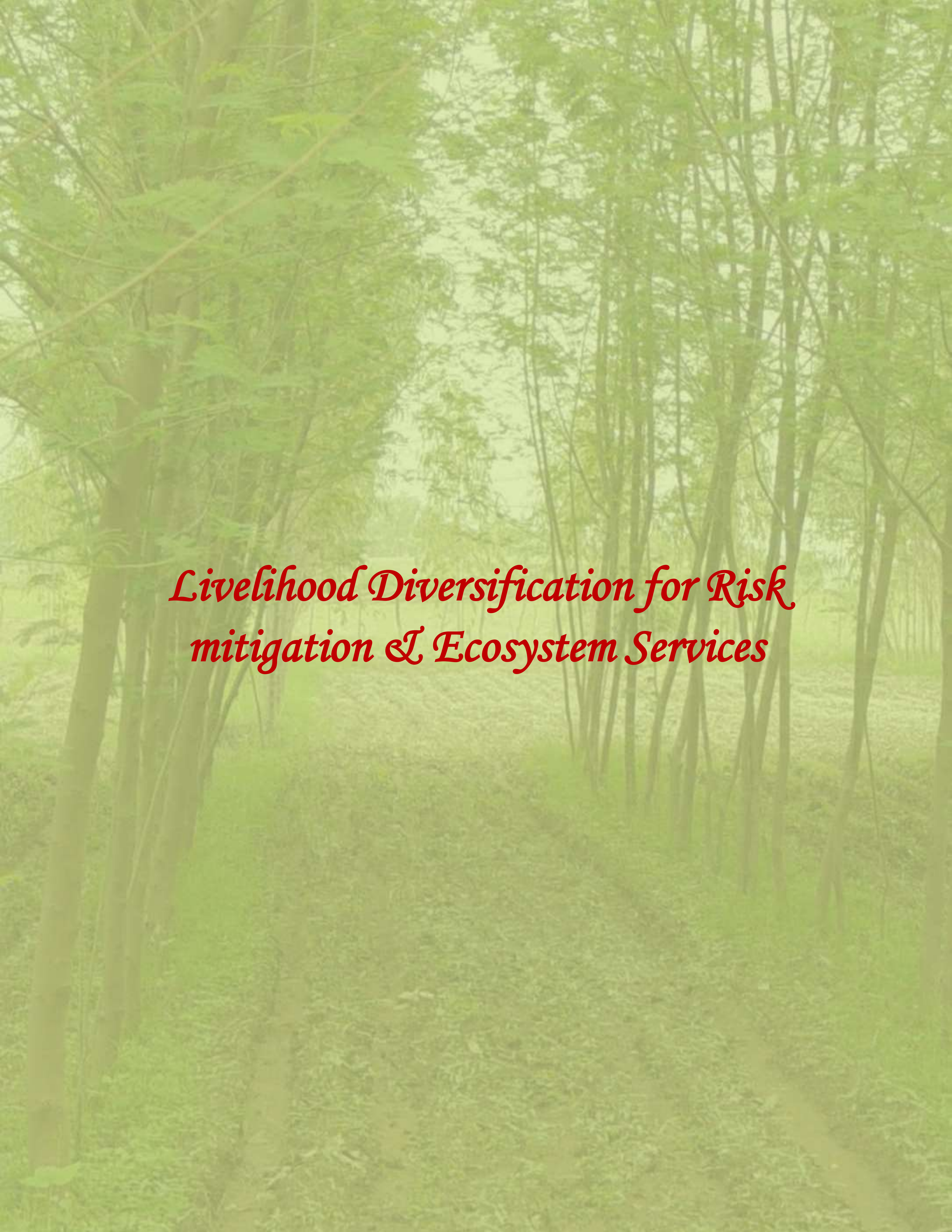
India is the largest producer of pulses even; the domestic requirements will be 26.50 m.t. in 2050, necessitating us to increase the production by 82%. Blackgram mostly grown under rainfed condition faces a problem of excess soil moisture and water logging during early season and moisture deficit at reproductive phase resulted low productivity. Under such condition appropriate land configuration and drought mitigation technologies play an important role in increasing production. Hence, field experiments were conducted during 2017-18 and 2018-2019 in Rabi season at Agricultural Research station, Kovilpatti, Tamil Nadu to study the response of different drought mitigation technology on blackgram growth, physiological parameter, yield and economics under rainfed situation. The research trials were conducted in strip plot design and replicated thrice. The results of the experiment revealed that significantly higher grain yield (899 and 459 kg ha^{-1}), RWC (89.6 and 92.8 %), CSI (84.7 and 87.6 %) and

lower proline content (35.0 and 34.5 μg g^{-1}) were recorded by broad bed and furrow method during 2017-18 and 2018-19 respectively. Among the drought mitigation technology, the higher yield of 920 and 480 kg ha^{-1} was registered by the combined application of Pusa hydrogel with mulching + PPFM spray which was followed by combined application of Pusa hydrogel with mulching + KCl spray (900 and 458 kg ha^{-1}) against the hydrogel alone applied plot (795 and 391 kg/ha). Significantly higher RWC (92.8 and 93.5 %) and CSI (87.6 and 88.7 %) and lower proline content (34.5 and 34.5 μg g^{-1}) were recorded in the combined application of Pusa hydrogel with mulching and PPFM spray.



Livelihood Diversification for Risk mitigation & Ecosystem Services

UID: 1012

Enhancing Crop Diversification and Resilience through Soybean-Pigeon Pea Strip Intercropping under Rainfed conditions

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Soybean is one of the most important oil-bearing leguminous crops of the world with high productivity potential than other legumes. It is a richest source of quality protein which can be used for alleviating protein calorie malnutrition (IISR, 2021). Globally India stands in fourth position with the cultivable area of 12.81 million hectare with 12.90 million tone production. The Telangana state of India is producing 0.24 million tonnes of soybean from an area of 0.16 million hectares (Directorate of Economics and Statistics, 2021) and the northern region of Telangana state in India shares 2% of the total soybean production of the country. Adilabad district contributes 39.6% area with the production of 38.2% of total states area and production, respectively (Raghuveer *et al*., 2024).

Redgram, also known as pigeonpea (*Cajanus cajan* L.), stands as the fifth most prominent grain legume crop globally and holds second position in India after chickpea. It holds a significant position in the agricultural landscape as a vital pulse crop due to its nutritional value and economic importance. Globally, redgram is grown in an area of 63.57 lakh hectares with a production of 54.75 lakh tonnes and productivity of 861 kg ha^{-1}. India ranks first in redgram production globally with 42.2 lakh tonnes cultivated under 49.0 lakh hectares with productivity of 861 kg ha^{-1} (Sowmyasri *et al*., 2023). Pigeonpea is a drought tolerant, deep-rooted, often cross-pollinated, C3, short-day plant and hypogeal germination in nature. It is a common food grain crop and offers nutritional security due to its richness in protein (21%) with essential amino acids such as methionine, lysine and tryptophan, along with mineral supplementation, viz., iron and iodine. The drought resistance and nutritional value, making it essential for resource-poor farmers in semi-arid regions.

Strip intercropping has the potential of reducing interspecies competition, and increasing yields per unit area. Strip cropping is like any other intercropping strategy based on the management of plant interactions to maximize growth and productivity caused by efficient use of plant growth resources such as light, water and nutrients. Soybean and redgram can improve overall land productivity by effectively utilizing resources such as light, water, and nutrients (Ali *et al*., 2023). The complementary growth habits of these crops facilitate better pest management and reduce competition for resources, ultimately leading to higher yields and profitability. Furthermore, this practice promotes soil conservation and reduces erosion, making it a sustainable option for farmers. In light of the aforementioned, an experiment aimed at analyzing the soybean-pigeonpea strip intercropping was conducted at Agricultural Research Station, Adilabad.

Methodology

A field experiment was conducted during *kharif* seasons of 2021-22 to 2023-24 at Agricultural Research Station, Adilabad, PJTAU, Telangana to study the influence of soybean-pigeonpea strip cropping on yield, economics and Rain water use efficiency (RWUE) under rainfed condition. The experiment was laid out in randomized block design with 6 treatments *i.e.* T_1- Soybean 4.5 m (+) pigeonpea 5.4 m strip cropping (10:6 rows), T_2- Soybean 6.75 m (+) pigeonpea 8.1 m strip cropping (15:9 rows), T_3- Soybean 9.0 m (+) pigeonpea 10.8 m strip cropping (20:12 rows), T_4- Sole Soybean 4.5 m strip cropping (10 rows), T_5- Sole Pigeonpea 5.4 m strip cropping (6 rows) and T_6- Soybean (+) pigeonpea (7:1 ratio).

Results

It is evident from the mean data (Table) that the cultivation of soybean 9.0 m (+) pigeonpea 10.8 m strip cropping (20:12 rows) recorded higher soybean equivalent yield (3345 kg ha^{-1}), LER (1.87) and RWUE (2.48 kg/ha-mm) than other strip cropping and it was found on par with soybean 6.75 m (+) pigeonpea 8.1 m strip cropping (15:9 rows) and traditional intercropping method of soybean (+) pigeonpea (7:1 rows). Similarly, same trend was observed in terms of net returns (Rs. 87803 ha^{-1}) and B:C ratio (2.55:1) with same cropping systems. Cost of cultivation for Soybean 4.5 m (+) pigeonpea 5.4 m strip cropping (10:6 rows) is Rs. 56218 ha^{-1}, Soybean 6.75 m (+) pigeonpea 8.1 m strip cropping (15:9 rows) is Rs. 54729 ha^{-1}, soybean 9.0 m (+) pigeonpea 10.8 m strip cropping (20:12 rows) is Rs. 56218 ha^{-1}, Sole Soybean 4.5 m strip cropping (10 rows) is Rs. 53362 ha^{-1}, Sole Pigeonpea 5.4 m strip cropping (6 rows) is Rs. 47729 ha^{-1}and Soybean (+) pigeonpea (7:1 ratio) is Rs. 55752 ha^{-1}. The implementation of a strip cropping of soybean at 9.0 m (+) pigeonpea 10.8 m (20:12 rows), resulted in yield enhancement ranging from 7.7% to 50.5% showcasing the superior productivity of this configuration. Moreover, the land equivalent ratio (LER) demonstrated more efficient land use and higher productivity per unit area, reflecting the synergistic benefits of intercropping. Net returns were increased by 11.4% to 70.6% compared to other treatments. Resource-use efficiency, measured in terms of RWUE (kg/ha-mm), showed significant improvement, representing optimized utilization of water resources for crop production.

Conclusion

The adoption of soybean 9.0 m (+) pigeonpea 10.8 m strip cropping (20:12 rows) has proven to be a highly advantageous agronomic practice, resulting in higher yields, improved economic returns, better land use efficiency, and optimized resource utilization, thereby contributing to sustainable and profitable agricultural systems.

Effect of treatments on yield, economics and rain water use efficiency (Pooled data of 2021-22 to 2023-24)

Treatments	Soybean yield (kg ha^{-1})	Pigeonpea yield (kg ha^{-1})	SEY* (kg ha^{-1})	LER	MAI	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	RWUE (kg/ha-mm)
T_1	1883	970	2853	1.56	42462	53184	69174	2.31:1	2.07
T_2	1815	1274	3089	1.71	53504	54729	77986	2.42:1	2.26
T_3	1770	1575	3345	1.87	65652	56218	87803	2.55:1	2.48
T_4	2072	0	2072	1.00	0	53362	34961	1.67:1	1.54
T_5	0	1655	1655	1.00	0	47729	22327	1.46:1	1.16
T_6	2165	877	3042	1.64	49642	55752	75071	2.34:1	2.24
S. Em+	128	131	178	0.13	8698	1504	7995	0.12	0.19
CD (p=0.05)	2165	418	569	0.42	27763	4802	25518	0.40	0.63
CV (%)	13.6	21.4	11.5	15.7	42.7	14.8	22.6	10.2	17.5

*Soybean equivalent yield

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UID: 1030

Crop Diversification Through Legumes for a Sustainable Production

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Pulses are important for diversification and intensification of agriculture across the globe because of their intrinsic values such as nitrogen fixing ability (15-35 kg N/ha), high protein content and ability to survive in less endowed environment. Different FLDs (Front Line Demonstrations) were conducted to demonstrate the production potential of yellow mosaic resistant var. MH-421 of mungbean on the farmer's fields at Lohani and Dhareru villages of Bhiwani district of Haryana state in kharif 2023 in a given farming system. . Mungbean is drought tolerant crop and short life cycle of 75–90 days to maturity with a good potential for crop intensification and relay cropping with cereals using residual moisture. Plant grain yield was used for performance evaluation. Farmers used a wide range of techniques, such as IPM practices, biofertilizer treatment, fertilizer administration based on soil test results, and seed rate. The results showed that front-line demonstrations increased moong output by 24 percent as compared to the farmers' practices. It was also revealed that front-line demonstrations had a higher yield, larger gross and net return than local checks i.e 7.2 q/ha, Rs. 61560 and Rs. 17988, respectively, whereas in farmer's practices, they were 5.8 q/ha, Rs. 49932 and Rs. 7840.

UID: 1048

Livelihood Security of Farmers through Water Harvesting in Farm Pond under Rainfed Area of Ramanathapuram District

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Ramanathapuram district, located in the south eastern corner of Tamil Nadu, lies in a rain-shadow area and is highly prone to drought, making it one of the least developed districts in the region. Rainfall here is influenced by both the southwest and northeast monsoons, with the northeast monsoon being the primary source. Most rain arrives in the form of cyclonic storms by depressions in the Bay of Bengal, while southwest monsoon rainfall is unpredictable, and summer rains are minimal. Paddy is the main grain crop, and livestock plays a key role in supporting agricultural livelihoods, especially for small and marginal farmers as well as landless agricultural labourers. Agriculture in the district is largely dependent on rainfall, so crop performance varies with annual rainfall patterns. Farm ponds and recharge shafts have been

identified as effective rainwater harvesting techniques, particularly suited to the district's clay soil belts. Farm pond models were introduced in 2012 by the district administration, NICRA, and other initiatives to help farmers capture rainwater during the northeast monsoon and provide supplemental irrigation during critical moisture stages. This study was conducted with the aim of assessing the impact of farm ponds on the livelihood security of farmers in the rainfed areas of Ramanathapuram district.

Methodology

Category of farmers

Farmers (50) of NICRA operational area was selected for study and categorized (10 each) as follows

T_1	:	Farmer before establishment of farm pond
T_2	:	Farmers having farm pond during Good year
T_3	:	Farmers having farm pond during Bad year
T_4	:	Farmers not having farm pond during Good year
T_5	:	Farmers not having farm pond during Bad year

The details of annual average rainfall received in Ramanathapuram district from 2009 to 2023 was considered for the study. The average rainfall of Ramanathapuram district is 827 mm. Rainfall analysis and Paired T- test were used for comparative study. The survey was conducted at Malangudi village of Ramanathapuram district. Year of 2015 was considered as period before farm pond establishment. 2021 year was considered as period of good year (+101mm), whereas 2022 was considered as period of bad year (-167 mm) after farm pond establishment. Number of year extremities, parameters on change in the area under cropping, change in the net income in agriculture and allied sectors, contribution of income from agriculture and other sectors, total net income and employment of farmers were studied in farmers holding having farm ponds during good and bad year and farmers are not having farm pond.

Results

Rainfall variability

The rainfall received during north east monsoon (NEM: Oct to Dec) is indicated that there was a deviation in quantity of rainfall distribution. The deviation indicates that, out of 15 years of NEM, 7 years recorded deficit of rainfall from 52 mm to 327 mm. The remaining period of 8 years recorded excess rainfall of 35 mm to 393 mm (Fig 1).

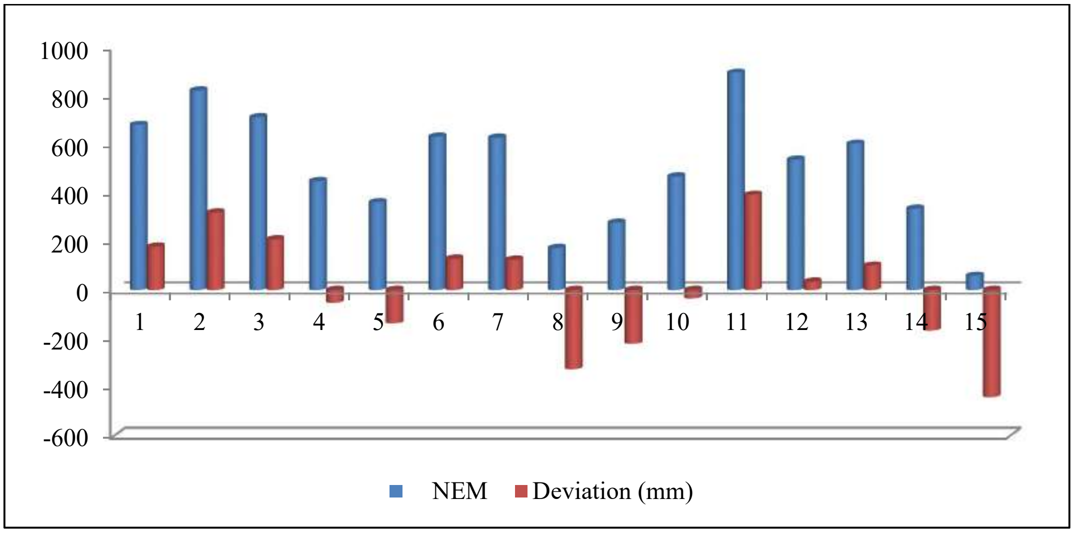

Fig 1. Extremities of rainfall in study area of Ramanathapuram district

Change in the annual net income

The total income of farmers with farm pond achieved the highest annual net income of Rs.11479 by the contribution of enhanced production of rice by changing the duration of rice from short duration to medium duration, increase in the milk yield and revenue from the sale of animal and efficient utilization of farm pond for fish rearing in farm pond with during good year. The difference of net income in farmer good and bad year in the category of farmers having farm pond and during good year and bad year is wider. The difference in net income of farmers is minimum irrespective of good or bad year under the category of farmers not having farm pond. Even under bad year, total net income is higher than the net income of farmers not having farm pond. The similar findings also reported by researchers (Owels and Hachum, 2006 and Ahmed *et al*., 2019).

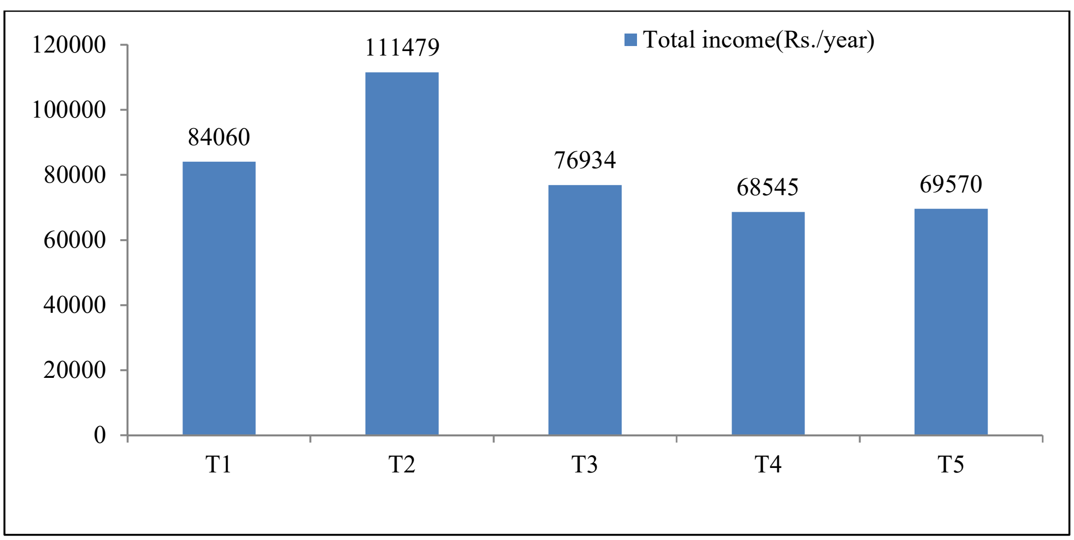

Fig 2. Total net income (Rs. /year) of each category of farmers

Among total income, animal husbandry enterprise contributed higher per cent in all the category of farmers. The net income difference is higher in cropping when compared to other enterprises by the influence of rainfall variability.

Conclusion

The result of the survey analysis indicates that construction of farm pond changed the cropping pattern of mono cropping to sequential cropping of rice. Comparison of farm pond with good year and bad year with and without farm pond beneficiary indicates that possible for additional area under cultivation, reduction in crop risk, additional income, short duration to medium duration rice, increase in higher number of filling, enhanced milk yield, increase in number of sale of animals, increase in total net income and employment opportunity by increase in man days. Establishment of farm pond under rainfed area is important to support for the maintenance of livelihood security with less risk of crop failure and also obtaining higher income through the contribution of cropping, animal husbandry and fisheries.

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UID: 1061

Crop Diversification through Inclusion of Mustard in Rice-Wheat System of Eastern Uttar Pradesh

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The rice-wheat rotation is the principal cropping system in south Asian countries that occupies about 13.5 million hectares in the Indo-Gangetic Plains (IGP), of which 10 million hectares are in India, 2.2 million hectares in Pakistan, 0.8 million hectares in Bangladesh and 0.5 million hectares in Nepal (Mahajan and Gupta, 2009). Continuous practice of cereal–cereal, especially the rice-wheat (R-W) system, has led to a decline in productivity and fertility status of soils in north-west India (Brar *et al.,* 2023). Indian agriculture is currently facing second-generation challenges, including declining water tables, nutrient imbalances, soil degradation, salinity, pest and disease resurgence, environmental pollution, and reduced farm profitability. Additionally, with globalization, Indian agriculture faces increased competition in the global market across various commodities. Among these, edible oilseeds are particularly significant, as the country faces a shortage of edible oils, leading to substantial expenditure on imports from overseas. Addressing these issues is critical to ensuring the sustainability and competitiveness of Indian agriculture. To overcome these shortcomings, crop diversification has been considered an important agriculture practice for improving agroecosystem productivity and lowering the carbon footprint (Harker *et al.,* 2009). Crop diversification could also improve the management of natural resources, such as soil, water, and solar radiation and space (Watson 2019). Diversifying cropping systems is essential to enhance oilseed production resiliency in a changing climate. With the aim of improving oilseeds production in Eastern part of Uttar Pradesh, KVK, Maharajganj conducted a field level demonstration (FLD) of high yielding variety of Indian Mustard on farmer's field.

Methodology

KVK plans to examine the effects of the adoption of mustard variety RH 749 along with the recommended dose of bentonite sulphur (25 kg ha^{-1}), on yields and economics of farmer in a two-year (*Rabi* 2022-23 and 2023-24) demonstration trial. The demonstration took place in three villages of Maharajganj viz. Karauta urf Nebuiya, Laxmipur Mahant of Ghughali block and Lendwa in Mithoura block where after harvesting of rice wheat is the major crop.

Sixty farmers from all three villages were selected for the study and randomly assigned a treatment and makes two sets of randomly selected farmers: those who received RH-749 seeds along with recommended dose of bentonite sulphur and those who did not. For making comparison, data from treatment farmers who received RH-749 and who did not receive were collected on mustard yields while economics was calculated by taking MSP as market price. For recording grain yield a 1 m^2 quadrates were used and a random sample from five places of each farmer's field were harvested. Data collected from five places of a plot were mixed and weight was weight in kg from 5 m^2 area and further converted to kg ha^{-1} by taking suitable conversion factor.

Results

Results show that grain yield of mustard was 16.9 and 18.1 q ha^{-1} which is 25.19 and 27.46% higher than farmers practice in 2022-23 and 2023-24 respectively. In terms of the economic benefits, gross return was 17170 and 21255 Rs. ha^{-1} and net return was 31.18 and 33.43% higher than farmers practice during 2022-23 and 2023-24 respectively. Bohra *et al*., also studied the diversification of Rice-wheat system and opined that mustard is a good option for wheat in rabi season to get more profit in terms of yield, economics and soil health as well. With the above findings, it might be concluded that adoption of high yielding variety of mustard is one of the promising options to replace some areas of wheat and help the country to achieve self-dependency in oilseeds production to fulfil the demands of our country's populations.

Table 1. Treatments detail.

Variables	Treatment (30 farmers)	Comparison (30 farmers)
	10 farmers from each village received 2 kg seed of RH-749 along with 10 kg bentonite sulphur for one acre of land.	10 farmers from each village who did not receive seed were followed making comparison.

Table 2. Effects of adoption of high yielding variety of mustard on grain yield and economics of farmers

Variables	2022		2023	
	Demo*	FP#	Demo	FP
Grain yield (kg ha^{-1})	1690	1350	1810	1420
Gross return (Rs. ha^{-1})	85345	68175	98645	77390
Net return (Rs. ha^{-1})	59865	45635	72105	54040
B-C ratio	2.34	2.02	2.72	2.31

*Demo= Demonstration, #FP= Farmers practices, mustard MSP Rs. 5050 for 2022-23 and 5450 for 2023-24.

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UID: 1105

Integrated Farming System for Sustainable Resource Management in Rainfed Condition of Vidarbha Region of Maharashtra

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In rainfed agriculture, the crop productivity was low due to degradation of natural resources, build up pests and diseases, this is further aggravated by climate change, market fluctuations, policy changes, which in turn increases distress among Indian farmers. In India, around 85 percent of the operational holdings are small and marginal, i.e. holdings of less than 2 ha. Due to increase in population, further fragmentation of land holdings is happening, and the operational size of holding has reduced from 1.84 ha to 1.08 ha during 1980 -81 to 2015-16. (GOI, 2015–2016). Small farmers could not afford farm investment from their own saving to transform traditional agriculture into modern scientific farming. In fact, the component and commodity–based research project for developing animal breed, farm implement and crop variety, mostly conducted in isolation and institution level (Behera *et al*., 2008) found inadequate in addressing the multifarious problem of small farmers (Jha, 2003). Due to such approaches, several ill effects have appeared in Indian farming, such as addressing factor productivity, resource-use efficiency and declining farm profitability and productivity.

To overcome the problems encountered by specialized, input driven agriculture, the integration of crops, livestock, and fishery components that sustain food and nutritional security with regular and periodic income to farmers is vital. The objective of the review was development of integrated farming system modules at local level by diversification of cropping system and different enterprises have been found successful to bring improvement in livelihood security, nutritional improvement, environmental safety and economic condition of small families.

Materials and Methods

The present experiment was carried out in 1 ha area at AICRP for Dryland Agriculture Research, Dr. PDKV Akola during 2023-2024. The location specific integrated field crops, horticultural crops livestock, kitchen garden and farm pond in different combinations were tried. To carry out this experiment, two farming systems were taken in which conventional cropping systems were compared with the IFS model. In the conventional cropping system, farmers adopted cropping systems such as cotton + pigeon Pea (6:1) and soybean - chickpea on 1 ha of area. The developed location specific Integrated rainfed farming system model (FS_2) comprising different components like crop (0.60 ha.) + Horticulture (0.15 ha.) + Alternate land use systems (0.15 ha.) + Livestock (0.03 ha.) + Compost (0.02 ha.) + Kitchen garden (0.02) + Farm pond (0.03 ha.) + Boundary plantation were considered.

Results

The perusal of data presented in Table showed that, Integrated farming system showed 2.708-time higher productivity over conventional system. Ravishankar *et. al*., (2007) and Jayanthi *et. al*., (2003) also reported similar findings. Cropping (0.60 ha) in IFS led to maximum net returns of ₹ 64395 followed by livestock components (₹ 58914). Net returns obtained from all the components were ₹ 147072 with 236 percent higher than conventional cropping. Also, IFS model generated 254 Man-day per year which was 285 percentage more than conventional system.

System productivity (q), GMR & NMR, (Rs.), B:C ratio and Mandays in conventional cropping system and IFS Model

Sr. No.	Treatment	SCEY (kg)	GMR (₹)	NMR (₹)	B:C	Man – days year^{-1}
1.	Crops alone	1780	129244	62203	1.92	89
2.	Integrated farming system Model					
A.	Cropping system					
a.	Cotton + Greengram					
b.	Soybean + Pigeonpeas					
c.	Green gram + foxtail millet - Chickpea + coriander	1773.2	121188	64395	2.16	56
d.	Soybean -Chickpea+ linseed					
A	Horticulture	126	12120	6878	2.31	16
C	Alternate land use system	167	11495	8710	1.48	22
D	Livestock	2548.4	148344	58914	1.74	142
E.	Kitchen garden	59	4100	1875	1.84	06
F.	Compost	102	7200	4900	2.6	08
G	Boundary Plantation	45	3000	1800	2.50	04
	Grand Total	4820.6	307447	147072	2.09	254

Conclusion

The integration of crops with horticulture, alternate land use systems and livestock resulted in higher system productivity, improved economics, and more employment generation compared to conventional systems. It benefited small holders for better living standards to secure livelihood security and achieve climate resilience.

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Intensification of Traditional Rainfed Integrated Farming System (IFS) for Small and Marginal Farm Holdings

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Integrated Farming System (IFS) is a sustainable system of agriculture where sequential linkages between two or more farming activities are utilized. IFS ensure maximum utilization of resources reduces risk of crop failure and provides additional income to farmers (Kumar & Ghosh, 2021). It can be recognized as a solution to the continuous increase of demand for food production, providing stability to the income and nutritional security particularly for the small and marginal farmers with limited resources. Hence, the situation calls for efforts to intensify the production in both time and space (Mamun *et al*., 2011). In traditional farming system, the small and marginal farmers generally included various agro components which are of low cost and input requiring in nature. Therefore, the present work has been planned to improve the existing IFS practices with proper combination of different enterprises in scientific ways with the following objectives:

Methodology

An on-farm trial was conducted at 24 nos. (Table 1) of both marginal and small farmer's field in four different villages under RIFs in three different modules by integrating improved technologies to assess the farm productivity, profitability by increasing diversification and resource integration. For assessment of different IFS modules, three modules viz. CLR (crop + large ruminant); CHLR (crop + hort + large ruminant) and CHLRSRPL (crop + hort + large ruminant + small ruminant + poultry) were accommodated in all the selected villages separately for small and marginal farmers. Data on household crop/livestock production, gross income were collected from farmers during 2021-21 & 2021-22 and presented in table 1 & 2 as mean of both the years.

Results and Discussion

The average data of two years of experiment (Table & Table) revealed that under rainfed situation, the RIFs module of CHLRSRPL involving the farmers of marginal and small category were found superior amongst the other modules of RIFs and categories of farmers with highest gross return of Rs.1, 34,999.60 and Rs. 2, 74,688.00 respectively from different components. Similar findings were also reported by Mukherjee (2013) & Vinodakumar *et al*., (2017). The performance of the module CHLRSRPL is superior over others may be due to the inclusion of a greater number of enterprises mainly horticultural and animal components which are more remunerative as compared to crop components. On the other hand, different land holding of small and marginal farmers also contributed in higher production and profitability of the superior IFS module.

Table 1. Performance of different IFS modules (Average of two years data i.e. 2020-21 & 2021-22)

	Farming System	Farm size (ha)	Crop Component Yield (q)		Horticulture Component yield	Animal Component (Nos)			
			Rice	Potato	Turmeric (q)/0.03 ha	LR	YS	SR	PL
Marginal Farmer	Traditional system	0.30	20.00	12.25	-	1		2	6
	CLR	0.734	41.43	18.37	-	3	1	-	-
	CHLR	0.295	12.00	74.73	7.45	2	1	-	-
	CHLRSRPL	0.875	33.99	19.20	7.70	2	1	2	8
Small Farmer	Traditional system	0.89	26.52	23.40	-	1		2	4
	CLR	1.033	58.94	84.87	-	3	1	-	-
	CHLR	1.066	45.72	31.01	7.60	5	2	-	-
	CHLRSRPL	1.631	72.95	48.21	7.55	6	2	8	8

Table 2. Economics of different IFS modules (Average of two years data i.e. 2020-21 & 2021-22)

Farming System	Income from crop (Rs/-)		Income from Horticulture (Rs/-)	Income from Livestock/Poultry /Rs/-			Gross farm income Rs/-
Marginal farmers							
Traditional System	40,800.00	12,250.00	-	5,000	7,000	3,900	68,950.00
CLR	84,517.20	18,370.00	-	6,000	-	-	1,08,887.20
CHLR	24,480.00	74,730.00	23,100.00	6,000	-	-	1,28,310.00
CHLRSRPL	**69,339.60**	**19,200.00**	**23,100.00**	**6,000**	**8.400**	**8,960**	**1,34,999.60**
Small farmers							
Traditional System	54,100.80	23,400.00	-	5,000	7.000	2.600	92,100.00
CLR	1,20,237.60	84,870.00	-	6,000	-	-	2,11,107.60
CHLR	93,268.80	31,010.00	23,100.00	12,000	-	-	1,59,378.80
CHLRSRPL	1,48,818.00	48,210.00	23,100.00	12,000	33.600	8.960	2,74,688.00

Conclusion

Data collected from the farmers during 2020-21 & 2021-22 revealed that, inclusion of horticulture and livestock components in existing system can increase the overall income of the participating farmers. The study shows that the module CHLRSRPL is the best module compared to other modules as it includes the integration of all the components together**.**

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UID: 1150

Enhancing Livelihood Diversification and Ecosystem Services with the Help of *Melia Dubia*

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Integrating trees with crops can satisfy local demands while simultaneously preserving the environment. Trees in farm lands have been known to increase farmers' socioeconomic standing, boost agricultural output, less soil erosion and enhanced fertility, and carbon sequestration to solve global warming issues. *Melia dubia* an emerging tree in the northern states of India has shown immense potential in present decade. It could be a great option for diversification of farming systems, enhancing farm income and simultaneously ecosystem services. Fast-growing trees are a need rather than a desire given the deteriorating environmental conditions. With its characteristic features this tree can tackle multiple issues the world is facing. *Melia dubia* fits ideally in integration with other crops because of its straight growing habits and least interference with the adjacent crops.

Methodology

Study was conducted in a four-year-old *Melia dubia* plantation planted at a spacing of 3 m × 3 m at village Gillan Khera in the district of Fatehabad in Western part of Haryana. In the interspaces of the trees, five wheat varieties were raised in four replication plots during Rabi season of 2018-19.

Tree species **-** Burma dek (*Melia dubia* Cav.), **Tree spacing --**3 m x 3 m

Varieties **-** Wheat WH 1105, WH 711, DBW 88, HD 3086 and HD 2967

Experimental Design – Randomised Block Design (RBD), **Replications** – 4

Treatments were also taken under control (Without trees).

Results

The different growth characteristics *viz.* fresh and dry matter accumulation and number of tillers were found higher in open conditions as compared to under *Melia dubia.* However, maximum number of days taken for spike emergence and maturity were recorded in intercropped conditions. Wheat variety DBW 88 took maximum number of days for 50% spike emergence and HD 2967 took maximum days to reach maturity. Minimum number of days for spike emergence and maturity were recorded in HD 3086 and WH 711 respectively. Among five wheat varieties HD 3086 was recorded with maximum number of effective tillers (107.3). Wheat variety WH 1105 was found with maximum number of grains per spike in intercropped and open condition. Test weight was recorded maximum in variety WH 711.

Conclusion

In contrast to the *Melia* plantation, the open condition yielded the highest values of several plant growth metrics, yield attributes, and wheat variety yield. In both conditions, wheat variety HD 3086 produced the maximum grain yield, followed by WH 1105 in second place. In conclusion the direct readings showed these parameters results better in open conditions owing to proper sunlight exposure of crop alike intercropped conditions where partial-shading effect was prominent. Results for wheat were better in open condition however, overall intercropped condition was found more beneficial as the reduction was compensated from the income generated from the *Melia dubia* trees at harvest.

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UID: 1162

Carbon Sequestration and Trade-Offs in Pearl Millet-Based Alternative Agriculture Systems for Climate Resilience in the Indo-Gangetic Plains

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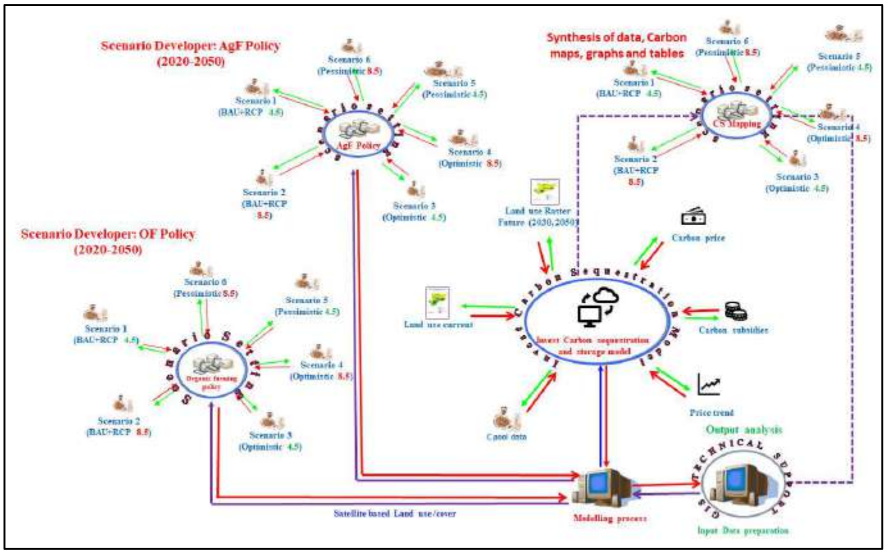
Challenges to achieving Sustainable Development Goals (SDGs) in agriculture arise from climate change, land degradation, low energy efficiency, and environmental impacts (IPCC, 2019). Sustainable alternative agriculture systems that ensure food security and reduce environmental harm are needed, especially in India, where balancing food-energy trade-offs is critical. Carbon sequestration through organic farming (OF) and agroforestry (AgF) has significant potential to mitigate climate change, improve soil health, and reduce greenhouse gas emissions. Studies demonstrate the effectiveness of OF and AgF in capturing atmospheric carbon, contributing to carbon neutrality. The proposed study explores carbon sequestration potential across various cropping systems in Uttar Pradesh under different climate scenarios, aligning with national and international climate goals, including India's Nationally Determined Contributions and the UN SDGs.

Methodology

The study focuses on Uttar Pradesh (UP), India's most populous state with a tropical monsoon climate. It spans 240,928 sq. km, with agriculture as the key occupation, contributing ~20% of India's total food grain production. Rainfall varies from 1700 mm in hilly areas to 840 mm in the west. Pearlmillet-wheat cropping system and integration of trees assessed under the alternative agriculture systems like organic farming and agroforestry in Aligarh district of Uttar Pradesh. The InVEST model estimates carbon storage and sequestration using spatial data and evaluates the economic value of carbon sequestration based on future scenarios under business as usual, optimistic and pessimistic scenario integrated with two climatic scenarios i.e. RCP 4.5 and 8.5. The amount of carbon sequestered, carbon price, discount rate, and price change over time, using $86 per metric ton for CO_2 equivalents.

In this study, six different land-use policies combined with two climate change scenarios (RCP 4.5 and RCP 8.5) for predicting carbon sequestration potential (CSP). The scenarios include Business as Usual (BaU), Optimistic, and Pessimistic policies. In BaU, organic farming expands by 10% per year, while agroforestry covers 10% of cropped land. In the Optimistic scenario, organic farming expands by 15% annually, with agroforestry covering 33% of the cropped area. Conversely, in the Pessimistic scenario, organic farming shrinks by 5% annually, with no change in agroforestry. These scenarios model CSP under medium (RCP 4.5) and high (RCP 8.5) emissions trajectories.



Methodology of the deliberated study (Adopted from Ansari et al., 2024)

Results

In Aligarh district, where the Pearl Millet-Wheat (P-W) cropping system predominates, significant changes in carbon stock (C-stock) and carbon sequestration potential (CSP) were observed under different climate and agriculture policy scenarios. For the baseline year 2020, the C-stock in Aligarh was estimated at 9.45 Mt. Under the "Business as Usual" (BaU) scenario with medium greenhouse gas emissions (RCP 4.5), C-stock increased slightly by 0.012 Mt for the year 2030 and 0.18 Mt by 2050, corresponding to an economic value increase of $3.62 million and $52.6 million, respectively. For the high-emission scenario (RCP 8.5), CSP increased by 0.002 Mt ($0.51 million) in 2030 and 0.16 Mt ($48.6 million) in 2050. The optimistic scenario, which assumed a 15% annual growth in organic farming and 33% agroforestry coverage, yielded the most substantial increases in CSP for Aligarh. For 2030, the CSP increased by 0.6 Mt ($184.9 million), while for 2050, it increased by 1.27 Mt ($380 million). Under a pessimistic policy, where organic farming shrinks by 5% annually, the C-stock decreased by 0.07 Mt in 2030 and 0.08 Mt in 2050, resulting in a loss of $21.2 million and $23.4 million, respectively.

The Pearl Millet-Wheat (P-W) cropping system in Aligarh demonstrated notable improvements in carbon sequestration under favourable policies. The adoption of organic farming and agroforestry in optimistic scenarios (S3 and S4) resulted in significantly higher CSP compared to the BaU and pessimistic policies (Ansari et al., 2024). The increase in CSP under the optimistic scenario highlights the benefits of integrating sustainable practices, contributing to both economic gains and climate mitigation efforts. However, the pessimistic scenario reflected the challenges of shrinking organic farming, with reduced CSP and economic returns. The results for Aligarh align with broader findings that prioritize organic and agroforestry practices for enhancing carbon sequestration potential. These findings emphasize the importance of policy support for sustainable agriculture to maximize carbon sequestration and mitigate the impacts of climate change in agricultural landscapes.

Conclusion

The study concludes that adopting nature-positive agricultural practices, such as organic farming (OF) and agroforestry (AgF), offers significant carbon sequestration potential. These practices could transform the agriculture sector into a carbon sink, contributing to climate change mitigation. The optimistic scenario, with a 15% annual increase in organic farming and 33% agroforestry coverage, offers the highest potential for carbon sequestration and economic benefits. However, challenges like standardizing carbon estimation methods, developing reliable baselines, and establishing fair carbon credit markets must be addressed to fully realize these benefits. Integrating these practices with global and national climate goals can support sustainable development.

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UID: 1182

Performance of Integrated Farming System models in Scarce rainfall zone under rainfed conditions

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Agriculture in semi-arid regions faces numerous challenges, primarily due to erratic rainfall, poor soil fertility, and limited water resources. In such areas, Integrated Farming Systems (IFS) can play a crucial role in enhancing farm productivity, ensuring food security, and improving the livelihoods of small and marginal farmers. The Anantapuramu district in Andhra Pradesh, India is characterized by its scarce rainfall and frequent droughts, making traditional farming practices often unsustainable and economically unviable. The traditional farming systems include crop cultivation integrated with small ruminants. This study is conducted with an objective to evaluate the performance of various IFS models under rainfed conditions and also to strengthen the traditional IFS models for small and marginal farmers focusing on improving productivity, economic returns, and employment generation

Methodology

On-Farm Research on Integrated Farming System was carried out during 2023-24 in Niluvurai village, Anantapuramu dt involving 7 modules like Natural Resource Management, Crop, Livestock, Perennial tree, Fodder, Optional (kitchen garden) and capacity building. Niluvurai village is located in Narpala mandal, Anantapuramu district of Andhra Pradesh. Soils of this village are shallow red sandy loams with low available nitrogen (167 kg/ha); medium available phosphorus (48 kg/ha) and potassium (294 kg/ha); deficient in micronutrients. Total rainfall of 480.5 mm was received from May to September against normal annual rainfall of 554.1 mm with an average of 96.1 mm with 26 rainy days. No rainfall was received from October. Crops and animals were raised by following improved management practices. Whereas, in existing farming system regular management practices were being followed. Yield of crops was calculated separately for each intervention and sheep by weight. Employment generation was calculated as 8 hours per day as one day. For economics, cost of inputs and outputs prevailing in the market were considered and calculated.

Results

For marginal farmers and small farmers the interventions resulted in a significant increase in yield, economics and employment generation. The additional benefits through IFS interventions were substantial, with Groundnut Equivalent Yield of 394 and 437 kg for marginal and small farmers, respectively. These findings align with literature suggesting that integrated farming systems, which combine multiple agricultural activities, optimize resource use and enhance productivity (Singh *et al.,* 2011). For marginal farmers' additional monitory benefit of Rs. 11277 with employment generation of 40 days were obtained with interventions. Whereas, for small farmers additional monitory benefit of Rs. 14335 with employment generation of 44 days were obtained This is consistent with findings by Soni *et al*. (2014), who reported that integrated farming systems improve farm income and sustainability in rainfed areas. The introduction of diverse farming activities within the IFS framework requires more labor, thus creating more employment opportunities. This is crucial for rural development and poverty alleviation, as noted by Reddy and Reddy (2017).

Yield and Economics of Integrated Farming System with and without interventions

Particulars	Area (ha)	Groundnut Equivalent Yield (kg)	Cost of production (Rs)	Net returns (Rs)	EG (man days)
Marginal farmers					
Integrated Farming System with interventions	0.9	2688	81985	87219	274
Integrated Farming System without interventions	0.9	2294	68462	75942	234
Additional Benefit with interventions		394		11277	40
Small farmers					
Integrated Farming System with interventions	1.4	3227	98785	106430	322
Integrated Farming System without interventions	1.4	2790	85320	92095	278
Additional Benefit with interventions		437		14335	44

Conclusion

In conclusion, the comprehensive approach in the farming system, incorporating advanced agronomic practices, effective water management, and diversification with livestock and perennial crops, has demonstrated significant improvements in productivity and economic returns.

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UID: 1198

Enhancing Agricultural Productivity and Sustainability through Climate-Resilient Practices in Rainfed Farming Systems

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Agricultural productivity and sustainability are significantly influenced by farming system typologies, particularly in rainfed systems. This study assessed the performance of climate-resilient interventions in rainfed farming systems with and without animal husbandry, focusing on their impact on yield and economic returns. Under the NICRA project, ICAR– KVK Chitradurga conducted demonstrations on intercropping groundnut with redgram (BRG-5) in Yalagatta village of Challakere taluk, Chitradurga, during 2023-24. Spanning 19 hectares and benefiting 38 farmers, the demonstrations showed remarkable Results. In rainfed systems without animal husbandry, the demonstration plot achieved a yield of 8 q/ha resulted in, a 12.67 per cent increase in yield over local practices (7.10 q/ha), with the highest gross returns (Rs. 48,000), net returns (Rs. 25,000), and a B:C ratio of 2.08. Similarly, in rainfed systems with animal husbandry, the demonstration plot recorded the highest yield (8.5 q/ha) compared to local practices (7.3 q/ha), along with gross returns of Rs. 52,000, net returns of Rs. 28,000 and a B:C ratio of 2.16. These Results underscore the potential of intercropping groundnut with redgram in combination with animal husbandry to enhance productivity and profitability in rainfed systems. The findings advocate for wider adoption of intercropping system which improves the sustainability and climate resilience of farming systems, especially in rainfed regions with diverse typologies.

UID: 1213

System Productivity and Soil Organic Carbon Relationship as Influenced by INM In Cotton+Greengram (1:1) Intercropping System

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Cotton (*Gossypium hirsutum* L.) is a major fibre crop of the semi-arid tropics grown in an area of 13.5 million hectares with a production of 36.5 million bales and productivity of 460 kg ha $^{-1}$ (COCPC, 2020). The central, western and some parts of the eastern Vidarbha are under this dryland agriculture zone. Cotton based cropping systems are most preferred cropping pattern in this region by the farming community to reduce the risk in agriculture. However, due to the erratic rainfall and rise in summer temperature, there is decline in standard yield potential of the crops. With the aim of maintenance of soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from organic plant nutrient sources available at farm level in the region, a fixed frame plot experiment with the combinations of organic and inorganic nutrient sources is being conducted in cotton + greengram (1:1) intercropping system on a Vertisol since 1987-88.

Methodology

The field experiment was conducted at research field of AICRP for Dryland Agriculture, Dr. PDKV, Akola (MS) during 1987-88 to 2023-24. The experiment was laid out in randomized block design (fixed site) with eight treatments and three replications. The treatments studied are

T_1: Control T_2: 100% RDF, T_3: 50% RDF, T_4: 50% N ha^{-1} through Gliricidia, T_5: 50% N ha^{-1} through FYM, T: 50% N through fertilizers + 50% N through gliricidia +100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers, T_7: 50% N through FYM + 50% N through fertilizers + 100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers, T_8: 100% N ha^{-1} gliricidia + 100% P_2O_5 + 100% K_2O ha^{-1} through fertilizers. The cotton and greengram were spaced at 60 x 30 and 60 x10 cm with varieties PDKV Suwarn Shubhra and Greengold, respectively.

Results

The pooled data (2010-2023) on yield of seed cotton, greengram and seed cotton equivalent yield in cotton+greengram intercropping system revealed that the significantly higher seed cotton, greengram and seed cotton equivalent yield was recorded with treatment 50% N through FYM + 50% N through fertilizers + 100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers.

Long-term integrated nutrient management with 50% N substitution through gliricidia or FYM significantly improved the soil quality. Further, significantly higher system productivity and sustainable yield index of cotton and greengram was observed under integrated nutrient management with 50% N substitution through gliricidia or farmyard manure, suggesting these two practices to be better options for the nutrient management in cotton + greengram intercropping system. These findings clearly indicate the necessity of using adequate nutrients in RD along with a partial substitution through organics under vertisols to sustain the performance of cotton and pulse intercropping systems. These findings are in confirmation with the findings of Nayak et al. (2012) and Yadav, Khokhar, and Yadav (2010).

Pooled yield 2010-2023 (Kg ha^{-1}) of cotton+greengram under (1:1) intercropping system

	Treatments	Seed cotton	Greengram	SCEY	OC (%)
T_1	Control	459.6	317.1	797.4	0.45
T_2	100% RDF	727.2	431.2	1185.9	0.65
T_3	50% RDF	610.3	384.7	1019.0	0.56
T_4	50% N ha^{-1} through gliricidia	559.0	358.8	942.7	0.60
T_5	50% N ha^{-1} through FYM	582.2	375.5	983.3	0.59
T_6	50% N through fertilizers + 50% N through gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers	845.7	469.9	1369.2	0.74
T_7	50% N through FYM + 50% N through fertilizers + 100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers	864.6	499.0	1396.4	0.72
T_8	100% N ha^{-1} gliricidia + 100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers	693.5	410.5	1133.2	0.71
	SE (m) ±	13.9	8.9	22.5	0.02
	CD at 5%	38.7	25.1	66.8	0.06

The highest 0.74 % soil organic carbon was recorded in treatment 50% N through fertilizers + 50% N through gliricidia + 100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers (T_6) followed by 0.72 % organic carbon content in 50% N through FYM + 50% N through fertilizers +100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers (T_7) and 100% N ha^{-1} through gliricidia + 100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers (T_8) which were found to be on par with each other. Further, the results of Dheri and Nazir (2021) and Faucon, Houben, and Lambers (2017) also support the findings of our study.

Conclusion

Long-term integrated nutrient management with application of 50% N through FYM + 50% N through fertilizers + 100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers(T_7), followed by application of 50% N through fertilizers + 50% N through gliricidia +100% P_2O_5+ 100% K_2O ha^{-1} through fertilizers(T_6) significantly had about 72 and 75% higher system productivity compared to control and 15 and 18% higher over 100% RDF with an increase in organic carbon status in soil.

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Integrated Farming System under Climate Resilient Agriculture for Livelihood Diversification for Risk Mitigation & Ecosystem Services through National Innovation on Climate Resilient Agriculture (NICRA) Project at Village Lagga, District Chamba (Himachal Pradesh)

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Agriculture in India is livelihood for a majority of the population and can never be under estimated. Although its contribution in the gross domestic product (GDP) has reduced to less than 20 per cent and contribution of other sectors increased at a faster rate, agricultural production has grown. This has made us self-sufficient and taken us from being a begging bowl for food after independence to a net exporter of agriculture and allied products.

Total food grain production in the country is estimated to be a record 291.95 million tonnes, according to the second advance estimates for 2019-20. This is news to be happy about but as per the estimates of Indian Council for Agricultural Research (ICAR), demand for foodgrain would increase to 345 million tonnes by 2030.

Increasing population, increasing average income and globalization effects in India will increase demand for quantity, quality and nutritious food, and variety of food. Therefore, pressure on decreasing available cultivable land to produce more quantity, variety and quality of food will keep on increasing.

India is blessed with large arable land with 15 agro-climatic zones as defined by ICAR, having almost all types of weather conditions, soil types and capable of growing a variety of crops. India is the top producer of milk, spices, pulses, tea, cashew and jute, and the second-largest producer of rice, wheat, oilseeds, fruits and vegetables, sugarcane and cotton.

In spite of all these facts, the average productivity of many crops in India is quite low. The country's population in the next decade is expected to become the largest in the world and providing food for them will be a very prime issue. Farmers are still not able to earn respectable earnings.

India's population touched 1.38 billion in 2020 which is 17.7 per cent of the world's population according to global population data. The country's population has increased 3.35 times since Independence; by 2027, it will surpass China to become the most populated country in the world.

And yet, India accounts for only 2.4 per cent of the global land. The average size of landholding per state is 1.08 hectares, according to the latest agricultural census. Farmers in half the Indian states are marginal (with land less than 1 ha); the remaining are small farmers (land holdings of 1-2 ha).

Most of them have been facing several major constraints such as input supply, credit availability, proper transport, and market facility, etc. Their share nearly 60 per cent in total food grain production: 49 per cent rice, 40 per cent wheat, 29 per cent coarse cereals and 27 per cent pulses as well as over half of the country's fruits and vegetable production, according to Agricultural Census 2015-16.

Agriculture is the primary source of livelihood for about 58 per cent of India's population. Other natural resource-based enterprises are also the foundation for the country's economic growth. Its related sectors, including field crops, horticulture, livestock, fishery and poultry are strongly associated with several United Nations Sustainable Development Goals (SDG) such as zero hunger, nutrition, and climate action, among others.

According to Union government estimates, India's food production was 291.95 MT in 2019-20; for 2020-21, the government had set the target up to 298.3 MT, which was two per cent from the previous year's output. Food production must double by 2050 to match the country's population and income growth. The small and marginal farmers, therefore, have a major role in the country's food security and meeting the SDG goals.

Nearly 14 per cent of the population (189.2 million) is still undernourished in India, according to State of Food Security and Nutrition in the World, 2020 report. The Global Hunger Index 2020 placed India at the 94th position among 107 countries. Achieving 'zero hunger' by 2030 is a humungous challenge, and needs an integrated and multi-dimensional approach for overall sustainable agriculture and food systems in the country.

Methodology

Lagga village in district Chamba lies in elevation ranging between 1528-2074 m (above msl), 32^{o} 33'N latitude and 76^{o}15'E longitude. The average rainfall is about 1100-1800 mm annually. During winters this area receives moderate to high snowfall. Earlier this area has single cropping system. Maize was the major crop of the area to meet their domestic requirements and farmers were very poor. But now maize, cabbage, cauliflower, apple, beans and potato are major crops grown in this area. Krishi Vigyan Kendra, Chamba has implemented National Innovation on Climate Resilient Agriculture (NICRA) project (2011-2024) in Lagga village of Chamba district of H.P. Water scarcity, drought, dry spell, delayed monsoon, cold waves and prolonged winter season are major climatic vulnerabilities of Lagga village. Runoff is common, drying of water bodies, stunted growth of crops, low yield, high incidences of insect-pests and diseases, fodder scarcity in winter and migration of small farmers are the consequences of these climatic vulnerabilities. To address these climatic vulnerabilities four interventions namely Natural

Resource Management, Crop Production, Livestock and Fishery and **Institutional Interventions** were carried out during this project period.

Results

Module I: Natural Resources Management

This module consists of interventions related to in-situ moisture conservation, water harvesting and recycling for supplemental irrigation, improved drainage in flood prone areas, conservation tillage where appropriate, artificial groundwater recharge and water saving irrigation methods. Under this intervention, 20 irrigation tanks of 10,000 liters capacity each are constructed in convergence mode with the department of Horticulture under HDP Project and SUVIDHA NGO, one irrigation scheme of worth rupees one crore was implemented by IPH department, one concrete check dam of capacity 2000 liters capacity, one community pond was constructed and six defunct Bauri/Bawari was renovated. 100 micro-irrigation sets have been given to the farmers to reduce the wastage of water. More than hundred farmers have been given mulching sheets to conserve moisture and control weed growth. All the families of NICRA village have Soil health cards.

Module II: Crop Production

This module consists of introducing drought/temperature tolerant varieties, advancement of planting dates of rabi crops in areas with terminal heat stress, water-saving paddy cultivation methods (SRI, aerobic, direct seeding), frost management in horticulture through fumigation, community nurseries for delayed monsoon, custom hiring centers for timely planting, location-specific inter-cropping systems with high sustainable yield index.

Integrated Farming System Module

IFS module was started in NICRA village in the year 2015-2016 to enhance the farm income of marginal and small landholding farmers against extreme weather conditions viz. cold and frost. Dependency on a single farm enterprise sometimes may not work adequately or fails. An IF involves more than one crop in a limited area in which residue of one is used as input for another enterprise to minimize the cost of cultivation and to get the sustainable yield. Components of integrated modules are fruit crops (apple), vegetable crops (cabbage, cauliflower, potato), Poly-houses (protected cultivation of capsicum, tomato and cucumber), Vermicompost (earthworms are used for compost preparation), Dairy (milk, meat, cow dung).

Protected cultivation

Protected cultivation has significantly helped the farmers in reducing dependency on rainfall and efficient utilization of land and water resources. Under protected cultivation, the construction of poly-house in the village started in the year 2011 onwards for the betterment of the farmers. Only 0.02 ha area was covered by protected cultivation in the year 2013-2014 with 2 poly-houses. In 2015, 0.03 ha area was under this and increased by 0.13 ha in 2016. At present, there are 127 numbers of poly-houses in the 1.8 ha area and more will be coming soon. Green capsicum, colored capsicum, tomato, cherry tomato, tomato and cucumber cultivation was taken up in the poly-houses with the support of a micro-irrigation system (Drip irrigation system). The average yield of capsicum under protected cultivation was realized up to 545 Q/ha with 3.28 BCR.

Crop diversification

Cauliflower: The demonstration on crop diversification with cauliflower was conducted over the past few years in NICRA village. In 2012, only 1.8 ha area has covered this intervention which is increased by about 59.5 ha in 2024.

Cabbage: Cabbage has demonstrated over 2.5 ha area in 2012 indicated the adoption of successful intervention of inter-cropping in the orchard. In 2024, 46.0 ha of area was under this crop.

Apple: Demonstration on crop diversification with the introduction of spur type variety of apple was successfully conducted over an area of 1.25 ha with twenty numbers of farmers in the year 2011. Before NICRA, only 5.12 ha area was under apple cultivation but after NICRA, the area increased tremendously. At present, the total area under apple cultivation in NICRA village is 35 ha and more farmers are interested in growing apples in their orchards.

High-Density Apple Plantation

Total 50 farmers including Progressive farmers like Dharo Ram, Sanjeev Kumar, Kavinder Thakur, Subhash Thakur, Mohinder Kumar, Narad Ram, Ram Singh, and Hem Chand have started high-density apple plantations. It was started by our Progressive farmer Dharo Ram initially in the year 2019. He has started earning money from this high-density plantation in the year 2020. In the year 2024, he earned ₹ 18 lakh from 4.5 Bigha land likewise Sanjeev Kumar earned ₹ 14 lakh form different interventions. At present 10 ha area is under high-density plantation.

Module III: Livestock and Fisheries

Use of community lands for fodder production during droughts/floods, improved fodder/feed storage methods, preventive vaccination, improved shelters for reducing heat stress in livestock, management of fish ponds/tanks during water scarcity and excess water, etc. Under this intervention cent percent vaccination of livestock against foot and mouth disease was carried out in convergence mode with the department of Animal Husbandry and a special insemination drive was carried out to upgrade local breeds of cows to Red Sindhi and Sahiwal breeds. To improve the health and milk production of cow's special mineral mixture, mineral blocks and power bolus have been distributed to the farmers of NICRA projects from time to time. To improve soil fertility and to increase the availability of green fodder white clover is introduced in apple orchards.

Module IV: Institutional Interventions

This module consists of institutional interventions either by strengthening the existing ones or initiating new ones relating to the seed bank, fodder bank, commodity groups, custom hiring centre collective marketing, the introduction of weather index-based insurance, and climate literacy through a village level weather station. Under this intervention, more than 250 awareness and training programs have been conducted during the project period. Two exposure visits of farmers were also conducted to know different new techniques and practices adopted by progressive farmers of other districts of the state. More than 50 important days have been celebrated.

Conclusion

One of the critical challenges for a country's food security is climate change and its impact in form of extreme weather events. The predicted 1-2.5 degrees Celsius temperature rise by 2030 is likely to show serious effects on crop yields. High temperatures may reduce crop duration, permit changes in photosynthesis, escalate crop respiration rates and influence pest population.

To grow cash crops more than 127 poly-houses have been constructed, spur type apple has been introduced on about 35 hectares of the area in the village, intercropping (Apple+Cabbage/Cauliflower) is also one of the major and successful interventions in the NICRA village, crop diversification with cauliflower is about 59.5 ha, crop diversification with cabbage is about 46.0 ha. Livestock rearing, goatry and poultry are the integral parts of the integrated farming system practiced by farmers of NICRA village.

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Assessing the Contribution of Diverse Ecosystem Services on Livelihoods of Local Inhabitants of Indian Sundarbans

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Sundarbans, the UNESCO World Heritage site, is the largest contiguous mangrove forest on earth. The confluence of several rivers, namely the Ganges, Brahmaputra, and Meghna created this dynamic ecosystem, which support for millions of peoples. Named after the "Sundari" (*Heritiera fomes*) trees that is seen here predominantly, the Sundarbans mangrove forest covers an area of about 10,000 km^2. Out of this 10,000 km^2, 38% (3800 km^2) is situated in India (Ghosh et al., 2015). Due to the ecological, economic and social importance of this mangrove forest, a vivid research study on mangrove ecosystem is the priority area. Mangrove forests can absorb about 100 tonnes of carbon per hectare, which is more than three times the capacity of non-mangrove forests, making them extremely effective carbon sinks in the global scale (Austin et al., 2020). Considering the brief background the objective set for the study is to assess the contribution of Sundarbans diverse ecosystem services on livelihoods of local.

One survey was conducted comprising of 110 respondents to assess the various contributions of these ecosystems to the livelihoods of the inhabitants of Sunderbans. Nine spatially distributed villages, namely Bongheri, East Gopalganj, Deulbari, Binodpur, Amlamethi, Satyanarayanpur, Mathurakhand, Vivekananda Palli and Second-scheme village were considered for the survey. The respondents from each village belong to different occupational classes and income categories and their level of dependence on forest products also varies from region to region. That's why a stratified random sampling technique was used to select the respondents. A comprehensive household survey was undertaken to gather data on the diverse array of direct (provisioning) and indirect (regulating) benefits derived from the mangrove ecosystem of Indian Sundarbans.

The study focused on assessing the contribution of Ecosystem Services (ES) to the annual household income in the Indian Sundarbans region. The highest reliance on ES was observed in villages like Amlamethi, Satyanarayanpur, Mathurakhand, Vivekananda Palli, and Second-scheme of Gosaba, as well as Basanti block, where ES constituted 100% of the household income. This highlights the dominance of ecosystem services as the sole income source in these communities, thus the local people depend on surrounding environment. East Gopalganj exhibited a substantial contribution of 60.87% from ES; Bongheri and Deulbari villages depended on ES to a lesser extent, with contributions of 20.24% and 18.64% respectively. The results revealed that the contribution of ES to the total annual household income vary between Rs. 17,333.00 to Rs. 43,000.00 across the surveyed villages.

The ranking of different provisioning ecosystem services (PS) and regulatory ecosystem services (RES) were assessed. It was observed that among different PS, the river transportation is the most important, with a weighted mean of 3.71 in the 0 to 5 scale. Freshwater ranked as the second most important provisioning service, with a weighted mean of 3.24. The other important PS are food and fibre, fuel, natural medicine and genetic resources. The important RES of the study region are erosion control, soil retention, water regulation and gas regulation, nutrient regulation and pollination and climate regulation.

Thus, the paper has highlighted the perceptions and priorities of local communities of Indian Sundarbans region regarding the ranking and contribution of ecosystem services. It can be concluded that the local community heavily relies on various ecosystem services and food, river transportation, fresh water, and fibre represented the most valued ES component.

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Climate Resilient Technologies for Livelihood Security and Reduction of GHGs Emissions in Sundarban, India

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The lowland rainfed ecology of Sundarban is primarily characterized by rice cultivation during the *kharif* season, relying on monsoonal rainfall. The major challenges in this region include impeded drainage, imbalanced fertilizer application, and the lack of appropriate stress-tolerant rice varieties. Majority of cultivated area remains fallow during *rabi* season due to lack of irrigation facilities. Therefore, technological intervention and capacity building of the farmers of Sundarban are necessary for better livelihood. Besides this, lowland rainfed rice ecology also contributes to methane (CH_4) and nitrous oxide (N_2O) emissions (the important greenhouse gases (GHGs)) which contribute to global warming. Specifically, rice contributes to greenhouse gas emissions, accounting for about 30% of global methane and 11% of nitrous oxide emissions

(Husain et al. 2015; IPCC 2022). Thus, the reduction of GHGs emissions is of prime importance in climate change mitigation. To address these issues, four key climate-resilient technologies were validated: (i) introduction of submergence-tolerant rice variety, *Swarna Sub-1*, (ii) real-time nitrogen (N) management using a Customized Leaf Colour Chart (CLCC), (iii) establishment of an improved drainage practices and (iv) the use of methanotroph formulation. The vulnerable rainfed rice ecology of Sundarban needs a holistic package of climate-resilient practices for sustainable livelihood security and climate change mitigation.

Methodology

We have conducted field experiments at rainfed lowland rice ecology in three different islands (Dayapur Island, Bali Island & Maipit Island) of Sundarban, West Bengal during *kharif* season 2022-2023. A comparative analysis was done among the traditional farmer practices (FP) with various climate-resilient technologies (CRT) among different location sites (Table 1). Each site was divided into blocks to compare; Farmer's Practice (FP) as the control and climate-resilient interventions, including a combination of rainwater harvesting & improved drainage; real-time nutrient management, use of climate-resilient varieties; and methanotroph formulations. The yield (t ha^{-1}) and GHGs {methane (CH_4), nitrous oxide (N_2O)} emissions were estimated under the different climate-resilient technologies (CRT).

Table 1. Treatment details

Experimental Sites	Treatments
Sundarban, India (Rainfed ecology)	
Dayapur Island	Farmers Practice (FP)
	Rain water harvesting for supplemental (2) irrigation, Customized leaf colour chart (CLCC) based N application, climate resilient rice variety (Swarna sub-1)
Bali Island	Farmers Practice (FP)
	Rain water harvesting for supplemental (1) irrigation, double transplanting and climate resilient rice variety (Swarna sub-1)
Maipit Island	Farmers Practice (FP)
	Recommended Dose of Fertilizer (RDF) (80:40:30) kg/ha + Methanotrophs (methane oxidising bacteria; Dose: 1kg/ acre; solid based formulation)

Results

The adoption of climate-resilient technologies led to significant improvements in yield across the study sites compared to traditional farmer practices (FP). Dayapur Island (West Bengal) marked a 19% increase in yield from 4.67 t ha^{-1} in FP to 5.56 t ha^{-1} in CRT. The similar trend was found in Bali Island (yield increased from 5.28 t ha^{-1} FP to 6.12 t ha^{-1} in CRT) reflecting a 16% improvement and in Maipit Island (increased yields from 6.53 t ha^{-1} FP to 6.75 t ha^{-1} CRT) also.

The methane emissions were consistently lower in CRT treatments employing climate-resilient practices than the Farmers' practice at all the sites of rainfed ecology. The CH_4 reduction percentage was 12-13.5% in the field treated with different climate-resilient technologies over the FP. The GHGs (CH_4 and N_2O) emissions were reduced in the field treated with climate-resilient technologies at the experimental sites of lowland rainfed ecology. A substantial reduction in GWP were observed, in Dayapur Island, where GWP decreased from 868 kg CO_2-eq ha^{-1} (FP) to 655 kg CO_2-eq ha^{-1} (24.5%) due to the interventions of CRT (Rain water harvesting for supplemental irrigation, CLCC based N application and climate resilient rice variety). Similarly, there are 34.4 % reduction in GWP due to the interventions of RDF (80:40:30) with methanotrophs applications in Maipit Island, Sundarban.

Table 2. Crop yield, GHGs emission and GWP at different site after treatment imposition

Sl No	Experimental site	Cropping Pattern	Climate Resilient technologies	Variety	Yield (t ha^{-1})	GHGs emissions		
						CH_4 (kg ha^{-1})	N_2O (kg ha^{-1})	GWP (kg CO_2-eq ha^{-1})
West Bengal, Sundarban, India (Rainfed Ecology)								
1	Dayapur Island	Rice-Fallow	Farmer's practice (FP)	Swarna Sub-1	4.67±0.2	37	0.7	868
2	Bali Island	Rice-Fallow	Farmer's practice (FP)	CR 1009 Sub-1	5.28±0.12	40	0.9	1248
3	Dayapur Island	Rice-Fallow	Rain water harvesting for irrigation, CLCC based N application, climate resilient rice variety	Swarna Sub-1	5.56±0.18	32	0.6	655
4	Bali Island	Rice-Fallow	Rain water harvesting for irrigation, double transplanting and climate resilient rice variety	CR 1009 Sub-1	6.12±0.3	35	0.6	1058
5	Maipit Island	Rice-Fallow	Farmer's practice (FP)	Sonachur	6.53±0.42	52.5	0.7	1365
6	Maipit Island	Rice-Fallow	RDF (80:40:30) + Methanotrophs	Sonachur	6.75±0.37	45.6	0.6	896

Conclusion

The integration of climate-resilient technologies in lowland rainfed rice ecology of Sundarban significantly increase yields and reduced greenhouse gas emissions. Key findings include:

1. Yield Improvements: The adoption of submergence-tolerant rice varieties, efficient nutrient management, and improved water management increased yields by 15–20% in three locations.

2. GHG Mitigation: Methane and nitrous oxide emissions, as well as the overall GWP, were notably reduced, highlighting the potential for climate-resilient practices to mitigate climate change.
3. Livelihood Security: These technologies offer a holistic approach for addressing the dual challenge of sustainable yield and environmental conservation in climate-vulnerable areas.

This study underscores the importance of transitioning to climate-resilient agricultural practices for enhancing productivity while minimizing environmental impacts. The results provide a pathway for scaling up these practices to other rainfed and flood-prone ecologies.

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Crop Diversification a Way Towards Risk Minimization in Agriculture

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In India, traditional agriculture aimed at increasing the production through two dimensions viz expanding the cultivated area and increasing the productivity per unit area the crop. The modern agriculture stresses the efficient use of available resources and thus there is need of hour to utilize the resources within a given time by raising two or more crops simultaneously by exploiting the space more effectively by planting crops of varying architecture. These practices not only minimize the risk of failure of the crop in the changing environmental condition but also provide the sustainability of income in present-day agriculture. The human population, as well as cattle population is increasing day by day and there is greater demand for the agriculture produce and fodders. In India, farmers are exposed to different kinds of risk from rainfall variability, heat and cold stress, market price fluctuations, credit uncertainty and adoption of new technology and many more which leads to crop failure or very low produce. The risk of crop failure can be minimized to some extent by adopting crop diversification and intercropping in diversified from, which is a good crop cultivation practice recognized in India.

Agriculture diversification aims to reduce inputs of energy and agrochemicals in order to mitigate the negative impact of intensive agriculture on soil quality, water pollution and eutrophication, emission of greenhouse gases, soil erosion, and biodiversity loss. If coupled with sustainable soil management strategies such as adopting cover crop, conservation agriculture, organic farming, and fertilization management, agricultural diversification could also contribute to stable yields, profitability, and make agroecosystem more resilient to climate change, environmental risks, and socio-economic shocks (Francaviglia, *et. al.* 2022).

High demand for land for non- agricultural sector limits the possibility for further expansion of land for cultivation. Besides, the productivity of most of the crop is low in the country, and there is a huge scope to raise the productivity to enable doubling the farmers income. Even within the country, there is huge yield variation of different crops among the states. Keeping the above facts in view field demonstrations of crop diversification were conducted with the objective to find out the best combination for crop diversification in changing climatic condition and to find out economics of diversified crop and traditional crop replacement.

Methodology

The field demonstration on crop diversification during the Kharif season of 2022 and 2023 were conducted under TDC NICRA project of the districts. The rainfall data of the demonstration districts West champaran I, Darbhanga, Nalanda, Godda and Garhwa are presented in the table 1. On the basis of the rainfall received the crop diversification programme were taken. On crop diversification main focus was on converting the paddy area in to the other crops like turmeric, green gram, okra, ragi and elephant foot yam during 2022 and 2023 in the selected farmers. Some of the farmers pre-assumed that the year 2022 and 2023 where the normal year respect of rainfall and number of rainy days and there will not be dry spell during crop growing stage. The selection of crop and verities in the crop diversification were on the basis of VCRMC (village climate risk management committee) and this committee decide the farmers and area to be taken under a particular crop. Under the TDC-NICRA the study is focused on farming system (FST) typology of the village based on the Data on crop yield, percent increase and decrease on yield and economics of the cultivation (gross cost, gross return, net profit and B:C ratio) were calculated of the demonstration plot and the final value has been converted for a 1hectare in rupees. The sale price of the produced is based on MSP/wholesale market rate of the crop. The demonstration during 2022 was conducted in 44.09 ha involving 187 farmers and 2023 was conducted in 29.45 ha covering 106 farmers.

Table 1: Rainfall data of the districts during 2022 and 2023

KVKs districts	Rainfall (mm)			Dry spell during monsoon season				No of rainy days > 60mm rainfall	
	Normal	Received 2022	Received 2023	2022 15 days	2022 20 days	2023 15 days	2023 20 days	2022	2023
West Champaran I	1472	1380	1245.1	01				01	06
Darbhanga	1142	389	1245.1	01					01
Nalanda	977	753	716.2	01			01	01	01
Godda	1094	636	1108.8	01					02
Garhwa	1078	666	816	01		02	01	01	02

Results

Agricultural crop diversification is an important stress relieving option for the economic growth of the farming communities. Crop diversification refers to the addition of new crop or cropping system to agricultural production on a particular farm taking into account the different returns from value added crops with complementary marketing opportunities. Crop diversification and inclusion of the new varieties can be some of the important technologies in increasing farmers income. In the present study, crop diversification aims to replace the paddy growing area by incorporating of suitable crops of the season as well as varieties. Data from Table 1 reveals that during 2022 monsoon season deficit rainfall from 45 to 65 % in the district under the study in comparison to normal rainfall. In such situation climate resilient crops like ragi, turmeric, okra and green gram has been grown in which 2.74 to 19.64 % yield enhancement in the demonstration plot over farmer practices has been recorded (Table 2). Highest B:C ratio 2.21 has been recorded in the case of turmeric var. Rajendra Sonia followed by 2.16 in case of green gram var. Virat under West Champaran I condition. The year 2022 was a drought year and in less moisture available condition only climate resilient crop can be grown successfully. Kumar *et. al* 2014 reported that turmeric and other tuber crops grown under the litchi orchard successfully as a climate resilient crop. Ragi, a known climate resilient crop has been taken 10 ha area and yielded 12.4 q/ha apart from the fodder in Garhwa district where a dry spell of 15 to 20 days also experienced. Year 2023 some parts of Bihar and Jharkhand received normal rainfall while majorities of the district have the scanty rainfall. The districts like Nalanda, Garhwa and Godda received up to 70% of the rainfall with 1 dry spell of 20 days coupled with one or two occasions of rainfall of 60 mm or more in a day. In a such type of situation crop diversification with climate resilient crop is highly beneficial and districts like Nalanda, West Champaran I yield enhancement up to 10.76 % in green gram and 2.47 % okra has been recorded table 3. In case of turmeric and elephant foot yam decease in yield about 7% from farmer practices has been recorded is due to the late sowing of the crop and heavy rainfall in one instance that made the condition unfavorable. However, it was a profitable crop diversification in comparison to those farmers who left the field fallow for cultivating the late rice. Crop diversification has been advocated by Khanam *et.al* 2018; Basantaray *et. al* 2024.

Conclusion

Crop diversification provide better condition for food security and enable farmers to grow surplus product for sale at market and thus help to obtained increased income to meet other needs related to household wellbeing. Crop diversification can enable farmers to gain access to national and international market with new products, food and medicinal plants. Diversifying from the monoculture of traditional staples can have important nutritional benefits for farmers in developing country and can support a country in becoming more self-reliant in terms of food production.

Table2: Cop diversification replacing paddy during 2022 in the NICRA adopted village

Name of KVKs	FST type	Crop (name)	Variety	No. of farmers	Area (ha)	Yield (q/ha)		% Increase in yield	Economics of demonstration (Rs/ha)		
						Demo	FP		Gross Cost	Net Return	BCR
West Champaran I	FST3/FST4	Okra	Pusa-5	16	0.10	150	146	2.74	41500	68500	1.65
West Champaran I	FST3/FST4	Turmeric	R. Sonia	12	0.40	163	148	10.14	42722	94000	2.21
	FST3/FST4	Green gram	Virat	12	0.40	13.4	11.2	19.64	24510	52990	2.16
Darbhanga	FST 4			122	33.19	9.57	8.11	18.00	16300	28865	1.77
Garhwa	FST1 & FST2	Ragi	BM-03	25	10.00	12.4	10.6	16.98	30600	13690	1.45
Total				187	44.09						

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Rainfed Rice to Sustain Productivity and Climate Change Mitigation

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Rainfed ecosystems are indispensable for maintaining livelihoods, biodiversity and agriculture in India. These regions covering more than 60% i.e., 67 Mha of the nation's net sown area, rely on monsoon rains for their water needs. Millions of farmers depend on rainfed areas, especially in arid and semi-arid regions, despite unpredictable rainfall and degraded soil. Rainfed ecosystems ensure food security by producing a significant amount of crops, such as rice, oilseeds, coarse grains and pulses. Cultivating rice in rainfed areas is essential for meeting growing food demand of the burgeoning population. Around 40% of rice in India is cultivated in rainfed regions, of which 23% are upland and 77% are lowland. Rice also contributes around 4–6% of anthropogenic methane emissions. So, sustainable management practices like integrated nutrient management, crop residue retention, crop rotation with legumes, and site specific nutrient management are crucial to increase rice productivity and climate change mitigation. Therefore, we compared specific climate resilient technologies for rainfed rice systems to judge their potential to sustain productivity, soil health and mitigate climate change.

Methodology

Data on yield, indicators of soil health and sustainability, carbon sequestration, and global warming potential of rice-based systems in rainfed regions of India were collected through a comprehensive literature search, focusing on recent peer-reviewed articles published between 2015- 2024. The search was conducted using various combinations of keywords, including "Rice", "Rainfed", "Methane", "Carbon sequestration", "Sustainable", "GWP", and "climate resilient". Five climate resilient technologies (SSNM, conservation tillage, crop rotation with legumes, integrated nutrient management, crop residue incorporation) in rainfed rice were compared representing three primary climates (tropical, subtropical, semi-arid zones) and four important soil textural classes (loam, sandy loam, clay loam & silt loam).

Results

The adoption of climate-resilient technologies in rainfed rice systems led to significant improvements in yield, sustainability indicators, carbon sequestration and reductions in methane emissions in the studied sites. Rice+cowpea (fodder) system in Phulbani, Odisha, with sandy loam soil texture, resulted in enhanced nutrient uptake and better energy use efficiency (3.5) with integrated FYM + fertilizer management. Under the same soil textural class in Tripura with no-till practice and legume introduction, i.e., rice-lentil produced lower GWP (7.9 CO_2-eq Mg/ha/yr) and GHGI (0.9 kg CO_2-eq/kg rice equivalent yield) compared to other cropping system. The rice-fallow system in Arunachal Pradesh, with INM practice, gave 3.5t ha^{-1} rice grain yield. However, the same rice-fallow in Assam with similar soil texture (sandy loam), when applied NPK + azolla compost, led to lower cumulative CH_4 emissions (18.3 ± 0.4 kg ha^{-1}) and significant carbon storage (28.1 Mg C/ha). In heavy textured saline soil of Central Soil Salinity Research Institute, West Bengal, crop residue retention in rice- maize system, led to increase in soil organic carbon content from 0.4% to 0.5%. Rice- fallow system in Banda, Uttar Pradesh with clay loam soil, showed a positive impact on rice grain yield by using Leaf Colour Chart and Rice Crop Manager. It recorded 51% higher N recovery efficiency along with lower emission (1kg CO_2-eq/kg grain). Similar results were exhibited in Burdwan, West Bengal, where rice- fallow cultivated in silt loam soil with zero tillage produced fewer emissions (2.5t CO_2-eq ha^{-1}) and also stored carbon in the range of 38.8– 62.0 t CO_2-eq ha^{-1}. Rice-mustard-green gram-jute system in Barackpore stored 0.6Mg C/ha/yr. Crop rotation with legumes significantly increased system productivity (11.9 Mg/ha) and sustainability index (0.8).

Table 1: List of climate-resilient technologies, indicators of sustainability, carbon sequestration and emissions in rice-based cropping systems in rainfed areas

Sl. No.	Cropping system	Experimental site and details	Climate resilient technologies	Indicator of soil health/ sustainability	C-sequestration/ C-storage	GWP/ GHGI/ CH_4 emission	References
01	Rice + cowpea (fodder)	**Location:** Research Farm of AICRPDA, Phulbani, Odisha **Climate:** Sub-tropical hot-humid **Soil texture:** Sandy loam	Integrated application of FYM (5 t ha^{-1}) and fertilizer (50% RDF)	Enhanced nutrient uptake; energy use efficiency (3.5); rice equivalent yield (energy) of 2999 kg ha^{-1}	-	-	Bastia et al., 2021
02	Rice-lentil	**Location:** Tripura **Climate:** Tropical warm humid **Soil texture:** Sandy loam	Legume introduction under no-till	Low energy input (22,486 MJ/ha); high energy and system productivity	-	GHGI: 0.9 kg CO_2-eq/kg rice equivalent yield; GWP: 7.9 CO_2-eq Mg/ha.yr	Yadav et al., 2017
03	Rice-fallow	**Location:** Banda, U.P **Climate:** Semi-arid **Soil texture:** Clay loam	Site specific nutrient management using Leaf Colour Chart & 'Rice Crop Manager'	Positive effect on yield: IRRI-LCC (4.8 and 5.1 t ha^{-1}) and PAU-LCC (5.0 and 5.1 t ha^{-1}); 51% higher N recovery efficiency	-	1 kg CO_2-eq emission kg^{-1} grain	Suman et al., 2024
04	Rice-maize	**Location:** ICAR-CSSRI, RRS, West Bengal **Climate:** Tropical wet and dry	Crop residue retention	Organic carbon increased from 0.4% to 0.5%; 14.6% increase in rice yield (3.7-7.3	-	-	Sarangi et al., 2020

		Soil texture: Heavy textured		t/ha); 41% reduction in soil salinity (from 3.64 to 2.15 dS m^{-1})			
05	Upland rice-fallow	**Location:** KVK, Tirap, Arunachal Pradesh **Climate:** Subtropical humid **Soil texture:** Sandy loam	Integrated nutrient management (75% RDN through FYM + 25% RDF)	Grain yield(3358–3418 kg ha^{-1})	-	-	Borah et al., 2016
06	Rice-fallow	**Location:** CRSMF, Burdwan, West Bengal **Climate:** Tropical humid **Soil texture:** Silty loam	Zero tillage	Grain yield:12.3 t ha^{-1}	38.8-62.0t CO_2-eq ha^{-1}	GWP: 1.4 tCO_2-eq $ha^{-}1$; low methane emissions-2.5 tCO_2-eq ha^{-1}	Gangopadhyay et al.,2022
07	Rice-fallow	**Location:** Assam **Climate:** Subtropical monsoon **Soil texture:** Sandy loam	NPK + azolla compost	Total organic carbon 16.9 ± 0.4g kg^{-1} ; grain yield= 6.5 Mg ha^{-1}	28.1 Mg C ha^{-1}	GWP: 625.2 ± 13.0 kg CO_2 ha^{-1}; low cumulative CH_4 emission: (18.4 ± 0.4 kg ha^{-1})	Bharali et al., 2018
08	Rice-mustard-green gram-jute	**Location:** CRIJAF, Barrackpore, West Bengal **Climate:** Tropical humid **Soil texture:** Loam	Crop rotation with legumes	Higher sustainability index (0.8); total organic carbon 3.3 Mg/ha (0-15cm); system productivity: 11.9 Mg/ha	0.6Mg /ha/year	-	Kumar et al., 2023

Conclusion

The study compared five specific climate-resilient technologies of rainfed rice system to assess their potential to sustain rice yield and mitigate climate change. Among three major rice-based cropping systems studied, rice-legume is opted first as these are having the higher potential to produce better yield involving less energy input and emitting lower CH_4 emissions. It also resulted in build-up of soil organic carbon which could improve the system productivity. Furthermore, for better results, SSNM tools could be integrated to optimize nutrient management in rice and reduce excess fertilizer use. Implementation of these practices in rainfed rice holds the promise of bringing environmental sustainability and climate resilience.

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Impact of climate resilient technologies and crop diversification on economic conditions of the farmers

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Climatic stresses, such as erratic precipitation, pest infestations, and extreme weather events, have a major impact on agricultural stability as agriculture is the foundation of the rural economy (Singh *et al*., 2021). Although the Bihar state's varied climate supports a variety of crops, it also makes vital mainstays like rice and wheat more vulnerable. Projections of a 2.8°C rise in temperature by 2050 intensifies need for a strong climate-resilient agriculture plans across state's varied Agro-climatic zones (Birthal *et al*., 2021). Nalanda district of Bihar is prone to flood in major areas during *Kharif* season. During *rabi* season, it experiences extreme weather events such as cold wave, heat wave as well as moisture stress. To overcome these weather extremities and ensure agricultural sustainability, several climate resilient technologies were demonstrated in NICRA adopted villages of Nalanda. Crop diversification and incorporation of high value crops were progressively embraced by the farmers to ensure income stability.

Methodology

The study was conducted in two villages of Nalanda district of Bihar *viz*., Sherpur and Ghokulpur, adopted under NICRA project by Krishi Vigyan Kendra, Nalanda. Data have been collected for two consecutive years i.e., 2022-23 and 2023-24. Several climate resilient interventions such as submergence tolerant paddy variety (Swarna Sub-1), heat tolerant wheat variety (DBW-187), zero tillage (ZT) in pulses, oilseeds, ZT and mulching in potato, micro-irrigation in horticultural crops were demonstrated in both the villages. Percent area coverage of demonstrated technologies, per cent change in yield and net income were calculated. Crop wise change in cropping pattern and crop diversification index were also determined. The collected data was statistically analyzed by using suitable simple descriptive statistics (mean, percentage change, growth rate), pivot tables.

Results

The study revealed that prior to NICRA project implementation, area under cereals was predominant in both *kharif* and *rabi* seasons. However, a significant rise in area under fruits, vegetables, pulses and oilseeds was observed after implementation of the project.The area under paddy remains constant due to prevalence of low land and water-logged condition. In *rabi* season, area under wheat declined by 2.70 % whereas area under pulses and oilseedsincreased by 36.27% and 74.38% respectively. In case of horticultural crops, tremendous increase in area under fruits (47.92%) and vegetables (23.08%) was observed after the project implementation. The per cent share of green gram in summer season marginally increased by 3.57% and total area under fodder production enhanced by 13.33% (Table 1).

The project interventions also led to increase in crop diversification index from 0.59 to 0.63 on the scale indicating crop diversification has taken place by shifting the cultivated area from cereals based cropping system to oilseeds, fruits and vegetables. The adoption of various climate resilient technologies in NICRA villages enhanced tolerance to climatic stresses such as flood, heat wave and cold wave. Crop yield and net income of each crop in NICRA adopted villages increased in comparison with non-NICRA villages due to reduction in cost of cultivation, recycling of nutrients and maximum resource utilization. The maximum per cent increase in yield was observed for chickpea (47.89 %) followed by green gram (33.79 %) and mustard

(23.91 %). The per cent increase in net income was recorded highest in case of Potato (16.29 %), followed by Mustard (12.50 %) and Lentil (10.69 %) (Table 2).

Table 1. Shift in cropping pattern in NICRA adopted villages after implementation of the project

Crop	Before the project implementation				After the project implementation				Change in area (%)			
	Kharif	*Rabi*	Summer	Total	*Kharif*	*Rabi*	Summer	Total	*Kharif*	*Rabi*	Summer	Total
Paddy	122	0	0	122	122	0	0	122	0	0	0	0
Wheat	0	74	0	74	0	72	0	72	0	-2.70	0	-2.70
Pulses	2.31	32.98	0	35.29	3.67	44.42	0	48.09	58.87	34.69	0	36.27
Oilseed	0	8.08	0	8.08	0	14.09	0	14.09	0	74.38	0	74.38
Greengram	0	0	56	56	0	0	58	58	0	0	3.57	3.57
Vegetables	4.5	18.98	9.7	33.18	6.2	23.24	11.4	40.84	37.78	22.44	17.53	23.09
Fruits	1.67	2.13	1.25	5.05	2.95	3.23	1.29	7.47	76.64	51.64	3.2	47.92
Fodder	3.5	4.7	2.3	10.5	3.9	5.2	2.8	11.9	11.43	10.64	21.74	13.33
Total	133.9	140.8	69.2	344.1	138.7	162.1	73.4	374.3	184.7	191.0	46.04	195.8

Pooled data of two years (2022-23 and 2023-24)

Table 2. Economic impact of climate resilient technologies in NICRA adopted villages

Crop	Technology Demonstrated	NICRA				Non-NICRA				% change in Yield	% change in net return
		Yield (q/ha)	Cost Rs/ha	Net Return Rs/ha	B:C	Yield, q/ha	Cost, Rs/ha	Net Return, Rs/ha	BCR		
Paddy	Swarna Sub-1(Submergence tolerant)	53.05	37970	77838	3.05	48.08	38150	73569	2.9	10.34	5.80
Wheat	DBW-187 (Heat tolerant) + ZT*	46.1	28810	69152	3.4	41.12	32156	64929	3.0	12.11	6.50
Mustard	ZT	12.23	89875	36778	2.23	9.87	93634	32690	1.3	23.91	12.50
Lentil	ZT	13.15	27600	53000	2.86	10.97	31500	47880	2.5	19.87	10.69
Chickpea	ZT	18.25	32405	69590	3.14	12.34	35890	64700	2.8	47.89	7.55
Potato	ZT + Mulching	275	93870	126130	2.34	247.53	108978	108456	1.9	11.09	16.29
Okra	ZT	127	86870	167130	2.92	115	91450	159800	2.7	10.43	4.58
Greengram	ZT	8.75	23250	44606	2.92	6.54	26840	40900	2.5	33.79	9.06
Berseem	*HYV	120	12200	242800	20.92	113	12200	236900	20.4	6.19	2.49

**ZT: Zero tillage, *HYV: High Yielding Variety, Pooled data of two years (2022-23 and 2023-24)*

Conclusion

The results revealed that the project interventions have helped in cop diversification from cereals based cropping system to cultivation of vegetables, fruits, pulses and oilseeds. This acts as a mechanism to mitigate risk related to climate change and optimize land utilization. Also, adoption of climate resilient technologies such as submergence tolerant paddy variety, heat tolerant wheat variety, zero tillage (ZT) in pulses, oilseeds, ZT and mulching in potato, micro-irrigation in horticultural crops have shown significant increase in yield and net income of the farmers as compared to non-NICRA villages.

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Performance of Soil Enzymatic Activity as Influenced by Farming Types and Cropping Systems

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Activity of the enzymes infers the good soil health and maintaining sufficient balance of biological active microorganism in soil is the only way to safeguard the soil health. However, sustainability of soil health to the longer duration was major task in the changing climate condition. Need based use of synthetic input materials safeguards the soil dwelling microorganism as well as it avoids the contamination of soils and food. Not only with respect to management aspects but also cropping pattern matters in increasing productivity of the land. In order to know the sustainable way of soil health management following experiment was designed under various farming types and cropping systems.

Methodology

A field experiment was conducted during *kharif* 2021 and 2022 at ZAHRS, Navile, KSNUAHS, Shivamogga under sandy loam soils. The experiment was designed under split plot technique with farming types (conventional, organic and natural farming) as main plot and cropping systems (groundnut + maize 4:1 intercropping, groundnut + finger millet 4:1 intercropping, sole groundnut, sole maize and sole finger millet) under sub plot treatments.

Conventional farming follows the package of practice where nutrients were supplied both from organic and inorganic sources, weed management was through using herbicides, pest management was through synthetic pesticides. Organic farming method obtained nutrients through organic manures (specifically farm yard manure) based on P equivalent basis for groundnut and N equivalent basis for maize and finger millet. Natural farming was supplied with one ton of ghanjeevamrutha and 2000 l of jeevamrutha supplied in four intervals.

Nutrients was supplied in intercropping based on plant population of particular crop and other management aspects were common for all the treatments.

Activity of dehydrogenase, phosphatase and urease were estimated according procedure encasted by Casida *et al*. (1964), Eivazi & Tabatabai (1977) and Kandeler & Gerber (1988) respectively. Enzymatic activity was compared between 67 DAS and at harvest.

Results

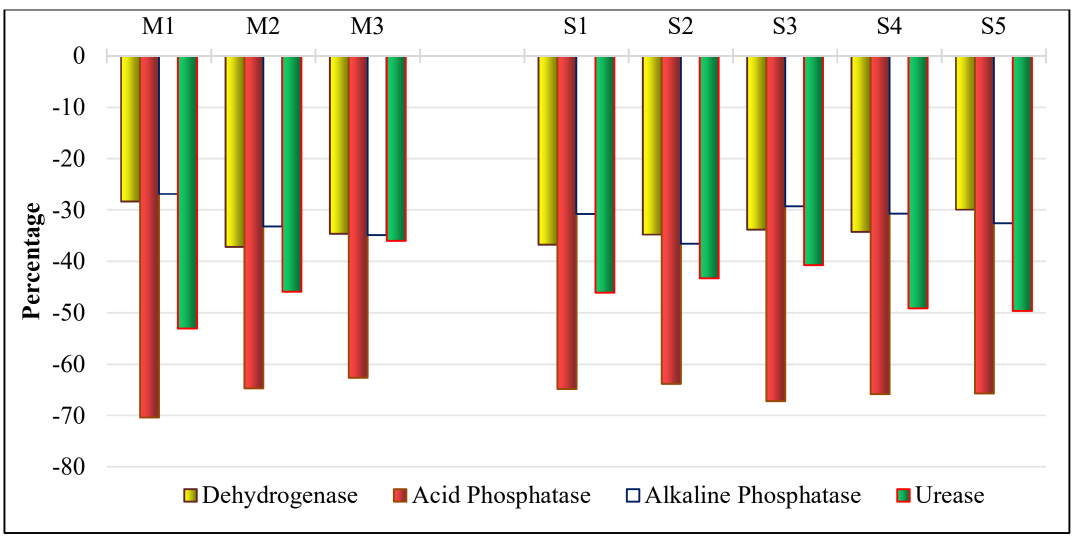
Among different farming types organic farming recorded significantly higher values of dehydrogenase and phosphatase activity (acid and alkaline) than conventional farming this may be due to greater amount of substrate availability was noticed in organic farming followed by avoiding chemical inputs enhanced the effectiveness. In converse, conventional farming observed significantly higher values than organic farming and natural farming for urease activity at 67 DAS due to supply of synthetic source of nitrogen in conventional farming enhanced the activity as it obtained the substrate for its activity as noticed by Gowthamchand *et al.* (2020) and Ragini (2022).

Activity of various enzymes as influenced different types and farming types

Treatments	Dehydrogenase (µg TPF g^{-1} day^{-1})	Acid Phosphatase (µg pNP g^{-1} hr^{-1})	Alkaline Phosphatase (µg pNP g^{-1} hr^{-1})	Urease (µg urea hydrolysed g^{-1} hr^{-1})
Farming types				
M_1- Conventional farming	13.19	13.60	2.38	4.92
M_2-Organic farming	21.12	19.54	3.25	4.27
M_3- Natural farming	17.89	17.64	3.35	3.61
S. Em±	0.39	0.23	0.06	0.11
C.D (P=0.05)	0.91	0.54	0.14	0.25
Cropping systems				
S_1-Groundnut + Maize intercropping	19.36	18.21	2.86	4.23
S_2- Groundnut + Finger millet intercropping	18.08	17.14	3.12	4.18
S_3- Sole Groundnut	17.80	17.45	2.97	4.00
S_4- Sole Maize	16.46	16.23	2.93	4.56
S_5- Sole Finger millet	15.30	15.60	3.07	4.37
S. Em±	0.60	0.33	0.06	0.10
C.D (P=0.05)	1.20	0.67	0.12	0.20
Interaction				
S. Em±	1.03	0.57	0.10	0.17
C.D (SP at same level of MP)	NS	NS	NS	NS
C.D (MP at same or different level of SP)	NS	NS	NS	NS

Among cropping systems, groundnut intercropped with maize recorded onpar observations with groundnut intercropped with finger millet and significantly higher values over sole crops of groundnut, maize and finger millet for dehydrogenase, alkaline phosphatase and acid phosphatase activity because interspecific interaction of roots of different crops under intercropping helps in production of flavanoids and polysaccaride compounds which helps in enhancing the soil dwell microorganisms, further improved their catalytic activity. However, sole maize and sole finger millet recorded higher values of urease activity than sole groundnut and intercropping system at 67 DAS due to greater application of recommended dose of fertilizers in the respective treatments increases the substrate for the enzyme activity as reported by Chen *et al.* (2018) and Babu *et al.* (2020**)**. Interaction of various farming types and cropping systems recorded non significant values for dehydrogenase, urease, acid phosphatase and alkaline phosphatase activity. The values are represented in the table.

Activeness of all the enzymes was recorded higher at 67 DAS as compared at the stage of harvest, the data was represented in the figure below which infers that there was a drastic reduction in the performance of all the major enzymes. There was 70 percent reduction of the acid phosphatase activity was noticed at harvest as compared to 67 DAS. The activity of enzymes was greater in 67 DAS was due to active root exudation enhances the performance followed by the availability of moisture was lower at harvest as compared to 67 DAS as quoted by Li *et al.* (2019) and Sharma *et al.* (2022).



Percent change of various enzymatic activity in harvest as compared to 67 DAS

Conclusion

Activity of major enzymes was higher in 67 DAS as compared to their activity at harvest. Among farming types, organic farming followed by natural farming soils have more enzymatic activity except urease as compared to conventional farming. Among cropping system, performance of biological catalysts were higher under intercropping system than respective sole crops except for urease.

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BARI System: A Traditional Farming System of North-East India for Livelihood Security

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Agro-forestry has long been practiced through traditional homestead farming systems, found widely in both the plains and hills of the NE states. One prominent example is the *bari* system, which has evolved in Northeast India over generations, playing a vital role in biodiversity conservation, household consumption, and resource management. The *bari* serves as a multifunctional unit where various crops, including trees, are cultivated alongside livestock, poultry, and fish to meet a rural household's essential needs. This practice is especially common in the homes of the Thengal-Kachari community (Barooah and Pathak, 2009). The *bari* serves as a multifunctional unit where various crops, including trees, are cultivated alongside livestock, poultry, and fish to meet a rural household's essential needs. In Assam, *bari* also refers to a traditional land-use approach, often situated around the house or in separate, distant plots. These areas support a diverse mix of plants, including timber, firewood, vegetables, fruits, plantation crops, spices, herbs, and ornamental plants. Additionally, they incorporate other farming elements like livestock, poultry, fishery, sericulture, and beekeeping, managed by family members to fulfill a range of household needs (Barua *et al*, 2019).

Methodology

The study is being conducted in two blocks of Biswanath district, namely Baghmara and Biswanath, and included four village's *i.e* Gingia, Disiri, Maralgaon, and Kumalia. A questionnaire is prepared to gather information directly from the farmers. In total, 24 farmers were chosen across the four villages, and data were collected by interviewing them using a pre-tested questionnaire.

Results and Discussion

The study covered the *bari* agro-forestry practices of 24 farmers from four villages in the Biswanath district, capturing various details of land use, labours, crops grown, gross income and challenges faced.

The findings are as follows

Area and System Age: The average area under the *bari* system is approximately 0.24 hectares, with systems averaging around 35 years in age. Land size ranges from 0.052 to 0.535 hectares, with the oldest systems going back to 65 years, indicating a long tradition of *bari* agro-forestry.

Labour Use: On an average, each household typically employs around 2 family members and nearly 10 hired labour annually in a *bari system*. The need for hired labour varied greatly, with some farms requiring none, while others engage as many as 36 hired workers per year, likely based on farm size and crop diversity.

Crops Diversity: Farmers grow a diverse mix of crops, including arecanut, coconut, banana, betel vine, bamboo, mango, tea and various fruit trees such as guava, lemon, and jackfruit. Some farmers also incorporated spices like black pepper and *bhoot jolokia (chilli)* alongside tea and other plantation crops. This diversity supports both subsistence and commercial needs.

Income: The average annual gross return from the *bari* systems is around Rs. 29,254.17, though individual returns varied widely from zero in the newly developed bari along with high incidence of pest and disease, lack of irrigation. However, a higher income amounting to Rs. 177,000 was recorded in the farm of Mr. Nirmal Sarmah who has been engaged in production of high value crops such as tea and spices.

Constraints: Key challenges faced by the farmers include low soil fertility, water scarcity and labor shortages, alongside pest and disease problems affecting crops and livestock. Some farms also reported issues with fencing, squirrel and monkey interference, and weed overgrowth.

Farms in Kumolia, in particular, faced pest issues, fencing, and irrigation problems that limit productivity.

Information on Traditional *Bari* System (Farmer wise)

Name	Village	Area under Bari system (ha)	Approx age of the system (years)	No of family worker available	No of hired worker engaged per year	Details of crop Component	Gross return per year (Rs.)	Constraints (if any)
Sri Swapan Paul	Gingia	0.052	50	3	0	Arecanut, Coconut, Orange, Jackfruit, Mango, Banana, Papaya and Lemon	13000.00	Low fertile soil. Squirrel problem
Sri Shudhir Mondal	Gingia	0.334	50	2	8	Coconut, Lemon, Palm, Bamboo, Tea plantation	72000.00	Squirrel problem
Sri Prasanna Das	Morolgaon	0.200	30	1	6	Areacanut, Banana, Lemon, Jackfruit, Gomari ,Bamboo	21000.00	labour problem, livestock disease
Sri Prabhat Das	Morolgaon	0.270	50	1	12	Areacanut, Betelvine, Mango, Jackfruit, Coconut, Bamboo, lemon, Pumelo, Bhootjolokia	23500.00	Labour problem, livestock disease
Sri Dulal Das	Morolgaon	0.130	12	3	0	Arecanut, Banana, Jackfruit, Mango, Guava, Bamboo, Drumstick	10200.00	Weed problem
Sri Sarat Das	Morolgaon	0.107	50	1	10	Arecanut, Coconut, Banana, Jackfruit, Papaya	11000.00	Weed problem
Sri Mukul Gogoi	Morolgaon	0.200	50	1	6	Arecanut, Banana, Betelvine, Bamboo, Jackfruit	12000.00	Pest problem, Problem in Livestock
Sri Upen Das	Morolgaon	0.267	20	2	4	Arecanut, Coconut, Betelvine, Bamboo, Banana, Lemon, Goosberry, Guava, Atlas fruit, Papaya, Jackfruit	29500.00	Squirrel problem
Sri Anupam Borah	Morolgaon	0.133	40	2	2	Arecanut, Banana, Betelvine, Lemon, Guava,Pumelo,Bamboo	13500.00	Squirrel problem
Sri Anil Das	Morolgaon	0.200	50	1	12	Arecanut, Lemon, Jackfruit, Betelvine, Bamboo	15200.00	Squirrel problem
Sri Girish Das	Morolgaon	0.133	7	1	6	Arecanut, Banana, Papaya, Bamboo, Coconut, Mango	3500.00	Squirrel problem
Sri Putul Gogoi	Morolgaon	0.333	50	1	6	Arecanut, Betelvine, Mango, coconut, banana,Lemon,Bamboo	22500.00	Squirrel Problem, Monkey problem
Sri Nobin Gogoi	Morolgaon	0.200	50	1	6	Arecanut, Betelvine, Mango, Coconut, Banana, Bamboo	18000.00	Squirrel Problem, Monkey problem
Sri Abdul kalam	Morolgaon	0.267	2	1	0	Arecanut, Mango, Jackfruit, Coconut, Segun tree, Lemon	0	Fencing problem, Insect-pest

								and Disease problem,
Sri Eejihar Rahman	Kumolia	0.200	15	5	12	Arecanut, Betelvine, Mango, Jackfruit, banana, Gauva ,Lemon, Ber, Segun tree, Bamboo	39700.00	Fencing problem, Insect-pest and Disease problem,
Sri Abdul karim	Kumolia	0.200	2	2	10	Arecanut, Mango, Ber, Lemon	0	Fencing problem, Insect-pest and Disease problem, Irrigation Problem
Sri Dildar hussain	Kumolia	0.200	20	5	6	Arecanut, Betelvine, Pineapple, Jackfruit, Mango, Bamboo, Coconut	35000.00	Fencing problem, Insect-pest and Disease problem,
Sri Ismile Ali	Kumolia	0.267	30	3	6	Arecanut, Betelvine, Banana, Lemon,Guava,Mango, Jackfruit, Plum, Coconut	23500.00	insect-pest problem, goat disease
Sri Sonewar Islam	Kumolia	0.200	50	1	0	Arecanut, Mango, Banana	0	Fencing problem, Insect-pest and Disease problem,
Sri Nirmal Sarmah	Disiri	0.267	20	2	20	Arecanut, Coconut, Mango, Banana, Tea, Lemon, Betelvine	177,000.00	Low Production, Pest Problem
Sri Kamala Upadhaya	Disiri	0.200	27	2	5	Arecanut, Coconut, Banana, Lemon, Betelvine, Ogoru tree, Bamboo	25000.00	Low fertility of Soil
Sri Vijoy Roy	Disiri	0.535	41	1	36	Arecanut, Banana, Coconut,Tea plantation,Black pepper	11000.00	Insect-pest problem
Sri Durga Sarmah	Disiri	0.334	65	2	33	Arecanut, Coconut, Banana,Tea, Bamboo	62000.00	Low fertility of Soil
Sri Surya Sarmah	Disiri	0.535	65	2	33	Arecanut, Banana, Tea Plantation	64000.00	Low fertility of Soil
Average		0.240	35.25	1.90	9.96		29254.17	

Conclusion

The data recorded from the 24 farmers practicing *bari* system of farming highlights both the economic potential and the challenges faced by farmers in sustaining *bari* agro forestry practices, underlining the need for improved infrastructure and pest management to optimize productivity. Since, the family members of the farmers are actively involved in the farming system, therefore the labour cost is reduced and income automatically increases. Thus, it can be concluded that the farming systems approach in rainfed agriculture not only helps in addressing income and employment problems but also ensures food security of the farming community.

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Climate Resilient Rainfed Integrated Farming System for Small Holders

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Integrated farming systems (IFS) have emerged as a promising approach to address the challenges faced by rainfed agriculture based small holders. Despite the potential benefits, the adoption of IFS in rainfed regions of India is still limited due to various constraints, including lack of awareness, inadequate infrastructure, and limited access to technology and credit (Bhargavi and Behera, 2020).

Methodology

A field experiment on integrated farming system (IFS) was initiated in 2023 at Hayathnagar Research Farm (HRF), ICAR-CRIDA to develop a climate resilient rainfed IFS model generating sustainable productivity, income, and employment and to assess the resource flow matrix among various IFS components. Component wise details are given in Table 1

Results

Results revealed that cropping systems maize (DHM-117) + greengram (WGG-42) intercropping system yielded 0.45 q of redgram equivalent yield (REY). The super napier grass yielded about 0.17 q. The cropping system productivity is 2.72 q of REY. A farm pond of 750 m^3 capacity has reached its full capacity with the excess runoff by the end of July (476 mm of rainfall). Supplemental irrigations were provided to the maize + green gram, pigeonpea and super napier grass during dry spells (Table 3). A total 35 Black Bengal goats (BBG) with 30 female and 5 male animals were maintained. The effect of different levels of concentrates were studied on live weight gain, dry matter intake, crude protein intake, conception frequency, birth weight of kids and growth rate of kids.

Conclusion

The study clearly indicate the potential of the IFS to improve the livelihood of small farmers besides making the system sustainable. IFS produced diverse food products i.e field crops produce, vegetables, fruits, eggs and meat. Further direct benefits from IFS, apart from increased household nutrition and income, the provision of employment for household members round the year. Biodiversity is being maintained in reality with utmost care of each and every plant and animal at the farm.

Table 1. Rainfed integrated farming system model with agri-allied components

Component	Area (ha)/ No.s
Cropping system (0.65 ha)	i. Pigeonpea – horse gram (0.3) ii. Sorghum (0.1) iii. Maize + green gram (0.25)
Farm pond (0.12 ha)	750 m^3 capacity
Goatery	Black Bengal (30 + 5 No.s)
Poultry	Rajashri (100 No.s)
Horticulture (0.4 ha)	Mango (25), Jamun (15), Sapota (10), Jack fruit (5), Guava (10), Amla (10), Pomegranate (20), Lemon (15), Karonda (5)
Agroforestry (0.1 ha)	Moringa, *Melia dubia*
Fodder crops (0.24 ha)	Super napier grass

Table 2. Yield and rainwater use efficiency of cropping systems under IFS

Crop	No. of irrigations	Crop growth stage	Dry spell (days)	Irrigation (m^3)
Maize (0.24 ha)	1	Silking	27	216 (9 cm)
Red gram (0.4 ha)	2	Flowering & pod formation	31	270 (6 cm)
		Pod development	20	216 (5 cm)
Super napier grass (0.2 ha)	1	After first cut	33	108 (5 cm)

Table 3. Supplemental irrigation through harvested water at critical crop growth stages

Cropping system	Redgram equivalent yield (REY) (q)	Rainfall (mm)	RWUE (kg/ha-mm)
Maize + Green gram (3:1) (0.24 ha)	0.45	169	0.26
Red gram (0.4 ha)	3.1	343	2.25
Super napier grass (0.2 ha)	0.17	320	0.13
Total	2.72	343	

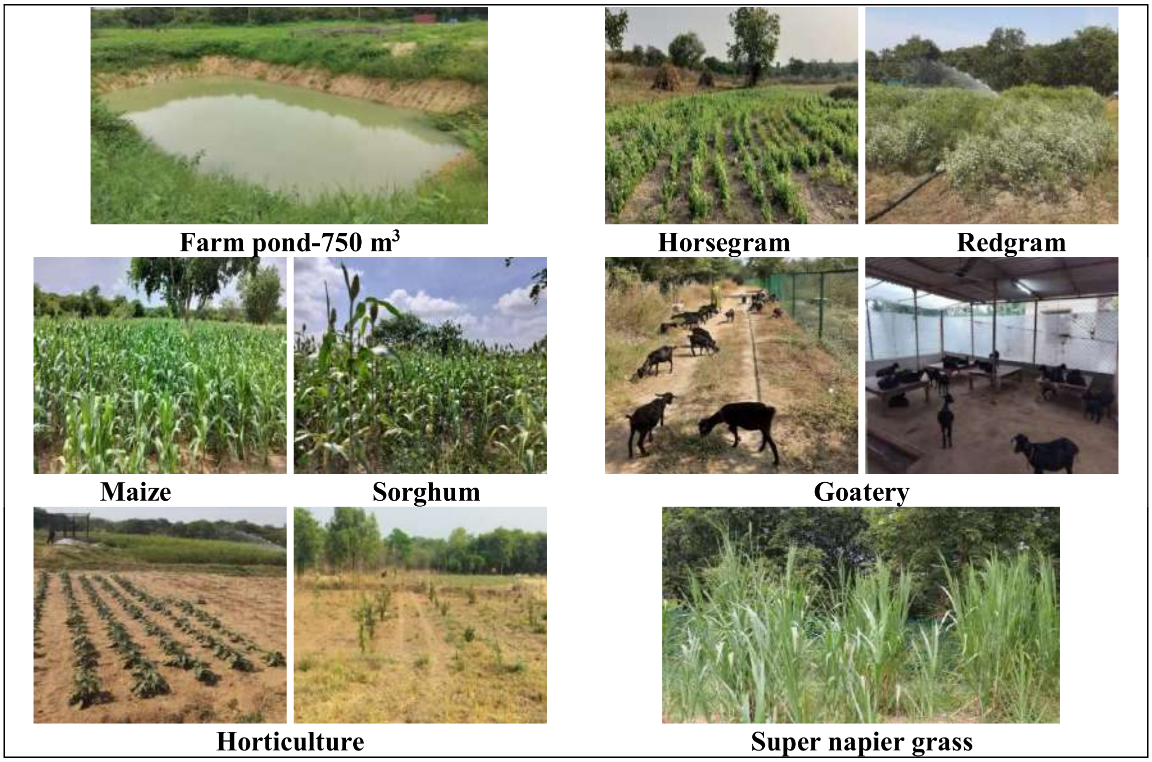

Fig 1. Rainfed IFS with various agri-allied components

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Resilient Technologies for Farming System Typologies of Kharif Crops at NICRA and non-NICRA Villages under Bundelkhand Agro-Climatic Zone

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The FLDs (Front-line Demonstrations) conducted in NICRA village on FSTs (Farming System Typologies) of *Kharif* crops production with or without animal under rainfed conditions at village- Kodiya of district-Tikamgarh. The district is situated under Bundelkhand Agro-climatic zone of Madhya Pradesh. The demonstrations were carried out for two years 2022-23 and 2023-

24 in *Kharif* season. The climate change in Bundelkhand Agro-climatic zone has potential influence on various aspects of agriculture and allied sectors. Some key aspects of climate change are change in temperature, rainfall, extreme weather events like dry spells and intensive rains. Changes in temperature and rainfall patterns can affect crop yields and the timing of agricultural activities. Increased frequency of extreme weather events can result in crop damage and economic losses for farmers. The possible impacts of climate change, like change in cropping patterns, hampering of crop productivity, carbon released, losses of irrigation water and in-situ moisture, increased in cost of cultivation as well as increased labours, inputs, cost of productions, pests and insect attack may threaten the agro-biodiversity and food security of the district. Climate change has hit the agriculture-based livelihoods and food grain production in the Bundelkhand districts has decreased by 58%, it is very serious for the agriculture-based society and economy.

Methodology

The FLDs were conducted under NICRA Project at villages NICRA (technologies demonstrated) and non-NICRA (farmer existing practices) during *Kharif* seasons of 2022-23 to 2023-24 on Rainfed Farming System Typologies (FSTs) which have been already existed in Bundelkhand Agro-climatic zone. The demonstrations were conducted under the FST-1 (Rainfed without animal) and FST-2 (Rainfed with animal) with the major *Kharif* crops as soybean, black gram, ground nut and sesame. The interventions were taken up in soybean as *in-situ* moisture conservations because of farmers' practices non-*in-situ* moisture conservations practices as flat bead sowing method while in black gram varieties growing by farmers are very susceptible to MYMV diseases therefore, to minimize the viral incidence as biotic stress resistant varieties were demonstrated. The ground nut and sesame were major crops grown by farmers with local and susceptible varieties to biotic and abiotic stress, so in this regarding resilient varieties were demonstrated. The resilient technologies were demonstrated to reduce the lost from biotic and biotic stress as in soybean (BBF sowing method to ensure the in-situ moisture during dry spell and drain out the excess rain water during heavy rains), biotic-stress resilient variety MU-2 & PU-1 for the management of MYMV disease in black gram, resilient varieties GJG-32/K-1812 in ground nut and GT-4/TKG306 in sesame against the low yield and non- resilient varieties and susceptible varieties against the abiotic and biotic stress. In both the FSTs 1 & 2 the same interventions and technologies were conducted at NICRA village-Kodiya in which, the total households farmers were129 in which there were 10 belong to FST-1 and 116 in FST-2, the demonstrations were conducted with 10 farmers for each one technological demonstration under interventions under rainfed conditions cultivations in major crop cultivations without (FST-1) or with animals (FST-2). Each plot size of demonstration was 0.4 ha with the same size of plot of the farmer practices were too maintained. The sowing of demonstration plots was made from 5-10 July during in 2022-23 & 2023-24 and all kharif crops were harvested up to end of Sept. The nutrients (NPK) requirements were made as per available fertilizers RDF doses (kg/ha) for the *kharif* crops grown in demonstrations of NICRA village where as in non-NICRA village there was no practices as per RDF of the crops. The seed rates (kg/ha) were used as recommended for the each *kharif* crops in technologies demonstrations while in farmers' practices of non-NICRA village, the seed rates (kg/ha) were used moer than recommended practices of the same crops. The labour requirements were more in non-NICRA than NICRA village due to lack of agricultural implements. The weather vulnerability, rainfall, temperature, RH% and extremely events like rainfall monsoon (SMW), early withdrawal of monsoon, dry spells (days and durations), heavy rains(mm), drought(days) with the crop growth stages and technological impact to mitigations of abiotic stress on yield and productivity of crops were observed and recorded. The data were also compared with results of non-NICRA village which was farmers' practices. The data were statically analyzed.

Results

The results from(Table-1)average data of two years 2022-23 to 2023-24 pooled which reflected that the maximum productivity (Kg/ha) were observed and recorded as in soybean, black gram, ground nut and sesame were 1330, 770, 1720 and 540,respectively of NICRA village demonstrations under FST-1(Rainfed without animals), while the results of non-NICRA village under FST-1, the maximum productivity (Kg/ha) were recorded in soybean, black gram, ground nut and sesame as 730, 480, 1420 and 330, respectively. On compared the data showed that yield (kg/ha) saving were found in soybean, black gram, ground nut and sesame 600,290, 320 and 210, respectively due to mitigation of climatic stress through technologies interventions on FST-1 under NICRA village but in non-NICRA villages yields were could not save due to climatic stress impact in loss of yield. Increase in water use efficiency, increase in crop productivity.The technologies like BBF (soybean-sowing method), resilient varieties-black gram (MU-2/PU-1), ground nut (GJG-32/K-1812) and sesame (TKG-306/GT-4) were played role in saving the yield and mitigations of climatic abiotic and biotic stress in NICRA village. The saved yield given maximum return (Rs/ha) as in soybean (21115), black gram (21885), ground nut (69165) and in sesame (20557) in NICRA village with higher B:C ratio as compared to non-NICRA village.

Table 1. Productivity (Kg/ha), Net Return (Rs. /ha) and B:C ratio of Demonstrations in NICRA and non-NICRA villages underFST-1 (Rainfed without animal) during 2022-23 to 2023-24 of *Kharif* crops

Crop	FST-1 NICRA Village			FST-1 Non-NICRA Village		
	Productivity (Kg/ha)	NR (Rs/ ha)	B:C Ratio	Productivity (Kg/ha)	NR (Rs/ha)	B:C Ratio
Soybean	1330	21115	1.7	730	4285	1.2
Blackgram	770	21885	1.8	480	4740	1.2
Groundnut	1770	69165	2.6	1450	25426	1.7
Sesame	540	20557	1.9	330	11995	1.5

Cost of cultivations (Rs/ha) for the year (2022-23) of Demos, in NICRA village/non-NICRA village were as soybean (30500/27300), black gram (26000/23800), ground nut (43500/40714) and Sesame (23100/20300) and in (2023-24) soybean (32500/31100), black gram (28700/27600), ground nut (43500/39600) and Sesame (25100/24300), The results from (Table-2) average data of two years 2022-23 to 2023-24 pooled which reflected that the maximum productivity (Kg/ha) were observed and recorded as in soybean, black gram, ground nut and sesame were 1160, 820, 1850 and 540,respectively of NICRA village demonstrations under FST-2 (Rainfed with animals), while the results of non-NICRA village under FST-2, the maximum productivity (Kg/ha) were recorded in soybean, black gram, ground nut and sesame as 740, 475, 1150 and 335, respectively. On compared the data showed that yield (Kg/ha) saving were found in soybean, black gram, ground nut and sesame due to mitigation of climatic stress through technologies interventions on FST-2 under NICRA village but in non-NICRA villages yields were could not save due to climatic stress impact in loss of yield. Increase in water use efficiency, increase in crop productivity.The same technologies wereused in FST-2 as there were used in FST-1. The saved yield given maximum return (Rs/ha) as in soybean (4745), black gram (4865), ground nut (27675) and in sesame (11995) in NICRA village with higher B:C ratio as compared to non-NICRA village. The results were found similar to findings of Singh et.al (2011), Swaminathan (2007), Chandrasekharan and Pandian (2009),Mudhalvanet.al (2024) and Ojong-Trade et.al(2023).

Table 2. Productivity (Kg/ha), Net Return (Rs. /ha) and B:C ratio of Demonstrations in NICRA and non-NICRA villages under FST-2 (Rainfed with animal) during 2022-23 to 2023-24 of Kharif crops

Crop	FST-2 NICRA Village			FST-2 Non-NICRA Village		
	Productivity (Kg/ha)	NR (Rs/ ha)	B:C Ratio	Productivity (Kg/ha)	NR (Rs/ha)	B:C Ratio
Soybean	1160	20455	1.6	740	4745	1.1
Blackgram	820	24148	1.7	475	4865	1.1
Groundnut	1850	65895	2.5	1150	27675	1.7
Sesame	540	20557	1.9	335	11995	1.5

Selling rate (Rs. /q) on Govt. MSP for the year-2022-23 soybean (4380), black gram (6600), ground nut (5850) and Sesame (7830) and in (2023-24) soybean (4600), black gram (6950), ground nut (6376) and Sesame (6376)

Conclusion

The FST-1 and FST-2 of rainfed conditions affected with climatic abiotic and biotic stress of climate change but the interventions taken up with resilient technologies and practices were found effectively in mitigations of these adverse effect of climatic stress during kharif seasons of the two years 2022-23 and 2023-24. The maximum productivity, net return and B:C ratio were recorded in soybean, black gram, ground nut and sesame with both FSTs in NICRA village compared to non-NICRA. Reduction in cost of cultivations due to use of RDF fertilizers, BBF machine, seed rate was found in FSTs technologies demonstrations while in non-NICRA village these inputs and cost of cultivations were greater than NICRA village. The indiscriminate used of inputs leading to release of excess nitrogen which decreased the soil microbial activities and increased mineralization of elemental nitrogen, reduction in soil moisture, nitrogen immobilization, reduction in C:N ratio, reduced mineral action and Lack of use of potash increased susceptibility to biotic and abiotic stress to plants. The crops cultivations with animals provided as animals wastes those were used as manures and natural resources management leading to decompositions of carbon into soil as carbon sequential. leading to susceptibility in the plants to biotic and abiotic stress.

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Enhancing Climate Resilience through Crop Diversification: Evaluation of Millets, Maize and Short Duration Rice in Upland Kharif Season

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In the face of escalating climatic uncertainties, upland farming systems demand an urgent transition toward resilient and sustainable agricultural practices. Frequent dry spells and erratic rainfall have increasingly constrained traditional short-duration rice cultivation, particularly in the upland kharif regions. The present study was conducted by Dhaanyaganga KVK during Kharif-2024, to evaluate the potential of climate-resilient crops like millets and maize as alternatives to short-duration rice. By integrating the principles of crop diversification and efficient water management, this research offers an innovative pathway for enhancing farm-level sustainability in partially irrigated upland ecosystems with objectives of to assess the yield potential and water productivity of sorghum, finger millet, and maize compared to short-duration rice under upland conditions, evaluate the impact of these crops on irrigation frequency, nutrient uptake, and overall economic returns. and identify scalable, climate-resilient alternatives to address the challenges of water scarcity and declining productivity in upland kharif agriculture.

Methodology

The study was conducted in a randomized complete block experiment in the upland areas of Murshidabad, West Bengal,in a rice–mustard–green gram production system. The experiment wasconducted with eight replications, in 0.26 ha under partially irrigated conditions.

Three innovative technology options were tested:

1. Replacement of short-duration rice with sorghum (Var. CSV 15).
2. Substitution of rice with finger millet (Var. Subra).
3. Incorporation of maize (Var. P 3526) into the cropping system.

These options were juxtaposed with the existing farmers' practice of cultivating short-duration rice (Var. GB 3). Critical indicators, including grain and straw yield, irrigation frequency, water productivity, plant height, nutrient uptake, and economic returns, were systematically monitored.

Results

The findings underscore the transformative potential of introducing climate-resilient crops into traditional upland farming systems. Maize (Var. P 3526) emerged as a standout performer, registering the highest grain yield (3.8 t/ha) and water productivity (1.2 kg/m³). Sorghum (Var. CSV 15) and finger millet (Var. Subra) also exhibited better performance, particularly in reducing irrigation requirements and enhancing grain and straw yields.

Comparative Performance of Crops

Parameters	Sorghum (T1)	Finger Millet (T2)	Maize (T3)	Short-duration Rice
Grain Yield (t/ha)	2.9	2.6	3.8	2.2
Straw Yield (t/ha)	3.8	3.2	4.2	3.5
Irrigation Events	4	3	5	7
Water Productivity (kg/m³)	0.9	0.8	1.2	0.6
Net Returns (₹/ha)	22,000	20,000	28,000	17,000

Maize recorded the highest net returns (₹28,000/ha), this was followed by sorghum and finger millet, But they were more remunerative in water scarce regions as they require less no of irrigations than short-duration rice.

Discussion

This study revealed the role of crop diversification in adapting to climate variability. The superior performance of maize, sorghum, and finger millet affirms their potential to replace water-intensive rice in upland kharif systems. The reduction in irrigation frequency across the alternative crops underscores their water efficiency and alignment with sustainable farming practices.on millet-based farming(Michaelraj and Shanmugam 2013) and rainfed agriculture (Sharma et al., 2010). Further more, these resilient crops are addressing the dual challenges of productivity and water scarcity. By integrating these crops into the existing rice-based systems, farmers can achieve greater ecological and economic stability, laying the foundation for sustainable agriculture in water-stressed regions.

Conclusion

The adoption of maize, sorghum, and finger millet as alternatives to short-duration rice represents a pragmatic solution to the challenges of upland kharif farming. These crops not only enhance yield and economic returns but also significantly reduce irrigation demands, aligning with the overarching goals of climate-resilient agriculture.

Scaling these innovations across similar agro-ecological zones can catalyze a paradigm shift in upland farming, fostering sustainability and resilience in the face of climatic uncertainties. Future endeavors should focus on fine-tuning these technologies and facilitating their adoption through targeted extension and policy interventions.

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Climate Resilient Integrated Farming System (IFS) Model: A Boon to the Coastal Farming Community of North 24 Parganas District of West Bengal

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The coastal blocks of West Bengal are highly vulnerable to the impacts of climate change, including rising sea levels, saline water intrusion, erratic rainfall, and cyclonic storms. These challenges threaten agricultural productivity and the livelihoods of small and marginal farmers who depend on traditional farming systems. To address these vulnerabilities and build climate resilience, the promotion of Climate Resilient Integrated Farming System (IFS) models has emerged as a transformative solution (Chatterjee *et. al*.,2020).

In North 24-Parganas district, the Krishi Vigyan Kendra (KVK) at North 24 Parganas has been spearheading the implementation of IFS in the Sandeshkhali-I & II, Haroa, Minakhan, Hasnabad, and Hingalgunj blocks. These blocks, situated in the ecologically fragile coastal belt, are prone to frequent environmental stressors that necessitate innovative and adaptive farming practices. The IFS model introduced by the KVK integrates multiple components, including crop cultivation, aquaculture, livestock, poultry, and agroforestry, into a cohesive system that optimizes resource use and enhances the resilience of farming communities (Mukherjee *et. al*.,2021; Banerjee *et. al*.,2021).

Through region-specific interventions, such as the introduction of saline-tolerant crop varieties, integrated fish-duck farming, bio-fencing, and rainwater harvesting, the IFS model addresses the unique challenges of these coastal blocks. This holistic approach not only ensures food security but also diversifies farmers' income sources, reducing their dependency on climate-sensitive crops and enhancing their economic stability (Chowdhury *et. al*.,2021; Ghosh *et. al*.,2020; Hazra *et. al*.,2021)

Materials and Methods

The coastal region of North 24 Parganas is characterized by saline soils, mono-cropped lands (40%), and low-lying terrain (62% below 5m MSL), making it highly vulnerable to waterlogging and salinity issues. The Climate Resilient Integrated Farming System (IFS) Model was introduced to enhance productivity and economic returns by integrating diverse farming practices while utilizing farm waste and harvested rainwater.

1. **De-siltation of Ponds**: Derelict ponds were de-silted, raising nearby land levels and strengthening dykes. The reclaimed areas are used for year-round vegetable or rice cultivation, while the ponds serve as reservoirs for rainwater storage and irrigation.
2. Innovative Cultivation Systems:
   - *Floating Rice Seedbed Nursery*: Rice seedlings were prepared on floating bamboo platforms, avoiding the need for additional land.
   - *Aerial Cultivation*: Viny vegetable crops were grown on pond embankments, spreading over water to reduce evaporation and regulate temperature for fish farming.
3. **Integrated Livestock and Aquaculture**:
   - *Duckery in Floating Houses*: Ducks were housed in movable, floating bamboo structured houses, reducing land requirements while enriching pond water with organic nutrients for fish farming.

- o *Climate-Adaptable Fish Farming*: Mixed fish species, including tilapia and high-value prawns, were cultivated using harvested rainwater.

4. **Dissemination and Upscaling**: This model can be adapted to various climatic and land-use conditions, providing scalable solutions for other districts and regions.

The IFS Model demonstrates sustainable practices that reduce salinity, enhance farm incomes, and promote climate resilience in coastal farming systems.

Results and Discussion

Integrated Farming Systems (IFS) combine multiple agricultural practices to optimize land, labour, and other resources for improved sustainability and profitability. In this case, the integrated farming system involves vegetable cultivation, aerial farming, climate-adaptable fish farming, rice seedling preparation, and duck farming in a floating duck house. Below is an analysis based on the given data.

Sl No.	Particulars	Production	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)
Vegetable cultivation in pond dyke					
1.	Brinjal (two times in a year)	5390 kg	72307.00	107690.00	35383.00
2.	Bitter gourd (two times in a year)	5390 kg	66150.00	92300.00	26150.00
Aerial Cultivation					
3.	Bottle gourd (Two times in a year and half of the embankment area)	3850 pcs	23100.00	61550.00	38450.00
4.	Indian spinach (Two times in a year and half of the embankment area)	4620 kg	13800.00	46150.00.00	32350.00
Climate adaptable fish farming					
5.	Fish production	3850 kg	436530.00	961500.00	524970.00
Rice Seedling preparation in Floating seedbed					
6.	Paddy seedling	For 1 ha	2630.00	10770.00	8140.00
Duck farming in Floating Duck House					
7.	Egg (156 egg/duck/yr.)	2340 pcs	16050.00	24060.00	5010.00
Total			630567.00	1257870.00	670453.00

1. Vegetable Cultivation in Pond Dyke

- **Brinjal** and **Bitter Gourd** cultivation on the pond dyke are highly productive. Brinjal produces 5,390 kg per hectare annually, and Bitter Gourd produces the same quantity. The cost of cultivation for both crops is relatively high but yields a significant gross return. The net return for Brinjal is ₹35,383, while for Bitter Gourd, it is ₹26,150. These crops are well-suited for the marginal lands of the pond dyke and offer decent profitability per cycle.

2. Aerial Cultivation

- **Bottle Gourd** and **Indian Spinach** are grown aerially on half of the embankment area. Bottle Gourd yields 3,850 pieces per hectare per year, with a net return of ₹38,450. Indian Spinach yields 4,620 kg per hectare, with a net return of ₹32,350. Both crops are cost-effective and have high returns relative to the input costs. Aerial cultivation maximizes space on the embankment area while providing diversification in the farming system.

Aerial cultivation and **vegetable cultivation** provided additional income while optimizing land usage, particularly in coastal saline conditions.

3. Climate-Adaptable Fish Farming

A major component of this IFS is fish farming, which contributed 78% of the net return and turned out to be the most profitable element with 3,850 kg produced per hectare. At ₹4,36,530, the investment in fish farming is substantial, but it yields a substantial return of ₹9,61,500, resulting in a net return of ₹5,24,970. The system's use of fish farming increases overall productivity and offers a consistent revenue stream all year long. The nutrient-rich water produced by other agricultural endeavours is also advantageous to it.4. Rice Seedling Preparation in Floating Seedbed.

- **Paddy seedling preparation** in floating seedbeds adds a small but important component to the IFS. The gross return is ₹10,770, with a net return of ₹8,140. While this practice might not yield substantial returns individually, it supports the rice production system by preparing seedlings in a cost-efficient manner.

5. Duck Farming in Floating Duck House

The integration of duck farming with fish cultivation plays a crucial role in minimizing feed costs and enhancing overall profitability within the Integrated Farming System (IFS). Ducks, which yield 2,340 eggs annually, provide additional value to the system, contributing a gross return of ₹24,060 and a net return of ₹5,010. Beyond their economic contribution, ducks also help with pest control in the vegetable and rice systems, reducing the need for chemical pesticides. This makes duck farming a sustainable and valuable component of the IFS, fostering an efficient, integrated farming model that optimizes resource use and supports environmental health.

Overall Economic Viability

The total cost of cultivation for all integrated components was **₹6,30,567/ha**, while the gross return amounted to **₹12,57,870/ha**, resulting in a substantial net return of **₹6,70,453/ha**.

Conclusion

In conclusion, the Climate Resilient Integrated Farming System (IFS), which has been put into place in the coastal blocks of North 24-Parganas, has shown itself to be a successful tactic for reducing climate risks while simultaneously raising agricultural output and the standard of living for farmers. The IFS model improves resource use, increases farm income, and lessens climate vulnerability by combining various elements like crop cultivation, aquaculture, and livestock. The significant net return demonstrates the system's economic feasibility, with fish farming turning out to be its most lucrative element. This strategy has a lot of potential to improve climate resilience and promote sustainable agriculture in coastal areas that are at risk.

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Adaptive strategies for Flood Risk management in the Bhabar and Tarai Plains of Uttar Pradesh

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Bhabar and Tarai region of Uttar Pradesh is severely exposed to vulnerability of flood. These territories are dominated by Rapti, Sharda and Ganga rivers and are close to Shivalik foothills. Due to its closeness to Nepal, the area experiences severe flooding. Floods harm 26.89 lakh hectares yearly, causing Rs.432 crore in agricultural, home and animal losses (National Informatics Centre, Uttar Pradesh). In 2024, releases of water from dam in Uttarakhand and heavy rainfall in river catchment regions triggered significant floods in numerous Tarai districts of Uttar Pradesh plains. Due to heavy rainfall in river catchment regions and dam releases, several villages in Pilibhit, Lakhimpur, Kushinagar, Balrampur, Shravasti and Gonda districts were flooded (State Disaster Response Force). The tarai floods damage agriculture and human settlements. Uttar Pradesh has 20.08 lakh hectares of cropland under risk of flooding. About 18,676 hectares are extremely high to high flood danger while 64,019 are intermediate. The major flood occurring district in Uttar Pradesh is Bahraich, Basti, Gonda, Gorakhpur, Kushinagar, Maharajganj etc. (Table 1).

Table 1. District-wise cropped area (in hectares) in different flood hazard zones

District	Very low	Low	Moderate	High	Very High	Total	Climate Risk
Basti	33626	8478	1565	132	0	43801	Very High
Bahraich	55616	4120	376	69	-	60182	Very High
Gorakhpur	72700	34489	16092	3902	492	127675	High
Gonda	22978	3336	982	236	20	27551	Very High
Kushinagar	18552	2337	116	-	-	21005	High
Maharajganj	84073	12968	2412	73	1	99527	High

*Source -Flood hazard atlas of Uttar Pradesh - A Geospatial approach

Methodology

The present study was conducted in six districts of flood prone region of Uttar Pradesh. Demostration Conducted across the FSTs (Farming System Typologies) in flood prone districts of Bahraich, Basti, Gonda, Gorakhpur, Kushinagar and Maharajganj. The data was recorded under NICRA farmer's schemes. The data on crop productivity with net return was recorded and comparison was made between both the groups.

Results

1. Machinery interventions

Land levelling through laser guided land leveller

This technology helps in levelling of undulated lands. The machine takes or removes extra soil from higher points and shifts it to lower points of land. District Gonda used this machine to level the land of 50 hectares in sandy loam soil at depth of 2-3 feet. The machinery reduced soil erosion by 10-15% which enhanced the yield of paddy variety NDR-359 by 20% and net return of 45% to farmers.

Sowing of paddy with the use of Drum seeder

Drum seeder is the manual machine that helps in sowing of seed in proper alignment of lines and rows at precise depth in soil. District Kushinagar has shown increased yield with the use of drum seeder in paddy variety (S-52) under Direct Seeded Rice (DSR). The productivity and net return under intervention recorded to 17.55% and 64.11%.

Cultivating of wheat through zero tillage

Sustainable technique such as zero tillage or ZT tillage involves sowing of seeds directly in soil without disturbing the soil profile. District Kushinagar reported increased crop production and net return in Wheat variety DBW-252 by 19.24% and 47.99%, respectively. Similarly Gonda district recorded increased production and net return of 14.70% and 28.27%, respectively.

Wheat cultivation with super seeder

Super seeder is the advanced machine that sows seeds of crops in definite rows directly in soil without prior soil and field preparation facilitates timely sowing of wheat in flood prone areas. District Basti sowed wheat variety DBW-187 and recorded increased production and net return of 23.20% and 46.54%, respectively. Similarly district Gorakhpur recorded increased production and net return of 13.23% and 56.54%, respectively for the same variety.

2. Climate- resilient agriculture

Flood tolerant variety

Flood-tolerant varieties are crops engineered to withstand water-logging, ensuring survival and yield stability during flood conditions. District Gonda showcase the increased productivity and net return of 27.85% and 52.85%, respectively with the use of rice variety Samba sub-1. District Bahraich has cultivated rice crop in 10 hectare land of variety Swarna sub.1. Increased yield of 43.78%, was recorded under stagnate water field for 15 days at 60-105 cm.

Short duration or medium duration variety

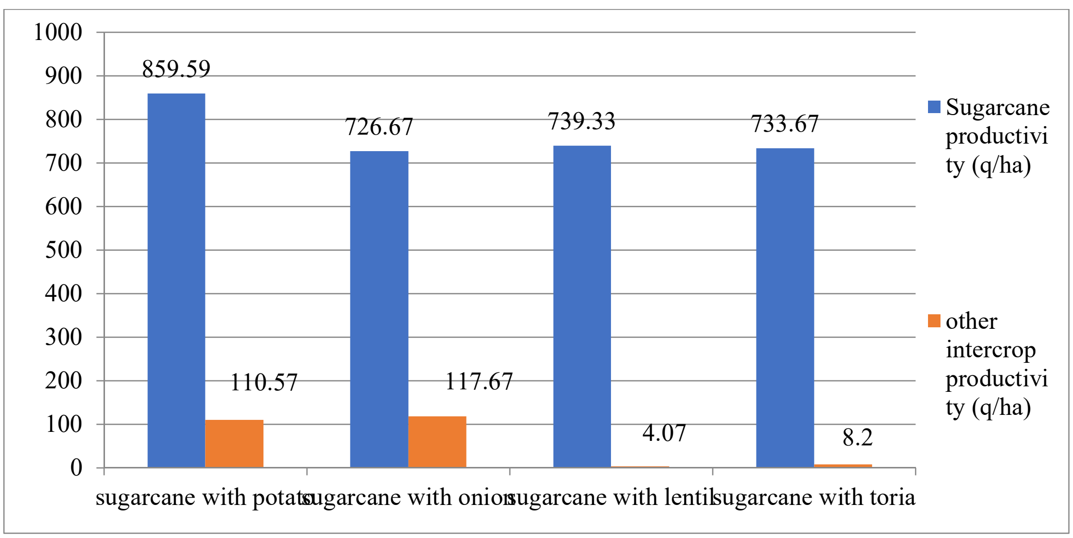
Short-duration or medium-duration varieties mature quickly, reducing the risk of crop loss due to unpredictable weather or flooding. District Kushinagar recorded increased production and net return of 51.24% and 42.50%, respectively in green gram variety “Virat”. This variety also shows resistant against wilt. District Bahraich reported increased production and net return of 23.48% and 17.64%, respectively in rice medium duration variety NDR- 2065.

Introduction of fodder crops

Introducing flood-tolerant crops enhances agricultural resilience, enabling farmers to maintain productivity even in flood-prone areas with water-logging challenges. District Kushinagar reported introduction of new crop “Jowar” (variety Anant) as catch crop and stated production of 908.33 q/ha with net return of Rs. 26,691.33 to farmers with buffalos and Rs. 19,027.71 to farmers with cows.

Intercropping

Intercropping involves planting different crops together, optimizing space, improving soil fertility and reducing pest risks for higher yields. Kushinagar district reported increased benefits to farmers with intercropping of sugarcane with onion in trench method. They recorded 642.33 q/ha of sugarcane without any intercropping, whereas 117.67q/ ha and 726.67 q/ha of onion and sugarcane, respectively recorded in intercropping. This intervention increased net return of 11.26% to farmers.



Representation of intercropping of crop in district Kushinagar

Green manuring

Green manuring involves growing cover crops to enrich soil fertility, improve structure and enhance nutrient content for future crops. Maharajganj district has followed intervention of green manuring followed by paddy cultivation in variety PBT-5204. They recorded increased production and net return of 24.76% and 38.15%, respectively in rice. Similarly Gorakhpur reported increased production and net return of 21.71% and 66.14%, respectively in rice variety Swarna sub-1 with green manuring.

Mulching

Mulching involves covering soil with organic or synthetic materials to conserve moisture, suppress weeds and improve soil fertility. Gonda district recorded increased production and net return of 8.90% and 13.66%, respectively by use of mulch in sugarcane.

Introduction of compensatory crop

Compensatory crops are introduced to replace or supplement damaged crops, ensuring continued productivity and reducing economic losses due to failure of main crops in adverse conditions. District Gonda has recorded production and net return of 29.44% and 47.99%, respectively in compensatory crop "Toria".

3. Agriculture and allied sectors

Vermi-composting

Vermi-composting uses earthworms to decompose organic waste into nutrient-rich compost, enhancing soil fertility and promoting sustainable agriculture practices. District Gonda recorded productivity of 6.70 q/unit and net return of Rs. 3,925.00 /unit.

Household kitchen garden

A kitchen garden grows fresh vegetables, herbs and fruits at home, promoting sustainability, healthy eating and reducing grocery costs. Kushinagar adopted food security with kitchen garden, amounting earning of Rs. 3436.00 /ha with productivity of 286.33 q/ha in total area of 12 hectare.

Conclusion

Effective adaptation mechanisms to address flood vulnerability in Bhabar & Tarai and North Eastern plains of Uttar Pradesh require integrated approaches. Inclusion of improved machinery interventions, sustainable agriculture practices, early warning systems and climate resilient mode of agriculture can enhance overall yield and production. Strengthening infrastructure and policy coordination will enhance resilience against recurring floods in these regions.

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Adaptation strategies and measures disseminated in central plain zone of Uttar Pradesh for addressing Sodacity

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The state of Uttar Pradesh has the largest concentration of salt-affected lands (1.37 M ha) out of which 1.35 M ha. is under Sodic lands. Sodacity is a pervasive soil health issue characterized by an excessive accumulation of sodium ions, leading to soil degradation, reduced fertility and decreased agricultural productivity. This complex problem affects millions of hectares of land worldwide, posing significant challenges to food security, environmental sustainability and rural livelihoods. Sodic soils often exhibit poor drainage, reduced water infiltration, and increased erosion, further exacerbating the problem. As the global population continues to grow, understanding and addressing sodacity is crucial for developing sustainable agricultural practices, improving soil health, and ensuring long-term ecosystem resilience. Following data shows impact of salt affected areas in district Pratapgarh in Uttar Pradesh.

Year	Land Detail (in ha)			
	Total Land	Fallow Land	Mono Cropping	Multi Cropping
2015-16	407.00	158.00	132.00	116.00
2019-20		74.00	108.00	225.00
2022-23		46.00	89.00	272.00
Increase / Decrease %		234.50	48.90	134.50

Methodology

The present study was conducted in four districts of sodacity region of Uttar Pradesh. The data was recorded from the prevailing FST (Farming System Typology) in sodacity districts of Kanpur Dehat, Bhadohi, Pratapgarh and Kaushambi. The data on crop productivity (q/ha) and net return (Rs/ha) was recorded and comparison was made between NICRA and Non-NICRA farmers' yield and profitability was subdued.

Results

1. Natural Resource Management

Laser Land Levelling

Laser land levelling ensures precise field levelling for water efficiency, enhancing crop yields, reducing soil erosion and promoting sustainable farming practices. District Pratapgarh performed said technology in 20.23 ha land and shown increased production of 28.62 % in paddy.

Soil amendments

Soil amendments are materials added to soil to improve its physical properties, fertility and nutrient content for enhancing plant growth and development. District Kaushambi recorded increased production and net return of 25% and 38%, respectively with the use of sulphur @ 20 kg/ha in mustard variety RH-725 in rainfed condition.

Microbial consortium

District Pratapgarh has demonstrated soil inoculants and microbial population growth increased with the help of “Halo mix” by ICAR-CSSRI, Lucknow. This microbial consortium is effective in regions of salt affected soils (Halophilic). Following table shows the change in chemical parameters of soils after use of halo mix in district Pratapgarh-

Year	pH	EC (dSm/m)	OC (%)	Available (Kg/ha)			Available (mg/kg)			
				N	P	K	Sulphur	Zinc	Boron	Ferrous
2015-16	10.91	2.52	0.15	175.51	13.65	143.40	10.00	2.45	0.60	9.36
2019-20	10.43	1.38	0.22	223.33	18.27	155.16	10.34	3.44	0.88	10.63
2022-23	9.68	0.88	0.43	271.15	21.88	216.16	14.75	4.47	1.46	11.55

Green manuring

Green manuring enhances the overall efficiency of soil to produce maximum yield and productivity. District Pratapgarh recorded saving of 300-400 q of sesbania at Rs. 1240 in paddy crop before sowing. Pratapgarh also covered area of 95 ha with green manuring for enrichment of soil.

2. Crop enterprise

Salt tolerant varieties

Salt-tolerant varieties thrive in saline soils that are offering sustainable solutions for agriculture in arid regions. The following data in district Pratapgarh and Bhadohi upholds the importance of salt tolerant verities in central plains of Uttar Pradesh:

Crop and variety	*Kharif and rabi (NICRA farmers)*		*Kharif and rabi (non-NICRA farmers)*	
	Productivity (q/ha)	**Net return (Rs./ha)**	**Productivity (q/ha)**	**Net return (Rs./ha)**
District pratapgarh				
Salt tolerant Wheat (KRL-210)	29.97	29674.44	25.06	21677.78
Salt tolerant Mustard (CS-58)	13.67	53367.78	11.17	42082.78
Salt tolerant Rice (CSR-36)	34.10	37900.00	26.03	24133.33
District bhadohi				
Mustard variety RH-749	17.83	53875.00	16.25	51337.00

Bio-fortified crops

Bio-fortified crops are genetically enhanced to improve nutritional content, addressing deficiencies in essential vitamins and minerals for better health. District Kaushambi recorded increased production with the use of bio-fortified crop Bajra (AHB-299). They record the increased production and net return by 21% and 27%, respectively in bio-fortified crop.

Growing of salt resistant crops

Growing salt-resistant crops involves cultivating plants which are genetically adapted to thrive in saline soils. Kaushambi district reported production of 225.67 q/ha with net return of Rs. 3,27,810 /ha to farmers in Beetroot variety Ragini. Similarly district Bhadohi reported increases production and net return of 18% and 15%, respectively in Bajra variety “NSC-1071P”.

Short duration variety

Short-duration crop varieties mature quickly which enabling multiple harvests annually, reducing farming risks and supporting efficient agricultural practices. District Bhadohi reported productivity and net return of 52.95 q/ha and Rs. 1,23,429 /ha in short duration variety of rice (Co-51). The crop matured in 105-110 days with the help of DSR technology. Similarly Kanpur Dehat district recorded productivity and net return of 21.50 q/ha and Rs. 86,500 /ha in short duration variety of gram (RVG 202). The variety also show prominent resistant against wilt.

Conclusion

The result demonstrated that NICRA (National Innovations on Climate Resilient Agriculture) farmers consistently outperform non-NICRA farmers in terms of both productivity and net returns across various crops and varieties in the *Kharif* and *Rabi* seasons. Districts across Uttar Pradesh showed enhanced yield and productivity with integrated approaches such as Natural Resource Management and advanced crops in sodic soils.

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Role of NICRA's Interventions in Carbon Footprint Reduction: A Study from Himachal Pradesh

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Climate change poses a global challenge, significantly impacting agriculture, especially in vulnerable regions like India. Agriculture's heavy dependence on climate makes it particularly susceptible to adverse conditions, emphasizing the need for capacity building in climate resilience and effective resource management. Bridging farmers' understanding of climate-agroecosystem interactions and adopting adaptive practices can mitigate risks and support sustainable agriculture. Achieving carbon neutrality is a critical global priority to combat climate change. Cropland contributes significantly to greenhouse gas emissions, accounting for nearly 8% of methane (CH_4) and 32% of nitrous oxide (N_2O) emissions globally. Reducing agricultural emissions and enhancing soil carbon sequestration are vital for meeting global climate targets under the Paris Agreement. Efforts to achieve carbon neutrality require effective policies and technological innovations to ensure a safe future. The National Innovations in Climate Resilient Agriculture (NICRA) program aims to mitigate climate change impacts by promoting sustainable agricultural practices. This study focuses on the role of NICRA interventions in reducing carbon footprints at Seradh village in Himachal Pradesh, implemented through KVK Mandi. By adopting strategies such as carbon sequestration, efficient resource management, and climate-resilient farming techniques, the program demonstrates its potential to enhance environmental sustainability while empowering rural communities.

Methodology

The study employed a comparative survey-based approach to evaluate the impact of NICRA interventions on carbon footprint reduction in Seradh village, Himachal Pradesh. Data were collected before and after the implementation of NICRA initiatives through structured surveys and field observations. Key parameters, such as agricultural practices, resource use efficiency, and carbon sequestration potential, were measured and analyzed. Statistical methods were applied to compare pre- and post-intervention data, highlighting the effects of NICRA interventions on carbon balance and sustainability outcomes.

Results

The NICRA interventions at Seradh village revealed significant shifts in agricultural, livestock, and horticultural practices, positively influencing carbon balance:

1. Agricultural Intensification: Increased cropping area for paddy (+2 ha), maize (+2.6 ha), and wheat (+3 ha), alongside diversification with legumes (soybean, black gram) and vegetables. Enhanced yields were observed due to improved varieties and better crop management, contributing to higher biomass and carbon sequestration.
2. Horticulture Expansion: Introduction of fruit crops like lime, persimmon, plum, and pomegranate on 1.6 ha, promoting perennial vegetation that acts as a carbon sink.
3. Livestock Management: Improved livestock feeding (enhanced concentrate and roughage proportions) and manure handling (shift to solid manure usage) potentially reduced methane emissions while maintaining nutrient cycling.
4. Energy Efficiency: Village-wide adoption of electric irrigation pumps, replacing manual systems, improved water management efficiency. A slight increase in LPG usage (140 households) and reduced reliance on dung cakes lowered indoor air pollution and carbon emissions.
5. Economic Returns and Sustainability: Improved net returns in major crops like wheat (from ₹7,100 to ₹14,350/ha) reflect economic viability, which incentivizes sustainable practices.
6. Residue Management: Adoption of mulching over burning enhanced soil organic carbon and reduced emissions from residue combustion.

Conclusion

The NICRA study in Seradh village highlights increased agricultural productivity and diversification, adoption of improved crop varieties, and enhanced livestock management practices. These changes contributed to improved carbon balance through efficient resource utilization, better yields, and reduced cultivation costs, promoting sustainable rural development.

UID: 1695

Enhancing Productivity and Sustainability through Integrated Farming Systems

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The predominant sugarcane-wheat cropping system in western Uttar Pradesh has led to declining water tables and soil degradation, necessitating diversification. The IFS approach provides a pathway for sustainable intensification by incorporating complementary enterprises while adhering to principles of resource recycling. By minimizing external inputs and promoting nutrient and energy recycling, IFS models mitigate environmental impacts and enhance productivity, profitability, and sustainability for small and marginal farmers, who constitute 87% of India's farming community (Meena et al., 2022). The Integrated Farming System (IFS) model has emerged as a holistic solution for achieving sustainable agricultural growth. By integrating various agricultural enterprises, the IFS model optimizes resource use efficiency, minimizes environmental impact, and improves economic resilience in farming communities. The primary objectives of the study were to identify ecologically and economically viable enterprises suitable for diverse agro-climatic regions under the current climate change scenario, and to evaluate economic suitability of the modules and model.

Methodology

The Integrated Farming System (IFS) model was established on a 0.72-hectare area, integrating diverse components to achieve ecological balance, economic viability, and social sustainability. The cropping systems occupied the largest portion, spanning 0.38 hectares. Three distinct crop rotations were adopted to ensure diversity and nutrient cycling: biofortified rice followed by biofortified wheat and mustard, with green gram as a summer legume; sweet corn followed by garlic and vegetable cowpea; and maize intercropped with soybean, followed by ryegrass and fodder sorghum. These cropping patterns were selected for their adaptability to the region, high productivity, and nutritional value.

Multi-layer farming was established on 0.18 hectares to maximize vertical space utilization and increase productivity per unit area. This innovative approach included turmeric as a base crop combined with leafy vegetables such as red amaranthus, fenugreek, and coriander, while cucurbits and papaya were grown in the upper layers. Multi-layer farming not only diversified income sources but also ensured year-round production of fruits and vegetables, meeting dietary and economic needs. An agri-horticulture system covering 0.12 hectares was integrated into the model to combine fruit and spice production. Papaya and banana plantations were intercropped with turmeric, utilizing the interspaces effectively while maintaining soil fertility. This component aimed to provide high-value crops, enhance biodiversity, and contribute to income stability. Boundary plantations were established along the perimeter of the farm, covering 0.02 hectares. Karonda and guava were planted as fruit-bearing species, while napier grass was included for its role as fodder for the dairy unit. These plantations served dual purposes, providing an additional income source and contributing to environmental sustainability by reducing soil erosion and enhancing farm biodiversity. A dairy unit was also integrated into the system, comprising one buffalo and one cow, with a dedicated area of 0.01 hectares. Secondary agriculture activities such as processing and recycling were emphasized to maximize resource utilization and increase the economic returns from farming operations.

Table 1. Components of IFS model

Sl. No.	IFS model (details of components)	IFS Area (ha)
1.	Crop (1. Biofortified rice-Biofortified wheat and Mustard-Green gram, 2. Sweet corn-Garlic-Vegetable cowpea, 3. Maize + soybean- ryegrass-fodder sorghum) (0.38 ha) + Multi-layer farming (Turmeric+ green/leafy vegetables (Red Amaranthus- Fenugreek-Coriander) + Cucurbits + Papaya) (0.18 ha) + Agri-horti (Papaya + turmeric, banana + turmeic) (0.12 ha) + Boundary plantation (karonda, guava, napier) (0.02 ha) + Dairy (1 Buffalo + 1 Cow) (0.01ha) + Secondary agriculture	0.72 ha

Results

Area and Income Contribution of IFS Components

The contribution of each component to the total area and net income was analyzed, with crops forming the backbone of the system.

Productivity and Profitability Analysis

The cropping systems contributed the highest share to both area utilization and income generation, accounting for 67% of net returns. Dairy emerged as the second most significant contributor, with a 23% income share despite occupying only 2.8% of the area. Multi-layer farming, though resource-intensive, showed potential for improvement with optimized management.

Table 2. Area and Income share of components in IFS model

Farming System Modules	Area share (%)	Income share of Net Return with family labour (%)
Crops / cropping systems	52.8	67
Agri-horti	16.7	0
Multi-layer farming	25.0	-6
Dairy	2.8	23
Boundary plantation	2.8	4
Total	100	100

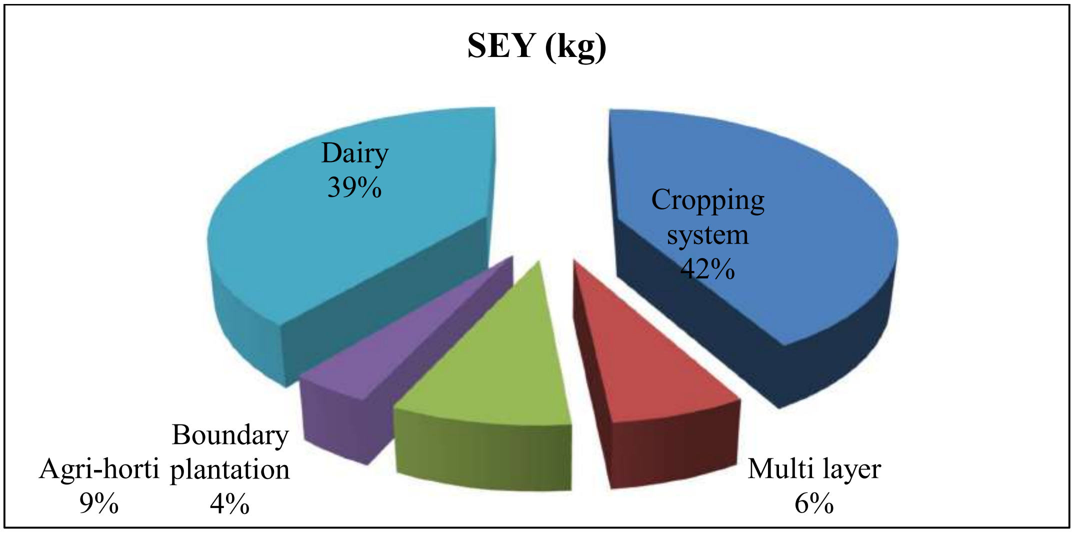

Fig 1. Sugarcane equivalent yield from different components

Sugarcane Equivalent Yield (SEY)

The productivity of the integrated components was evaluated using the Sugarcane Equivalent Yield (SEY). The analysis revealed that the cropping systems, dairy, and boundary plantation components contributed significantly to overall productivity. The productivity of the integrated components was evaluated using the Sugarcane Equivalent Yield (SEY). The cropping system emerged as the largest contributor, accounting for 42% of the total SEY, emphasizing its role as the backbone of the system. Dairy followed closely, contributing 39% to the overall productivity, showcasing its significance in providing consistent income and nutritional security. Agri-horti enterprises contributed 9% to the SEY, reflecting the potential of diversification in enhancing productivity. The multi-layer farming system accounted for 6% of the SEY, underlining its role in optimizing land use through vertical crop arrangements. Lastly, boundary plantations contributed 4%, demonstrating the importance of utilizing non-arable spaces efficiently. These findings indicate that integrating complementary components such as dairy, agri-horti, and boundary plantations alongside cropping systems can significantly enhance the overall productivity and sustainability of the farming system.

The analysis of net returns from the Integrated Farming System (IFS) components reveals that the cropping system is the primary contributor, generating 67% of the total net returns. These findings align with previous studies (Meena et al., 2022). This highlights the economic significance of cropping systems as the foundation of farm income. Dairy, the second-largest contributor, accounts for 23% of the net returns, emphasizing its vital role in enhancing farm profitability and providing regular cash flow. Boundary plantations contribute 4% to the net returns, showcasing the economic utility of utilizing marginal spaces effectively. Conversely, the multi-layer farming system exhibited a negative contribution of -6%, indicating higher labour cost. The agri-horti component recorded no significant contribution to net returns, suggesting the need for further optimization or adjustments in its integration. Overall, the findings underscore the importance of diversifying farming enterprises to enhance economic stability while identifying areas for improvement to maximize profitability in an IFS model.

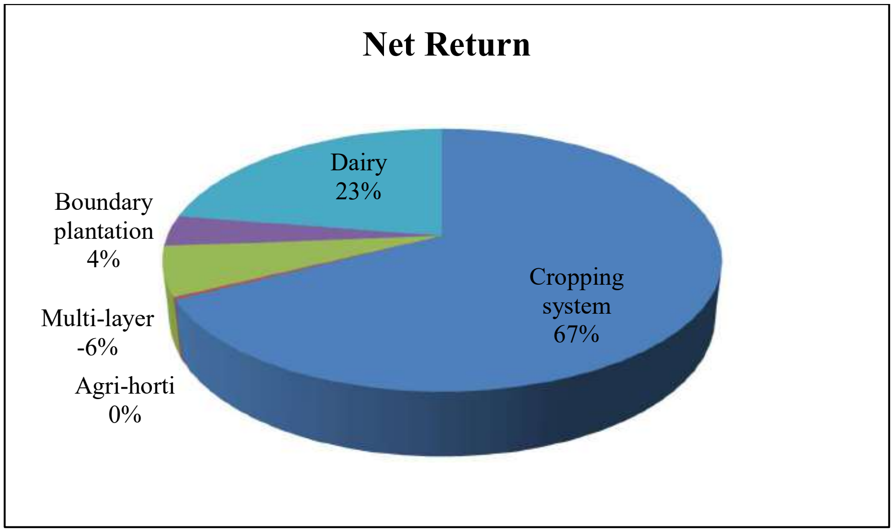

Fig 2. Net returns from different components of IFS

Conclusion

The Integrated Farming System (IFS) model has proven to be an effective strategy for sustainable agricultural development, particularly in addressing the challenges of declining soil fertility, water scarcity, and reduced farm incomes in western Uttar Pradesh. The study highlighted the significant contributions of cropping systems and dairy enterprises to both productivity and profitability. Cropping systems formed the backbone of the model, contributing 42% to Sugarcane Equivalent Yield (SEY) and 67% to net returns, while dairy complemented it by providing 39% to SEY and 23% to net returns. Other components, such as agri-horti, boundary plantations, and multi-layer farming, demonstrated potential for resource optimization, though some require further refinement to enhance their economic viability. The IFS model not only diversified farm income sources but also improved resource use efficiency through recycling and integration. By combining ecological and economic sustainability, the model offers a viable pathway for small and marginal farmers to improve livelihoods while ensuring environmental conservation. These findings emphasize the importance of promoting IFS for sustainable intensification and resilience in Indian agriculture.

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UID: 1701

Climate Resilient Agriculture and Allied Sector for Improving the Livelihood of Small-scale Farmers in the Hills of Kalimpong District

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NICRA, Kalimpong KVK, UBKV, Kalimpong

Kalimpong district is a district in the state of West Bengal. In 2017, it was carved out as a separate district to become the 21st district of West Bengal. Kalimpong district is bounded on the north by the State of Sikkim, on the south by Jalpaiguri district; on the west by Darjeeling district of west Bengal and on the east by Bhutan. Geographically the district is situated between 26°51’ and 27°12’ N latitude and between 88°28’ and 88°53’E longitude. The district covers an area of 1056.5 sq.km. placed between the Teesta and the Jaldhaka rivers and stretched from the lesser Himalayas to its foothills. The Kalimpong district is rich with an abundance of flora and fauna, with temperate climate that favours agro-horticulture. More than 80% of people in Kalimpong depend on farming for their livelihood. Major agro-products include paddy, maize, millet, pulse, oilseed, potato and vegetables; however Kalimpong is more widely known as a hub of cash crops like ginger, cardamom, betel-nut and oranges. Kalimpong is also the home to the Dalle Khursani (*Capsicum annuum*), extremely hot chillies, which add delectable pungency to the exotic cuisine of the hills.

Since 2 years Paiyong Khasmahal and its sourrounding villages of the Kalimpong district have been selected as NICRA village for a network project, National Innovations in Climate Resilient Agriculture (NICRA), under the Indian Council of Agricultural Research (ICAR), by Kalimpong KVK, which seeks to improve the agricultural sector in the regions. Several climate-smart technologies have been disseminated to farmers in an effort to reduce the impact of climate change on extreme weather. With a total land size of 861.99 hectares, Paiyong Khasmahal is situated in the Lava Block of the Kalimpong district in West Bengal. The area is generally used to be the most productive on the aspects of variety of fruits and vegetables with several commercial crops, including ginger, cardamom, and chilly, in order to improve the standard of living for residential farmers. However, in recent years, these regions have been under the influence of climate change, which has had an impact on agriculture because of certain rise in temperature, more unpredictable precipitation, and extreme weather events like droughts and landslide. Infestations of pests and invasive weeds have also increased recently, according to local farmers. Darjeeling KVK has undertaken various farming and agricultural operations through NICRA project, such as; Demonstrations (FST) includes Rain fed farming with Animal, Scaling up technologies which include In-situ moisture conservation Water saving irrigation, Vermi-compost production, Rain water harvesting, Intercropping, Crop diversification- with improved varieties , Mushroom production, Demonstration of fodder crops.

In addition the demonstrations such as;

1) Demonstration on NRM such as Rain water harvesting through Poly tank, Vermi compost production through organic waste under polybag method, Organic mulch in cole crop, where more than 70 farmers benefitted.

2) Demonstration on crops such as Dalley Chilli cultivation through poly-mulching, Tomato cultivation through poly-muclhing , Intercropping of cole crops and legumes, Intercropping of legumes with Maize, Darjeeling Mandarin grafted with rough lemon, Avocado seedlings, Turmeric (var. local and Suranjana), Mushroom production, Napier hybrid grass, African tall Maize hybrid, where 144 farmers were benefitted.

3) Demonstration on Livestock includes Pig shelter, Animal health camp where 47 farmers were benefitted.

An innovative conceptual framework based on improving the livelihood of small-scale farmers was presented through the National Innovations in Climate Resilient Agriculture (NICRA) project. Numbers of demonstrations regarding their precarious situation were conducted to minimize the current and potential risk vulnerability faced by small-scale farmers.

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UID: 1710

Enhancing Productivity and Profitability through On-Farm Intercropping of Pulses and Vegetables in Summer Sugarcane

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Sugarcane, the dominant sugar crop of India, is cultivated on over 5.88 million hectares, with a total production of 494 million tonnes. Uttar Pradesh leads in both area and production, with sugarcane serving as a vital livelihood crop for farmers in the Western Plain Zone. In northern India, sugarcane is planted in autumn (October/November), spring (February/March), and summer (April/May). Farmers often intercrop mustard and vegetables with autumn-planted sugarcane, though this practice is limited due to the predominance of spring and summer planting, especially after wheat harvest in the sugarcane-ratoon-wheat system. An on-farm trial was conducted in Meerut district during summer 2024 to evaluate the intercropping potential of short-duration vegetables and pulses in sugarcane using the trench planting method. Intercrops included urdbean (987 kg/ha), okra (11,079 kg/ha), cucumber (13,512 kg/ha), vegetable cowpea (10,300 kg/ha), and tomato (6,100 kg/ha). Results showed that okra achieved the highest sugarcane equivalent yield (SEY) of 136 t/ha, followed by vegetable cowpea (106 t/ha) and cucumber (68 t/ha). Similarly, okra intercropping provided the highest gross returns, followed by vegetable cowpea. Farmers identified challenges such as stray cattle and blue bull damage, particularly in legume-based intercrops. Despite these issues, the study concluded that intercropping short-duration vegetables and pulses in summer-planted sugarcane significantly enhances system productivity and profitability. Okra and vegetable cowpea emerged as the most profitable options for intercropping, offering a sustainable pathway to improve farmers' income. This research highlights the potential of integrating vegetables and pulses into sugarcane systems, providing an effective strategy for enhancing land use efficiency and economic returns.

UID: 1712

Enhancing Climate Resilience and Livelihoods: Evidence from NICRA Interventions in Odisha

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The National Innovations on Climate Resilient Agriculture (NICRA) project, implemented by Krishi Vigyan Kendras (KVKs), is designed to enhance the adaptive capacities of farmers through technology demonstrations and livelihood diversification. This study evaluates the livelihood diversification initiatives undertaken by KVK, Ganjam-I, under NICRA over two consecutive years (2022-2023). With a focus on 120 respondents (40 per village) from three selected villages, the paper highlights the impacts of these interventions on income generation, resource utilization, and climate resilience. Statistical analyses, including paired t-tests, multiple regression, and ANOVA, were employed to evaluate the effectiveness of these initiatives. Key findings reveal significant income increases, adoption of climate-resilient practices, and improved resource optimization, emphasizing the role of tailored interventions in sustaining livelihoods under climate variability.

Introduction

Climate variability poses significant challenges to smallholder farmers, particularly in regions with limited adaptive capacities. The NICRA project, implemented by Krishi Vigyan Kendras (KVKs), aims to address these challenges through climate-resilient agricultural practices and livelihood diversification strategies. This study evaluates the effectiveness of NICRA interventions in enhancing income stability, resource optimization, and resilience among farming households in Chopara, Nada, and Chikili villages in Jagannathprasad block, Ganjam district.

The selected interventions include backyard poultry, mushroom cultivation, vermicomposting, and integrated farming systems (IFS)(Mihiretu et al., 2020). These activities were designed to address village-specific challenges and leverage local resources. This study analyzes the impact of these activities over two years, with 40 respondents sampled per village, ensuring robust representation across diverse demographic and agro-ecological contexts.

Materials & methods

Study Area: The study was conducted in three villages—Chopara, Nada, and Chikili—located in Jagannathprasad block under the jurisdiction of KVK, Ganjam-I. These villages were chosen based on their vulnerability to climate variability, active involvement in NICRA interventions, and diverse agro-ecological conditions. The selection ensures comprehensive insights into the impacts of livelihood diversification across varied farming systems.

Sample Size and Sampling Design: A total of 120 households (40 per village) were purposively selected. Respondents were categorized into beneficiaries who actively participated in NICRA interventions and control households who did not engage in these activities. This approach facilitated a comparative analysis to evaluate the program's impacts.

Data Collection

Baseline and Follow-Up Surveys: Data were collected during kharif and rabi seasons for the years 2022 and 2023. Surveys captured information on income levels, resource utilization, adoption rates of interventions, and socio-economic characteristics of households.

Focus Group Discussions (FGDs): FGDs provided qualitative insights into barriers to adoption, resource optimization strategies, and community-level benefits. Separate sessions were conducted for men and women to understand gender-specific dynamics.

Village-Specific Activity Performance: Detailed records of intervention outcomes (e.g., yield, income, and adoption rates) were maintained for all three villages, ensuring activity-wise evaluation.

Analysis Framework

Descriptive Statistics: Calculated means, medians, and standard deviations to summarize household income, resource utilization, and adoption rates.

Paired t-tests: Assessed income changes before and after interventions for statistical significance.

Multiple Regression: Identified key determinants of income growth, including socio-economic and program-related variables.

Result & Discussion

1. Descriptive Analysis

The descriptive analysis highlighted significant improvements in household incomes and resource optimization across all interventions.

Activity	Village	Avg. Income Before (₹)	Avg. Income After (₹)	% Income Increase
Backyard Poultry	Chopara	3,200	7,500	134%
	Nada	3,600	7,800	117%
	Chikili	3,700	8,000	116%
Mushroom Cultivation	Chopara	2,600	5,800	123%
	Nada	2,900	6,300	117%
	Chikili	3,000	6,500	117%
Vermicomposting	Chopara	1,100	4,500	309%
	Nada	1,300	4,800	269%
	Chikili	1,200	5,100	325%
Integrated Farming Systems	Chopara	7,800	15,800	103%
	Nada	8,100	16,200	100%

	Chikili	8,200	16,500	101%

2. Statistical Analyses

Paired t-test Results: Income increases across all activities were statistically significant, as shown below

Activity	Village	t-Statistic
Backyard Poultry	Chopara	8.50
	Nada	8.12
	Chikili	8.65
Mushroom Cultivation	Chopara	7.90
	Nada	8.20
	Chikili	8.50
Vermicomposting	Chopara	10.20
	Nada	10.80
	Chikili	11.00
Integrated Farming Systems	Chopara	7.90
	Nada	7.80
	Chikili	7.95

$p<0.01$

Regression Analysis: Key predictors of income growth included education, landholding size, and access to training, as detailed below

Predictor Variable	Coefficient (β)	Standard Error	t-Statistic
Education Level	1,250	320	3.91
Landholding Size	2,100	540	3.89
Access to Training	1,800	450	4.00
Extension Visits	1,500	400	3.75
Adoption of ICT Tools	900	310	2.90

$p<0.01$

Statistical Inferences and Impacts: The paired t-test results confirmed statistically significant income increases across all interventions, with p-values consistently below 0.01. For example, vermicomposting demonstrated the highest percentage income gain, with increases of 309% in Chopara, 269% in Nada, and 325% in Chikili. Mushroom cultivation showed consistent adoption across villages, with income increases averaging over 120%.(Hamza & Iyela, 2012; Mihiretu et al., 2020; Yahaya et al., 2022).

Regression analysis revealed education level, landholding size, and access to training as significant predictors of income growth. Notably, a unit increase in education resulted in an additional ₹1,250 in household income, emphasizing the role of knowledge dissemination in enhancing adaptive capacities. Access to training contributed ₹1,800 to household income growth, highlighting its critical role in driving adoption and improving productivity (Demem, 2023; Manyanga et al., 2022).

Village-Specific Trends: Chopara exhibited the highest gains in mushroom cultivation and vermicomposting, attributed to strong extension service presence and market accessibility.

Nada's success in integrated farming systems underscores the importance of larger landholdings, which enabled better resource optimization. Chikili excelled in backyard poultry due to its focus on community-based training and existing infrastructure(Unganai & Murwira, 2010).(Weldlul Ayalew Lemma, 2016).

Gender Dynamics: Women's participation was most notable in vermicomposting and mushroom cultivation, contributing significantly to household income and food security. However, their involvement in integrated farming systems was limited, underscoring the need for gender-specific interventions to promote inclusive participation in all activities.(Arabinda Padhee, 2018; Phiri et al., 2021).

Sustainability and Climate Resilience: The sustainability of NICRA interventions is evident in the adoption of practices like vermicomposting and integrated farming systems, which reduce reliance on external inputs and enhance soil health. These interventions align with broader climate resilience goals, providing a replicable model for scaling in similar agro-ecological zones (Ehsan et al., 2022; Hess, 2019; Joshi & Tyagi, 2019).

Conclusion

The NICRA interventions implemented by KVK, Ganjam-I, have significantly enhanced livelihoods in Chopara, Nada, and Chikili villages. Key livelihood activities, such as backyard poultry, mushroom cultivation, vermicomposting, and integrated farming systems, demonstrated measurable benefits in terms of income generation, resource optimization, and resilience building. Statistical analyses identified education, access to training, and landholding size as critical determinants of these outcomes.

The program's alignment with sustainable agricultural practices highlights its potential for addressing income stability and environmental conservation. Gender inclusion, although improved in specific activities like vermicomposting, requires further efforts to ensure balanced participation across all interventions. Tailored, localized strategies and market-driven approaches are essential to sustaining these gains and ensuring scalability. As climate variability continues to pose challenges, the NICRA model serves as a replicable framework for enhancing agricultural resilience and sustainability across diverse agro-ecological contexts.

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UID: 1744

Replacement of paddy through soyabean for empowering farmers

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The NICRA project was approved in the year 2022 at ICAR-Krishi Vigyan Kendra Panchmahal under Central Research Institute for Dry land Agriculture (CRIDA) Hyderabad. Krishi Vigyan Kendra Panchmahal selected Bedhyia as operational village under this project. Its total area is 1239.47 ha & cultivated area is 613 hectares, of which 521 hectares is Rainfed area and 92 hectares is irrigated area. The total population of the village is 8348, of which the total number of houses is 1658. Under the climate-resilient technologies component, the project focused on two typologies in Bedhyia village rainfed with animal and irrigated with animal. For the rainfed with animal typology, farmers traditionally relied on paddy cultivation, which required substantial irrigation due to erratic rainfall. Over time, groundwater levels declined due to excessive reliance on borewell irrigation. Additionally, timely water supply from borewells was often a challenge, and the income from paddy cultivation was insufficient.

To address these issues and enhance farmers' income, a shift from paddy to soybean cultivation was promoted. This transition aimed to mitigate climate risks and reduce the need for excessive irrigation. Moreover, increasing soybean production in India can help meet domestic vegetable oil demand and reduce foreign exchange expenditure on oil imports (Singh, 2010).

Methodology

The present study was conducted in Panchmahal district of central Gujarat during 2024 in Bedhyia village under the National Innovation on Climate Resilient Agriculture (NICRA) village program. Fifty farmers were selected for conducting the demonstrations to ensure their active participation. Under the NICRA, farmers were made aware about new techniques through trainings, Field days, method demonstrations, extension activities etc.The study was divided into two treatments:

1. Traditional Farming: This treatment involved the conventional farming practices followed by the farmers in the village, including the cultivation of water-intensive paddy crop.

2. Climate-Resilient Farming: This treatment involved the adoption of improved agronomic practices, including the cultivation of soybean variety NRC-37, efficient water management techniques and integrated pest management.

Production and economic data of both the crops were collected.

Results

The replacement of paddy with soybean as a climate-resilient crop presents a sustainable solution for addressing both environmental and economic challenges faced by farmers. The growth and yield of rice is significantly decreased because it is high water demanding crop to meet its water requirement lot of ground water is pumped out with the result water table is going deep due to uneven rainfall (Jeevandas *et al*. 2008). Paddy crop also affected by different insect, pest and diseases and farmer did not get actual rate of produce. In contrast, soybean, as a leguminous crop, requires significantly less water, making it better suited to changing climatic conditions (Ahlawat *et al*. 1998). In the present study, yield performance of soya bean was 16 q/ha despite lower yield, soybean generated a significantly higher net profit of Rs 65,680. This is due to the higher price i.e., @ 4,900 Rs/q compared to paddy crop. The lower cost of cultivation in soya bean also contributed to a higher net profit. As comparison to paddy crop, total cost of cultivation was substantial, at Rs 20,275 per hectare. Paddy exhibited higher yield but lower price per quintal resulted in lower overall profit. Despite the higher yield, the net profit of Rs 43,725 was moderate due to the lower price and higher costs.

Paddy COC/ha			Soybean (NRC-37) COC/ha		
Components	**Quantity**	**Price**	**Components**	**Quantity**	**Price**
Seed	15-20 kg	4000	Seed	62 kg	4620
Tillage	7	1400	Tillage	4	1600
NPK	N-675 kg	4000	NPK	-	-
	P-125 kg	3375			
Irrigation	5	1000	Irrigation	Rain	Rain
Insect & Pest Control	10 Pump @150 Rs/pump	1500	Insect & Pest Control	10 Pump @150 Rs/pump	1500
Harvesting		5000	Harvesting		5000
Total cost of cultivation/ha		20275	Total cost of cultivation/ha		12720
Yield	32 q @ Rs 2000/q	64000	Yield	16 q @ Rs 4900/q	78400
Net Profit		43725	Net Profit		65680

As a result, soybean cultivation was introduced on approximately 50% of the land that was previously used for paddy cultivation. Farmers got 50.21% profit by doing demonstration of soybean as compared to paddy crop.

Conclusion

In conclusion, the shift from water-intensive paddy cultivation to more resilient soybean cultivation offers a promising solution to address the challenges posed by climate change. Soybean's lower water demand, coupled with its higher market value, results in superior economic returns. While paddy may offer higher yields, its vulnerability to climate variability and lower profitability make it a less attractive option. It also improves soil health by fixing atmospheric nitrogen, reducing the need for synthetic fertilizers. By adopting soybean cultivation, farmers can enhance their resilience to climate change, reduce water consumption and improve their overall economic sustainability.

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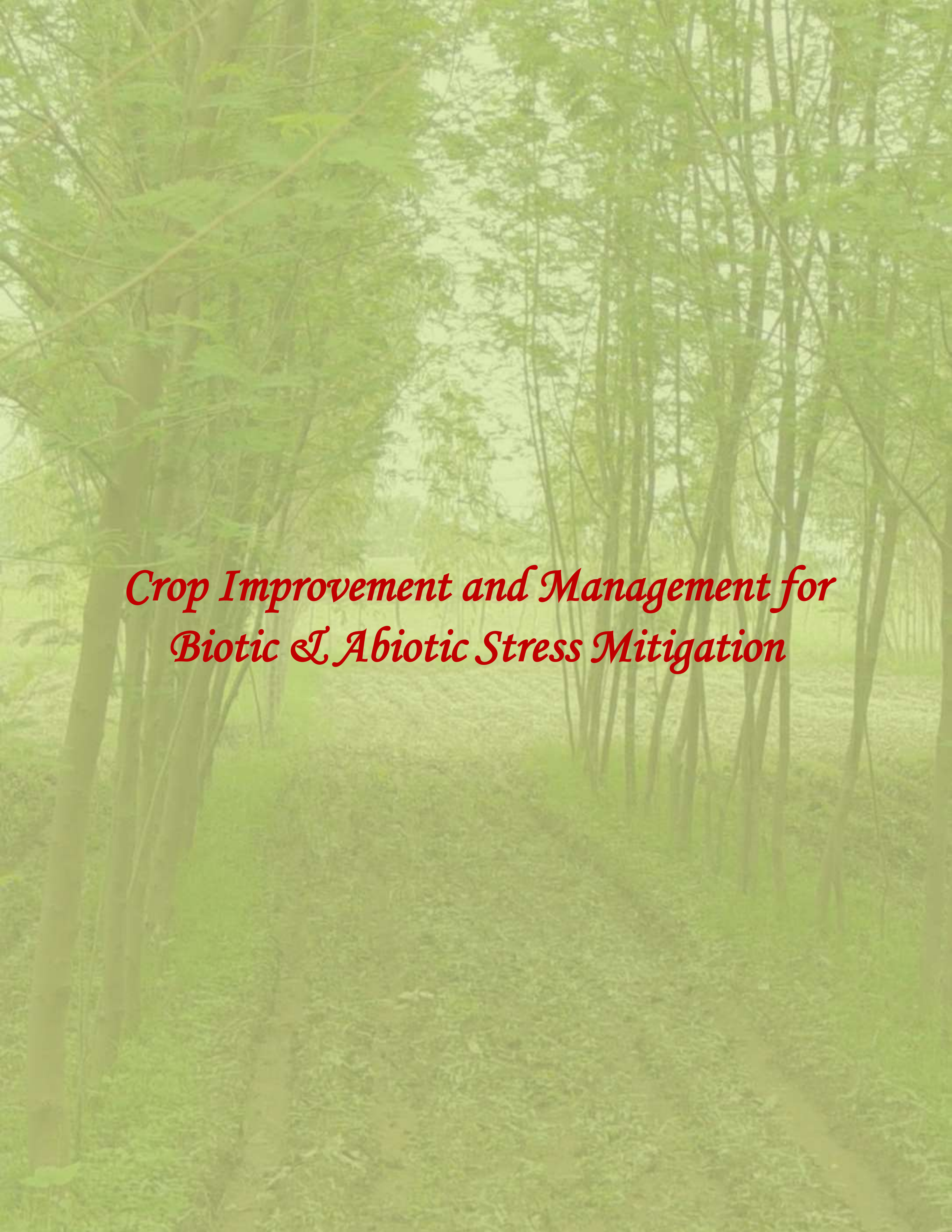

Crop Improvement and Management for Biotic & Abiotic Stress Mitigation

UID: 1007

Drought Tolerant Inbreds for Development of Climate-Resilient Hybrids in Sunflower

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Sunflower crop can be grown throughout the year owing to their photo-insensitive nature and therefore fits into any cropping pattern. It's short duration, coupled with photo-insensitivity, makes it the best choice as a contingent crop too. In India, sunflower area is slowly shifting to rabi and spring seasons as the kharif crop experiences pollen wash off if flowering coincides with rain and is subject to numerous pests and diseases leading to poor yield. Rabi sowings on residual soil moisture and spring sowing with limited irrigation facilities render the crop prone to water deficit at later stages of crop growth. Therefore, an attempt was made to identify drought tolerant inbreds of sunflowers so as to develop hybrids with tolerance.

Methodology

73 lines (65 CMS and R lines with 6 hybrids and 2 varieties) were evaluated for tolerance to drought under field conditions at Narkhoda farm of ICAR-IIOR by sowing in summer (30 Jan 2023) season to avoid incidence of rain during crop season in a split plot design with water stress treatments in the main-plot and inbreds in sub-plot. Crop was subjected to water stress by with holding irrigation from 35 DAS till maturity. The last irrigation received was on 25 DAS. Control plots received irrigation as and when necessary. This exposes the crop to water stress at the most critical stage of crop growth, i.e., flowering and anthesis. All other packages of practices were followed as recommended. The crop received 75 mm of rain from sowing to flowering and 48.2 mm from flowering to harvest. That is the reason why the stress imposition was extended to maturity as against the initial plan of relieving on the 75th day.

Results

Crop experienced optimum temperatures throughout the growing period (Table 1). Despite the rain received, the crop experienced a drought intensity index of 0.61 which is considered as severe drought. Inbreds showed significant differences for drought tolerance. Geetha et al. 2012 also reported genetic differences for a wide range of traits across cultivated sunflower lines, and thus potential for improvement through breeding. Among the traits studied, days to flowering and days to maturity did not show any differences (Table 2), while the most affected are leaf area (52%), total dry matter production (47%), capitulum weight (54%) and seed yield (61). Many findings reported (Rauf and Sadaqat, 2008; Yasaswini et al 2020; Yasaswini et al 2021) that low soil moisture content decreased above ground dry mass, harvest index and caused an increase in lower ground dry mass (root mass). Root mass seems to increase at the expense of above ground dry mass. None of the hybrids tested fall into the tolerant category, though the majority of them show moderate tolerance. The higher range for seed yield of moderately tolerant and sensitive types is mainly due to the presence of hybrids in that category.

Tolerant inbreds were identified based on the drought susceptibility index of Fischer and Maurer, 1978 and % reduction in yield along with yield in stress condition. CBE-COSF-3B, LAT-CMS-852B, BLR-ARM-249B, LAT-CMS-10B showed tolerance to drought with low drought susceptibility index. Among them only PI 686817, BLR-ARM-249B, LAT-CMS-10B showed higher seed yield (>10g/plant) even in stress condition which can be directly used in breeding programs.

Table 1. Weather during crop growth period

Crop stage	Max. Temp (°C)	Min. Temp (°C)	Mean Temp (°C)	Rain (mm)
Sowing to flowering	33.0	15.8	24.4	75 (3)
Flowering to harvest	36.0	21.3	28.7	48.2 (6)

Values in parenthesis are number of rainy days

Table 2. Effect of stress on different traits

Sl. No.	Character	% Reduction
1	Days to flowering	Nil
2	Days to harvest	Nil
3	Plant height	16
4	Leaf number	14
5	Stem girth	14
6	LAI	52
7	Head diameter	21
8	Leaf weight	25
9	Stem weight	40
10	Petiole weight	26
11	Capitulum weight	54
12	TDM	47
13	Seed weight	61
14	HI	28
15	Test weight	30

Conclusion

Availability of variation in the inbreds gives scope for planning breeding programmes aimed at abiotic stress tolerance. The identified tolerant lines can be used in breeding programmes to develop climate resilient hybrids of sunflower.

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UID: 1008

Evaluation of Trait Specific Castor (Ricinus Communis L.) Germplasm Accessions for Drought Tolerance

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Castor, a crop more tolerant to water deficit, is frequently grown in marginal and sub marginal shallow soils under rainfed conditions with low inputs. Crop is often subjected to moisture stress at critical stages, resulting in yield reduction. Genetic improvement of drought tolerance and drought management are the options to increase realizable yields. Testing the performance of genotypes under stress situation is a very useful step because it allows a direct estimate of drought tolerance or susceptibility of individual genotypes. The basic advantage in taking yield as a selection criteria is that it integrates all additive traits of many underlying mechanisms of drought tolerance (Kambiranda et al., 2011). Hence, an experiment was conducted with the objective to screen trait specific castor germplasm for their drought tolerance in the field to be included in breeding castor varieties and hybrids for rainfed situations.

Methodology

Eleven (11) trait specific germplasm lines, along with 2 checks (48-1, DCH-519) were sown in the field during November, 2020 and water stress was imposed from 30-90 DAS along with irrigated control plots in three replications each in split plot design. Crop growth before relieving stress (BRS) viz., plant height, branches, stem, leaf, spike weight and total plant dry matter (TDM) and spike data of different spike orders (spike length, ESL, capsule number, spike weight and seed weight), total seed yield were recorded. Genotypes were selected based on drought susceptibility index (DSI) values as given by Fischer and Maurer (1978).

Results

Crop growth before relieving stress (BRS) showed a reduction in plant height, branches, stem, leaf, spike weight and total plant dry matter (TDM) with moisture stress till 90 DAS and genotypic differences were also significant for all traits as reported in earlier studies in castor (Lakshmamma et al., 2004; Lakshmamma and Lakshmi, 2006). Primary and secondary spike growth was affected by drought stress. There was a reduction in spike length, ESL, capsule number, spike weight, seed weight of primary and secondary spikes with drought stress from 30-90 DAS. Very few germplasm lines produced tertiary branches in control at 90 DAS and in stress after relieving stress.

There was a significant reduction in primary, secondary, tertiary and total seed yield with drought stress. Control/irrigated crop recorded 113 g/plant total seed yield and water stressed crop recorded 70.3 g/pl. seed yield. Tested lines recorded a 16.0 to 54.6% reduction in total seed yield with a mean of 36.7%. Genotypes with ≤30% reduction in seed yield are RG 1594, RG 1663, RG 2818, RG 2822 and 48-1. Genotypes with high seed yield in control (142-193 g/pl.) including RG 2818 and RG 3798, with high seed yield in stress (77-119 g/pl.) include RG 1594, RG 2818, RG 3798 and DCH-519. Genotypes with ≤30% reduction in seed yield and with ≤0.8 DSI are RG 1594, RG 1663, RG 2818, RG 2822 and 48-1 (Table 1).

Table 1. Total Seed yield, % reduction in stress, DSI, TDM and HI of the studied genotypes

SL. No	Genotypes	Total Seed yield (g/pl.)		% reduction in seed yield	Drought susceptibility Index (DSI)	TDM at harvest (g/pl.)	
		Control	Stress			Control	Stress
1	RG 1587	83.2	45.9	44.8	1.19	251	157
2	RG1594	97.8	77.0	21.3	0.56	284	213
3	RG1663	82.0	61.2	25.4	0.67	222	157
4	RG2067	85.8	54.7	36.2	0.96	259	223
5	RG2149	100.9	58.5	42.0	1.11	297	162
6	RG2296	96.1	61.0	36.6	0.97	252	158
7	RG2781	126.4	60.0	52.5	1.39	316	162
8	RG2787	128.7	66.7	48.2	1.27	349	165
9	RG2818	142.0	119.4	16.0	0.42	428	266
10	RG2822	107.2	74.6	30.4	0.80	312	203
11	RG3798	193.1	87.7	54.6	1.44	487	211
C1	48-1	93.7	66.0	29.6	0.78	228	184
C2	DCH-519	132.5	80.7	39.1	1.03	352	192
means		113	70	36.7	0.97	311	189
				CD (0.05)			
Irrigations		*6.7*				*8.2*	
Genotypes		*15.4*				*31.4*	
interaction		*21.7*				*44.4*	
CV (%) a		*7.5*				*3.4*	
b		*14.4*				*10.8*	

There was a significant reduction in TDM at harvest with stress and reduction was not significant for harvest index (HI). The selected drought tolerant germplasm showed an increase in SPAD chlorophyll meter reading (SCMR) and specific leaf weight (SLW) with drought stress (data not presented). Reduction in crop growth with water stress and selection of genotypes based on DSI in castor was also reported in earlier studies at IIOR (Lakshmamma et al., 2017).

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Indigenous Microbial Consortia for Plant Growth and Plant Protection in Peas (Pisum sativum L.)

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Peas (Pisum sativum L.) are important members of the Leguminosae that are cultivated all over the world for their nutritional benefits. Besides being an important vegetable and field crop, peas are rich source of proteins, vitamin A and C, zinc and antioxidants. They are also a crop of choice because of their nitrogen fixing nodules found on their roots. A study was conducted for isolation of Rhizobia and plant growth promoting rhizobacteria and development of consortia of micro-organisms for use in peas under dryland conditions of Karewas in the temperate region of the Union Territory of Jammu & Kashmir.

Methodology

Rhizobium was isolated from the nodules of roots of peas in the active growing season. Plant growth promoting bacteria, mainly Pseudomonads, were isolated from the rhizoplane of peas by the serial dilution technique. After purification and preliminary screening, one strain of Rhizobium and one of Pseudomonas were used for further studies. The strains were tested individually and in combination for evaluation of plant growth promoting properties and response to major diseases of peas.

Results

It was found that the plant growth promoting properties of the microbial consortia were significantly higher than either Rhizobium or Pseudomonas used alone and also significantly higher than the control in which neither Rhizobium nor Pseudomonas had been added. The present investigations reiterate the importance of microbial consortia for successful crop regime, particularly under rainfed conditions of Kashmir. Foliar application of R. leeguminosarum was found to increase plant growth and nodulation in peas (Kashyap and Siddiqui, 2020). Kuzina et al., (2022) demonstrated the positive effect of Pseudomonas strains on the germination, growth and development of leguminous plants.

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Productivity and Sustainability of Moth Bean as Influenced by Improved Technology of National Innovations on Climate Resilient Agriculture (NICRA) under Hyper Arid Partially Irrigated Zone of Rajasthan

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Moth bean (Vigna aconitifolia) is a drought-resistant legume, native to arid and semi-arid regions, particularly in India. It is a valuable crop for enhancing soil fertility through nitrogen fixation and serves as a crucial food source for rural communities. The importance of moth bean has increased in the context of climate change. In Rajasthan, particularly in hyper arid and partially irrigated zones, the cultivation of moth bean faces significant challenges due to water scarcity and soil degradation. The National Innovations on Climate Resilient Agriculture (NICRA) program was launched to address these challenges by promoting innovative agricultural practices and technologies that enhance the resilience of farming systems. Improved technology under NICRA includes the introduction of drought-resistant varieties, efficient water management techniques, and integrated nutrient management. These advancements aim not only to enhance the productivity of moth bean but also to ensure the sustainability of agricultural practices in challenging environments

Methodology

The field experiments of 0.40 ha each were conducted at 25 farmers' fields in the adopted village, Kanasar of Bikaner district of Rajasthan (India) under the demonstration of NICRA (National Innovations on Climate Resilient Agriculture) during four consecutive kharif seasons, 2022 to 2024, to evaluate the economic feasibility and sustainability of improved technology of moth bean. Before conducting FLDs, a list of farmers was prepared from group meetings and specific skill training was given to the selected farmers regarding the package of practices. The difference between the demonstration package and existing farmers practices is given in Table 1.

Soils under study were loamy sand in texture with a pH range of 8.3 to 8.7. The soils are poor in available nitrogen, medium in phosphorous and potassium varied between 250-260, 15-19 and 227-230 kg ha-1, respectively. However, the soils were deficient in micro nutrients, particularly zinc and ferrous. The necessary step for the selection of site and farmers and lay out of demonstration were followed as suggested by Choudhary (1999). The traditional practices were maintained in case of local check. The data output was collected from both FLD plots as well as control plot and finally the extension gap, technology gap, technology index along with the incremental benefit-cost ratio were calculated as suggested by Raj et al. (2013). Data were recorded at harvest from each demonstration blocks and farmer's practice blocks. These recorded data were computed and analyzed for different parameters using following formula suggested by Prasad et al. (1993).

Extension Gap = Demonstration yield (Di) - Farmers practice yield (Fi)

Technology Gap = Potential yield (Pi) - Demonstration yield (Di)

Technology Index = (Pi-Di)/Pi x 100

Data were further analyzed for standard deviation and coefficient of variation as per standard procedure given by Panse and Sukhatme (1961). Sustainability indices (sustainability yield index and sustainability value index) were worked out using the formula given by Singh et al., 1990.

$$SYI/SVI = \frac{Y - O}{Ymax}$$

Where:

Y= Estimated average yield/ net return of practices over the year

O= Standard deviation

Y_{max} = Maximum yield/maximum net return.

Results

The Results presented in Table-2 demonstrate the impact of improved technology demonstrations of the National Initiative on Climate Resilient Agriculture (NICRA) on the seed yield and net return of moth bean across three years (2022, 2023, and 2024).

Comparison between NICRA demonstration package and existing practices under moth bean crop

Particulars	Moth bean crop	
	Demonstration	Farmers Practice
Farming situation	Unirrigated	Unirrigated
Variety	RMO-2251	Local seed
Time of sowing	First or second week of July	First or second week of July
Method of sowing	The line sowing of seed with row spacing of 30 cm. was done after application of basal fertilizer dose	Some farmers adopted line sowing with 30 cm. row spacing. However mostly farmers use broadcasting method of sowing. The fertilizers mixing with seed is a common practice in sowing.
Seed treatment	Carbendazim @ 2.0 g kg^{-1} seed	No seed treatment
Seed rate	15 kg ha^{-1}	20 kg ha^{-1}
Fertilizer dose	NPK (10:20:00) 50 % RDF	NPK (Nil)
Micronutrient	Two sprays of 0.5 % $FeSO_4$ with citric acid and $ZnSO_4$ with lime were done due to deficiency occurring during growth period of crop.	No $ZnSo_4$ applied
Weed management	Application of pre-emergence herbicide pendimethalin @ 1.00 kg ha^{-1}. If the weeds emerge after planting, Imazethapyr @ 37.5 g *a.i.* ha^{-1}.as post-emergence sprayed at 30 days after sowing.	Application pendimethalin @ 1.00 kg ha^{-1} as pre-emergence.
Plant protection	Approaches of Integrated pest and disease management for the management of pest and diseases. Spray of COC @ 30 g + 2g streptocycline per 10 litre of water against bacterial blight. Spray of Quinalphos 25 E.C. @ 1.2 litre against pod borer and monocrotophos 36 SL 1.0 litre ha^{-1} against white fly attack.	Injudicious use of pesticides and fungicides.

The data show significant variations between the improved technology (IT) and the farmer practice (FP) across all years and pooled Results. Seed yield of moth bean varied from 631-981 kg ha-1 in improved technology and 359-782 kg/ha in farmers practice (Table). Results indicated that the implementation of improved technology significantly increased moth bean yields, achieving a mean yield of 765 kg ha^{-1}, which represents a 24.5 percent increase compared to the 616 kg ha^{-1} yield from traditional practices. Furthermore, the sustainability of moth bean production was reflected in a higher sustainability yield index (0.704) and sustainability value index (0.570) compared to farmers' practices. These findings underscore the potential of improved agricultural technologies to enhance both yield and sustainability in moth bean cultivation.

Conclusion

The findings from this study underscore the positive impact of NICRA's improved technology demonstrations on both seed yield and net returns for moth bean cultivation. The enhanced productivity and profitability associated with improved technology suggest that such interventions are essential for promoting sustainable agricultural practices and improving farmer livelihoods in the face of climate change.

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Impact of Planting Time on Dual Purpose Sorghum Drymatter Yield under Different Crop Geometries

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Sorghum (*Sorghum bicolor (L.) Moench*) is the staple food for millions of people in the Semi-Arid Tropic regions of Asia and Africa. It is the main source of food and fodder and widely grown forage crop for dairy animals, with key characteristics being wide adaptability across environments and tolerance to biotic and abiotic stresses, especially among the resource poor small-scale farmers (Dahlberg *et al*., 2011; *Gill et al.,* 2014). In Tamil Nadu it is cultivated in an area of 4.01 lakh hectares with a productivity of 612 kg ha^{-1}. The major sorghum growing districts in Tamil Nadu are Namakkal, Dindigul, Tiruppur, Salem, Coimbatore, Trichy and Dharmapuri. Sorghum is mainly cultivated as a rainfed crop during monsoon season and with residual moisture during *rabi* season. Despite the importance of sorghum, its cultivation areas have witnessed a remarkable decline starting from the mid-eighties, which is the peak of its production until the present time due to climatic changes. Therefore, it has become necessary to search for other means or technologies that lead to increasing the yield and improving its quality, such as adjustment of sowing date to accommodate the thermal trend, maintaining optimum plant density, development of new varieties suitable for adapting to the changing climate (Zhang and wang, 2019). Keeping all this in view, in order to optimize the spacing, date of sowing, to have the fodder availability in all the seasons with good fodder yield (green and dry) to the livestock the following research has been undertaken with the objective to study the effect of sowing window and crop geometry on drymatter yield of dual-purpose sorghum.

Methodology

A field experiment was conducted at the research farm of Department of Agronomy, TNAU, Coimbatore during Kharif 2022 and Rabi 2022-2023 to study the effect of planting time and crop geometry on drymatter yield of dual-purpose sorghum. The experiment followed a Strip Plot Design with three replications. The treatments included three sowing windows I Fortnight (FN) of May (D1), I FN June (D2), I FN July (D3) during the Kharif 2022 and II FN of August (D1), II FN September (D2), and II FN October (D3) during the Rabi 2022-2023 and crop geometry viz., 45 × 15 cm (S1), 45 × 10 cm (S2), 45 × 5 cm (S3), 30 × 15 cm (S4), 30 × 10 cm (S5), and 30 × 5 cm (S6). The sorghum CO-32 variety chosen for the study was released from Tamil Nadu Agricultural University (TNAU) in the year 2020. Healthy and viable sorghum seeds were dibbled on the side of the ridges according to the treatment spacing. All the necessary cultural operations were performed following the guidelines of TNAU as and when needed. Five plants were taken for dry matter production from the sample rows. For assessing the drymatter yield five plants were taken from the sample rows. The material was air dried and then oven dried at 80 ± 2°C until a constant weight was attained and expressed in kg ha-1.

Results

Sowing window and crop geometry significantly influenced the dry matter production (DMP) of dual-purpose sorghum. During Kharif significantly higher DMP of 15542 kg ha-1 was registered with June I FN sown crop followed by July I FN sown crop with 14896 kg ha-1. The lowest dry matter production was observed in May I FN sown crop. Regarding crop geometry at harvest significantly higher DMP of 22051 kg ha-1 was observed with 30 × 5 cm followed by 45 × 5 cm (S3) with a yield of 17332 kg ha-1. The lowest drymatter production of 10489 kg ha-1 was observed with wider spacing of 45 × 15 cm. This might be due to the fact that under early sown conditions sorghum plants could not accumulate the sufficient photosynthates which resulted in poor vegetative growth and ultimately resulted in low dry matter production. Similar Results were reported by Mishra et al. (2017) and El-Raouf et al. (2013)

During *Rabi* DMP was higher with II FN of September crop with 14679 kg ha^{-1} drymatter followed by II FN of August sowing which recorded drymatter of 14025 kg ha^{-1}. Crop geometry had similar effect as of *Kharif* with 20636 kg ha^{-1} of dry matter with was 30 × 5 cm spacing followed by 45 × 5 cm with 16223 kg ha^{-1}. This might be due to the fact that narrower spacing provided increasing stem density due to an increase in plant population and efficient utilization of solar energy.

Drymatter production (kg ha^{-1}) of dual purpose sorghum at harvest as influenced by sowing window and crop geometry during *Kharif* and *Rabi* seasons

Treatment		Dry matter Production	
Sowing window	***Kharif***	**Sowing window**	***Rabi***
D_1 – First FN of May	14342	D_1 - Second FN of August	14025
D_2 - First FN of June	15542	D_2 - Second FN of September	14679
D_3 – First FN of July	14896	D_3 - Second FN of October	13411
SEd	175	SEd	191
CD (P= 0.05)	488	CD (P= 0.05)	532
Crop geometry		**Crop geometry**	
S_1 - 45 × 15 cm	10489	S_1 - 45 × 15 cm	9872
S_2 - 45 × 10 cm	13069	S_2 - 45 × 10 cm	12308
S_3 - 45 × 5 cm	17332	S_3 - 45 × 5 cm	16223
S_4 - 30 × 15 cm	11674	S_4 - 30 × 15 cm	11189
S_5 - 30 × 10 cm	14944	S_5 - 30 × 10 cm	14005
S_6 - 30 × 5 cm	22051	S_6 - 30 × 5 cm	20635
SEd	200	SEd	277
CD (P= 0.05)	445	CD (P= 0.05)	617
D x S	S	D x S	S

Conclusion

It can be concluded that I FN of June and II FN of September were the best sowing windows with a spacing of 30 × 5 cm for achieving higher drymatter yield.

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Studies on varietal demonstration of Gram, *Cicer arietinum* L. in rainfed conditions

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Chickpea, Cicer arietinum L. is an important pulse crop in India. It is the major crop with share of about 49 per cent of the total pulses being produced in country. A demonstration was conducted in Sirohi District, Rajasthan, evaluated the potential of high-yielding gram variety GNG-2144 under rainfed conditions, enhancing farmers' income and food security through improved cultivation practices. Gram, a vital legume crop in Rajasthan, is grown primarily under rainfed conditions, but low yields and limited economic returns hinder adoption of improved technologies. Demonstration plots (20 ha) were established in Villages Dhanta and Sindrath, with GNG-2144 variety sown in October-November 2023, following standardized package of practices. Results showed an average yield of 16-20 quintals/ha (25-30% increase over local farmers) and net income of ₹63,000/ha (35-40% increase over traditional practices), with improved disease resistance and drought tolerance. The study demonstrated GNG-2144 superior performance under rainfed conditions, highlighting its suitability for local conditions and resulting in significant yield and income gains for participating farmers. Recommendations include large-scale adoption of GNG-2144, capacity building for farmers and expansion of demonstration plots. This study enhances food security through increased gram production, improves economic returns for farmers and increases confidence in adopting new technologies.

UID: 1037

Evaluation of Raffinose Family Oligosaccharide Concentrations in High-Yielding Released Chickpea cultures bred at RARS, Nandyal

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Chickpea is the most widely cultivated legume crop in India, positioning the nation as the world's top producer (FAOSTAT, 2022). Regional Agricultural Research Station, Nandyal, as a main center for the All India Coordinated Research Project on chickpea, released nine high-yielding chickpea varieties, and they are significantly contributing to national production. Additionally, RARS has bred three more promising lines currently under pre-release testing. These cultures are thoroughly examined for yield, biotic and abiotic factors, and nutritional characteristics. But their anti-nutritional properties were not yet focused; among them, Raffinose family oligosaccharides (RFO) are major components. These RFO's include raffinose, stachyose and verbascose. They are non-digestible grain oligosaccharides present in chickpea seeds that cause flatulence in humans and other mono-gastric animals due to the absence of the α-galactosidase enzyme. The levels of RFOs affect human health; in high amounts, they can cause digestive discomfort, while in low amounts, they may serve as beneficial prebiotics (Zhang et al., 2017). Therefore, developing high-yielding chickpea lines with reduced RFO content is essential to improve consumer acceptance. In this context, our study was formulated to estimate grain RFO concentration in high yielding chickpea cultures bred and to identify the high yield chickpea cultures with low grain RFO concentrations.

Methodology

The experimental material consisted of 12 chickpea cultures developed at the Regional Agriculture Research Station, Nandyal. These included nine released varieties (NBeG 3, NBeG 47, NBeG 49, NBeG 119, NBeG 452, NBeG 776, NBeG 810, NBeG 857, and NBeG 1267) and three pre-released lines (NBeG 440, NBeG 833, and NBeG 844). Grain samples of these cultures were subjected to Ultra-Performance Liquid Chromatography coupled with Quadrupole Time-of-Flight Mass Spectrometry (UPLC-QTOF-MS) technique to estimatate RFOs (Raffinose, Stachyose, and Verbascose). Grain extractions were prepared by following a protocol adapted from Lisec *et al.* (2006). The extracts were injected along with buffers (LCMS grade 0.1% NH_3 (solvent A) and acetonitrile (solvent B)) to estimate the grain raffinose, stachyose, and verbascose concentrations. Mass spectrometric detection was performed using a Xevo G2 QTOF mass spectrometer, supported by MassLynx 4.1 software.

For quantitative analysis, QuanLynx software was utilized and the concentrations were expressed in mg g^{-1}.

Results

The LC-MS Results indicated that the concentrations of raffinose varied from 17.07 to 69.60 mg g^{-1}, stachyose from 4.8 to 35.20 mg g^{-1} and verbascose from 0.02 to 0.33 mg g^{-1}. The overall RFO concentration ranges from 24.85 (NBeG 1267) to 104.87 (NBeG 833) mg g^{-1} in chickpea seeds. Raffinose was the most abundant RFO, while verbascose was present in the lowest concentrations. Among 12 cultures, except NBeG 833, all remaining contained <50 mg g^{-1} RFO in the seeds, which indicates these genotypes are having low RFO concentrations (Elango *et al*., 2022).

Conclusion

The low level of RFO can reduce the risk of flatulence and also act as a prebiotic substance, which improves gut health, increases nutrient absorption and controls blood sugar levels. The concentration of RFOs was relatively low for all the cultures except NBeG 833; hence, consumption of these chickpea lines would not cause any adverse effect for humans. This exclusive study adds an inclusive advantage for these developed varieties with soundful traits. They can be promoted as both high-yielders and prebiotic-rich varieties, which will increase their economic value in the consumer market.

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Evaluation of Soybean Germplasm Accessions for Resistance Soybean Rust

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Soybean rust, caused by the obligate fungus *Phakopsora pachyrhizi* (Sydow. & Sydow.) is one of the economically important diseases of soybean, widespread globally, with reported yield losses ranging up to 80% under conducive environmental conditions (Sarbhoy and Pal, 1997) In India, this disease has become a serious production constraint in productive regions of southern, central and northeast states. The pathogen is appearing endemically every year in the Krishna River basin region in adjoining districts of Karnataka and Maharashtra and also in North eastern states. Indeed, the rapid spread of rust pathogen has become a major concern for expanding soybean growing area. Farmers use chemical fungicides for control of the disease which increases the cost of cultivation and is also environmentally unsafe. Breeding soybean varieties resistant to rust is the most efficient, environmentally safe and sustainable disease management approach. Till now, seven loci resistant to *P. pachyrhizi* have been identified and named as *Rpp1* to *Rpp7* (Bromfield and Melching, 1982; Hartwig, 1986; Hyten et al., 2007; Garcia et al., 2008; Li et al., 2012; Yu et al., 2015; Childs et al., 2018). Also, different alleles of *Rpp* genes were described (Chakraborty et al., 2009; Chen et al., 2015). In India, although rust resistant soybean varieties have been developed and released, the level of resistance in the existing rust resistant varieties has come down due to the emergence of new pathotypes in field populations of *P. pachyrhizi*. Therefore, identification of new sources of resistance and utilization in breeding program to introgress resistant genes is an effective way to develop long term resistance against rust. Therefore, this study was conducted to identify resistance sources against soybean rust.

Methodology

A total of 30 germplasm accessions along with the susceptible check (JS 335) and rust resistant varieties (DSb 23 and DSb 34) were evaluated for soybean rust under natural epiphytotic condition at IARI, RRC farm, Dharwad during *kharif* 2024. The germplasm set contained rust differential lines, accessions with known resistant genes and lines with unknown resistant genes. The lines were evaluated for rust incidence on lower, middle and top leaves between R3 to R6 development stage. Data were collected for disease severity (percent of leaf area with rust lesions), lesion type (RB, tan, or mixed), no. of uredinia per lesion and sporulation level. The data was analyzed using Microsoft Excel.

Results

The lines were scored for reaction to rust when the disease severity was highest in the susceptible check. Disease severity calculated as percent disease index indicated that the lines EC1187661 had the lowest value of 3.7 followed by EC1187660 (11.11%), EC1187636 (18.52), EC1187659 (18.52) and EC1187663 (25.93). The resistant check varieties had >70% disease index whereas the susceptible check JS 335 had >90% disease index. The line JS 335 has tan type lesions whereas the lines DSb 23 and DSb 34 has mix of tan and reddish brown (RB) type lesions. Most of the germplasm lines exhibited mixed type of lesions containing both reddish brown and tan type lesions. The lines EC1187660, EC1187661, EC1187662, EC1187663 exhibited RB type lesions and the lines EC1187639, EC1187641, EC1187642, EC1187644, EC1187646, EC1187647 and EC1187648 produced tan type of lesions. However, none of the lines showed immune reaction.

The level of sporulation in soybean lines was observed using hemocytometer, number of uredospores w counted and calculated spore concentration (spores/ml) as no. of spores observed × dilution factor × 104. The lines EC1187659, EC1187660 and EC1187661 exhibited lowest sporulation (0.17 × 104 uredospores per ml) followed by EC1187662 (0.33 × 104). High level of sporulation was produced by the line EC1187648 (12.50 × 104), EC1187649 (6.33 × 104), EC1187652 (5.67 × 104). While the susceptible check JS-335 exhibited very high sporulation (16.67 × 104) and resistant varieties also had high level of sporulation with 7.67 × 104 (DSb 23) and 6.33 × 104 (DSb 34) uredospores per ml.

The number of uredinia per lesion was counted using stereomicroscope. From the data, it was found that the line EC1187635 produced highest number of uredinia per lesion (9.09) followed by EC1187648 (7.70), EC1187645 (7.50), EC1187649 (7.37), EC1187642 (6.77) and EC1187650 (6.07). Whereas, the lowest number of uredinia per lesion was recorded in the lines EC1187662 (0.63) followed by EC1187660 (1.43) and EC1187661 (1.67) as against 11.57 uredinia per lesion in the case of susceptible check JS 335. However, released varieties DSb 23 and DSb 34 had 12.23 and 10.43 uredinia per lesion, respectively.

Conclusion

In summary, evaluation of 30 soybean accessions for resistance to P. pachyrhizi population under field conditions at Dharwad identified four lines (EC1187659, EC1187660, EC1187661, EC1187662) that are resistant to soybean rust. These lines need to be further studied to confirm the resistant reaction and also tested at multiple locations to utilize in soybean breeding program.

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Unveiling the Variations for Phosphorous Use Efficiency in Mungbean Genotypes on Inceptisol of Northern Transitional Zone of Karnataka

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Genetic modification of root system traits can be an effective strategy for improving crop varieties with low P tolerance and high PAE. Several researchers have already reported that breeding for genotypes with high P-uptake efficiency is the best approach under P-deficient soils while genotypes with high P-utilization efficiency will produce more dry matter per unit of P consumption. Annual grain crops like cereals, oilseeds and pulses provide 58 percent of the dietary energy of world's growing population. Increasing the efficiency of Phosphorus fertilizer for crop growth requires enhanced P acquisition by plants from the soil. Potentially large gains in efficiency can be made in improving P acquisition. In view of the above, pot experiments were conducted at IIPR- Regional Research Station, on Inceptisols at IIPR-Regional Research Station, Dharwad, (North Transitional zone), Karnataka during 2021 to evaluate different genotypes of mungbean for P use efficiency.

Methodology

Pot culture experiments were conducted using cemented pots of size 1200 x 800 mm during *kharif* season of 2021 at IIPR-Regional Research Station, Dharwad, Karnataka using 15 genotypes of mungbean. The soil of experimental site belong to Inceptisol, with alkaline reaction pH (8.0) and Electrical Conductivity 0.15 dS/m with available N,P and K contents 218, 9.0 and150kg/ha respectively. Treatments consisted of two Phosphorus levels (0 and 50 kg P_2O_5 ha^{-1}) with 2 replications. P was applied in the form of Single Super Phosphate(SSP) and the quantity of SSP applied was on the basis of Area of cylindrical cemented pots. The seeds of greengram were sown in the cemented pots according to recommended spacing of pulse crops i.e., 30x10 cm. Uniform number of plants were maintained in each pots. At the time of maturity, agronomic and root architectural traits were recorded. The plant samples were analyzed for N and P uptake was calculated (Osborne and Rengel, 2002). Root length was estimated using direct measurement at 45 DAS and expressed in cm. Root volume was measured using water displacement technique as suggested by Misra and Ahmed and expressed in cc (8) plant . The PUE was assessed as described earlier (Osborne and Rengel, 2002, Baligar et al., 2001).

Results

Effect on various agronomic traits: Results revealed that greengram genotypes differed significantly with respect to plant height. days to 50 % flowering, days to maturity, number of pods per plant and seed yield per plant.

Plant height (cm): All the genotypes recorded significantly higher plant height due to phosphorous application (P_{50}) compared to without phosphorous application (P_0). Greengram genotypes differed significantly with respect to plant height and most of genotypes recorded higher plant height due to phosphorous application as compared to no phosphorous application. The greengram genotypes viz., DGGS-4, IPM-14-35 and DGGV-2 recorded maximum plant height at both the levels of phosphorous application. These genotypes are capable of extracting more native soil phosphorous compared to other genotypes.

Days to flowering and Days to maturity: Significant variations were observed among the mungbean genotypes for days to 50% flowering and days to maturity. Phosphorous level (P50) reduced the number of days to flower and maturity among the genotypes and the effect is non-significant. It could be due to limited number of genotypes used in the present study.

Number of Pods per plant: Wide range of variations was observed among the mungbean genotypes for number of pods per plant. Phosphorous application influenced the formation of pods per plant. Genotypes, IPM-14-35 (49), DGGS-2 (45) had more number of pods per plant and IPM-9901-6-1 had lowest number of pods (25) at P 50 level.

Dry matter yield at 45 DAS: Application of phosphorous (SSP) significantly increased the dry matter yield in all the genotypes over non-application of P. The genotypes viz., DGGV-2, DGGS-4, IPM-14-35, IPM-9901-6-1 produced higher dry matter compared to other genotypes at higher levels of phosphorous (P_{50}). Genotypes differ significantly with respect to production of dry matter yield. Differential uptake of nutrients by these genotypes and their genetic traits might have contributed for significant variation in dry matter yield.

Grain yield per plant: Phosphorous application significantly enhanced the grain yield of most of genotypes over non-application of phosphorous. Increased grain yield of genotypes could be due to role of phosphorous and sulphur present in SSP fertilizer that played a significant role in various biological functions of plant cells leading to enhanced grain yield (Das, 1997). P is a constituent of biological molecules such as phospholipids, phytin and inositol phospholate which contribute for higher grain yield. Wide range of variations were observed for grain yield among the genotypes of mungbean due to phosphorous application. Higher grain yields were observed in DGGS-4, DGGV-2 and IPM-14-35. These genotypes could have better ability to absorb native soil nutrients as well as externally applied nutrients and it could be due to their better nodulation capacity as well as root architectural traits leads to production of higher dry matter and grain yield.

Effect of phosphorous on Root architectural traits: Root architecture is crucial for P acquisition by plants. It is flexible and responds to low P in soil for facilitating the P acquisition. Application of phosphorous (P_{50}) significantly increased the root length and root volume in all the genotypes of mungbean. Genotypes differed significantly with respect to root length. Maximum root length was observed in IPM-14-35 (25 cm) and lowest in IPM-14-10 (16 cm) and IPM-9901-6-1 (13cm). The genotypes such as IPM-312-394-1 and IPM-14-35, DGGS-4 and DGGV-2 had higher root volume providing more area for root nodulation. Variation in root length and root volume in different genotypes might be attributed to differential ability of these genotypes to absorb phosphorous and other soil nutrients.

Number of root nodules per plant: Greengram genotypes differed significantly with respect to number of root nodules. Among the genotypes, irrespective of phosphorous application, DGGV-2, IPM-14-35 and DGGS-4 had more number of root nodules. Root nodulation greatly influenced by phosphorous as it improves root morphological features such as more number of secondary roots and high surface area of roots providing more area for nodulation. High number of nodules related to root architectural features of these genotypes which are genetically controlled and they are most efficient genotypes to extract more phosphorous, calcium and sulphur from the soil even under deficit condition. In the present study the application of phosphorous enhances the root nodules in most of the mungbean genotypes as P essential for biological nitrogen fixation in leguminous crops.

Uptake of Nutrients (N and P)

Nitrogen uptake: Phosphorous application significantly enhances the nitrogen uptake (27.58 kg/ha) in all the genotypes. Increased uptake of nitrogen was due to higher root growth in these genotypes. The genotypes DGGV-2 (37.56 kg/ha), DGGS-4 (34.52 Kg/ha) and Ipm-14-35 (30.78 Kg/ha) are recorded higher nitrogen uptake compare to other genotypes.

Phosphorous uptake: Application of phosphorous significantly increased the phosphorous uptake (4.68 K/ha) in all the genotypes over the lower levels (No phosphorous) (4.38 kg/ha). Genotypes diifered significantly with respect to phosphorous uptake at 45 DAS. Maximum P uptake (6.00Kg/ha) was recorded in DGGS-4 followed by DGGV-2 (5.90 Kg/ha) and IPM-14-35 (5.40Kg/ha).

Phosphorous use efficiency of greengram genotypes: Results of PUE revealed that significant differences are observed among the mungbean genotypes. These results depicted that genotypes vary widely to absorb native soil phosphorous. Genotypes, DGGV-2 (45%), DGGS-4 (41.5%) and IPM-14-35 are showed highest PUE compared to other genotypes. High PUE values indicate that these genotypes are most efficient in absorbing native soil phosphorous. These genotypes are also had higher root volume and length. Improvement in phosphorous uptake and efficiency is required to enhance productivity. The P concentration significantly decreased with the advancement of crop age, suggesting necessity of taking plant samples for analysis to diagnosis of deficiency or sufficiency purposes.

Conclusion

In the present study, mungbean genotypes responded significantly to Phosphorous level and revealed variations for agronomic traits as well as root architectural traits. Based on growth parameters and PUE values the following genotypes such as DGGS-4, DGGV-2, IPM-14-35 are considered as P efficient genotypes and these genotypes can be further utilized in breeding of mungbean for development of P efficient cultivars in mungbean.

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Effect of Different Sowing Dates on the Growth and yield of Pigeonpea (Cajanus cajan L. Millsp.) Varieties

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Pigeonpea also known as red gram, arhar and tur [*Cajanus cajan* (L.) Millsp.] is the most important *kharif* grain legume crop. It belongs to the family Leguminoseae, sub-family papilionaceae, originated from the Africa. It has the lowest harvest index of 19% but is a rich source of protein but a rich source of protein (22%) and amino acids like lycine, tryocene, cysteine and arginine and can be cultivated in a wide range from pH 5 to 8. Time of sowing, a non-monetary input, has a considerable influence on the growth and yield of this crop. It ensures the complete harmony between vegetative and reproductive phases on one hand and climatic rhythm on the other hand. Sowing time also plays an important role in dry matter accumulation by the crop. Early sown crop may accumulate excessive dry matter and reduce podding, whereas late sown crop may reduce the biomass accumulation and consequently reduction in yield. Delayed sowings beyond the optimum period result in low grain yields of pigeonpea. Further, genotypes may vary in productivity and are equally important in realizing the potential yield of this crop. Long duration genotypes produce higher yield than early maturing genotypes, but they take more time to mature which may delay the sowing of succeeding crop such as wheat in a sequence cropping system. Hence a field experiment was entitled "Evaluation of pigeonpea varieties (*Cajanus cajan* L. Millsp.) under different sowing dates" was conducted at the College of Agriculture, Badnapur, VNMKV, Parbhani.

Methodology

The aim of the present experiment was to find out suitable sowing dates for pigeonpea varieties, to study the performance of pigeonpea varieties under different sowing dates and to study the interaction effect of sowing dates and varieties of pigeonpea. The gross and net plot size of the experiment was 7.2 x 5.0 m and 5.4 x 4.6 m, respectively. Sowing was done by adopting dibbling method on 15th June, 30th June, 15th July and 30th July, 2015 for D_1, D_2, D_3 and D_4, respectively at a spacing 90 cm x 20 cm and the varieties used were, BSMR-736, BSMR-853, BDN-711, BDN-708 and VIPULA. The recommended dose of fertilizer (RDF) 25:50:00 NPK kg ha^{-1} was applied at the time of sowing. To evaluate the treatment effect, the various growth observations were recorded in the experiment from 30 DAS up to the harvest at an interval of 30 days, while the observations on yield attributing characters and post-harvest studies were recorded at respective stages. The crop was harvested at the maturity stage on 25th December

2015, 09th January 24th January and 09th February 2016 for D_1, D_2, D_3 and D_4 sowing dates, respectively.

Result

Effect of sowing dates: Different sowing time had a profound influence on the grain yield. Significantly superior grain yield (1456 kg ha^{-1}) was obtained when the crop was sown on 15th June than later sowing time of 30th June, 15th July and 30th July. Crop sown on 30th July recorded the lowest grain yield (987 kg ha^{-1}). The mean values were higher when the crop was sown on 15th June for all vegetative and reproductive attributes indicating that 15th June sowing enabled the crop to express the inherent potential to the maximum as compared to later sowings. Reddy *et al* (2014) have noted similar decisive effect of sowing time on pigeonpea growth and development and reported reductions in various morpho-physiological attributes with delayed sowing due to less favourable weather variables.

There was significant variation in mean straw yield due to sowing dates. The higher straw yield recorded by 15th June sowing date than later sowing time of 30th June, 15th July and 30th July. The lowest straw yield (4211 kg ha^{-1}) recorded on 30th July. Similar Results were reported by Mishra *et al* (2008) and Hari *et al* (2011).

The gross monetary returns were significantly influenced by different sowing dates. Significantly higher gross monetary return (Rs 119080 ha^{-1}) was obtained by crop sown on 15th June over the rest of the sowing dates. The lowest value of gross monetary returns was recorded on sowing time 30th July (Rs 82451 ha^{-1}). The net monetary return was significantly influenced by sowing dates. The highest net monetary return (Rs 96573 ha^{-1}) was recorded by 15th June sowing over rest of the sowing dates. The highest benefit: cost ratio (5.29) was recorded at 15th June sowing. The lowest value was recorded at 30th July sowing treatment.

Effect of varieties: There was statistically significant variation in seed yield due to varieties. The highest grain yield (1433 kg ha^{-1}) was recorded in variety BSMR-736 which was found at par with variety BSMR-853. However, the lowest grain yield (1065 kg ha^{-1}) was produced by variety BDN-708. The difference in straw due to different varieties was significant. Variety BSMR-736 recorded significantly higher straw yield (5189 kg ha^{-1}). The lowest straw yield (4453 kg ha^{-1}) observed in variety BDN-708.

The cost of cultivation for all varieties, was Rs. 22507 ha^{-1}. Pigeonpea variety BSMR-736 significantly recorded higher gross monetary returns of (Rs 117280 ha^{-1}) as compared to the remaining varieties. The highest net monetary return (Rs 94767 ha^{-1}) was recorded by BSMR-736 variety over the rest of the varieties. The highest benefit: cost ratio (5.21) was recorded in BSMR-736 variety at rest of the varieties. The lowest value of benefit: cost ratio (3.88) was recorded in BDN-708. Similar Results were reported by Mishra *et al* (2008), Hari *et al* (2011) and Reddy *et al* (2015).

Interaction effect: The interaction effect between sowing dates and varieties was found to be non significant in straw yield, except in grain yield.

Effect of sowing dates on yield and economics of pigeonpea varieties under different sown dates

Treatment	Grain Yield (kg/ha)	Straw yield (kg/ha)	Gross monetary return (Rs ha^{-1})	Net monetary return (Rs ha^{-1})	Benefit: cost ratio
Sowing dates (D)					
D_1 : 15th June	1456	5111	119080	96573	5.29
D_2 : 30th June	1324	5036	108430	85922	4.81
D_3 : 15th July	1165	4672	95541	73033	4.24
D_4 : 30th July	987	4211	82451	58610	3.60
SE ±	22.77	50.63	1124.3	1107.1	-
CD at 5 %	63.02	140.12	3111.5	3063.8	-
Varieties (V)					
V_1 : BSMR-736	1433	5189	117280	94767	5.21
V_2 : BSMR-853	1305	4805	106830	84323	4.74
V_3: BDN-711	1207	4750	100690	76512	4.40
V_4: BDN-708	1065	4453	87465	64957	3.88
V_5: VIPULA	1154	4590	94620	72112	4.20
SE ±	47.32	130.91	2329	2151.5	-
CD at 5 %	130.96	362.29	6445.7	5954.2	-
Interaction (D x V)					
SE ±	94.64	261.81	4658.1	4302.9	-
CD at 5 %	NS	NS	NS	NS	-
General Mean	1233	4757	101380	78534	4.48

Conclusion

The early sowing on June 15th was shown to be the most effective date for achieving increased seed production and GMR, NMR, and B:C ratio among other Pigeonpea sowing dates, based on a season of field experiments. In comparison to BSMR-853, BDN-711, VIPULA, and BDN-708, it was discovered that the Pigeonpea variety BSMR-736 was very prolific. To make a meaningful conclusion, though, more validation is needed as the Results are based on a single year of study.

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UID: 1042

Root Architecture: Potential tool to counter climate induced challenges

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Root systems are designed to cater shoot demands, and their role in enhancing the resilience of ecosystems to climate change is significantly coherent. The structure, depth, and spread of roots significantly influence how plants withstand environmental stress, such as drought, flooding, and soil erosion, which are exacerbated by climate change. Breeding crops for optimal root architecture can play a significant role in increasing drought tolerance, improving nutrient acquisition, enhancing overall crop resilience and adding a survival advantage during periods of drought. As global climate change accelerates, it will be important to improve belowground plant parts, as well as aboveground ones, because roots are front-line organs in the response to abiotic stresses such as drought, flooding, and salinity stress. A study on 10 elite germplasm lines in common beans for their root and shoots attributes unravelled numerous findings confounding the importance of root attributes in deciding the above ground performance at juvenile growth stages. Two-way analyses revealed significant variation in different levels of treatments. All the traits exhibited significant variations due to genotypes and moisture regimes. However, Root Shoot Ratio (RSR) and Root Surface Area were not affected by moisture regimes. Significant interaction between germplasm lines and moisture regimes was observed for all traits except NDVI and Dry Root Weight. PPR-13 exhibited a non-significant interaction with factor 2 for maximum number of traits followed by PPR-9, PPR-7, PPR-14 and PPR-12 indicating either tolerance to water input variation or remains unfazed by less water. Trait correlation revealed Root diameter having a significant positive correlation and RSR exhibited negative correlation with yield per se. The regression analysis revealed significant effects of all five observed root traits on yield. Root diameter exhibited maximum positive effect on yield whereas NDVI had the least. As climates continue to shift unpredictably, breeding for root plasticity will become increasingly important. By improving root architecture through breeding, agriculture can become more sustainable and resilient, capable of withstanding the stresses imposed by climate change and ensuring global food security.

UID: 1046

Assessment of drought tolerance practices in Greengram in Jhunjhunu district of Rajasthan

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Jhnjhunju district of Rajasthan has characterized arid climate with hot summers and cool winters. Over the course of the year, the temperature typically varies from 0°C to 48°C. The annual average rainfall of Jhunjhunu district is about 416 mm with unequal distribution and fewer rainy days. Soils of the district is sandy loam with low organic matter and poor water holding capacity. Drought stress is a major challenge in Kharif season. The risk of drought is increasing due to climate change-caused reduced precipitation, higher temperatures and shifting seasons.

Drought stress can be mitigated through different management practices, like supplemental irrigation, water conservation practices, i.e., deep ploughing, mulching, use of plant growth regulators (PGRs), and a diversified farming system. However, they have cost involvement and are sometimes quite difficult for the socio-economic conditions of the farmers of the district. Therefore, the absolute relieve of drought is not possible. The best option is, thus, to select drought tolerant cultivars for sustainable crop production in the moisture deficit stress. Therefore, this study was conducted to explore those practices that are associated with the drought tolerance in Greengram.

To minimize the effect of drought, various climate resilient practices Viz, deep ploughing before rainfall to restrict water runoff, use of bio-fertilizers, growing of drought tolerant varieties, use of agro-chemicals to mitigate drought stress were demonstrated in combinations and combined effect was recorded. All demonstrations were conducted from Kharif 2020 to Kharif-2024 in Bharu, Chakwas and Madansar village of Jhunjhunu district under NICRA project during Kharif-2020 to Kharif-2024. Quantitative data of five year were recorded and analyzed statistically. Combined effect of resilient practices minimized the effect of drought stress in Greengram. Result reveals that in demonstration fields average grain yield of Greengram was recorded 7.59 quintal per hectare while in farmers field it was 6.42 quintal per hectare. Average cost of cultivation in demonstration fields and farmers field was rupees 24438 & 23441 rupees per hectare respectively while net income was 60006 & 50770 rupees per hectare respectively.

UID: 1050

Genetic Diversity Analysis and Phenophase Characterization of Finger Millet Varieties of India for Climate-Resilient Millet Production in Rainfed Agro-Ecologies

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Millets are important cereal crops in the semi-arid tropical areas of Asia and Africa whose role in ushering in food, nutritional and economic security is widely reported and accepted. Among the millets, Finger millet [*Eleusine coracana* (L.) Gaertn.] is an important rainfed crop, the 3rd most important millet after pearl millet and sorghum, nutritionally important for humans and livestock. It is a self-pollinated, allotetraploid (AABB) species (2n = 4× = 36) whose genome (1196Mb) has been sequenced from India. The world produces 3.33 mt of finger millet from 2.31 mha area with yield of 1442 kg/ha, while India produces 1.58 mt of finger millet from 1.10 mha area with yield of 1436 kg/ha. India, Ethiopia, Nepal, Uganda and Malawi are the major countries and in India, Karnataka, Tamil Nadu, Uttarakhand, Maharashtra, Odisha, Andhra Pradesh, Gujarat, Jharkhand and Telangana are the major states. The potential yield of finger millet is reported to be ≈3000 kg/ha.

Although millets are tolerant to most abiotic stresses, further improvement is needed to make them more resilient to unprecedented effects of climate change and associated environmental stresses (Numan et al. 2021). Incorporation of stress tolerance traits in millets will improve their productivity in marginal environments and will help in sustainable agriculture and nutritional security amidst profound adverse effects of climate change (Vetriventhan et al. 2020). Yield losses in finger millet due to drought stress are reported to be up to 61% (Maqsood & Ali 2007; Krishnamurthy et al. 2016). Earlier studies on drought tolerance were either based on a limited number of genotypes and/or were mostly limited to controlled conditions (Bhatt et al. 2011; Krishnamurthy et al. 2016) and there is very limited field phenotyping of finger millet germplasm lines for its comprehensive assessment against drought stress. The popular and newly released varieties have not been evaluated for drought stress to identify the most drought tolerant finger millet variety to be used as a candidate for climate resilient millet production. The field phenotyping is highly realistic, relevant, and efficient in identifying the drought stress tolerant genotypes (Fu et al. 2022). Though few finger millet lines have been identified for drought tolerance through surveying limited set of germplasm, no finger millet genotype has been registered for drought tolerance with ICAR-NBPGR, which can be utilized for breeding drought tolerant finger millet varieties. In this regard, a field experiment was conducted with the objectives of assessing the extent of genetic diversity among the popular and recently released finger millet varieties of India and characterizing their phenophases for their further screening against drought stress.

Methodology

In the last 10 years, ≈35 improved varieties finger millet have been developed and released in India (Hariprasanna, 2023). These varieties, along with the popularly cultivated varieties, were short-listed for study. A total of 54 popular and recently released finger millet varieties developed from 10 different institutions or state agriculture universities of India (Fig. 1a) were procured and were evaluated in alpha lattice design with 3 replications at ICAR-CRIDA, Hyderabad, during *kharif* 2023-24. Each variety was sown in 3 rows with a 4m length at a spacing of 45×10cm in each replication. Forty-eight out of 54 varieties provided good germination and proper crop stand. These 48 finger millet varieties of India were characterized for their phenophases and the diversity for 15 different growth, yield, and physiological characters [Days to 50% Flowering (DFF); Days to Maturity (DM); Plant Height (PH); Tiller Number (TN); Panicle Number (PN); Finger Number per panicle (FNP); Finger Length (FL); Finger Width (FWd); Finger Weight (FWt); Seed Weight per Panicle (SWP); Yield per plant (YPP); Test weight (TW); Canopy Temperature Depression (CTD); Leaf Chlorophyll Content (SPAD); Normalized Difference Vegetation Index (NDVI)] were studied. The experimental data was statistically analyzed to understand the diversity among the finger millet varieties using the R statistical package (de Mendiburu, 2023).

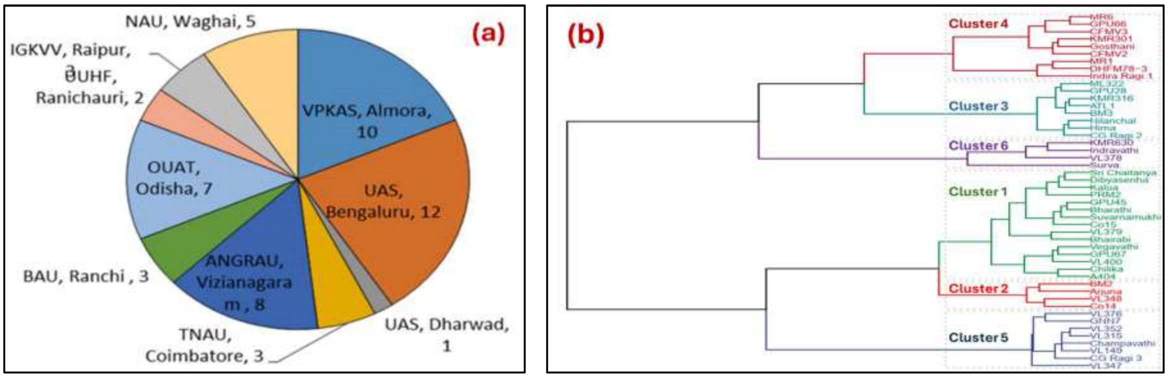
Results

The analysis of variation revealed that there was significant variation for all the 15 traits studied among finger millet varieties. Days to 50% flowering ranged from 64.93 (Bhairabi) to 89.62 (Indira Ragi 1)with an mean of 76.69 days across varieties. Variety VL348 with plant height of 53.62cm was the shortest, while Surva variety (96.78cm) was the tallest. The mean tiller number, panicle number, finger number per panicle, finger length and finger width across varieties were 4.06, 4.96, 5.91, 7.91cm and 4.70cm, respectively. Yield per plant ranged from 7.96g to 40.63g with an average of 16.67g across 48 finger millet varieties. The highest test weight (1000 seed weight) was recored for Co15 (3.91g) and lowest was observed in VL378 (2.43g).

Based on the genetic variability for the studied traits, the Indian finger millet varieties were grouped into six different clusters. Cluster 1 was the largest cluster with 15 varieties while cluster 2 and 6 were the smallest, each with 4 varieties. The varieties in cluster 5 were early in maturity, while varieties in cluster 3 had higher seed weight. The finger millet varieties in cluster 6 had higher yield, tiller number, and panicle number.The highest inter-cluster distance (57.54) was recorded between cluster 2 and 6 while, lowest inter-cluster distance (22.69) was observed between cluster 1 and 2 (Table). The highest (35.81) and lowest (11.40) intra-cluster distances were recorded for cluster 6 and 2, respectively. Higher values for intra- and inter-cluster distances indicates higher genetic variability within and between clusters, respectively.

Conclusion

Significant genetic variability was observed among the finger millet varieties of India for the studied traits, indicating their broader genetic base. Flowering is the critical stage for drought screening in finger millet, and there is wide variation in the flowering time (65 to 90 days) among the finger millet varieties. Based on genetic divergence, the Indian finger millet varieties were grouped into 6 different clusters. The information generated in the present study is valuable for understanding the genetic base in finger millet and also for stage-specific drought screening to identify the drought tolerant finger millet varieties.



Finger millet varieties of India (a – source; b – clustering based on genetic divergence)

Intra- and inter-cluster distances among finger millet varieties *(intra-cluster distances are vitalized)*

Distance	c1	c2	c3	c4	c5	c6
Intra-cluster	***24.17***	***16.93***	***11.40***	***24.01***	***18.46***	***35.81***
c2	26.95	-	-	-	-	-
c3	22.69	31.76	-	-	-	-
c4	41.71	48.82	30.81	-	-	-
c5	32.19	33.23	31.50	48.28	-	-
c6	48.79	57.54	41.04	38.02	45.48	-

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UID: 1056

Impact of Adoption of Flood Tolerant Rice Variety in Mahrajganj District of Uttar Pradesh

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Climate change poses a severe challenge to farmers, as extreme weather patterns increase both the likelihood of crop destruction due to drought, flooding, high temperature, salinity and variability in output levels (Gautam *et al.,* 2019). River floods affect approximately 21 million people each year, primarily in developing countries, according to the World Resource Institute. India is the country with the most people affected, with an average of 4.8 million people exposed to river flood risk each year. Climate change is projected to exacerbate the likelihood of floods, heat waves, and other extreme weather events (Mallappa *et al*., 2021). As per the scenario of India, most of the farming families come under marginal and small land holding category, cope up with extreme weather events is very challenging. Among the various weather abnormalities, heavy rainfall led to the flood kind of situation in most of the norther river, particularly river that originates from Nepal. The border districts of Uttar Pradesh that are neighbours to Nepal especially Maharajganj, Sidharthnagar, Balrampur, Shrawasti etc. are facing flood like situations during monsoon season, most of the cases not due to heavy rainfall in these districts but due to water drained by Nepal. Rice being a staple food crop due to soil and agroclimatic situations favouring their cultivation, it is grown in the larger part of the land holding by most of the farming families. The resultant flooding of the rice fields causes more frequent and longer periods of inundation of the rice plants, in turn causing abiotic stress which adversely affects the growth of the rice plants. Sometimes, early inundation of rice filed leads to complete crop failure and farmers forced to leave fields unsown due to longer periods of water stagnation during *kharif* season. To sustain the rice production system in these regions, KVK, Maharajganj conducted a field level demonstration (FLD) of submergence tolerant rice variety on the farmer’s field.

Methodology

Swarna-Sub1 rice is resilient to flood submergence for up to two to three weeks, thereby reducing risk and providing a higher yield potential for farmers. KVK plans to examine the effects of Swarna-Sub1, a flood tolerant variety of Swarna rice, on yields and the economics of farmers in a two-year (*kharif* 2022 and 2023) evaluation. The evaluation took place in three villages of Maharajganj viz. Karauta urf Nebuiya, Laxmipur Mahant of Ghughali block and Lendwa in Mithoura block where there are frequent floods and submergence was faced due to low land topography. One hundred twenty farmers from all three villages in the most flood prone areas of the villages were selected for the study and randomly assigned a treatment and made two sets of randomly selected farmers: those who received Swarna-Sub1 seeds and those who did not.

For making comparisons, data from treatment farmers who received Swarna-Sub1 and who did not receive were it collected on rice yields while economics was calculated by taking MSP as market price. For recording grain yield a 1 m^2 quadrates were used and a random sample from five places of each farmer's field were harvested. Data collected from five places of a plot were mixed and weight was weight in kg from 5 m^2 area and further converted to kg ha^{-1} by taking suitable conversion factor.

Results

Data (Table 2.) revealed that grain yield of rice was 715 kg and 762 kg higher than local variety in 2022 and 2023, respectively. The higher grain yield might be due to stress tolerant (submergence) capacity of the variety Swarna-Sub1 Results higher growth and yield attributing parameters. Dar *et al*., (2013) also observed that flood tolerance rice variety have higher yield over local check. In terms of the economic benefits, gross return was Rs. 14586 and 16634 ha^{-1} and net return was 30.43 and 30.01% higher than farmers practice during 2022 and 2023, respectively.

Table 1. Treatments detail.

	Treatment (60 farmers)	Comparison (60 farmers)
Variables	20 farmers from each village received 12.5 kg seed of Swarna-Sub1 for one acre of land.	20 farmers from each village who did not receive seed were followed making comparison.

Table 2. Effects of adoption of submergence tolerance variety on rice grain yield and economics of farmers

Variables	2022		2023	
	Demo*	FP#	Demo	FP
Grain yield (kg ha^{-1})	4150	3435	4312	3550
Gross return (Rs. ha^{-1})	84660	70074	94130	77496
Net return (Rs. ha^{-1})	53120	40720	62590	48146
B-C ratio	1.69	1.39	1.98	1.64

*Demo= Demonstration, #FP= Farmers practices, MSP of Rice Rs. 2040 and 2183 for 2022 and 2023 respectively.

Conclusion

With the above findings, it might be concluded that the adoption of submergence tolerance rice variety (Swarna-Sub1) in flood prone areas of Mahrajganj district is one of the promising technologies to sustain crop productivity and the livelihood of the farmers.

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UID: 1057

Isolation and Screening of Endophytic Microorganisms from Rainfed Crops for Plant Growth Promotion

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Global agricultural productivity faces significant challenges from abiotic stresses such as drought, salinity, extreme temperatures, and soil pH variations, compounded by climate change and anthropogenic pressures. Drought, a critical stress, disrupts physiological and metabolic processes, affecting nutrient uptake, photosynthesis, and seed germination, reducing crop. Beneficial microbial strains offer sustainable solutions to abiotic stress, enhancing plant growth and resilience (Kumar & Verma, 2018). Endophytes, microbes residing within plant tissues without causing harm, play key roles in stress tolerance and growth promotion, aiding plants under challenging conditions. Endophytes play a pivotal role in helping crops acclimatize to abiotic stress, promoting growth, managing phytopathogens, and activating stress-responsive genes that are otherwise dormant under normal conditions. In this regard, we explored isolation and characterization of endophytes from leaf, root and stem of various rainfed crops for plant growth promotion

Methodology

Collection of samples and isolation of endophytes: Leaf, root, and stem samples of rainfed crops were collected from three locations, Vijayapura (Karnataka), Ballari (Karnataka), Parbhani (Maharashtra) and the research farms of CRIDA (Central Research Institute for Dryland Agriculture). For each plant,three healthy leaves, stems, and roots free from disease or pests were selected. The samples were brought to the laboratory, where they were thoroughly washed under running tap water to remove any dirt. Endophytes were isolated as per the protocol described by Li et al. (2014). Briefly, the samples were cut into small pieces using a sterile blade. The pieces were sterilized by immersing them in 70% ethanol for 1minute, followed by 2% sodium hypochlorite for 3 minutes. They were then rinsed twice with sterile waterfor 1 minute each, immersed again in 70% ethanol for 30 seconds, and blot-dried on sterile filter paper. Thesterilized pieces were placed on Potato Dextrose Agar (PDA) and Nutrient Agar (NA) media, with four pieces per plate. To ensure the effectiveness of surface sterilization, tissue imprints were taken on culture media plates. Allplates were incubated at 28 ± 2°C. Subculturing of isolates was performed on PDA and NA slants, and thecultures were stored at 4°C for further use.

Screening for Indole-3-acetic acid (IAA) production: To determine the amounts of IAA produced by eachisolate, a colorimetric technique was performed with Van Urk Salkowski reagent using the Salkowski's method (Ehmann, 1977). IAA production was checked by adding double the volume of culture to SalkowskiReagent (1 ml of 0.5 mol/L $FeCl_3$ in 50ml of 35% $HClO_4$. The mix was incubated for 30 min in the dark at28 ± 2 °C, and then the absorbance was measured at 530 nm. The concentration of IAA produced was estimated using a standard IAA curve. All IAA determinations were made in triplicate.

Collection of samples from different rainfed regions during vegetative to flowering stage

Sampling locations	Crop	Total samples collected	Sample type
Vijayapura, Karnataka	Sorghum, Pearl millet	30	Leaf, root, stem
Ballari, Karnataka	Sorghum, Pearl millet	18	
Parbhani, Maharashtra	Maize	20	
HRF, GRF Farms, ICAR-CRIDA, Hyderabad	Sorghum, Pearl millet,Maize	10	

Results

A total of 137 microbial isolates were obtained from the roots, stems, and leaves of rainfed crops. These isolates were evaluated for their potential to grow under conditions of moisture stress, which was experimentally induced using polyethylene glycol (PEG-6000) at concentrations ranging from 20% to 50%. Furthermore, the isolates were assessed for their ability to produce indole-3-acetic acid (IAA), a plant growth-promoting phytohormone critical for root development and overall plant health. The amount of IAAproduced varied among the isolates, ranging from 15 to 34 µg/ml. These results underscore the significant variation in the growth-promoting potential of the isolates and highlight their potential application in enhancing the performance of crops under abiotic stress conditions.

Screening of endophytes for production of indole 3 acetic acid production

Crop	Isolate code	Isolated from	IAA (µg/ml)
Bajra	VBRE4	Root	25.34
	VBRE1	Root	20.07
	VBRE2	Root	16.75
	HBRE2	Root	21.91
	BBSE2	Stem	20.99
Maize	HMLE1	Leaf	18.22
	PMLE1	Leaf	32.56
	PMLE2	Leaf	20.38
	PMRE1	Root	18.39
	PMRE5	Root	15.43
	PMLE5	Stem	15.1
	PMSE6	Stem	15.74
	PMSE8	Stem	34.5
	PMSE5	Stem	16.25
Sorghum	BSRE2	Root	31.81
	VSRE3	Root	23.39
	BSSE2	Stem	22.19

Conclusion

This study highlights the potential of endophytic microorganisms from rainfed crops to combat abiotic stresses like drought. Isolates were tolerant to moisture stress and produced indole-3-acetic acid (IAA), promoting plant growth. These findings emphasize their application as bio-inoculants for sustainable agriculture in enhancing crop productivity.

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UID: 1058

Maize + Redgram Intercropping System as a Climate Resilient Technology for Doubling Farmers' Income in Drought Prone Area of Gadag District

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Gadag is the drought prone district that comes under the agro-climatic zone of Northern dry zone-3 and region-2 of Karnataka State. The climate of the district is semiarid and average annual rainfall varies from 450-650 mm. Agricultural drought is very common with probability of more than 70%. The rainfall is usually erratic and is characterised by long dry spells in between two rains during *kharif* season. This affects the successful crop production of major crops like maize, greengram, groundnut, onion, *rabi* sorghum etc in the district. To address this climatic variation and in order to solve productivity constraint, KVK Gadag introduced intercropping system of maize+redgram (5:1) as a climate resilient technology for doubling farmers' income under dryland condition from 2015-16 to 2023-24. In these nine years, totally this demonstration was conducted in 170 hectares area covering 425 farmers through NICRA Project. This intercropping demonstration has shown good impact on the farmers even in severe drought situation. The Average Net Returns obtained from Maize sole crop (local check) was Rs.22532/ha and from maize+redgram (5:1) intercropping system (demonstration), it was Rs.36276/ha resulting in 61% increase in net return. This intercropping system impressed the neighboring farmers and in these nine years the area has been extended to 2380 hectares in the district. Thus, the maize+redgram (5:1) intercropping system became economically viable than sole crop of maize in dry land situation characterised by long dry spells with erratic rains. Hence, this intercropping system is more suitable to address the climate variation in dryland areas.

UID: 1063

Studies on Maize Based Triple Cropping System under Rainfed Ecosystem of Assam

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Maize (*Zea mays* L.) has been recognized as a common component in most intercropping system and it seems to lead as the cereal constituent of intercrop and is regularly combined with dissimilar legumes. Intercropping cereals with legumes have huge capacity to replenish soil mineral nitrogen through its ability to biologically fix atmospheric nitrogen. Increasing cropping intensity by growing two or more crops in a piece of land as well as diversification of crops is also an important area of concern at present in India.

Methodology

The present study was conducted at the Experimental farm of All India Coordinated Research Project on Dryland Agriculture at Biswanath College of Agriculture, AAU, Biswanath Chariali during *kharif, rabi and summer* season 2019-20, 2020-21. And 2021-22. The experiment was started from the *kharif* season and ended with summer season. In *kharif* season, maize was grown in paired row system intercropped with greengram and blackgram in additive series of intercropping. After *kharif* maize, six *rabi* crops (toria, linseed, buckwheat, niger, rajmah and potato) were sown in the *rabi* season and the 3rd crop (greengram/ blackgram) is sown in summer season. In *kharif* season, Maize and intercrops were sown in the month of July and harvested in first week/ fortnight of November in all the three years. The rabi crops were sown within the third week of November and harvested in February/March The summer crops were sown within March. During the crop growing period, annual rainfall was 1590, 1542 and 2122 mm during 2019-20, 2020-21 and 2021-22, respectively. The experiment was laid out in RBD with 3 replications. The recommended spacing of Maize crop in Assam is 75cm x 25cm. In paired row systems, two rows are brought closer by 15cm and the spacing is 90cm x 60cm x 25cm.

The treatments are:

T_1	Maize +	Greengram ---	Toria---	Blackgram
T_2	Maize +	Greengram ---	Linseed --	Blackgram
T_3	Maize +	Greengram ---	Buckwheat -	Blackgram
T_4	Maize +	Greengram ---	Niger---	Blackgram
T_5	Maize +	Greengram ---	Rajmah--	Blackgram
T_6	Maize +	Greengram ---	Potato --	Blackgram
T_7	Maize +	Blackgram ---	Toria--	Greengram
T_8	Maize +	Blackgram ---	linseed --	Greengram
T_9	Maize +	Blackgram ---	Buckwheat-	Greengram
T_{10}	Maize +	Blackgram---	Niger -	Greengram
T_{11}	Maize +	Blackgram ---	Rajmah-	Greengram
T_{12}	Maize +	Blackgram ---	Potato-	Greengram

Results

Kharif Maize

From the study it has been found that the yield of maize crop was not significantly affected by the intercrops grown although some differences of yield were recorded. The pooled results from three years data revealed that average yield of Maize was 40.49 q/ha while greengram was grown as intercrop and the average yield of maize was 40.58 q/ha while blackgram was used as intercrop. The highest Maize yield (43.53 q/ha) was observed in the treatment T_8 i.e. Maize + Blackgram-Linseed-Greengram. The reason for better yield although not significant may be due to cereal- legume intercropping system improving soil health, soil moisture, and thereby overall output (Ummed *et. al*., 2008).

Intercrops

Among the intercrops grown with maize in paired row system of planting, greengram showed comparatively better results as compared to blackgram in all the years of study. From the pooled data average yield of greengram recorded was 4.26 q/ha against the average yield of 3.62q/ha in blackgram. The increase of greengram yield as intercrops with maize over blackgram was found to be 27.07% from 3 years of experimentation.

Rabi Crops

As six different rabi crops were grown, the yield were converted in maize equivalent yield for calculation of system studies.

Summer Crops

Blackgram performance was better in summer season than the greengram in the three years of study. The average yield of blackgram was 4.77 q/ha whereas the average yield of greengram was 3.43 q/ha.

Total System Yield

All the crops grown both intercrop and sequence crops were converted to maize equivalent yield and finally total system yield was calculated. (Table 1). From the table it has been observed that total system yield was more in the sequence where potato was grown in rabi season. The highest system yield (115.10 q/ha) was recorded in the sequence T_6 i.e Maize + greengram-potato-blackgram.

Economics

The cost of cultivation, Gross return, net return and B:C ratio was calculated in all the treatments of the experiment considering the MSP of the crops and B:C ratio was calculated from gross return and gross cost. Among the four treatments, highest B:C ratio of 2.45 was observed in the treatment T_5 i.e in the sequence Maize +greengram-rajmah-blackgram.

Conclusion

From the twelve different sequence studied under the experiment, it can be concluded the sequence Maize +greengram-rajmah-blackgram will be the best sequence considering the B:C ratio although yield was better in some other sequence.

Maize Equivalent yield and of the intercrops and sequence crops (q/ha)

Treatments	Intercrops	Rabi crops	Summer crops	Total System yield	B:C ratio
T_1	12.11	25.55	11.86	90.00	2.39
T_2	12.03	22.89	11.00	84.70	2.25
T_3	12.53	18.69	12.00	83.60	2.21
T_4	12.59	21.41	11.88	91.80	2.31
T_5	12.11	40.50	12.19	101.21	2.45
T_6	12.58	48.22	12.72	115.10	1.29
T_7	9.48	29.83	8.41	90.60	2.40
T_8	8.79	26.31	8.08	87.40	2.38
T_9	8.33	17.68	7.87	73.40	2.18
T_{10}	8.33	22.16	8.50	78.70	2.25
T_{11}	7.88	44.83	9.16	97.10	2.37
T_{12}	7.52	47.78	8.26	102.50	1.26
CD at 5%	3.96	4.38	1.12	5.19	____

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UID: 1067

Impact of Elevated Temperature and its Interaction with CO2 on Growth and Yield of Maize (Zea Mays L.) Genotypes- Studies with FATE Facility

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Crop productivity in the future is expected to be impacted by increased temperature and atmospheric carbon dioxide concentration. The temperature below or above the optimum range during the crop growth period decreases the vegetative and reproductive growth and Results in yield loss (Siebers *et al*. 2015). While, elevated CO_2 is expected to increase growth and yield, especially with C3 crop plants, some studies with C4 crops revealed that they also recorded positive responses (Ghannoum *et al*. 2000). In recent reports, it was observed that increased CO_2 concentration can alleviate the ill effects of eT even with C4 crops like maize (Vanaja *et* *al*. 2023). Studies with maize- a C4 cereal response to double the ambient CO_2 showed varying effects on growth ranging from 0 to 50 % stimulation of biomass. The temperatures up to 35ºC or higher during pollination and grain filling decreases the maize yield. The present study aimed at to assess the response variability of maize genotypes at elevated temperature (eT) and amelioration of elevated CO_2 (eT+eCO_2) conditions in terms of biomass and grain yield.

Methodology

Four maize (*Zea mays* L.) hybrids- DKC-7074, Bio-605-Early Checks; LG-34-05, CMH-08-292-Medium Checks were evaluated at eT (+ 3°C ±0.5°C) individually and in combination of eCO_2 (550ppm) in FATE facility during *Summer* 2024, and the crop experienced more than 40°C during flowering and grain filling stage. The free Air Temperature Elevation (FATE) facility consists of nine 8m diameter FATE rings to maintain the treatments as three replications of aT, eT and eT+eCO_2 conditions (Vanaja *et al*., 2019). The observations were recorded on the phenology of flowering, biomass and yield parameters.

Results

Days to anthesis and silking was reduced under eT as compared to aT, however there was an increase in ASI due to the differential response of anthesis and silking at eT. The negative impact of eT was reduced to some extent with the presence of eCO_2 along with eT thereby reducing the ASI (Fig.). The ASI is being considered as a very critical trait for fertilization in maize crops for realizing better yield.

The eT reduced the biomass and yield of all four maize genotypes, however the magnitude of response differed with genotype. The presence of eCO_2 reduced the ill effects of eT. The eT reduced the total biomass and grain yield of maize hybrids by 4% & 9% (CMH-08-292) to 23% & 34% (Bio- 605) respectively. The eT reduced grain number by 9% (CMH-08-292) to 20% (Bio- 605), while it increased 100 kernel weight, except with CMH-08-292. The presence of eCO_2 ameliorated the ill effects of eT for both biomass and grain yield of maize- a C4 crop, higher response was recorded with Bio- 605 (Fig).

Conclusion

The eT increased the ASI of all four maize hybrids, which resulted in reduced grain number and yield. The presence of eCO_2 reduced the impact of eT and improved biomass and grain yield of this C4 crop. However, the selected four maize hybrids showed differential responses for biomass and yield parameters with eCO_2 as the highest response to eCO_2 for grain yield was with Bio-605 due to increased grain number and its filling, revealing that the eCO_2 condition ameliorates the ill effects of eT of this C4 cereal crop.

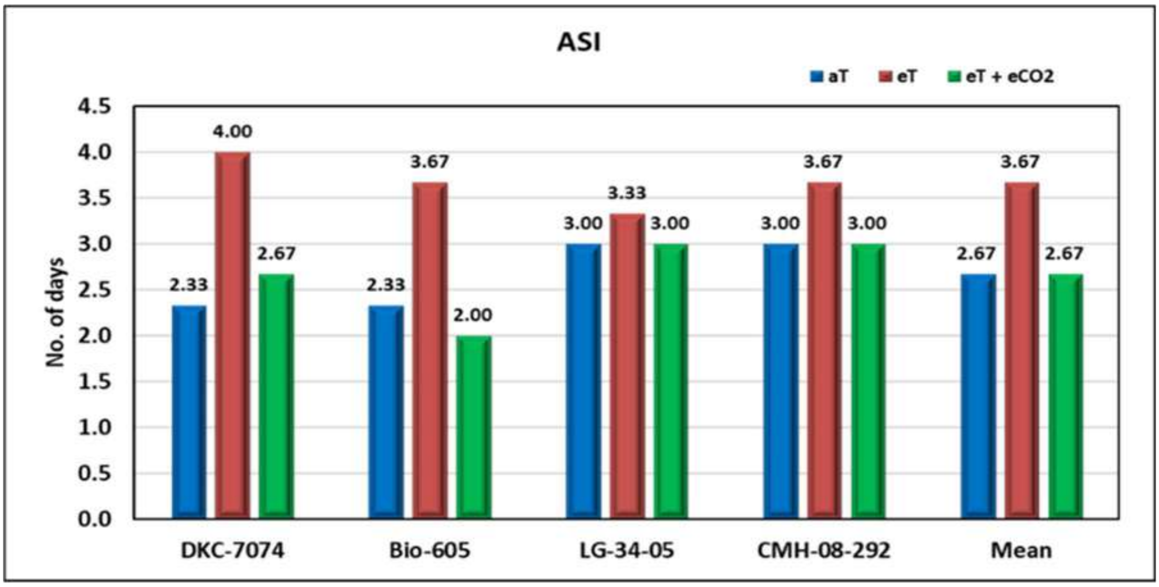

Fig 1. Phenology of four maize hybrids- DKC-7074, Bio-605-Early Checks; LG-34-05, CMH-08-292-Medium Checks at aT, eT & eT+ eCO_2.

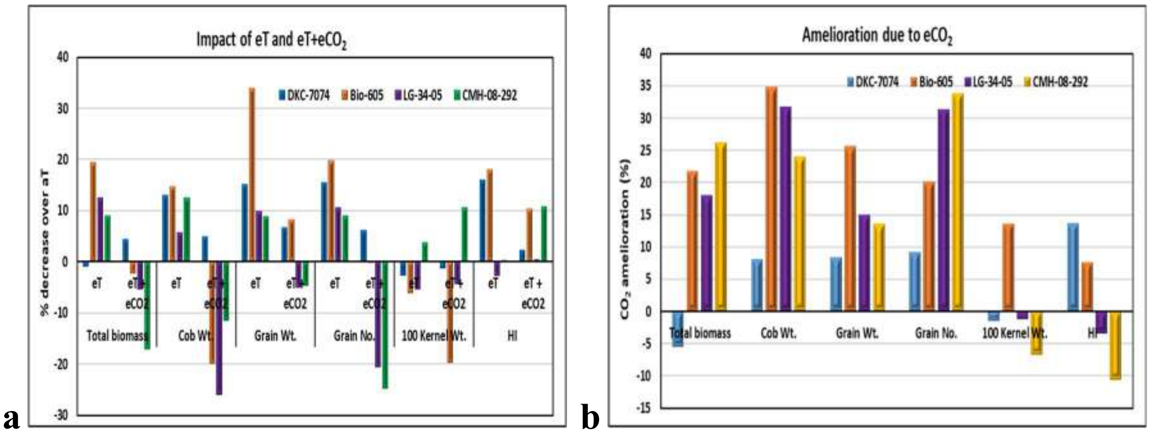

Fig 2. a. ***Impact of eT and eT+eCO_2 on total biomass, yield and yield parameters and*** **b.** ***Amelioration of eCO_2 against the ill effects of eT on total biomass, yield and yield parameters of four maize hybrids***

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UID: 1069

Compendium Technology to Overcome the Problem of Early Drought or Delayed Monsoon in Rainfed Areas of Ramanathapuram District

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Ramanathapuram district, classified as both drought-prone and an aspirational district, lies in Tamil Nadu's rain-shadow region and faces significant developmental challenges. Rainfall in the district is influenced by both the southwest and northeast monsoons; however, southwest monsoon rains are highly erratic, summer rains are minimal, and crop success largely depends on the northeast monsoon after initial establishment. The district's total gross cropped area is 54,752 hectares, with a net sown area of 178,074 hectares. Major food crops include paddy, sorghum, cotton, chilies, ragi, and pulses, following a seasonal cropping sequence: paddy from September to January, cotton and chilies from January to March, and ragi and pulses from June to October. Paddy, the primary crop, is cultivated on approximately 125,000 to 139,000 hectares depending on the onset of the southeast monsoon, while the success of its cultivation relies heavily on the quantity and timing of northeast monsoon rains. Farmers sow paddy under semi-dry conditions, awaiting saturation and subsequent submergence from the monsoon. An early onset of the monsoon can cause stress and intermittent drought, often requiring re-sowing. The sowing period for paddy extends from the 33rd to the 40th standard week. The success of paddy cultivation hinges on timely sowing and technologies that enable pre-monsoon sowing and drought resilience. This study was conducted to assess the effects of integrated drought-resilient technologies, such as drought-tolerant varieties, seed hardening, pre-monsoon sowing, and mechanized seeding, on the productivity and economic outcomes of paddy farmers in the rainfed areas of Ramanathapuram district.

Methodology

South west monsoon rainfall quantity and distribution correlated with sowing window, quantity of seed utilized and per cent of crop establishment was analysed. The study compared the management practices to overcome the problem of delayed onset of monsoon and early drought by compendium technology of adoption of drought tolerant variety (ADT 53), seed hardening with vidhai amirtham, pre-monsoon sowing and mechanised seeding in NICRA adopted farmers compared with non adopted farmers in NICRA operational village. The parameters of crop failure, number of re sowing, seed quantity, yield parameters and yield, cost of cultivation and net income were studied by using Paired T- test for comparative study. The performance of four year periods of rainfall at sowing window and performance of crop during *Rabi* was considered for analysis and interpreted the Results.

Results

Character of South west monsoon

The analysis of sowing window (Table 1) indicates that higher (71.55) percent of deviation was observed at initial period of sowing and minimum deviation (-8.69) observed in the consecutive month for crop germination and establishment. The technology which supports better germination and establishment is important for the success of the crop. Pre-monsoon sowing of paddy with hardened seed by mechanised seeding able to support germination and establishment even sowing at the period of starting sowing window (33 or 34th standard week) and achieved higher level of germination and establishment (89) per cent with optimum quantity of seed s@ 50 kg/ha where as farmers practices of non NICRA farmers utilized 125 kg seeds by broad casting method of sowing with 1.25 times of re-sowing with the germination percent (72).

Table 1. Rainfall character during sowing period

Month	10 yrs. Average RF	Rainfall (mm)				Difference in average rainfall (mm)	% Deviation
		2020	2021	2022	2023		
August	44.40	7.50	5.50	33.00	4.50	12.63	-71.55
September	49.50	86.20	33.50	58.50	2.60	45.20	-8.69

Adoption of compendium technology of drought tolerant variety ADT 53 with seed hardening, sowing with mechanised seeding achieved the higher crop establishment with single pre monsoon sowing resulted in higher grain yield (4876 kg/ha) with less cost of cultivation (Rs.38,240/ha) by avoiding resowing as well as higher seed rate and higher net income of Rs.54,244/ha with BCR of 2.42 when compared to the existing farmers practices in non NICRA farmers. According to Jain et al., (2022) pre-sowing hardening or priming of seeds is one of the best methods for altering the biochemical and physiological process of seeds for favourable condition to induce drought tolerance in emerging seedlings. The recurrent phenomenon in rainfed areas i.e. soil moisture stress immediately after sowing affects seeds germination and their establishment. Seed hardening enhance the growth and yield parameters and yield (Thangavelu et al., 2023).

Table 2. Perfomance of compendium technology on yield and economics

Category	Yield (kg/ha)	Cost of cultivation (Rs./ha)	Net income (Rs./ha)	BCR
Adopted farmers	4876	38240	54,244	2.42
Non adopted farmers	3468	41380	24,512	1.59

Conclusion

Comparative study concludes that optimum seed rate (@50 kg/ha), with pre monsoon sowing of drought tolerant variety seed hardening with vidhai amirtham by mechanised seeding is important to avoid resowing, reduce the quantity of crop failure, cost of cultivation and achieve higher per cent of germination and establishment and also to achieve higher yield, net income and BCR in rainfed areas.

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UID: 1086

Biplot Technique for Assessment of Drought Tolerance Indices for Screening of Castor (Ricinus Communis) Parental Lines

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Drought resistance is the relative yield of a genotype compared to other genotypes subjected to the same stress (Hall, 1993). For selection of genotypes based on their yield performance in stress and control conditions, different quantitative criteria have been proposed. Based on these indicators, genotypes are compared in irrigated and stress conditions or in different levels of irrigation (Taghian and Abo-Elwafa, 2003). Mohammadi et al., 2010 identified that the genotypes with high YSI is expected to have high yield under stressed and low yield under non-stressed conditions. ATI and SSPI indices are able to separate relative tolerant and non-tolerant genotypes better than previous indices. Farshadfar and Sutka (2002) improved the efficiency of STI as a modified stress tolerance index (MSTI). The objective of the study was to determine the best drought index out of quantitative drought tolerance indices and for screening of castor parental lines for drought tolerance based on the best index.

Methodology

Yield data of all the lines in both stress and control conditions were considered for the calculation of drought indices. Drought indices used for comparison were Tolerance Index (TOL), Mean Productivity Index (MP), Geometric Mean Productivity (GMP), Stress Susceptibility Index (SSI), Stress Tolerance Index (STI), Yield Index (YI) , Yield Stability Index (YSI), Resistance index (RSI) and formulae used to calculations of indices mentioned by Ezatollah Farshadfar et al (2012) using iPASTIC of R software. Rank sum (RS) was calculated by the following formula

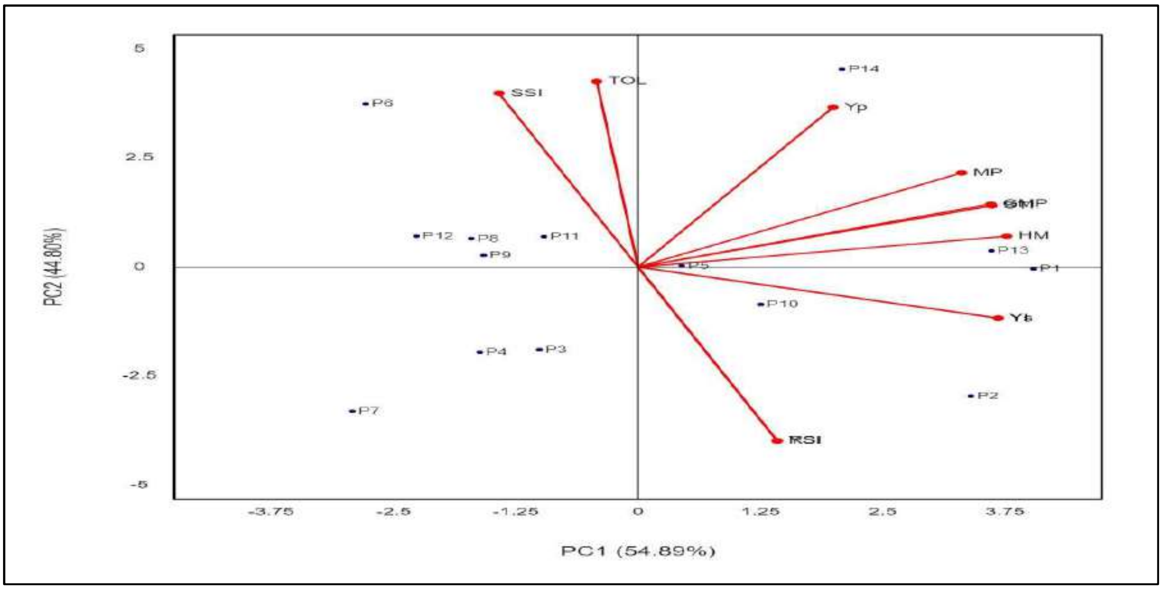
Rank sum (RS) = Rank mean (R) + Standard deviation of rank (SDR)
Biplot analysis of drought indicators was done by R software.

Results

Genotypes with larger PCA1 & lower PCA2 score have high yields and stable genotypes HM, GMP and STI were better predictors of yield. Overall STI was a better predictor of both means. It was also reported that cultivars producing high yield in both drought and control conditions can be identified by STI , GMP and MP values. TOL and SSI separates tolerance genotypes from non-stress genotypes. Using mean rank, standard deviation of ranks and biplot analysis, genotypes 1932-1, ICS-164, DPC-9, and ICS-321 are the most drought tolerant lines.

Value of Drought indicators for each parental line

Parental lines	Yp	Ys	RC	TOL	MP	GMP	HM	SSI	STI	YI	YSI	RSI
1932-1	130.5	93.9	28.0	36.6	112.2	110.7	109.2	0.79	0.90	1.25	0.72	1.12
ICS-164	110.7	95.1	14.1	15.6	102.9	102.6	102.3	0.39	0.78	1.27	0.86	1.34
ICS-200	100.0	72.8	27.2	27.2	86.4	85.3	84.3	0.76	0.54	0.97	0.73	1.13
ICS-299	97.2	70.0	28.0	27.2	83.6	82.5	81.4	0.78	0.50	0.93	0.72	1.12
ICS-321	117.7	77.1	34.5	40.6	97.4	95.3	93.2	0.97	0.67	1.03	0.66	1.02
IPC-41	132.8	56.9	57.2	75.9	94.9	86.9	79.7	1.60	0.56	0.76	0.43	0.67
IPC-42	84.3	65.1	22.8	19.2	74.7	74.1	73.5	0.64	0.40	0.87	0.77	1.20
IPC-44	113.4	66.4	41.4	47.0	89.9	86.8	83.8	1.16	0.56	0.89	0.59	0.91
IPC-46	111.3	67.5	39.4	43.8	89.4	86.7	84.0	1.10	0.55	0.90	0.61	0.94
DPC-9	115.1	82.1	28.7	33.0	98.6	97.2	95.8	0.80	0.70	1.10	0.71	1.11
DPC-22	116.7	69.7	40.3	47.0	93.2	90.2	87.3	1.13	0.60	0.93	0.60	0.93
DPC-25	111.5	63.8	42.8	47.7	87.7	84.3	81.2	1.20	0.52	0.85	0.57	0.89
48-1	131.7	91.2	30.8	40.5	111.5	109.6	107.8	0.86	0.89	1.22	0.69	1.08
DCH-519	157.7	76.7	51.4	81.0	117.2	110.0	103.2	1.44	0.89	1.02	0.49	0.76



Biplot analysis of drought indicators.

P1-P14 are codes for 14 parental lines, Ys and Yp Yield in stress and Yield in control

Conclusion

Based on biplot analysis, the indices of GMP, MP, HM, STI exhibited strong correlation (acute angles) with Ys and Yp, So, they can discriminate drought tolerant genotypes with high grain yield. Based on all indices using rank sum method, genotypes 1932-1 (RS=5.1), ICS-164 (RS=6.0) DPC 9 (6.3) and ICS 321 RS=7.5) were the most drought tolerant genotypes.

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UID: 1091

Influence of Plant Geometry and Foliar Nutrition on Growth and Yield of Rice Fallow Cotton (RFC) in Coastal Deltaic Region of Karaikal

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Cotton (Gossypium sp.) considered as white gold, is one of the most important commercial crop in the world. It is the second most important oilseed crop and most important textile fiber crop in world. Cotton alone contributes nearly 75 per cent of total raw material needs of textile industry and provides employment opportunities to about 70 million people in India (Meena et al., 2019).

Seed cotton yield per unit area is still below that of many other cotton-growing countries in the world. Among the various factors responsible for low yield of cotton crop in the country, low plant population and nutrient deficiency are of primary importance. Plant population is very crucial for attaining optimum crop growth and yield under rice fallow condition.

In cotton plant spacing, there are effects on the growth and yield characteristics of the plant. Maximum yield can be obtained by maintaining optimum plant population according to plant morphological characteristics (Ali et al., 2009). Sadhiket al. (2022) reported that 100 seed weight, seed germination, dry matter production and vigour index were higher in wider plant spacing.

Foliar application is the technique of feeding the plants with liquid fertilizers, phyto-hormones, foliar nutrients in the form of spray directly on the leaves (Alshaal and El-Ramady, 2017) as their nutrient uptake is faster than the soil application (Smolen, 2012). TNAU Cotton Plus is a consortium of macro and micronutrients as well as plant growth regulators in a definite proportion, when given as a foliar spray acts as a growth booster in cotton (Sritharan et al., 2013). Keeping this in view, the present study was conducted to determine the effect of plant spacing and foliar nutrition on the growth and yield parameters of rice fallow cotton.

Methodology

A field experiment was conducted under rice fallow condition at farmer field of Athipadugai village under the guidance of NICRA project, Krishi Vigyan Kendra, Karaikal during *summer* season (March 2022 to August 2022) and(March 2023 to August 2023). The experimental site is located at 10.9078° North latitude and 79.7931° East longitude and at an altitude of 4 m above the mean sea level. Karaikal district has a tropical climate with the mean maximum and minimum temperature of 34.8˚C and 24.8˚C, respectively. The mean annual rainfall is 1384 mm, annual evaporation is 865 mm and the annual bright sun shine hours is 2514.3. The soil has a sandy clay loam texture with a pH of 6.18. The EC was 0.14 dS/m. The soil fertility status was low in available nitrogen (205.0 kg/ha), high in available phosphorus (28.7 kg/ha) and medium in available potassium (161.6 kg/ha), respectively.

The statistical design adopted for the experimentation was Randomized Block Design, with three replications and seven treatment. The treatment of the study is furnished below, T1- Control (60 cmX 30 cm) , T2- 90 cm X 60 cm + Foliar application of Panchakavya @ 3% at flowering and boll formation, T3- 90 cm X 60 cm + Foliar application of Fish Amino acid @ 0.5% at flowering and boll formation, T4- 90 cm X 60 cm + Foliar application of TNAU Cotton Plus @ 6.25 kg ha-1at flowering and boll formation, T5-90 cm X 90 cm + Foliar application of Panchakavya @ 3% at flowering and boll formation, T6- 90 cm X 90 cm + Foliar application of Fish Amino acid @ 0.5% at flowering and boll formation, T7- 90 cm X 90 cm + Foliar application of TNAU Cotton Plus @ 6.25 kg ha-1at flowering and boll formation.

The cotton (RCH 659) was sown by dibbling method at a depth of 4 to 5 cm as per spacing in treatments. Fertilizer dose of 100:50:50 kg NPK. ha^{-1} was applied. First irrigation was given at the time of sowing to ensure uniform germination and life irrigation was given on third day after sowing. The subsequent irrigations were scheduled at 7-10 days interval depending upon the field moisture condition. Other crop-management practices were followed as per crop production guide. All the growth, yield attributes and seed cotton yield were recorded and statistically analysed as described by Gomez and Gomez (2010).

Results

Growth parameters

The growth parameters *viz.,* plant height, number of symbodial branch $plant^{-1}$ and number of squares $plant^{-1}$ were recorded

The two years of mean data showed that plant spacing and foliar nutrients had significantly influenced the plant height, number of symbodial branch $plant^{-1}$ and number of squares $plant^{-1}$. Rice fallow cotton spacing 90 cm × 90 cm + foliar application of TNAU Cotton Plus @ 6.25 kg ha^{-1}at flowering and boll formation(T_7) had registered highest plant height (135.8), number of symbodial branch $plant^{-1}$(21.7) and number of squares $plant^{-1}$(35.5) as compared to other treatment. However, they are statistically on par with T_2, T_3, T_4 and T_6. Statistically the lowest plant height (128.6), number of symbodial branch $plant^{-1}$ (17.5) and number of squares $plant^{-1}$(30.1) were registered in control(T_1) followed by 90 cm × 60 cm foliar application of Panchakavya @ 3% at flowering and boll formation (T_5).

Increased growth components at plant spacing of 90 cm × 90 cm + foliar application of TNAU Cotton Plus might have a synergic effect and foliar application of micro nutrient might have enhanced the photosynthetic activity and enzymatic reactions in the plant and also supplied more nitrogen by fixation for better growth. These Results are in close conformity with the findings of Sanjivkumar *et al*. (2021), Singh *et al*. (2017) and Zeidan *et al.* (2010).

Yield parameters and seed cotton yield

A significant difference in yield parameters and seed cotton yield due to plant spacing and foliar nutrients in rice fallow cotton were recorded.

Among the treatments under study, plant spacing 90 cm × 90 cm + foliar application of TNAU Cotton Plus @ 6.25 kg ha^{-1}at flowering and boll formation(T_7) had registered highest number of bolls plant^{-1} (24.7)and boll weight (3.86) as compared to other treatment. However, they are statistically on par with T_2, T_3, T_5 and T_6. Statistically the lowest number of bolls plant^{-1} (18.8) and boll weight (3.01) register with in control (T_1) followed by 90 cm × 60 cm foliar application of TNAU Cotton Plus @ 6.25 kg ha^{-1} at flowering and boll formation (T_4).

From the two years of experimental studies, it was found that the significant effect was aroused on seed cotton yield due to plant spacing and foliar application of nutrients. According to the two years of experimental Results, it could be revealed that, plant spacing 90 cm × 90 cm + foliar application of TNAU Cotton Plus @ 6.25 kg ha^{-1} as foliar sprays two time respectively at flowering and boll formation stages recorded distinctly higher seed cotton yield (SCY) of 2,870 kg ha^{-1}.

This might be due to the fact that better aeration, adequate interception of light and lesser competition for available nutrients and moisture than higher plant density have resulted into synthesis of higher photosynthates and in turn helped to produce higher number of yield attributes which ultimately resulted in higher seed cotton yield in 90 cm × 90 cm + foliar application of TNAU Cotton Plus. These findings are in agreement with those of shah *et al.* (2022) and Honali *et al.* (2010).

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UID: 1096

Bacillus sp. Inoculation Improves *Brassica juncea* L. Root Viability and Macronutrient Uptake under Drought and Nutrient Stress

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Mustard (*Brassica juncea* L.) is the third most important edible oilseed crop in the world, after soybean and oil palm. The yield of this oilseed crop is reduced by 17–94% due to its increased sensitivity to water fluctuations, particularly during crucial growth stages like pre-flowering and siliqua formation (Asha et al., 2021). Drought is also known to disrupt beneficial root-microbe associations which are crucial for nutrient mobilization and uptake. Drought may cause decreased nutrient transport from the roots to the shoot, which is directly correlated with lower plant yield (Rouphael et al., 2012). To mitigate the drought stress, an eco-friendly approach is the application of plant growth promoting rhizobacteria (PGPR). *Bacillus* is the most common bacterial genus in soil, plant rhizosphere, and endosphere among the PGPR groups. This bacterial group can endure extreme environmental conditions for long periods of time, through production of metabolites and formation of resilient spores. This study evaluated the potential of the rhizobacterium *Bacillus* sp. strain MRD-17 to mitigate the negative impacts of drought and nutrient stress in the drought-sensitive mustard variety, Pusa Karishma LES-39.

Methodology

The study investigated the interactive effects of rhizobacterium *Bacillus* sp. strain MRD-17 (Nivetha et al., 2024) and macro-nutrients nitrogen, phosphorus, and potassium (N, P, K), 100% and 50% of recommended dose of fertilizer (RDF) on shoot-root growth and nutrient uptake and assimilatory enzymes by mustard under well-watered (-0.33 bar) and water deficit (-8 bar) stress. Forty days after sowing (DAS), the plants were exposed to drought stress for a period of 30 days. The sampling was carried out 70 DAS in order to ascertain the impact of rhizobacterial inoculation and drought stress on plant growth and nutrient uptake.

Results

Drought, for 30 days period, reduced root growth, but inoculation with Bacillus sp. strain MRD-17 under drought and nutrient stress enhanced plant growth, root viability (260% and 63%, respectively) and root architecture. Rhizobacterial inoculation under drought and nutrient stress improved the plant nutrient content (Fig. 1A, B and C) such as shoot nitrogen, phosphorus, and potassium content, and seed potassium content (78% and 9.5%, respectively).

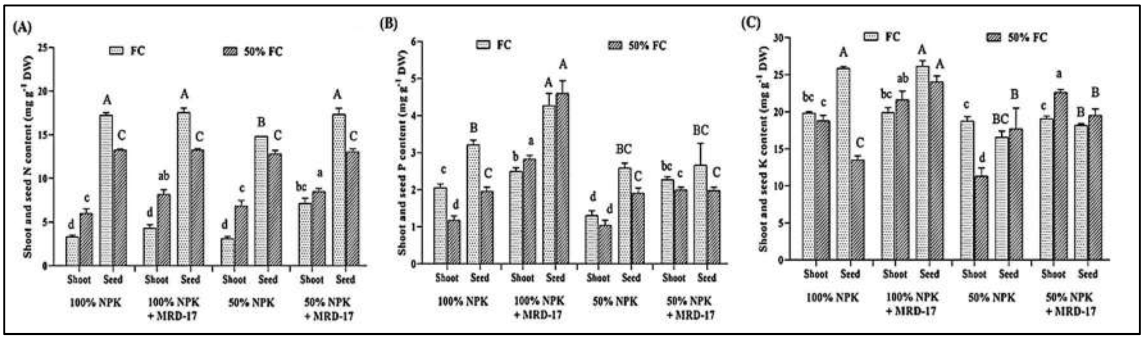

Fig 1. Effect of inoculation with rhizobacterium on plant nutrient status, under drought and nutrient (NPK) stress.

(A) shoot and seed N-content, (B) shoot and seed P-content and (C) shoot and seed K-content. NPK (nitrogen, phosphorus, and potassium), FC (field capacity). Different lowercase and uppercase letters indicate difference between treatments in shoot and seeds, respectively according to Tukey's HSD at $P \leq 0.05$ in mean values.

Furthermore, under drought and nutrient stress, activity of nutrient uptake and assimilatory enzymes (Fig. 2A and B) like, nitrate reductase (25% and 14%, respectively) and glutamine synthetase activity (27% and 29%, respectively) was enhanced in the inoculated plants; while decrease in acid phosphatase activity (23%) was noted under drought stress (Fig. 2C). The interaction, however, had no effect on the seed N and P content under drought and nutrient stress. Thus, Bacillus sp. strain MRD-17 is promising rhizobacterium for mitigation of drought and nutrient stress.

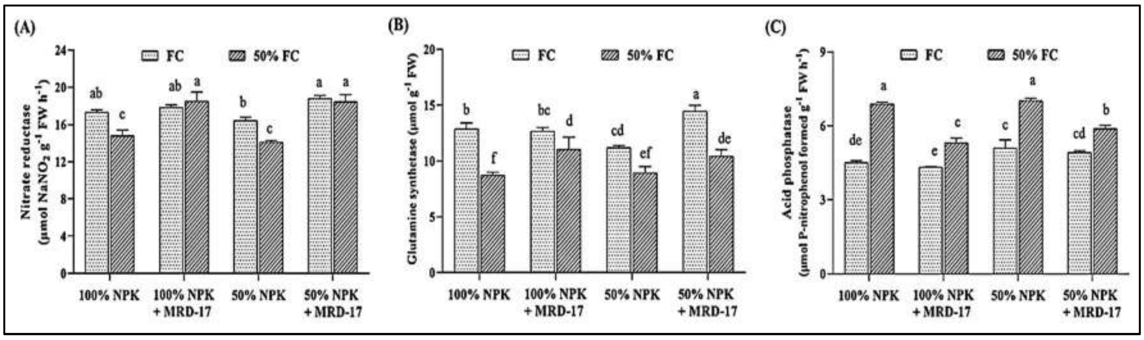

Fig. 2: Effect of inoculation with rhizobacterium on nutrient uptake and assimilatory enzymes, under drought and nutrient (NPK) stress

(A) nitrate reductase, (B) glutamine synthetase and (C) acid phosphatase activity. NPK (nitrogen, phosphorus, and potassium), FC (field capacity). Different letters indicate difference between treatments according to Tukey's HSD at $P \leq 0.05$ in mean values.

Conclusion

Our study revealed that drought and nutrient stress in mustard crop impacted nutrient uptake and, ultimately, plant growth. *Bacillus* sp. strain MRD-17 inoculation under these situations, improved shoot and root growth, root architecture and viability, NR, GS activity and N, P, and K concentrations in the shoot. These Results showing that inoculation may be significant way to lessen the detrimental impacts of drought and nutrient stress in mustard.

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UID: 1097

Sustainable Paddy Based Cropping System in Darbhanga, Bihar

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Rice-wheat is a dominating cropping pattern followed in Bihar, India. But it has a lower productivity (4.8 t per ha.) as compared to national average (6.8 t per ha) in Bihar, this might be due to several biotic and abiotic factors. Among abiotic; climate and old cultivation practices are matter of concern for the farmers and researchers. Keeping all these views, this study aimed to find out a best cropping system and mechanized cultivation method to achieve higher profit in sustainable manner. In this regards, a study conducted during 2022-23 in 3 adopted villages of district Darbhanga of Bihar under the Project "National Innovation on Climate Resilient Agriculture (NICRA)" to find out sustainable mechanized cropping system for higher productivity as well as for long term conservation of soil health. In these 6 improved rice varieties ('Rajshree', 'Rajendra Mahsuri', 'R. Bhagwati', 'R. Neelam', 'R. Sweta' and 'R. Suwasini') were involved in different mechanized methods of cultivation. As a result the highest grain yield with highest B:C ratio were found in the variety 'R. Mahsuri' sown with zero tillage (45.74 q/ha yield & 2.66 B:C ratio) followed by the method of 'water harvesting &

field bunding in rice' (44.65 q/ha yield & 2.17 B:C ratio) and 'community irrigation' (43.12 q/ha yield & 2.10 B:C ratio). The total average grain yield and B:C ratio (56.33 q/ha & 1.98) were found to be higher than local technology (50.66 q/ha & 1.68) at farmers field. Rice-wheat cropping system recorded highest (40 q rice & 32.5 q wheat) in raised bed system followed by Rice-Lentil (43.30 q rice & 11 q lentil) whereas highest profitability was noted in Rice-Lentil (Rs. 32375/- per ha) followed by Rice-Wheat (Rs. 26250/- per ha) cropping system. It is suggested that rice can be cultivated successfully with zero tillage without harming nature and soil physical properties for its long-term sustainability.

UID: 1103

Growth Parameters and Grain Yield Influenced by Moisture Regimes and Weed Management Practices in Drum Seeded Rice

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Rice (Oryza sativa L.) is a staple food for more than half of the world's population, and its cultivation is significantly influenced by various agronomic practices. Among these, moisture management and weed control are critical factors that can affect growth parameters and grain yield. The drum seeding method, which involves sowing pre-germinated seeds in puddled fields, has gained popularity due to its efficiency and potential to improve crop establishment. In general, farmers used to keep rice fields submerged throughout the growing season on the idea that doing so would result in a larger grain yield. Irregular drainage, on the other hand, was shown to boost rice growth and grain output. Continuous submergence is a frequent technique during the growing stage. Following the removal of ponded water, 7 cm irrigation at 1-3 days boosted grain output and water usage efficiency, according to the studies. In terms of plant height, dry matter accumulation and number of grains/panicle (Kumar *et al.,* 2013) found that 7 cm irrigation at one day after disappearance of ponded water (DADPW) was significantly superior to 7 cm irrigation at 3 and 5 DADPW respectively (Singh *et al.,* 2022). For instance, maintaining optimal soil moisture levels can lead to improved root development and increased biomass, ultimately contributing to higher grain yields.

Direct seeded rice faces higher competition since the crop and weeds emerge at the same time, causing the crop to suffer during the early stages of development. As a result, the rice yield is reduced. In direct seeded rice, yield loss due to weeds ranges from 40 percent to 100 percent

(Singh *et al.,* 2016). Integrated weed management (IWM) is a holistic strategy aimed at controlling weed populations while minimizing their negative impact on crop growth, particularly in direct-seeded rice systems, effectively reduces competition for vital resources such as sunlight, water, and nutrients allows rice plants to grow taller and accumulate more dry matter. Additionally, IWM enhances soil health by improving structure and fertility, which supports better root development and microbial activity, further facilitating nutrient uptake. As a result, rice plants exhibit improved photosynthetic efficiency and resource utilization, leading to increased grain yields and also promotes sustainable agricultural practices by fostering healthier ecosystems.

Methodology

A field experiment was conducted during *Kharif* season of 2021 at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, (U.P.). The experiment was conducted in split plot design with 15 treatment combination which comprised of 3 Moisture regimes (Main plot) 6 cm at 1 DADPW (Days after disappearance of ponded water), 6 cm at 4 DADPW, and 6 cm at 7 DADPW and 5 weed management practices (Sub plot) viz., Weed free, Organic mulch (Rice straw@3 t ha^{-1}), Pretilachlor (PE) @0.75 kg a.i ha^{-1}+ Bispyribac sodium 10% SC @200 ml ha^{-1} (PoE), Two hand weeding (at 20-25 DAS and 40-45 DAS), and Weedy check. Plant height was recorded from the length between the base of stem touching the ground level to the top of top most plant leaf with the help of meter scale based on the average of randomly selected five hills and average plant height were recorded. Dry matter accumulation was recorded by selecting five plants randomly from each plot, the plant shoots m^{-2} were cut carefully closed to the ground level and put in the paper bags and kept for sun drying for about 2 days. After sun drying, the samples were dried into hot air oven at 65 to 70^0C till the constant weight attained. Grain yield was estimated by weight of total biomass, the produce of each net plot was threshed separately and clean grains were sun dried to maintain the moisture content at standard level of 14% moisture. The grain yield was recorded as the weight in kg per net plot by balance and finally grain yield per plot was converted in to t ha^{-1} by conversion factor. Statistical analysis of the data was carried out using standard analysis of variance (Gomez and Gomez, 1984).

Results

Plant height, dry matter accumulation and grain yield was significantly ($p \leq 0.05$) influenced due to various moisture regimes and weed management practices in rice crop. Plant height significantly ($p \leq 0.05$) recorded maximum with MR1 option (105.44 cm), which was significantly higher over MR3 (93.86 cm) while did not show significant difference over MR2 (101.26 cm) respectively. The magnitude of plant height increases by ~3.96% and~11.02% in MR1 over MR2 and MR3 options respectively. Meanwhile, maximum dry matter accumulation had recorded with MR1 (1183.6 g/m^2) as compare to MR3 (928.8 g/m^2) but this was not differed significantly over MR2 (1139.8 g/m^2). Grain yield had significantly ($p \leq 0.05$) maximum noted with MR1 option (4.75 t/ha), which was significantly higher over MR3 (3.71 t/ha) while did not show significant difference over MR2 (4.57 t/ha) respectively. The magnitude of grain yield increase by ~3.78% and~21.90% in MR1 over MR2 and MR3 options respectively.

Plant height significantly ($p \leq 0.05$) recorded maximum with WM1 option (106.40 cm), which was significantly higher over WM2 (98.23 cm) and WM5 (90.43 cm) while did not show significant difference over WM3 (101.70 cm) and WM4 (104.17 cm) respectively. Meanwhile, maximum dry matter accumulation had recorded with WM1 (1244.1 g/m^2) as compare to WM5 (858.8 g/m^2) and WM2 (952.3 g/m^2) but this was not differed significantly over WM3 (1166.7 g/m^2) and WM4 (1198.4 g/m^2) respectively. Grain yield had significantly ($p \leq 0.05$) maximum noted with WM1 (5.01 t/ha), which was significantly higher over WM5 (3.38 t/ha) and WM2 (3.81 t/ha) while did not show significant difference over WM3 (4.69 t/ha) and WM4 (4.82 t/ha) respectively. The magnitude of grain yield increase by ~3.79%, ~6.39%, 23.95% and~32.53% in WM1 over WM4, WM3, WM2 and WM5 options respectively.

Effect of moisture regimes and weed management practices on growth parameters and grain yield of rice

Treatments	Plant height (cm) at harvest	Dry matter accumulation (g/m^2) at harvest	Grain Yield (t/ha)
Moisture regimes			
MR1	105.44±3.784	1183.6±106.968	4.75±0.447
MR2	101.26±3.637	1139.8±102.842	4.57±0.430
MR3	93.86±3.386	928.8±82.128	3.71±0.349
SEm±	2.44	21.36	0.10
LSD (p≤0.05)	8.45	73.93	0.35
Weed management practices			
WM1	106.40±3.593	1244.1±91.638	5.01±0.371
WM2	98.23±3.334	952.3±66.489	3.81±0.283
WM3	101.70±3.422	1166.7±85.305	4.69±0.348
WM4	104.17±3.510	1198.4±87.704	4.82±0.358
WM5	90.43±3.069	858.8±62.179	3.38±0.250
SEm±	2.51	22.01	0.11
LSD (p≤0.05)	7.33	64.24	0.33

Note: MR_1 :6 cm at 1 DADPW, MR2:6 cm at 4 DADPW, MR3:6 cm at 7 DADPW, WM_1: Weed Free, WM_2: Organic mulch (Rice straw @ 3t ha^{-1}), WM_3: Pretilachlor (PE)@0.75kg a.i ha^{-1} +Bispyribac sodium 10% SC @ 200 ml ha^{-1} (PoE), WM_4: Two hand weeding (at 20-25 DAS and 40-45 DAS) and WM_5: Weedy check.

Conclusion

The most suitable moisture regimes were found in MR1 with maximum plant height (105.44 cm), dry matter accumulation (1183.6 g/m^2) and grain yield (4.75 t/ha) over MR3 and MR2. Suitable weed management practices were found in WM1 with maximum plant height (106.40 cm), dry matter accumulation (1244.1 g/m^2) and grain yield (5.01 t/ha) over WM4, WM3, WM2 and WM5 respectively based on the grain productivity of each treatment.

UID: 1106

Integrated Rainfed Farming System Typologies for Sustainable Development in the Semi-Arid Tracts of Southern India

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In India, the shrinking per capita availability of land due to population growth, land fragmentation, industrialization, and urbanization has limited the scope for expanding farmland. Increasing food production on existing land requires innovative approaches like Integrated Farming Systems (IFS), which are economically viable and ecologically sustainable. IFS, particularly in rainfed areas, integrates multiple allied enterprises with crop components to optimize resource use and improve productivity and profitability while preserving natural resources. This integration benefits from synergistic interactions among enterprises, diversifies production, and provides resilience against environmental risks, making it a strategic choice for smallholder farmers (Behera and France, 2016). This integration enhances resource use efficiency and reduces dependency on external inputs by recycling organic wastes back into the system. By reusing by-products and minimizing waste, IFS not only improves farm productivity but also promotes soil health and ecosystem stability, contributing to long-term sustainability. Studies show that energy outputs in IFS exceed inputs, as the by-products of one enterprise serve as inputs for another, creating a self-sustaining system (Paramesh et al., 2022). With highly variable rainfall and limited irrigation, rainfed farmers often hesitate to invest in inputs due to the risk of crop failure. Integrating multiple enterprises into IFS can mitigate these risks, as income sources are diversified, reducing dependency on any single enterprise. This diversification provides a more stable income, increases resource use efficiency, and improves household food security by supplying multiple food products.

In the study area, farmers face constraints like low productivity, poor integration of farming systems, and limited income and employment opportunities, resulting in minimal improvement in their livelihoods. Traditional monocropping systems limit their ability to increase productivity and adapt to environmental challenges. By adopting IFS approaches, farmers in these regions could potentially increase both production and income, addressing livelihood security concerns. Enhancing the integration of appropriate farming systems within rainfed agriculture offers a pathway to boost agricultural productivity and generate employment. IFS also promotes environmental sustainability by enhancing soil health and conserving resources. The recycling of organic matter within IFS improves soil structure, water retention, and nutrient availability, which are crucial in rainfed regions where soil degradation and water scarcity are common. This focus on soil health not only supports crop productivity but also aligns with ecological preservation goals, as balanced nutrient recycling reduces the need for synthetic inputs and minimizes environmental degradation.

In this context, it is essential to identify and promote suitable IFS models tailored to specific agroecological conditions and resource availability in rainfed regions. With this background, the present study was initiated to characterize farming systems, particularly focusing on farm households using typologies, identifying constraints, and proposing cost-effective and sustainable farming systems interventions tailored to each farm type to address these constraints.

Methodology

A sample survey focused on six villages each in Solapur and Vijayapura districts, located in the semi-arid region of Maharashtra and Karnataka states, respectively was conducted during 2018-19 with 480 households. This district was chosen as a representative site for semi-arid tracts of Southern India. The survey aimed to examine local farming conditions and identify specific interventions to support rainfed and partially irrigated farming systems.

A multi-stage random sampling method was used to select households. First, two blocks were randomly chosen within the district, and then three villages were selected from each block. Households within these villages were categorized by landholding size, small (1-2 ha), marginal (<1 ha), and medium (2-4 ha). In each village, 40 farmers were selected, including 20 who relied exclusively on rainfed farming and 20 who had partial irrigation (less than 30% of their land). The survey focused on collecting information about each household's farming practices. The study did not involve active participation beyond gathering this data and followed the guidelines of the All India Coordinated Project for Dryland Agriculture (AICRPDA), ICAR-CRIDA, Hyderabad. The surveyed households were grouped into relatively similar types, known as "farm types," using statistical methods, namely principal component analysis (PCA) and cluster analysis (CA). Each type was identified based on its main characteristics, making it easier to analyze the specific needs and challenges faced by each group.

To understand each farm type, seven structural features were analyzed, including the age of the household head, family size, total land owned, land under cultivation, and land used for horticulture. Variance analyses were performed to test if the differences among the four identified clusters were statistically significant for both structural and performance variables. Based on the survey data, key farming challenges across the selected areas were identified.

After analyzing these challenges, discussions were held with local experts and both survey participants and non-participants to develop practical, location-specific solutions. The interventions designed to address the unique challenges of each farm type were then implemented, and changes in net income were measured to assess the impact. This targeted approach provided farmers with tailored support to help improve their productivity and resilience in a semi-arid environment.

Results

The integrated farming system is an approach wherein emphasis is given on diversification of cropping systems in general and farming systems as a whole has been found successful to bring improvement in economic conditions of small and marginal families of study area.

Land use patterns in Vijayapura revealed that of the total 982.5 acres, 95.9% was dedicated to crop cultivation. Orchards occupied 2.7% of the land, while 0.5% remained uncultivated, 0.7% housed dwellings, and 0.2% was used for livestock structures or farm ponds. The high percentage of land devoted to annual crops highlighted a focus on traditional cropping over diversification. This data helped guide the development of integrated farming systems tailored to local needs, supporting sustainable, resource-efficient agriculture. Two main farming models were identified: the crop-only model and the crop-livestock model. The study evaluated 12 farming systems that combined three farmer categories (marginal, small, medium) and two growing conditions (rainfed and partially irrigated). Through principal component analysis (PCA), three principal components were extracted, accounting for about 59% of the variation across farm households. The first principal component (PC1) captured 24.3% of the variability, linked to machinery use, food grain cultivation, and income from food grains. The second component (PC2), explaining 21.1% of the variability, highlighted the area and income from fruits and vegetables, on-farm income, and farm expenses. The third component (PC3), which explained 13.4% of the variation, related to fodder land area and income, reflecting the diverse production objectives and resource allocations among households. Four distinct farm types emerged from the analysis, each with unique characteristics including distribution of the farm household and source of income (Fig. 1).

Farm Type 1: Marginal and small low-income crop-livestock farms (28.5%) – Comprising mostly marginal (51%) and small (44%) farmers, this type earns an annual income of ₹88,000. Primary income (66%) comes from crops like pigeonpea, rabi sorghum, and chickpea, with 34% from small livestock (goats). Low on-farm income necessitates off-farm work to meet expenses.

Farm Type 2: Medium moderate-income crop-livestock farms (16.7%) – Predominantly medium farmers (53%), earning ₹178,000 annually with primary income from crops (₹140,000). Production costs are high due to machinery expenses, with off-farm work supplementing income.

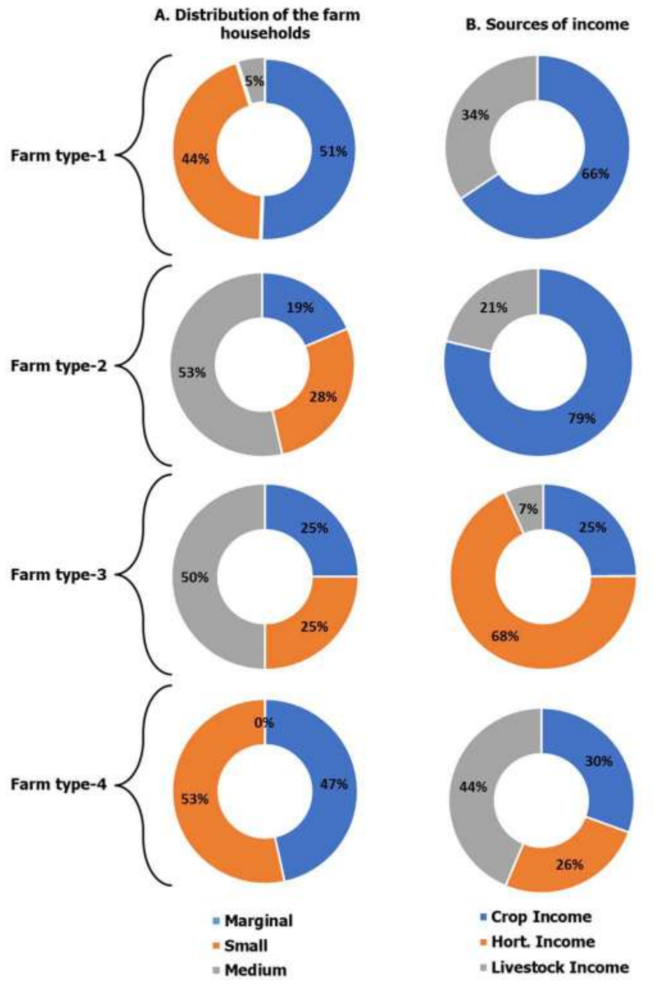

Fig. 1. (a) Distribution of the farm households and (b) sources of income across the farm types

Farm Type 3: Medium high-income crop-horticulture-livestock farms (7.1%) – Medium and small farmers, earning mainly from horticulture (68%) with crops like onions and grapes. High input costs (₹71,600) for intensive horticulture limit off-farm engagement.

Farm Type 4: Small moderate-income crop-horticulture-livestock farms (47.7%) – The largest group (53% small, 47% marginal), earning solely from farm activities. Income relies on livestock (44%), with onions, grapes, pigeonpea, and maize as major crops. Production costs are relatively low.

Across the farming systems, key challenges were identified, including pest and disease outbreaks in pulses, moisture stress in rabi crops (e.g., sorghum), and a lack of crop-specific nutrient management. Limited availability of improved crop varieties and ineffective pest management practices further constrained yields, particularly in onion and pigeonpea. Livestock productivity was hindered by local breeds and poor nutrition for milking animals. Common cropping practices like sole cropping or poorly managed intercropping also led to inefficiencies. To address these constraints, tailored interventions focused on conservation techniques, improved varieties, precise nutrient management, and effective pest control were recommended and implemented, aiming to enhance sustainability and profitability in Solapur and Vijayapura's semi-arid farming systems.

Conclusion

Livelihood security for small and marginal farmers remains a key concern in Indian agriculture, with low income and limited employment opportunities. This study on Vijayapura and Solapur farms reveals that most land is dedicated to annual crops, with minimal horticulture and crop-livestock integration. Four distinct farming types were identified, each facing challenges like pest issues, moisture stress, and nutrient inefficiencies. Key interventions, including rainwater harvesting, improved crop varieties, nutrient management, and livestock health measures, were proposed for sustainable development in semi-arid tract of southern India.

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UID: 1108

Performance of Cotton *Bt* Variety (CICR *Bt* 20-31) under Different Nitrogen Levels and Plant Densities in Rainfed Vertisols of Scarce Rainfall Zone of Andhra Pradesh

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Presently, more than 90% area is under Bt hybrids, the cotton productivity in India is low compared to world average (>750 kg/hectare) and is found stagnated at around 500 kg lint per hectare for past many years (Kranthi and Stone,2020). One of the reasons attributed to this productivity stagnation is deployment of Bt technology in the form of Bt hybrids in rainfed conditions which accounts to more than 60% of cotton area in India. Generally, hybrids possess strong vigour and demands higher inputs. Majority of the popular Bt hybrids are long duration that suffer moisture stress at boll formation stage due to poor water retention of shallow soils in rainfed regions. Productivity enhancement in India can come from yield improvement in rainfed ecosystems through development and deployment of Bt cotton varieties. (Singh et al., 2021). Bt varieties provide higher yields with an option of high-density planting, provide good protection against bollworms owing to presence of transgene in homozygous conditions with no further segregation. Seed of varieties can be saved for re-use next year. They are relatively tolerant to sucking pests, early in maturity, are less input demanding and more climate resilient.

Methodology

Field experiment was conducted during the *kharif* season of 2023–24 at the Regional Agricultural Research Station, ANGRAU, Nandyal, Andhra Pradesh with an objective to find out geometry and nutrient requirement of pre-released *Bt* (*G. h*) variety (CICR *Bt* 20-31) under rainfed conditions of scarce rainfall zone of Andhra Pradesh. The soil experimental field was clayey in texture, low available nitrogen (132 kg/ha), medium in available phosphorus (30 kg/ ha) and high available potassium (358 kg/ ha) and slightly alkaline in reaction (pH 8.4). The experiment was laid out in a Factorial randomized block design, with three replications with a gross plot size of 5.4 m X 3.0 m. The experiment comprised of 9 treatment combinations, consisting of 3 levels of geometry (S1: 60 cm X 15cm, S2: 60 cm X 30 cm, S3: 90 cm X 15 cm) and 3 nitrogen levels (N1: 75 % RD of Nitrogen, N2: 100% RD of Nitrogen (40-20-20 NPK kg/ha), N3: 125% RD of Nitrogen). The crop was sown as per treatment by dibbling by one seed per hill.

Results

The results revealed that among the geometry levels, significantly higher yield parameters like number of sympodia per plant (13.3), number of bolls per square meter (56.6), boll weight (3.5 g) and seed cotton yield (2187 kg ha^{-1}) was recorded with spacing of 60 cm x 15 cm. Lower yield parameters like number of sympodia per plant (10.7), number of bolls per square meter (44), boll weight (3.0 g) and seed cotton yield (1847 kg ha^{-1}) was recorded with spacing of 90 cm x 15 cm. Among the nitrogen levels, number of bolls per square meter (55.7), higher boll weight (3.4 g) seed cotton yield (2171 kg ha^{-1}) was recorded with 125% RDN, comparable with 100% RDN (1900 kg ha^{-1}), whereas lowest with 75% RDN.

Conclusion

The new *Bt* cotton variety (CICR *Bt* 20-31) is a medium staple variety, early in maturity (140-150 days), suitable for HDPS. This variety can help to Indian cotton farmers to escape from damage of pink bollworm, terminal drought stress and also provide an opportunity for taking up second crop. This new *Bt* variety can help cotton farmers in rainfed regions of south India achieve better productivity, profitability and sustainability of cotton production with additional 25% of fertilizer dose.

Growth and yield parameters as influenced by spacing levels and nitrogen levels

Treatments	Plant height (cm)	No of monopodia	No of sympodia	Bolls / m^2	Boll weight (g)	Seed cotton yield (kg/ha)
Spacing						
S1.60X 15 cm	100.6	0.4	13.3	56.6	3.5	2187
S2.60X 30 cm	93.4	0.3	12.2	50.5	3.3	1908
S3.90X 15 cm	86.5	0.3	10.7	44.0	3.0	1847
SE d	3.1	0.06	0.54	1.9	0.12	85
SE m+	2.2	0.04	0.38	1.4	0.08	76
LSD (p=0.05)	6.6	NS	1.1	4.1	0.25	240
Nitrogen levels						
N_1: 75% RDN	88.9	0.4	11.5	43.8	3.0	1870
N_2: 100 % RDN	92.9	0.4	12.4	51.7	3.3	1900
N_3: 125 % RDN	98.8	0.4	12.3	55.7	3.4	2171
SE d	3.1	0.06	0.54	1.9	0.12	85
SE m+	2.2	0.04	0.38	1.4	0.08	76
LSD (P=0.05)	6.6	NS	NS	4.1	0.25	240
Interaction	NS	NS	NS	NS	NS	NS
CV (%)	9	14	12	10	10	12

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Bioregulators as a solution to improve moth bean growth and productivity in hot arid India

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Moth bean (*Vigna aconitifolia*) is a hardy legume known for its exceptional drought and heat tolerance, making it particularly well-suited to cultivation in Asia's arid and semi-arid regions (Singh et al., 2020). The crop is highly versatile, providing food, fodder, animal feed, and green manure. However, moth bean yields remain relatively low due to its cultivation on marginal lands with minimal irrigation and limited soil fertility, as well as a lack of optimized agricultural practices. Plant bioregulators (PBRs) can significantly boost moth bean's drought tolerance and productivity. Various PBRs, such as thiourea, potassium sulphate, salicylic acid, and acetic acid, have demonstrated potential in enhancing both productivity and drought tolerance in diverse crops. The use of foliar sprays (e.g., urea, NPK, and potassium sulphate) combined with PBRs can further improve moth bean's growth, water status, and antioxidant activity, ultimately boosting yield and drought resilience under arid conditions.

Methodology

At the ICAR-Indian Institute of Pulses Research, Regional Research Centre, Bikaner (28°07' N; 73°32' E; 225.3 m above mean sea level), Rajasthan, India, an experiment was carried out in the kharif seasons of 2021 and 2022 (June–September) to evaluate the impact of bio-regulators on the physio-biochemical alterations, and yield of moth bean under drought stress. Three replications were included in the factorial randomized design of the experiment. Thiourea 1000ppm (TU), 0.5% K_2SO_4 (potassium sulphate), 100 ppm Salicylic acid (SA), Urea 2% spray, 0.5% NPK solution, 20 mM acetic acid (AA), and 0.5% magnesium sulphate ($MgSO_4$) were the seven growth supplements/bioregulators that were tested. For easier comparison, water spray was used as the control treatment. These PBRs were applied at 25 and 45 DAS, which correspond with the active vegetative and flowering initiation stages of the moth bean. For better comparison, cultivars of different nature moth bean (CZM 2 and RMO-2251) were kept.

Results

Dry matter accumulation (DMA) and leaf area were taken at 40 DAS, 60 DAS and at harvest, and at 40 DAS, DMA, leaf area and CGR was not significantly affected by varieties and application of growth supplements, it might be due to non-occurrence of water stress and sufficient amount of rainfall was received during the period. But, growth attributes at 60 DAS and at harvest was significantly higher in application of AA, and the increase in DM was around 24.6% over water spray treatment and DMA and growth attributes was statistically at par with TU, K_2SO_4 and SA. Anti-oxidant enzymatic activities and proline accumulation along with low MDA production was recorded in moth bean crop indicates its higher tolerance to water stress. Among the cultivars, RMO-2251 of moth bean performed better than CZM-2. SOD (47%) and Catalase (65.7%) activity was recorded significantly higher with the application of AA over water spray. CZM-2 responded better to growth supplements and recorded higher yield, net return and B:C ratio as compare to RMO-2251. Application of AA resulted in 29.6% % higher seed yield over water spray and it was statistically at par with TU and potassium sulphate.

Table1. Chlorophyll concentration, RWC, MSI yield and economics of different cultivars of cluster bean and moth bean as influenced by different growth supplements

Varieties	Chlorophyll		RWC		MSI	Seed yield (q ha^{-1})	Net returns (10^3x ₹ ha^{-1})	B:C ratio
	40 DAS	60 DAS	40 DAS	60 DAS				
CZM-2	1.95a	2.37a	73.8a	68.3a	72.6a	7.37a	37.5a	1.51a
RMO-2251	2.16a	2.50a	74.6a	68.9a	73.7a	6.56b	30.6b	1.23b
PBRs								
Water	1.55b	1.89e	69.9c	62.5d	63.2d	7.49f	37.6d	1.50e
TU(1000 ppm)	2.29a	2.66ab	80.8a	73.4a	74.1a	9.61a	50.1a	1.93a
K_2SO_4 (0.2%)	2.29a	2.68a	81.5a	74.1a	74.5a	9.64a	50.4a	1.95a
SA (100 ppm)	2.13a	2.50bc	78.1ab	70.7ab	71.2ab	9.11bc	47.8ab	1.91ab
Urea (2%)	1.91ab	2.29d	76.5b	69.1bc	66.1c	7.80e	40.8c	1.63d
NPK (0.5%)	2.07a	2.45c	77.2ab	69.7bc	70.3bc	8.82cd	45.5bc	1.80bc
AA(20mM)	2.28a	2.65ab	79.3a	71.8ab	75.4a	9.71a	51.1a	2.03a
$MgSO_4$ (0.5%)	2.33a	2.72a	75.7bc	68.3c	69.6bc	8.60d	44.2bc	1.76cd

RWC: Relative water content; MSI: Membrane stability index; DAS; days after sowing

Conclusion

The Results suggested that exogenous application of growth regulators led to a significantly higher number of pods per plant, seed yield and biomass as compared to water spray treatment. Improvement in seed yield and above ground biomass with acetic acid, potassium sulphate and thiourea could be attributed to significant improvement in yield attributes due to greater photosynthetic efficiency, antioxidant defense mechanism and partitioning of photosynthates.

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Evaluation of Native bio-agents integrated with organic amendments for the management of chickpea wilt in sick pots

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Chickpea is scientifically known as *Cicer arietinum* L. and commonly referred to as Bengal gram, holds a significant position among pulse crops, especially in regions with limited rainfall during the Rabi season in India. Some of the serious disease of chickpea in order of their importance are wilt (*Fusarium oxysporum* f. sp. *295icero*) wet root rot (*Rhizoctonia solani*), dry root rot (*Rhizoctonia, bataticola*) Ascochyta blight (*Ascocthya rabiei*), collar rot (*Sclerotium rolfsii*) and Chickpea rust. Among the several constraints affecting the productivity of chickpea, *Fusarium oxysporum* f. sp. *295icero* can impact the crop at any stage of its growth, with early wilting causing losses ranging from 77 to 94 per cent, while late wilting leads to losses of 24 to 65 per cent (Haware and Nene, 1980).

Biocontrol represents a compelling alternative to chemical methods offering both effectiveness and economic advantages for managing soil-borne pathogens. Various fungal bio-agents, including *Trichoderma* spp., *Aspergillus* spp., *Penicillium* spp., and others, have shown promise in combating different soil-borne pathogens. In case of bacterial antagonists, certain isolates of *Pseudomonas fluorescens* have ability to suppress wilt incidence while promoting the growth and yield of chickpea (Liu *et al*., 2007). P*seudomonas* and *Bacillus* strains exhibit substantial potential in controlling chickpea wilt caused by *Fusarium oxysporum* f. sp. *295icero* (Anjajah *et al*., 2003). In this view the present study was under taken to manage the chickpea wilt disease by native rhizosphere bio agents viz., *Trichoderma asperellum* (Tr-4) strain and *Bacillus subtilis* (Ba-9) strain integrated with organic amendments in sick pots.

Methodology

A sick pot experiment was conducted to evaluate the effect of seed treatment of effective native bio-agents from *in vitro* study along with organic amendments for the management of chickpea wilt in sick pots during *Rabi* 2022-23. The experiment was conducted at RARS, Vijayapur with 16 treatments and replicated thrice and the Genotype used for evaluation was BGD 111-1. The observation on wilt incidence was recorded by using the formula (Wheeler, 1969),

$$\text{Disease incidence} = \frac{\text{No. of plants showing wilting symptoms}}{\text{Total no. of plants observed}} \times 100$$

Results

The data revealed that, seed treatment with *Trichoderma asperellum* (Tr-4)10 g/kg seed+ soil application of farm yard manure 6 g/kg soil recorded minimum disease incidence of 6.83 per cent and showed 86.61 per cent disease control, which was at par with second best treatment, seed treatment with *Bacillus subtilis* (Ba-9) 10 g/kg seed + soil application of farm yard manure 6 g/kg soil with 7.14 per cent disease incidence and showed 86.00 per cent disease control, which were significantly superior over rest of the treatment. Next best treatments are seed treatment with *Trichoderma asperellum* (Tr-4)10 g/kg + soil application of vermi compost 6 g/kg with 9.89 per cent wilt incidence and seed treatment with *Trichoderma asperellum* (Tr-4)10 g/kg +soil application of goat manure 6 g/kg with 12.63 per cent incidence.Maximum disease incidence was recorded in untreated control with 51.01 per cent disease incidence. Smitha *et al*. (2017) reported that, *Bacillus subtilis* was effective in managing dry root rot and vascular wilt of chickpea (Table).

Evaluation of bio-agents integrated with organic amendments for the management of chickpea wilt in sick pots

Treatment	Treatment details	Disease incidence (%)	Per cent disease control
T1	*Trichoderma asperellum* (Tr-4) (10 g/kg seed)	17.58 (24.79)*	65.53
T2	*Bacillus subtilis* (Ba-9) (10 g/kg seed)	21.82 (27.84)	57.23
T3	Farm yard manure (FYM) (6 g/kg soil)	26.59 (31.03)	47.88
T4	Neem cake (5 g/kg soil)	39.94 (39.19)	21.70
T5	Vermi compost (6 g/kg soil)	28.79 (32.40)	43.57
T6	Goat manure (6 g/kg soil)	27.78 (31.80)	45.55
T7	*Trichoderma asperellum* (Tr-4) + FYM (10 g/kg seed + 6 g/kg soil)	6.83 (15.15)	86.61
T8	*Trichoderma asperellum* (Tr-4) + neem cake (10 g/kg seed + 6 g/kg soil)	13.06 (21.18)	74.39
T9	*Trichoderma asperellum* (Tr-4)+ vermi compost(10 g/kg seed + 6 g/kg soil)	9.89 (18.31)	80.62
T10	*Trichoderma asperellum* (Tr-4) + goat manure (10 g/kg seed + 6 g/kg soil)	12.63 (20.80)	75.23
T11	*Bacillus subtilis* (Ba-9) +FYM (10 g/kg seed + 6 g/kg soil)	7.14 (15.50)	86.00
T12	*Bacillus subtilis* (Ba-9) + neem cake (10 g/kg seed + 6 g/kg soil)	21.79 (27.82)	57.28
T13	*Bacillus subtilis* (Ba-9) + vermi compost (10 g/kg seed + 6 g/kg soil)	20.84 (27.15)	59.15
T14	*Bacillus subtilis* (Ba-9) + goat manure (10 g/kg seed + 6 g/kg soil)	13.12 (21.23)	74.28
T15	*Trichoderma harzianum* (10 g/kg seed)	15.02 (22.80)	70.56
T16	Control	51.01 (45.58)	
	S.Em±	0.58	
	C.D. (1%)	2.25	

*Figures in parenthesis indicate angular transformed values

Conclusions

In the management of chickpea wilt, seed treatment with *Trichoderma asperellum* (Tr-4)10 g/kg+ soil application of farm yard manure 6 g/kg had minimum wilt incidence of 6.83 per cent with 86.61 per cent disease reduction compared to control.

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Nutritional Profiling of Horse Gram Germplasm

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Horse gram [*Macrotyloma uniflorum* (L.) Verdc] is an important drought hardy, climate-resilient dual-purpose rainfed crop adaptable to poor soils with minimal or no input and aftercare. Being a leguminous crop, it is used as a green manure and cover crop and used as a contingent crop in case of delayed monsoon. Horse gram is the cheapest source of protein, vitamins, minerals and dietary fiber for the rural and tribal population. It is a nutritious forage for cattle and horses, especially in drylands where fodder shortage is a serious problem during the lean months. Horse gram is also well known for its excellent medicinal and therapeutic properties. Identification of diverse genotype with significant yield and nutritional traits is needed to evolve high yielding nutritionally rich varieties.

Methodology

The experimental material consisted of 78 horse gram genotypes obtained from ICAR-NBPGR and four released ICAR-CRIDA varieties as Check. The experiment was laid out in Augmented Block Design in three blocks. Each block consisted of 26 germplasm lines and four checks with a row spacing of 45 cm and plant to plant spacing of 10cm. Apart from recording the observations on yield and its attributes, dried seed samples of each genotype was ground to fine powder and used for the estimation of nutritional and antinutritional traits viz., protein content (%), carbohydrate (%), crude fibre (%), iron and calcium (mg/100g), trypsin inhibitor activity (units/mg) and phytic acid (mg/g). Statistical analysis was done using ANOVA of augmented block design following the method of Federer, 1956.

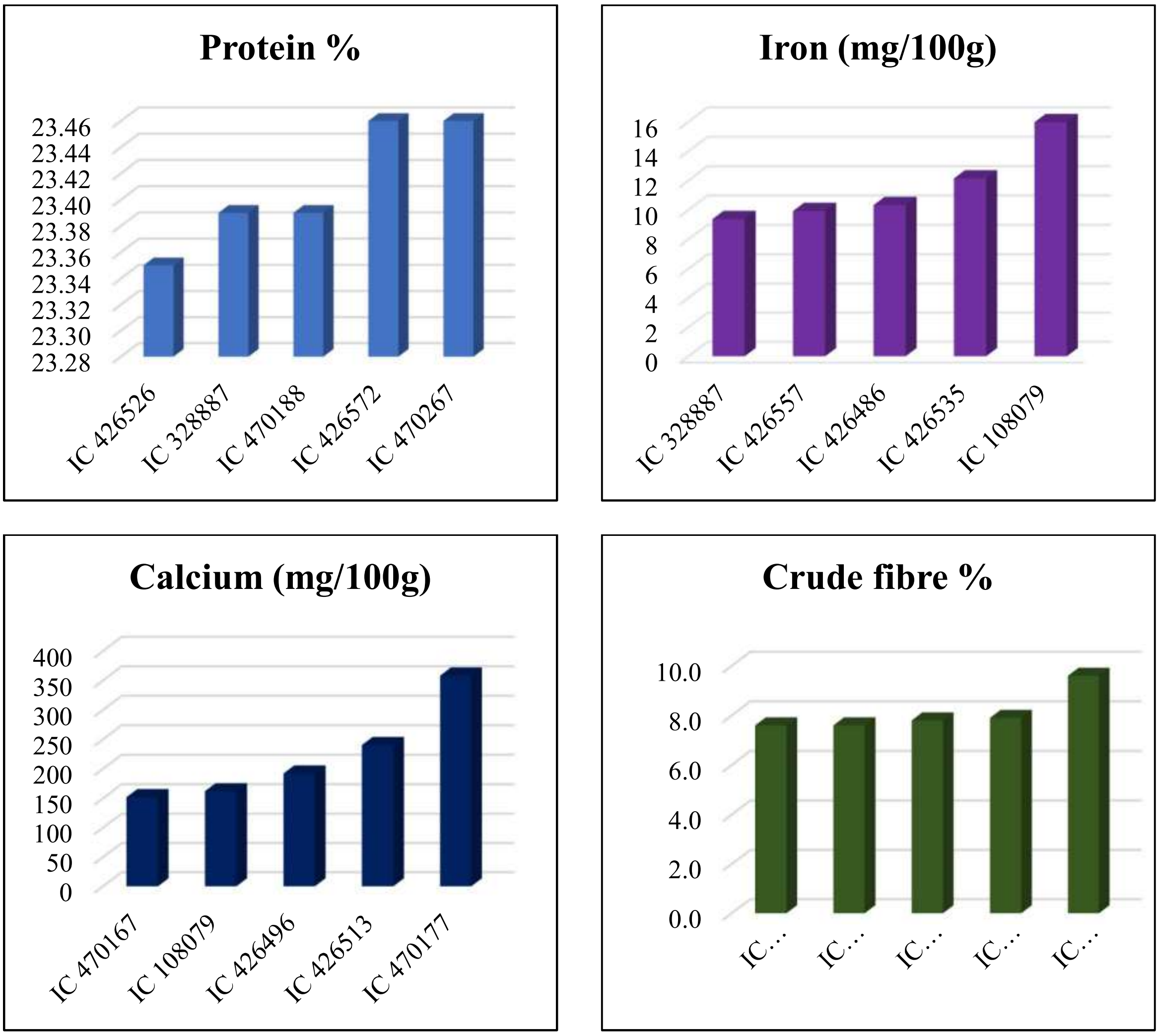
Results

Analysis of variance revealed significant variability among the genotypes for all the traits studied, indicating high variability among the horse gram genotypes. Selection can be used for the improvement of these characters among these genotypes.

Protein content ranged from 15.87 to 23.46 with a mean 22.06%. Eight genotypes were found to have significantly higher protein content than best performing check. Carbohydrate ranged from 35.48 to 60.15 with a mean of 51.41%. five genotypes were found to have significantly higher carbohydrate than the best check. Crude fibre ranged from 4.9 to 9.6 with a mean of 6.24%. Nine genotypes were performing better than the checks. The Results conform with Herath *et al* (2020). Iron content ranged from 3.02 to 15.98 with a mean of 5.36 mg/g. Thirty-four genotypes were found to have significantly higher iron content than the checks. Similar Results were reported by Aiswarya and Kasturba 2019. Calcium content among the genotypes ranged from 54.34 to 358.22 with a mean of 107.65 mg/100g. fifteen genotypes were found to have significantly higher calcium content than the checks. Trypsin inhibitor activity ranged from 10.18 to 17.82 with a mean of 13.11 units/mg. One genotype was at par with checks for this character. Phytic acid ranged from 5.03 to 5.76 with a mean 5.33 mg/g. two genotypes were at par as compared to checks.

Conclusion

The Results from the nutritional profiling of horse gram genotypes suggest wide variability in the nutrient and anti-nutrient composition in the germplasm studied. Genotypes IC 426572 and IC 470267 showed high levels of protein. Genotype IC 343872 recorded the highest carbohydrate content. Genotype IC 470190 recorded the highest crude fibre per cent and the genotypes IC 108079 and IC 470177 recorded the highest iron and calcium levels respectively. The genotypes IC 467863 and IC470267 recorded the lowest levels of anti- nutritional factors like trypsin and phytic acid respectively. The Genotype IC 470267 showed high protein content (23.46%) with low phytic acid (5.03mg/g). This information will further aid in selecting nutritionally efficient cultivars and it can be used as nutraceutical food to prevent various health ailments.



Five best performing genotypes of horse gram for nutritional traits

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Thermal Requirement and Radiation Use Efficiency of Chickpea Cultivars Under Different Sowing Environments

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Temperature among many weather parameters, is considered to be the prime determinant factor for growth and development of chickpea, being the long day plant. In India, chickpea is usually grown in post rainy season on residual moisture from preceding monsoon rain. Chickpea can perform well under various climatic and soil conditions. Temperature variations in the field can be treated by sowing crops in different environments in the season. Temperature is a major environmental factor that determines the rate of plant growth and development. Growing degree days (GDD) and helio-thermal units (HTU) are a measure of heat accumulation and used by agricultural scientists to predict crop development rates. Though accumulation of growing degree days and heliothermal units (HTU) for each developmental stage is relatively constant and independent of sowing date, crop variety may modify it considerably. Sowing date is among the predictable and major non monetary agronomic factor influencing the dry matter and radiation use efficiency in chickpea. Determination of sowing time depends upon the thermal time and thermal use efficiency of the crop (Agrawal and Upadhyay, 2009). Hence, the present investigation was undertaken to study the thermal requirement and radiation use efficiency and response of chickpea cultivars under different sowing environment under scarcity zone of Maharashtra.

Methodology

The field experiment was conducted in post rainy season for seventeen consecutive years during 2002-03 to 2018-19 at dry farming research station, Solapur. The centre is geographically situated at 17º 41′ North latitude and 75º 56′ East longitude. The rainfall of this region is characterized by inadequate, ill distributed and erratic nature. The annual normal rainfall is 723.4 mm in 40 to 45 rainy days while, the *rabi* normal is 237.8 mm. Normal Tmax and Tmin were in the range 29.8 to 34.5 and 13.3 to 21.8ºC, respectively and bright sunshine hours and photoperiod were in the range of 0.8-10.1 and 11.3- 12.2 hours, respectively during the crop growth period. The experiment comprised of four sowing environments as main plot treatments viz. MW 38 (Sept 17-23), MW 40 (Oct. 01-07), MW 42 (Oct. 15-21) and MW 44 (Oct. 29- Nov.04) respectively and two varieties *viz.* Vijay and Digvijay as sub plot. The experiment was laid out in split plot design and replicated four times. The observations were recorded at the end of each physiological growth stage. Meteorological data was obtained from the observatory of DFRS, Solapur for phasic calculation of GDD and HTU. The base temperature used for growing degree days (GDD) computations was 10°C. Thermal response calculated according to the equation given by Nuttonson (1955). Radiation use efficiency (RUE), which is a measure of amount of dry matter production per unit of thermal unit, was worked as per the procedures.

Results

Duration of phenological stages and growing degree days

Number of days and GDD required to attain phenological stages of varieties grown under four different environments are presented in Table 1. The data showed that, number of days and accumulated heat units significantly decreased with delay in sowing during all the years of experimentation. The number of days required to attain grain maturity stage and total heat units were higher in S_1 (17^{th}-23^{rd} September) sown crop (Table 1).

Table 1. Number of days and GDD required to attain phenological stages in chickpea as influenced by different treatments (2002-03 to 2018-19)

Treatments (SD x Var)	Phenological stage				
	Emer.	Branching	50 % Flow.	Pod form.	Pod mat.
S_1V_1	149 (8)	413 (23)	270 (11)	164 (22)	301 (22)
Cumulative	149 (8)	562 (31)	832 (42)	996 (64)	1297 (86)
S_1V_2	164 (9)	444 (28)	293 (11)	154 (22)	315 (23)
Cumulative	164 (9)	608 (37)	901 (48)	1057 (70)	1371 (93)
S_2V_1	148 (8)	415 (22)	246 (10)	163 (22)	310 (20)
Cumulative	148 (8)	563 (29)	809 (39)	972 (62)	1282 (82)
S_2V_2	168 (9)	444 (26)	278 (11)	155 (20)	304 (24)
Cumulative	168 (9)	612 (35)	890 (46)	1045 (66)	1349 (90)
S_3V_1	135 (7)	362 (22)	228 (09)	137 (20)	261 (20)
Cumulative	135 (7)	497 (29)	725 (37)	863 (58)	1123 (78)
S_3V_2	149 (8)	361 (26)	245 (10)	136 (18)	293 (22)
Cumulative	149 (8)	510 (34)	756 (43)	892 (62)	1185 (84)
S_4V_1	126 (7)	350 (20)	239 (09)	132 (19)	250 (20)
Cumulative	126 (7)	476 (27)	715 (36)	847 (55)	1097 (75)
S_4V_2	139 (8)	370 (22)	259 (09)	145 (18)	262 (20)
Cumulative	139 (8)	509 (30)	768 (39)	913 (57)	1175 (77)

(Figure in parenthesis indicates number of days required to attain phenological stage)

Among the varieties, GDD requirement is higher in Digvijay than Vijay. This is due to longer duration required for S_1 sown crop and Digvijay variety. Further, it was also noticed that the early sown crop received maximum amount of rainfall for which the soil moisture availability was more. However late sown crop suffered from moisture stress resulting early maturity. Among the growing environments, higher number of days were taken for 50 per cent flowering and for days to maturity under September II fortnight and October II fortnight growing environments. Higher number of days to grain filling was recorded under September II fortnight growing environment. The relation between GDD and grain yield showed that there is concurrent increase in seed yield (1150 -1350 kg ha^{-1}) with increase in thermal requirements within range 1097-1371°Days (Fig 1).

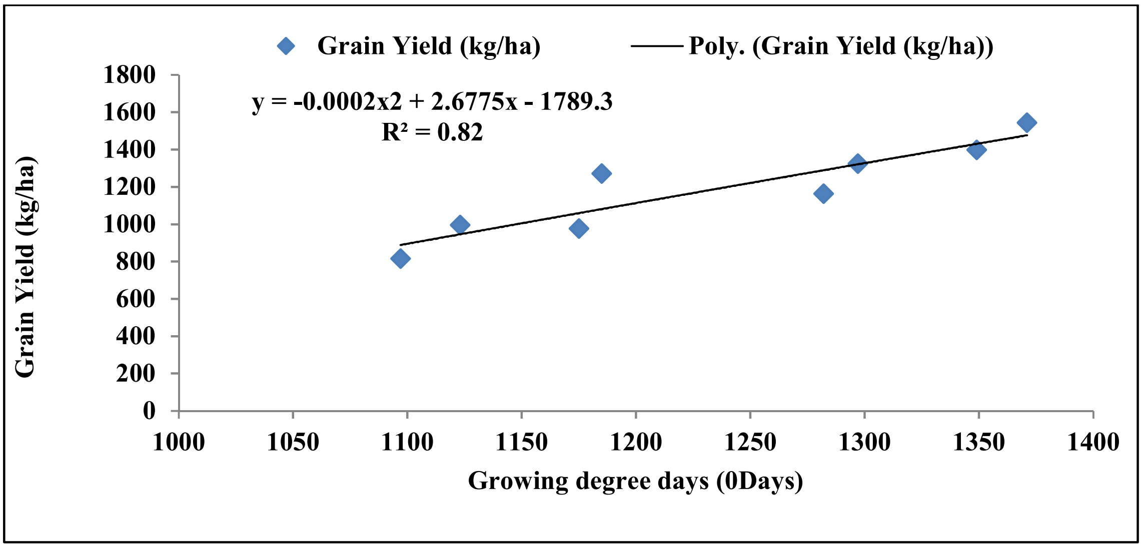

Fig 1. Relationship between seed yield and GDD in chickpea

Heliothermal Units (HTU)

The index HTU serves to express the effect of varying ambient temperature and bright sunshine hours on the duration of phenological events. The data regarding mean HTU for various phenophases are presented in Table 2. The mean HTU were higher in S_1 sown crop. Among the varieties, it is higher in Digvijay than Vijay. This was due to more duration required by S_1 sown crop and Digvijay variety.

Table 2. Mean cumulative heliothermal units required to attain phenological stages as influenced by sowing dates in chickpea (2002-03-2018-19)

Sowing time	Phenological stage				
	Emer.	Branching	50 % Flow.	Pod form.	Pod mat.
S_1V_1	969	3139	2079	1328	2589
Cumulative	969	4108	6187	7515	10104
S_1V_2	1066	3508	2285	1247	2741
Cumulative	1066	4574	6859	8106	10847
S_2V_1	962	3113	1943	1353	2697
Cumulative	962	4075	6018	7371	10068
S_2V_2	1126	3463	2224	1333	2645
Cumulative	1126	4589	6813	8146	10791
S_3V_1	1053	2860	1847	1192	2271
Cumulative	1053	3913	5760	6952	9222
S_3V_2	1162	2888	2009	1197	2549
Cumulative	1162	4050	6059	7256	9805
S_4V_1	995	2870	2079	1148	2200
Cumulative	995	3865	5945	7093	9293
S_4V_2	1098	3034	2279	1262	2358
Cumulative	1098	4132	6411	7673	10031

Radiation interception and Radiation Use Efficiency (RUE)

The data in Table 3 showed that, initially the RUE values were low and it increases up to 70 DAS *i.e.* up to 50 percent flowering to soft dough stage and in later stages it decreases in all most all the sowing dates and varieties. The values were low initially due to less LAI and reached highest due to full canopy cover and decreased due to leaf senescence of the crop. Among the varieties it was higher in Digvijay while in case of growing environments, RUE was found higher in 17-23 September (S_1) as compared to other growing environments. This indicates that the chickpea crop sown under earlier sowing time got exposed to the optimal thermal regime thereby in former sowing all the varieties were highly efficient in heat use (Mhaske *et al.,* 2019).

Table 3. Periodical radiation use efficiency (RUE g MJ^{-1}) as influenced by sowing dates and different varieties in chickpea (average over 2002-03 - 2018-19)

	DAS	S_1		S_2		S_3		S_4	
		Vijay	Digvijay	Vijay	Digvijay	Vijay	Digvijay	Vijay	Digvijay
38	SOW	SOW	SOW	-	-	-	-	-	-
40	14	0.34	0.40	-	-	-	-	-	-
42	28	1.36	1.40	0.26	0.29	-	-	-	-
44	42	2.40	2.54	1.25	1.27	0.28	0.27	-	-
46	56	2.31	2.39	2.19	2.23	1.25	1.23	1.13	1.12
48	70	2.08	2.16	2.10	2.12	2.22	2.25	2.11	2.09
50	84	1.79	1.87	1.81	1.84	2.12	2.12	1.95	1.93
52	98	-	1.74	1.60	1.61	1.83	1.83	1.75	1.71
2	112	-	-	-	1.45	-	1.62	1.49	1.38
3	119	-	-	-	-	-	-	-	1.27

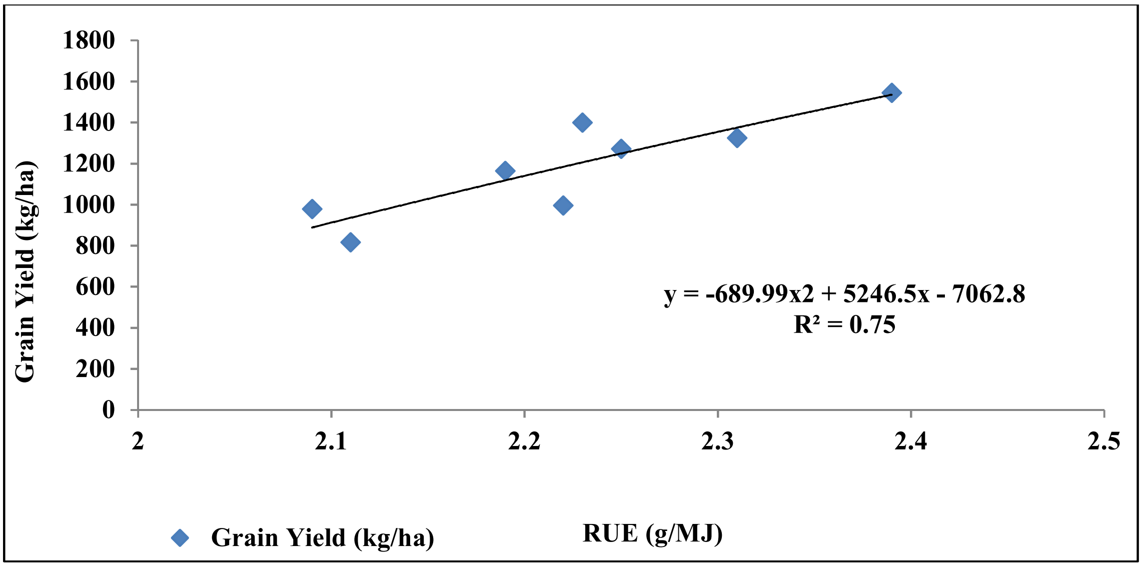

Fig 2. Relationship between seed yield and radiation in chickpea

Relationship between RUE and yield

The yield of two chickpea varieties under all the four sowing dates showed linear relationship with corresponding RUE values (Fig 2). The results showed that varieties grown under growing environments with higher RUE produced higher yield.

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UID: 1123

Evaluation of Climate Resilient Wheat Varieties for Mitigating Abiotic Stress

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Wheat is the most widely consumed crop globally, serving as a staple food for approximately 35% of the world's population. It plays a vital role in combating hunger and malnutrition worldwide. However, wheat production is significantly affected by abiotic stresses, including terminal heat stress, drought and soil salinity. Wheat is particularly vulnerable to terminal heat stress during its reproductive and ripening stages, as it requires specific temperature ranges for optimal growth, anthesis, and ripening—16–22°C, 12–22°C, and 21–25°C, respectively (Djanaguiraman *et al.,* 2020). When field exceed optimum temperatures 24°C during the peak reproductive stage, it causes heat stress, leading to yield reductions of up to 8–46% (Pan *et al.,* 2018). Extended heat exposure in rainfed regions can also exacerbate drought stress. Additionally, nearly 44% of the wheat-growing area in countries is rainfed, due to insufficient rainfall. So, slight moisture deficit and drought at critical stages of wheat can result in massive loss in its production. Yield loss of up to 60 % has been reported due to the influence of drought (Wan *et al.,* 2022). Salt stress induces similar effects on wheat when compared to drought because salinity hinders seed germination, leaf growth and tillering in stressed plants which Results in low grain yield (Grieve *et al*., 1993). Therefore, to mitigate the negative impacts of these abiotic stresses on wheat production, it is essential to adopt climate-resilient strategies, such as early planting and the use of climate resilient wheat varieties, which helps to maintain high yields and ensure global food security. These demonstrations aim to showcase and evaluate the performance of climate-resilient wheat varieties under abiotic stress conditions.

Methodology

Krishi Vigyan Kendra, Hisar has conducted demonstration on the various climate resilient varieties of wheat for evaluating their performance under various abiotic stresses such as drought, soil salinity, terminal heat stress in *Rabi* 2022-23. Total 70 field demonstrations were conducted to mitigate the negative effects of various abiotic stresses. These included the salinity tolerant wheat variety KRL 210 (20 demonstrations), the terminal heat stress-tolerant wheat variety WH 1124 (25 demonstrations), and the drought-tolerant wheat variety WH 1142 (25 demonstrations) by covering areas of 8 ha, 10 ha, and 10 ha, respectively. In the entire demonstrations soil samples were collected and analyzed before sowing. The sowing of wheat variety KRL 210 and WH 1142 was done during 2^{nd} fortnight of November and sowing of WH 1124 was done during 1^{st} week of December with full package and practice. The regular temperature and rainfall data were collected throughout cropping season to assess the performance of variety. At maturity, yield attributes were taken by selecting five random plants in each demonstrated field and at harvesting grain yield was taken. The average yield of all the different wheat variety demonstrations was compared with the yield of the farmer adopted variety (local check). The prevailing market price of inputs was considered for working out the cost of cultivation. BC ratio was worked out as a ratio of gross returns (Rs/ha) to cost of cultivation (Rs/ha). s

Results

Salinity tolerant variety of wheat (KRL 210): This wheat variety developed to withstand higher levels of salinity in the soil, which typically affects crop growth and yield. The result of demonstrations shows an increase of average yield of KRL 210 by 7.3 % over local check with a higher average net return of Rs. 89725/- and BC ratio compared to local check.

Drought stress-tolerant variety of wheat (WH 1142): This wheat variety is specifically bred to perform better under conditions of water scarcity or drought. The Results show that the 5.5 % increase in average yield with more net return of Rs. 87745/- and higher BC ratio of over local check.

Heat stress tolerant variety of wheat (WH 1124): This variety is designed particularly for areas where temperatures exceed optimal growing conditions for wheat. The resulted of trials shows that the 7.2 % increase in average yield with higher net returns and B: C ratio over local check.

Table: Performance of climate-resilient wheat varieties under various abiotic stresses

Technology Demonstrated	Demo yield (q/ha)	Check yield (q/ha)	Percentage Increase in yield	Net Returns (Rs./ha)	BC Ratio
Salinity tolerant variety of wheat (KRL 210)	55.2	51.4	7.3	89725	2.8
Drought stress tolerance variety of Wheat (WH 1142)	53.4	50.6	5.5	87745	2.8
Heat stress tolerance variety of Wheat (WH 1124)	50.2	46.8	7.2	79640	2.6

Conclusion

In areas with saline soils, KRL 210 performs better than conventional wheat varieties. The regions having unpredictable rainfall or limited access to irrigation wheat variety WH 1142 are useful for farmers. The WH 1124 heat-tolerant wheat variety is an excellent option for farmers in areas experiencing terminal heat stress.

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UID: 1124

Effect of autochthonous bacterial bio-inoculant on *Andrographis paniculata* [(Burm. F.) Wall ex., Nees] growth and yield under drought stress

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Budelkhand region, representing arid and semi-arid conditions of UP and MP, is considered a drought prone area and agriculture production is decreasing day-by-day in some parts of it. To increase the production or yield in such drought prone areas is a formidable task for the researchers. The present study aims to address such challenges by using the native bio-inoculants having plant growth promoting (PGP) traits in Andrographis paniculata under drought stress. Drought tolerant bio-inoculants from different drought affected areas of Bundelkhand were screened by amending media with 10-15% polyethylene glycol (PEG). Bacterial isolates were further tested for their PGP traits such as phosphate, potassium and zinc solubilization, siderophore and auxin production and nitrogen fixation ability. The three bio-inoculants having high drought tolerant (15% PEG), high exopolysaccharides (EPSs) producing and possessing one or more PGP trait were used for the validation under control conditions. The pot experiment was conducted in completely randomized design under control condition. The bio-inoculants viz. ADB-1, ADB-2 and ADB-3 were inoculated alone and their consortium with Andrographis paniculata seedlings (30 days old). After 20 days of plant growth, three water stresses were imposed: (i) Control (recommended irrigation for crop), (ii) Moderate drought {60% water holding capacity (WHC)} and (iii) extreme drought (40% WHC) and maintained till the experiment was over. The observations like plant height, branches, plant spread, chlorophyll content, carotenoids, proline and super oxide dismutase enzyme content, andrographolide content, soil dehydrogenase enzyme activity and bio-inoculants colonization were recorded. Plants inoculated with consortium of bio-inoculants showed high drought tolerance under moderate drought (60% WHC) followed by severe drought (40% WHC) and were capable of ameliorateing drought stress.

UID: 1131

Influence of sowing environments on moisture use of kharif pearl millet in scarcity zone of Western Maharashtra

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Pearl millet (*Pennisetum glaucum*) ranks as the fourth most widely cultivated food crop in India, covering an area of 6.93 mha with the production of 8.61 MT and an average productivity of 1,243 kg/ha. In Maharashtra, pearl millet is grown on 0.70 mha with an average production of 0.63 million tons (Anonymous 2020). However, challenges posed by water scarcity highlight the critical need for precise estimations of consumptive use and water use efficiency in pearl millet cultivation. Understanding water consumption dynamics and efficiency is essential for promoting sustainable agricultural practices. This research seeks to explore the complexities of consumptive use and water use efficiency, focusing on regions where pearl millet is cultivated under water-scarce conditions. The study aims to provide valuable insights to support resource-efficient strategies for pearl millet cultivation in water-scarce regions.

Methodology

A field experiment was conducted during two *consecutive rainy seasons* of 2021 and 2022 at the ZARS, Solapur, Maharashtra, positioned at a latitude of 17°41' N and a longitude of 75°56' E. An experiment was planned with the objective to determine the influence of sowing windows on consumptive use and moisture use efficiency of *kharif* pearl millet grown in scarcity zone of Maharashtra. The experiment was composed of three sowing windows: S_1 (26th June – 1st July), S_2 (23rd July - 29th July) and S_3 (27th August – 2nd September) as main plots, and three pearl millet cultivars ICTP-8203, Mahyco hybrid and Adishakti as sub-plots and laid out in split plot design with three replications. The CUM was calculated by using equation,

$$CU\ (mm) = \sum_{i=1}^{n} (Eo \times 0.8) + \frac{M_1 i - M_2 i}{100} (ASi \times Di)\ GWC + ER$$

The calculation of Moisture use efficiency is determined utilizing the subsequent formula:

$$MUE = \frac{Y}{CU}$$

Where,

MUE = Moisture use efficiency (kg of grains ha^{-1} mm^{-1})

Y = Grain yield (kg ha^{-1})

CU = Total seasonal consumptive-use of water (mm)

Results

Consumptive use (CU)

The mean consumptive use of moisture was found to be 338.4 mm. In the case of the Adishakti variety, the highest levels of consumptive moisture use were observed when the crop was sown within the 26 MW sowing window (S_1), resulting in a recorded consumption of 410 mm. Similarly, for the 30 MW sowing window (S_2), which occurred later, the moisture consumption remained relatively high at 380 mm. Conversely, for the ICTP-8203 variety, the lowest levels of consumptive moisture use were noted when the crop was sown within the 30 MW sowing window, leading to a consumption of 276 mm. Another low consumption value was observed for the 35 MW sowing window, amounting to 291 mm. These findings were in close confirmation with Shinde (2011).

When pooling the Results, the 26 MW sowing window (S_1) in conjunction with the Adishakti variety demonstrated the highest consumptive moisture use, reached 372.5 mm and lowest consumptive moisture use, reached in 35 MW sowing window (S_3) 314 mm in ICTP-8203. The highest consumptive use of moisture in sowing window (S_1) and variety Adishakti could be attributed to the synchronized interaction between favourable rainfall patterns, optimal soil moisture content, lower temperature, plant development stages, and plant characteristics.

Moisture use efficiency (MUE)

Among the various sowing windows, the 26 MW sown pearl millet exhibited the higher values of MUE for the Adishakti variety. Similarly, the 30 MW sowing window (S_2) showed a relatively high MUE of 3.9 Kg ha^{-1} mm for the same variety. In contrast, for the ICTP-8203 variety, the 30 MW sowing window (S_2) had the lowest MUE at 2.87 kg ha^{-1} mm, followed by the 35 MW window (S_3) with a value of 3.06 Kg ha^{-1} mm in both years. When the data from both years were combined, the Adishakti variety sown in the 26 MW window (S_1) demonstrated the highest overall MUE of 4.07 Kg ha^{-1} mm.

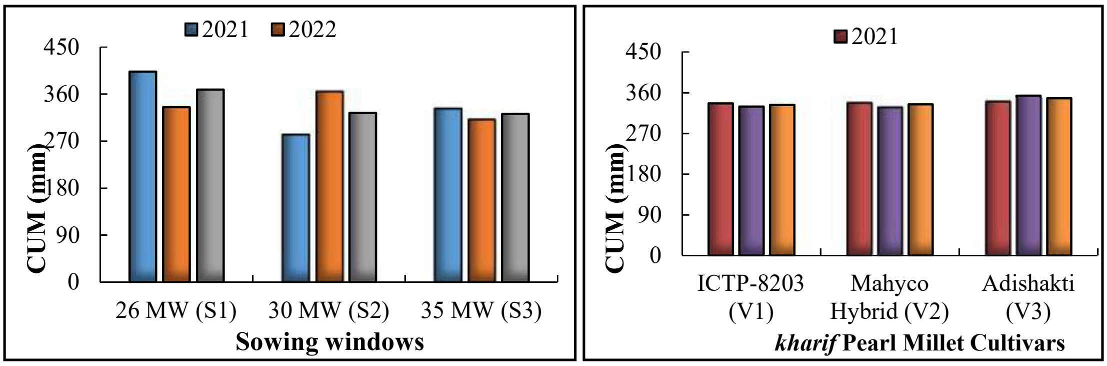
Table 1. Mean Consumptive use as influenced by sowing windows and varieties in Kharif pearl millet in 2021 and 2022

Treatments		2021		2022		Pooled
Sowing window	Varieties	CUM (mm)	Grain yield (kg ha^{-1})	CUM (mm)	Grain yield (kg ha^{-1})	CUM (mm)
	V1: ICTP-8203	396	1490	337	1037	367
	V2: M. Hybrid	403	1518	333	1099	368
S1: 26 MW	V3: Adishakti	410	1703	335	1288	373
	V1: ICTP-8203	276	831	360	1342	318
	V2: M. Hybrid	283	879	355	1353	319
S1: 30MW	V3: Adishakti	289	948	380	1483	335
	V1: ICTP-8203	337	1085	291	893	314
	V2: M. Hybrid	333	1126	300	941	317
S1: 35MW	V3: Adishakti	328	1346	345	1167	337
General Mean		339	1214	337	1178	338

The increased grain yield during the former sowing window was attributed to the advantageous interplay between synchronized factors, including beneficial patterns of rainfall, optimal soil moisture levels, favourable microclimate, low temperature, developmental stages of the plants, and inherent plant characteristics.

Table 2. Mean moisture use efficiency as influenced by sowing windows and varieties in *Kharif* pearl millet in 2021 and 2022

Treatments		2021		2022		Pooled
Sowing window	**Varieties**	**MUE (Kg ha-1 mm)**	**Grain yield**	**MUE (Kg ha-1 mm)**	**Grain yield**	**MUE (Kg ha-1 mm)**
	V1: ICTP-8203	3.63	1490	3.08	1037	3.35
	V2: M. Hybrid	3.77	1518	3.30	1099	3.53
S1: 26 MW	V3: Adishakti	4.31	1703	3.84	1288	4.07
	V1: ICTP-8203	2.87	831	3.73	1342	3.30
	V2: M. Hybrid	3.11	879	3.81	1353	3.46
S1: 30MW	V3: Adishakti	3.51	948	3.90	1483	3.70
	V1: ICTP-8203	3.22	1085	3.06	893	3.14
	V2: M. Hybrid	3.38	1126	3.14	941	3.26
S1: 35MW	V3: Adishakti	4.10	1346	3.38	1167	3.74
General Mean		3.54	1214	3.47	1178	3.51



Mean Consumptive use as influenced by sowing windows and varieties in *kharif* pearl millet in 2021 and 2022

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UID: 1135

Effect of Weather Parameters on Soybean yield (*Glycine max*)

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An experiment was conducted during *kharif* season of 2016-23 at Main Agricultural Research Station, UAS, Dharwad under AICRP on Agrometeorology scheme to study the effect of weather parameters on the yield of soybean and develop yield prediction models. Factorial randomised block design was used to conduct the experiment with three soybean varieties and three different growing environments each year for a period of eight years. The correlation between stage wise weather variables and final seed yield were calculated and regression models were developed for individual significant parameters in each stage for yield estimation of soybean crop irrespective of varieties. Correlation analysis between weather parameters during different phenological stages and grain yield indicated that the pod development stage and maturity stages were found very sensitive to weather parameters, as most of the weather parameters shown highly significant correlation with grain yield of soybean. Using these highly significant weather parameters yield prediction models were developed and validated. The models of vegetative stage showed lowest error of less than two percent, followed by those of flowering, pod development and maturity stages with error of less than 12 percent.

Soybean is one of the important oil seed crops and the best source of plant-based protein. The area under the crop is increasing in Karnataka, due to its health benefits. In Karnataka, the crop is grown in an area of 4.69 lakh hectares with the production of 5.58 lakh tonnes with an average productivity of 12 quintals per hectare (2022-23). It is mainly grown in Bidar, Belagavi, Kalaburgi, Dharwad and Haveri districts. Well drained and sandy-loam *soils* rich in organic matter with a pH between 6.0 and 7.5 are most suitable for the cultivation of soybean. The changing climatic patterns have prompted the scientists to keep a check on depleting growth variables of soybean crop so as to sustain and augment its production and yield. Weather plays a vital role in regulation of crop yield (Ankita Negi, 2020). The *crop* can be grown in the areas with a minimum rainfall of 500 mm and maximum of 1250 mm. As each crop has its own climatic requirements for its better growth and giving higher yields, an experiment was conducted using Factorial randomised block design for studying the effect of weather parameters on the grain yield with three different soybean varieties majorly used by the farmers and under three different growing environments each year for a period of eight years. The correlation between stage wise weather variables and final seed yield were calculated and regression models were developed for individual significant parameters in each stage for yield estimation of soybean irrespective of varieties. The stage-wise models were developed and validated using pooled long-term yield and weather data.

Methodology

A field experiment was conducted to find out effect of weather parameters on soybean crop using three cultivars (JS 335, DSb 21 and DSb 23-2) by sowing on three different dates with 15-20 days interval to get different growing environments during *khartf* season of 2016 and 2023 at Main Agricultural Research Station farm, UAS, Dharwad. The experiment was laid using randomised block design and sowing was taken up with an interval of 15-20 days starting from the onset of monsoon, replicated thrice by applying the recommended dose of fertilisers and managing the pest and diseases by following the package of practice during all the years. The prevailing weather data at various phenological stages of growth recorded at Meteorological observatory situated in the University and crop grain yield data were utilized in the present investigation. The phenological stage-wise weather parameters were correlated with the yield of soybean and simple regression equations were developed using highly/significantly correlated weather parameters to understand the extent of influence of weather on soybean crop yield.

Results

Effect of weather parameters on soybean yield

The eight year data was statistically analyzed for establishing relationships between stage wise meteorological variables and soybean yield through correlation procedure using eight years data (2016-2023) shows significant effect of various weather parameters during different phenological stages on soybean yield (Table 1).

Table 1. Correlation coefficients between grain yield and weather parameters during different phenological stages of soybean.

Parameter	Germination	Vegetative	Flowering	Pod Development	Maturity
MAXT	0.34^{**}	0.13	0.06	-0.22	-0.40^{**}
VP1	0.40^{**}	0.27^{*}	0.11	0.39^{**}	0.38^{**}
VP2	0.19	0.14	0.30^{*}	0.52^{**}	0.42^{**}
RH1	-0.08	0.06	0.20	0.49^{**}	0.52^{**}
RH2	-0.27^{*}	-0.02	0.01	0.41^{**}	0.45^{**}
CC I	-0.14	0.29^{*}	0.52^{**}	0.49^{**}	0.22
GDD	0.29^{*}	0.10	0.12	0.08	0.08

From Table 1. it is found that maximum temperature (0.34) and morning vapor pressure (0.40) during germination stage; morning cloud cover (0.52) during flowering stage; both morning (0.39) and afternoon vapor pressure (0.52) as well as both morning (0.49) and afternoon (0.41) relative humidity and morning (0.49) cloud cover during pod development stage; and, during maturing stage, both morning (0.38) and afternoon (0.42) vapour pressure, both morning (0.52) and afternoon (0.45) relative humidity showed highly significant correlation with soybean yield. Only maximum temperature (-0.40) during maturity stage showed highly significant negative correlation with soybean yield.

Yield models for Soybean crop

Keeping in view the correlations between stage wise weather variables and final seed yield of soybean, regression models were developed for individual significant parameters in each stage for yield estimation of soybean irrespective of varieties. The models are presented for individual crop growth stages in Table 2. Models using highly correlated weather parameters are presented in the table. Out of all the models presented in the Table 2., the highest coefficient of determination was noticed in case of morning cloud cover in flowering stage (0.31), morning relative humidity during maturity (0.28) and afternoon vapor pressure during pod development stage.

Table 2. Crop Stage wise and weather parameter wise yield prediction models for soybean cropes

Sl. No.	Crop Stage	Weather Parameter	Equation	Model ID	R^2 Value
1	Germination	GDD	y = 28.63x - 825.2	G-1	0.193
2		VP1	y = 383.6x – 5358	G-2	0.168
3		MaxT	y = 112.7x – 1375	G-3	0.166
4	Vegetative	VP1	y = 111.3x - 337.9	V-1	0.063
5		CC1	y = 231.0x + 48.74	V-2	0.059
6	Flowering	CC1	y = 232.1x + 210.9	F-1	0.306
7		VP2	y = 120.9x - 545.1	F-2	0.076
8	Pod development	VP2	y = 111.9x - 222.4	P-1	0.261
9		CC1	y = 132.3x + 1017.	P-2	0.225
10		RH1	y = 50.62x - 2789	P-3	0.223
11	Maturity	RH1	y = 31.88x - 1033.	M-1	0.281
12		RH2	y = 19.14x + 550.4	M-2	0.211
13		MaxT	y = -191.7x + 7283	M-3	0.196

Validation of regression models developed

The stage wise regression models developed were validated using the yield and weather data of 2023-24. The top three models with highest R square value were considered and percent errors for predicted yield were calculated and presented in the Tables 3. Afternoon vapor pressure and morning cloud cover the two weather parameters as in case of flowering stage along with morning relative humidity predicted the yields with less than 9 percent error (PD-1, PD-2 and PD-3) during pod development stage.

Table 3. Pod development stage yield prediction models for soybean crop

Year	Observed Yield	Predicted Yield			Percent Error		
		PD-1	PD-2	PD-3	PD-1	PD-2	PD-3
2023-24 : D1	1844	1831.7	1934.28	1790.42	-0.65	4.91	-2.89
2023-24 : D2	1558	1778.7	1709.37	1549.13	14.17	9.72	-0.57
2023-24 : D3	1363	1386.7	1528.56	1204.92	1.72	12.12	-11.62
				Average	5.08	8.92	-5.03

By looking in to the yield prediction models, it is clear that during the initial stages of the crop yield prediction was more dependent on vapor pressure and cloud cover. As the crop marches towards maturity the relative humidity parameter played important role in predicting the yield. Thus, the soybean yield prediction models developed for germination stage showed poor percent error compared to other models of later stages. Among the best models of all stages, the models for vegetative stage showed lowest error values in the validation process for the year 2023. This analysis showed the positive and negative influence of weather elements on soybean yield as was depicted by Landau et al. (2000)

Conclusion

The results from the eight-year experiment on soybean for crop weather relation studies indicate that, the Soybean yield forecasting with single variable can be made best in pod development stage, followed by maturity and flowering stages. The validation of models for the current year showed that models of vegetative showed lowest error of less than two percent, followed by those of flowering, pod development maturity stages with error of less than 12 percent. With these important conclusions, we wish to conclude this experiment and bring out a technical report.

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Influence of Crop Establishment Methods and Different Weed Management Practices on Growth, Yield and Quality of Direct Seeded Rice (*Oryza Sativa L.*).

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Rice (*Oryzasativa* L.) is a leading food crop and staple food of half of the world's population. In India about 43.97 m ha of lands are under rice cultivation with production of 104.32 million tonnes and an average productivity of about 23.72 q/ha. In Bihar rice is cultivated in around 3.34 m ha with a production of 7.2 million tones and productivity of 21.58 q/ha.Direct seeded culture has become increasingly important in rice cultivation due to scarcity of farm labour and higher water requirement and higher production cost of transplanted rice. Direct seeded rice needs only 34% of the total labour requirement and saves 27% of the total cost of the transplanted crop. The direct seeded rice culture is subjected to greater weed competition than transplanted rice because both weed and crop seeds emerge at the same time and compete with each other for nutrient and space, resulting in loss in grain yield. It is required to avoid any loss in yield because the dry weight of weeds increases greatly from 30 DAS in dry direct-seeded rice. Direct wet seeding of rice reduces labour requirement, hastens crop maturity, increases water use efficiency (WUE). Sowing of pre-germinated rice seeds under puddled condition either manually or drum seeding method reduces the demand of water for puddling and reduces the emergence of weed flora by placing the seed, stems and stolons of weed into sub-surface. Uncontrolled weeds reduce the yield by 96% in dry direct seeded rice and 61% in wet direct-seeded rice. Dry seeding with subsequent saturated soil conditions reduces the amount of water required during puddling and thus reduces overall water demand. Herbicides are more effective in controlling the weeds with balanced total energy requirement of rice cultivation (Singh *et al.*, 2014). Though, the conventional method of manual weeding is widely practiced, herbicides are more efficient in timely control of weeds in direct seeded rice. Chemical weeding preferably the use of pre-emergence herbicide is vital for effective and cost-efficient weed control in such situation, where weeds compete with the main crop right since the date of germination. Gogoi (1995) also summed up that the loss in grain yield due to weeds may beto the tunes of 20 to 95 per cent. Hence, the present research was planned to study the influence of pre-emergence and new post-emergence herbicides on weed flora, crop yield, nutrient uptake by weeds and crop in direct seeded rice under different establishment methods.

Materials and Methods

A field experiment was conducted during Kharifseason 2012 at Research farm of Rajendra Agricultural University Bihar, Pusa. The aforesaid is situated on the southern bank of the river *Budhi Gandak* in Samastipur district at 25.59^0 North latitude and 84.40^0 East longitude with an altitude of 52.3 m above the mean sea level (MSL). The soil of the experimental plot was clay loam with pH 8.79 and organic carbon 0.40%. The test variety under proposed research was Prabhat. The fertility status of the soil was low in available nitrogen (203.2 kg/ha), phosphorus (17 kg P_2O_5 /ha) and potassium (101.7 kg K_2O/ha). The factors under study comprised three establishment methods i.e. E_1-Wet seeded (broadcasting of sprouted seeds under puddled condition), E_2 - Dry seeded in rows at 20 cm apart, E_3 - Drum seeded puddled condition in main plots and 8 herbicidal treatments on direct seeded rice i.e. W_1- Butachlor @ 1.5 kg /ha (pre-emergence), W_2- Butachlor(pre-emergence) @ 1.5 kg /ha *fb*Bispyribac @ 25 g/ha (Post emergence). W_3- Pretilachlor @ 0.75 kg /ha (pre-emergence), W_4- Pretilachlor @ 0.75 kg /ha (pre-emergence) *fb*Bispyribac @ 25 g/ha (Post emergence), W_5- Pendimethalin @ 1.0 kg/ha (pre-emergence), W_6- Pendimethalin @ 1.0 kg/ha (pre-emergence) *fb*Bispyribac @ 25 g/ha (Post emergence), W_7- Hand weeding at 20 & 40 DAS, W_8- weedy check in sub- plots in strip plot design replicated thrice.The fertilizer dose viz. 100-60-40 kg N - P_2O_5 - K_2O / ha were applied in experimental field. Nitrogen was applied through urea and P_2O_5 as DAP whereas K_2O was applied through MOP (Singh *et al.*, 2014). Nitrogen was applied in three equal splits (sowing time, active tillering stage and panicle initiation stage). Single basal dose of P and K was applied along with N in three equal splits. Herbicides were applied through knap-sac sprayer fitted with flat fan nozzle. The harvest index was calculated by using the formula as described by Singh and Stockopf (1971).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield (grain + straw yield)}} \times 100$$

Results

Effect on weeds

Both weed population and weed bio-mass accumulation per unit area were less in sole pre-emergence application than the control weedy check. The combination of pre and post application of herbicides were more effective in comparison with their sole application. Similarly, two hand weedings was next only to pre-emergence Pendimethalin + Bispyribac. As in case of other characters single pre-emergence application of Pretilachlor was superior to other single applications of Butachlor and Pendimethalin. But, in case of pre-post combinations Pendimethalin + Bispyribac was quite ahead of the two other combinations. Quite in league with the weed population and weed biomass, the weed control efficiency was the best in Pendimethalin + Bispyribac (71.67%), followed by 2 HW (65.83%), Pretilachlor + Bispyribac (65.06%), Butachlor + Bispyribac (57.61), Pretilachlor alone (54.08), Pendimethalin in alone (46.50) and Butachlor alone (42.27%).

The efficacy of herbicides and their combination are interplay of weed flora present under varying moisture regimes and establishment methods Singh and Paikra (2014). The combination capable of covering the maximum diversity of weed flora performed comparatively better. The results as regards weed population and their bio-mass accumulation are in close conformity with the results reported earlier byVerma *et al.* (2015) Singh and Tongpong (2002) and Ravi Shankar *et al.* (2008).

Effect on crop

Number of panicles/m^2 was the maximum under Pendimethalin application followed by post - emergence Byspyribac application which was closely followed by 2 hand weedings. Important point to make a note here lies in the fact that pre-emergence application of Pretilachlor had higher panicles per unit area than pre-emergence application of Pendimethalin. But, when these two treatments were supplemented with Bispyribac as post - emergence application, the Pendimethalin + Bispyribac significantly superior than Pretilachlor + Bispyribac. Pendimethalin + Bispyribac combination also out classed Butachlor + Bispyribac with a big margin. The length of panicle also gave quite a similar result as in case of panicle/m^2. In case of number of grains per panicle, it was not only Pretilachlor but also the pre - emergence application of Butachlor, which had significantly higher number of grains per panicle than pre-emergence application of Pendimethalin. Quite amazingly when all the three pre-emergence applications were supplemented with post-emergence application of Bispyribac the Pendimethalin combination went for ahead of Butachlor and Pretilachlor application. In regard to 1000-grain weight the results although followed the same trend, but this time Butachlor @ 1.5 kg /ha (pre-emergence), Pretilachlor @ 0.75 kg /ha (pre-emergence) and Pendimethalin @ 1.0 kg/ha (pre-emergence)at one hand and Butachlor (pre-emergence) @ 1.5 kg /ha *fb*Bispyribac @ 25 g/ha (Post emergence), Pretilachlor @ 0.75 kg /ha (pre-emergence) *fb*Bispyribac @ 25 g/ha (Post emergence) and Pendimethalin @ 1.0 kg/ha (pre-emergence) *fb*Bispyribac @ 25 g/ha (Post emergence) at the other fared equally good.As witnessed in all growth and yield attributes, the grain and straw yields under pre-emergence Pendimethalin + post - emergence Bispyribac were the maximum again. However, their differences with other weed management treatments narrow as reflected though the fact that Butachlor + Bispyribac as well as Pretilachlor + Bispyribac were statistically alike with Pendimethalin + Bispyribac. However, the straw yield again was exactly on the lines of all other yield attributing characters. The grain and straw yields further consolidated the greater effectiveness of Pendimethalin in combination with Bispyribac. Butachlor and Pretilachlor are the herbicides specific to wet land rice. Whereas, Pendimethalin is more or less an Omni influensive herbicide (Singh *et al.* 2014). However, the combination of Pendimethalin with Bispyribac again a specific rice herbicide may be capable of suppressing wider range of weeds which are always expected there in direct seeded crop sown either in wet or dry condition. This explains the greater efficacy of Pendimethalin + Bispyribac even under the condition that Pretilachlor and Butachlor are more effective to Pendimethalin in their sole applications. Lower harvest index under weedy check condition may be explained on the basis that the menace of weeds go an increasing with increase in age. Hence, the vegetative growth was affected comparatively less than the reproductive growth of rice plants lowering the harvest index.

Nutrients depletion by weeds

Uptake of nitrogen, P_2O_5 and K_2O were the maximum under drum seeding followed by wet seeding, in which sprouted seeds were sown on puddled bed by broadcast methods. The least uptake of N, P_2O_5 and K_2O were recorded in the plots of dry seed beds sown in lines. On the contrary, the N, P_2O_5 and K_2O uptake by weeds was a complete reversal of treatments. The weeds in dry seeded plots took up significantly the maximum; while the treatment drum seeding in Wet beds exhibited the least uptake by weeds. There is not much to explain the behaviour of treatments as crop uptake is directly a function of biological yield. The plots giving higher biological yields exhibited higher nutrient uptake and so on in other cases. Similarly, as the dry seeded plots offered greater opportunity to weeds to come up and grow, their weeds took up a lion's share of nutrients from the plots. On the other hand, puddling is well known to suppress weeds particularly of broad leaved group hence; weeds there did not get congenial conditions for their growth and development. Hence, the nutrient uptake by weeds under wet seed bed was comparatively low. Amongst the two wet seed bed again the nutrient uptake by weeds under broadcast method was higher. The possible reason may be the expected error in uniformity of seed placement in broadcast method. Wherever weed seeds and plants got more space they grew at a faster rate suppressing crop plants.

Table 1. Effect of establishment methods and weed control methods on growth, yield attributes, yield and economics of direct seeded rice

Treatment	Plant height(cm)	No. of panicles/m^2	Length of panicle (cm)	No of grains/ panicle	1000 grain weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
Wet seeded (broadcasting of sprouted seeds under puddled condition)	61.55	211.12	18.05	94.62	19.45	32.70	47.29
Dry seeded in rows at 20 cm apart	58.42	187.75	17.07	80.75	18.90	29.56	44.74
Drum seeded in puddled condition	63.73	231.62	18.66	113.33	20.08	35.58	49.71
SEm±	0.20	0.45	0.06	0.36	0.10	0.91	0.90
LSD (P = 0.05)	0.81	1.80	0.24	1.43	0.40	3.57	3.55
Butachlor 1.5 kg / ha (pre -emergence)	60.50	202.00	17.63	92.66	19.30	31.63	43.93
Butachlor 1.5 kg / ha *fb*Bispyribac 25 g/ha	62.00	218.00	18.30	98.55	19.73	34.36	48.64
Prtilachlor 0.75 kg/ha (pre-emergenc)	61.36	212.33	18.13	97.33	19.46	33.60	47.26
Prtilachlor 0.75 kg/ha *fb*Bispyribac 25 g /ha	62.66	224.66	18.50	104.00	19.83	35.35	51.29
Pendimethalin 1.0 kg / ha (pre -emergence)	59.86	202.00	17.73	87.33	19.16	32.26	46.04
Pendimethalin 1.0 kg / ha *fb*Bispyribac 25 g /ha	63.20	230.00	18.73	110.66	19.93	35.55	52.57
Hand weeding at 20 & 40 DAS	62.96	227.00	18.53	108.66	19.96	35.36	51.62
Weedy check	57.33	165.33	15.86	70.66	18.43	22.80	36.63
SEm±	0.37	1.06	0.14	0.70	0.13	0.94	1.07
LSD (P=0.05)	1.13	3.22	0.42	2.14	0.40	2.87	3.27

Nutrients uptake by crop

Nutrient uptake in terms of N, P_2O_5 and K_2O by crop plant was the maximum under application of Pendimethalin followed by Bispyribac. Two hand weeding was close on the heels of Pendimethalin @ 1.0 kg/ha (pre-emergence) *fb*Bispyribac @ 25 g/ha (Post emergence). Amongst the herbicidal applications double applications (pre and post emergence) were superior to their corresponding single application (pre-emergence). Amongst the three pre-emergence applications, Pretilachlor was ahead of others in uptake of nutrients by crop plant. Reverse was the position in case of nutrient removal by weeds. The treatment making crop plants to take up more nutrients restricted weeds to the minimum removal. The protein content in rice grain reflected crop nutrient uptake.

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UID: 1143

Wheat Establishment Technology for Climate Resilient Agriculture Scenario at West Champaran Bihar: Observations and Highlights

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It is crucial to re-examine agriculture in a way that makes it economically viable, climate-resilient, and resource-efficient due to factors including population growth, climate change, resource scarcity, and the urgent need to meet sustainable development goals. Traditional sowing of wheat involves higher tillage and inefficient resource utilization, high cost of production, and emission of greenhouse gases such as methane. Zero tillage Wheat sowing, promoted for its climate-resilient nature, is often utilized by farmers in three different ways: line sowing after tillage, sowing with minimal tillage, and zero tillage. However, these establishment technologies have certain advantages and limitations, as perceived by farmers. The intention of this investigation is to examine wheat crop performance in detail under the aforementioned crop establishing techniques in NICRA village. The study was carried out in farmers' fields in villages such as Parsa and Bagahi Bagambarpur with equal consideration given to the freedom of the farmers and the research circumstances. The study aimed to analyse crop performance while emphasizing farmers' field-based knowledge to ensure a lab-land-lab loop for understanding the scope of refinement in agronomic as well as extension strategies. The Results of this study revealed that the superiority of yield under wheat sown by zero tillage (4.86 t ha-1) over broadcasting (3.8 t ha-1) and line sowing (4.42 t ha-1) in terms of crop performance and economic performance in the northwest alluvial plain zone of Bihar.

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Performance of Different Inter-Cropping Systems with *In-situ* Rainwater Conservation Practices in Assured Rainfall Zone of Marathwada Region, Maharashtra

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Marathwada region is one of the four regions of Maharashtra state, comprising cultivable area of 5.6 Mha and 85 per cent of cultivated land is rain dependent. Majority of population living in Marathwada region depend upon rainfed agriculture. The region receives annual rainfall in the range of 500 to 1100 mm. Occurrence of frequent dryspells is a common the features in the

region. The prominent cropping systems adopted in the region are, *kharif* sorghum+ pigeonpea, soybean + pigeonpea, cotton+ pigeonpea and cotton+ greengram/blackgram/soybean. Thus, the crop suffers with the moisture stress and ultimately the crop productivity lowered by 30 to 40 per cent. (Pendke *et.al.,*2000). The most important aspect of sustainable rainfed agriculture in the region is availability of sufficient soil moisture during crop growth period of *kharif* crops. Thus *in-situ* rainwater conservation plays an important role in maintaining the required soil moisture in stress period.

Methodology

The research experiment on various cropping systems viz. Sorghum + pigeonpea (4:2), Soybean + pigeonpea (4:2) and Cotton + soybean (1:1) with *in-situ* rainwater conservation techniques viz. Opening of furrow after 2 rows, opening of furrow after 4 rows , Conservation furrow after 6 rows, Conservation furrow after 12 rows and sole crop (Control) was undertaken for 6 years (2013 to 2018) on experimental field of Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani under rainfed / dryland condition. The experiment was planned with split plot design with three replications following the crop rotation. The crops were sown at a spacing of 45 cm row spacing in medium to deep black soil. The area comes under assured rainfall zone of Marathwada region. Recommended dose of fertilizer was applied to all intercropping systems. The opening of furrows were undertaken 30 to 35 days after sowing.

Results

Crop yield

Pooled data on Seed cotton equivalent yield during the period from 2013 to 2018 are presented in Table 1.

Cropping systems

Pooled data on seed cotton equivalent yield are presented in Table 2. Data indicated that among cropping systems no significant difference was observed with respect to mean seed cotton equivalent yield. However, higher mean seed cotton equivalent yield was recorded in soybean + pigeonpea (C_2) followed by cotton + soybean (C_3). The results verified the previous findings as (Dhoble *et. al.,* 1990) and reported that all intercropping systems resulted in yield advantage over sole crop. Garud *et al* (2019) reported that soybean + pigeonpea (2:1) intercropping recorded highest soybean equivalent yield.

In-situ rain water conservation techniques

Among *in-situ* rain water conservation techniques significantly higher mean seed cotton equivalent yield was recorded in conservation furrow at 2.7 m. (T_3) over opening of furrow after two rows (T_1) and control (T_5). The results verified the previous findings as (Pendke *et. al.,* 2000; Ranade et al., 2017) and reported that all *in-situ* moisture conservation practices resulted in yield advantage over control.

Table 1. Seed cotton equivalent yield as affected by cropping systems and *in-situ* rainwater conservation techniques during 2013-14 to 2018-19.

Treatments	Seed cotton equivalent yield, kg/ha						Pooled Mean
	2013	2014	2015	2016	2017	2018	
Cropping systems							
C_1 Sorghum + Pigeonpea (4:2)	1759	1740	1027	1291	1287	1270	1396
C_2 Soybean + Pigeonpea (4:2)	1236	1872	1570	1704	1347	1357	1514
C_3 Cotton + Soybean (1:1)	1124	1582	2168	1100	1467	1136	1430
SE +	41	68	52	58	30	60	63
CD at 5%	118	197	151	168	85	174	NS
***In-situ* Rain Water Conservation Techniques**							
T_1 Opening of furrow after 2 rows	1362	1739	1549	1275	1320	1181	1404
T_2 Opening of furrow after 4 rows	1400	1768	1588	1325	1374	1325	1463
T_3 Conservation furrow after 6 rows	1533	1984	1706	1725	1427	1516	1649
T_4 Conservation furrow after 12 rows	1475	1754	1732	1630	1437	1187	1536
T_5 Control	1095	1411	1366	870	1278	1064	1181
SE +	53	88	67	75	38	78	81
CD at 5%	153	254	195	217	NS	224	225
Interaction (CS x IRWCT's)							
SE +	92	152	117	130	66	134	141
CD at 5%	NS	NS	NS	376	NS	NS	NS
Interaction (season x treatment)							
SE +	146						
CD at 5%	423						
Mean	1373	1731	1588	1365	1368	1254	1447
CV(%)	11	15	13	16	12	19	16
Season rainfall (mm)	787	719	493	641	887	637	694

Interaction

The interaction between cropping systems and *in-situ* rain water conservation techniques was found non-significant. The interaction between season and treatment was significant.

Table 2. Mean moisture use efficiency (kg/mm/ha) during 2013 to 2018

Treatments	*In-situ* rain water conservation techniques					Mean
	Opening of furrow after 2 rows	Opening of furrow after 4 rows	Conservation furrow after 6 rows	Conservation furrow after12 rows	Control	
C_1 Sorghum + Pigeonpea (4:2)	3.12	3.42	3.94	3.58	2.53	3.32
C_2 Soybean + Pigeonpea (4:2)	3.57	3.78	4.50	4.22	3.06	3.83
C_3 Cotton + Soybean (1:1)	3.58	3.58	3.85	3.55	3.18	3.55
Mean	3.42	3.59	4.10	3.78	2.92	-

Conclusion

Soybean+ pigeonpea (4:2) intercropping system was found superior with respect to gross monetary returns, net monetary returns and B:C ratio, followed by cotton+soybean (1:1). Conservation furrow after6 rows was found significantly superior over control. Conservation furrow after 12 rows and opening of furrow after 4 rows were found at par effective with conservation furrow after 6 rows with respect to gross and net monetary returns. Highest soil moisture use and moisture use efficiency was observed in conservation furrow after6 rows followed by conservation furrow after 12 rows and opening of furrow after 4 rows. Conservation furrow after6 rows in cotton + soybean, soybean + pigeonpea and sorghum + pigeonpea intercropping systems was found effective for *in-situ* rainwater conservation and thereby enhancing productivity and moisture use efficiency in medium and deep vertisol in assured rainfall zone of Marathwada region.

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UID: 1146

Determination of bioaccessibility of iron and zinc content in horse gram genotypes grown under rain fed conditions -An Invitro dialyzability method

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Horse gram *(Macrotyloma uniflorum* (L.) Verdcis) one of the lesser known legumes of the tropics and subtropics, grown mostly under dryland agriculture. Horse gram which is commonly consumed in India by farming community and low-income groups, were screened for their iron and zinc contents and bioaccessibility by measuring the invitro digestibility. Horse gram is an excellent source of iron and zinc. Comparatively, horse gram grains had higher phytate and crude fibre content than most of the bean seeds. Hence horse gram samples were estimated for their iron and zinc contents and bioaccessibility by measuring the invitro dualizability. The most reliable method for determining bioavailability of iron from diets is to measure iron absorption. An invitro method, on, the other hand would have several advantages for rapid screening and testing of availability of iron from diets consumed and suggest improvements in the diets so as to increase availability of iron from the legume

Methodology

Four genotypes of horse gram samples (CRHG – 18R, CRHG – 22, CRHG-19 and CRHG – 4) were taken up which was cultivated under rainfed conditions at HRF, ICAR-CRIDA for the study. The highest yield was recorded by CRHG-22 followed by CRIDA-18R, CRHG-16 and CRHG-4. Iron and zinc contents the most essential micronutrients for human nutrition and bioaccessibility of the micronutrients in horsegram samples were analysed by measuring the invitro dualizability. Apart from iron and zinc contents, calcium and crude fibre and antinutritional factors such as phytates content were also analysed. Bioaccessibility of iron and zinc from horse gram samples were determined by an invitro method. Total iron, zinc and calcium, the metallic cations were determined in the di-acid method of the grain using AAS. Extraction of phytic acid from horse gram samples were determined Wheeler and Ferrel (1971). Estimation of crude fiber was estimated by using ANKOM fibre bag system, Physicochemical and hydration/cooking characteristics of horsegram i.e., Hydration capacity, hydration index, swelling capacity, swelling index, cooking time (min) and 100-seed weight were also estimated. All the samples were analysed in triplicate.

Results and Discussion

An in vitro method for the determination of availability of nonheme iron and zinc from horse gram samples were investigated. Four genotypes of horse gram samples (CRHG – 18R, CRHG – 22, CRHG-19 and CRHG – 4) were taken up for the study. Iron and zinc were estimated by the AAS method. The percent bioaccessibility of iron at pH 7.5 (7.23%) was found higher with CRHG – 18R. The bioaccessibility of zinc was significantly higher (32.21%) in genotype CRHG – 22. Significantly higher phytic acid content (213.00 mg/100 g) was observed in CRHG – 4. Calcium content was also significantly higher (120.16 mg/100 g) in CRHG – 19. Higher Crude fiber content (4.8 g) was observed in CRHG – 4. In cooking studies higher hydration capacity (0.041 g water per seed), swelling capacity (0.078 ml per seed), swelling index (1.066 ml) were higher in CRHG – 19.. Whereas , higher hydration index (1.106 g) was recorded CRIDA – 18R. Hence cooking time was significantly lower (6.02 min) in CRHG - 19.

Conclusion

Four horse gram genotypes (CRHG – 18R, CRHG – 22, CRHG-19 and CRHG – 4) were taken up for the study. Horse gram samples were screened for their iron and zinc contents and bioaccessibility by measuring the invitro dialyzalility. Significantly percent bioaccessibility of iron was found higher with CRHG – 18R and The bioaccessibility of zinc was significantly found to be higher in genotype CRHG – 22. CRHG – 18R and CRHG – 22 were found to be suitable for consumption, since the bioavailability of iron and zinc is found to be higher with lesser phytates compared to other horse gram genotypes. The most reliable method for determining bioavailability of iron from diets is to measure iron absorption. The available iron as measured by this in vitro procedure was shown to decrease considerably when inhibitors like phytic acid or tannin were included. Studies in humans have shown that phytates and tannins decrease considerably the absorption of nonheme iron, especially in foods of plant origin. Thus ionizable iron at pH 7.5 can be used as a valid measure of bioavailability of iron from horse gram grain.

UID: 1151

HDPS Cotton: A pathway for higher yields in rainfed situations

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SHE&CS, Krishi Vigyan Kendra, Yagantipalle, Nandyal, A.P. – 518 124

Cotton is one of the important commercial crop and leading natural fiber in the world, cultivated by 90-100 countries on 33.16 million hectares, which is accounting for 25.89 million tons. India is cultivating in 130.61 lakh hectares, which is 40% of world cotton cultivation area, producing 5.84 million tons with 23.84 % of world production and supporting millions of livelihoods and industries (Anonymous 2023). Sixty-seven per cent of cotton is produced under rainfed conditions and 33% under irrigated conditions. Most of the rainfed area soils are shallow to medium depth, have low water holding capacity, leading to limited growth and yields. Due to this, cotton productivity in India is very low (445 kg/ha) as compared to global cotton productivity (775 kg/ha). To overcome this challenge, the HDPS method of cotton cultivation created an option for improving productivity in rainfed situations. The aim of HDPS is to enhance cotton productivity per unit area rather than per plant basis by targeting amenable cultivars to soil type with appropriate geometry. In HDPS technology, short-duration, semi-compact cotton types are planted with a population of 74,073 plants per hectare, with a distance of 90 cm between rows and 15 cm between plants in a row with a seed rate of 7.125 kg/ha. To maintain accurate spacing cost-effective manual push seed planter was used with which one hectare can be completed in a single man day. Crop production practices are similar with conventional cotton cultivation except for canopy management in HDPS technology. Canopy management was done with PGR i.e. mepiquat chloride 1 ml/lit, when top five internal nodal distance is more than 20 cm.

Methodology

The study was carried out in Nandyal district based on the HDPS demonstrations conducted from 2023-24 to 2024-25 in farmers' field in 60 locations. Each demonstration was laid with 90x15cm spacing and control 120x30 cm with the same hybrid. Continuous rainfall (502 mm) in *Kharif* 2024, which resulted in excessive vegetative growth. HDPS farmers followed canopy management practices with mepiquat chloride 1 ml/lit at 45, 65, and 90 DAS.

The yield and economic performance of the demonstration were collected and the data is interpreted and presented in terms of percentage and quantity. Finally, the Kapas yield, cost of cultivation, net returns with benefit cost ratio were worked out.

An average of cost of cultivation, yield and net returns of different farmers was analyzed by the formula.

Average = [F1+ F2+F3. . . . . Fn] / N; F1 = Farmer; N = No. of Farmers.

In the present study, technology index was operationally defined as technical feasibility obtained due to implementation of demonstrations on HDPS Cotton. To estimate the technology gap, extension gap and technology index the following formula were used as suggested by Dayanand and Mehta (2012).

Per cent increase in yield = Demonstration yield - Farmers yield X 100 /Farmers yield
Technology Gap = Pi (Potential Yield) – Di (Demonstration Yield)
Extension Gap = Di (Demonstration Yield) – Fi (Farmers yield)
Technology index = [(Potential Yield – Demonstration yield/potential yield) X 100].

Results

The perusal of data (Table-1) indicated that, in demonstration farmers recorded a 33 q/ha yield in conventional method it was 26.7 q/ha. It indicates technology got 23.6 per cent of more yield than conventional method. The Results clearly indicate that the higher average yield was obtained in demonstration plots over the farmer's practice due to more plant population per unit area. Though the cost of cultivation is higher in experimental plot Benefit cost ratio is higher (1: 1.98) than control.

Extension gap is the yield difference between the demonstration plot and farmer's practice which was observed as 6.3 q/ha. The technology gap is the difference between potential yield and yield of demonstration plots which was recorded as 2 q/ha. The technology index is observed as 5.71 (Table 2), which shows the effectiveness of technical interventions.

Conclusion

It can be concluded that HDPS is a possible method in reversing the current trend of static yields in mostly rainfed cotton-growing areas with the application of HDPS in conjunction with adequate agronomic approaches, plant protection management, and superior genotypes.

Table 1. Difference between demonstration practice (HDPS) and farmer's practice (Conventional) in the study area

Sl. No.	Particulars	Conventional method	HDPS method
1	Soil type	Black Soils	Red, Mixed
2	Soil Depth	Deep soil	Shallow, Medium soil
3	Mode of irrigation	Rain fed	Rain fed
4	Seed rate	6.5 packets	15 packets
5	Spacing Adopted	120 x 30 cm	90 x 15 cm
6	Mode of sowing	Manual	Manual Push Planter
7	No. of plants per ha.	27,778	74,073
8	Hybrid Used	RCH 971 BG-II	RCH 971 BG-II
9	Canopy Management	Not Done	Two sprayings of Mepiquat Chloride
10	No. of burst bolls per plant (Randomly selected 25 Plants/ha)	33	16
11	Seed cotton weight of one fully burst boll (gram)	4.3	4.0
12	No. of Pickings	3.0	2.0
13	Yield of First Picking (q/ha)	19.1	23.1
14	Yield of Second Picking (q/ha)	5.0	9.9
15	Yield of Third Picking (q/ha)	2.6	-
16	Total Yield (q/ha)	26.7	33.0
17	Cost of cultivation (Rs./ha)	66,346	69,674
18	Gross income (Rs./ha)	1,68,210	2,07,900
19	Net income (Rs./ha)	1,01,846	1,38,226
20	B:C Ratio	1:1.54	1:1.98

Table 2: Productivity, technology gap, technology index and extension gap in HDPS Cotton

Cotton Yield			% increase in productivity	Technology gap (qt ha^{-1})	Extension Gap (qt ha^{-1})	Technology index (qt ha^{-1})
Potential yield (qt/ ha)	Demo yield (qt/ha)	Farmer practice yield (qt/ha)				
35.0	33.0	26.7	23.6	2.0	6.3	5.71

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Climate Resilient Intercropping Systems for Sustaining Food Security in Rainfed Medium Black Soils of Andhra Pradesh

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The significance of rainfed agriculture, covering about 58% of India's net cultivated area, underscores its vulnerability to challenges such as erratic rainfall, land degradation, and low soil fertility. Climate change exacerbates these issues, leading to prolonged droughts and floods, severely impacting livelihoods dependent on rainfed systems. Therefore, it is of utmost importance to enhance resilience of rainfed agriculture to climate change through planned adaptation of appropriate inter/sequence cropping systems and also with other management practices of natural resource management (Singh et al., 2004). Intercropping is an important aspect than sole cropping to address the issues of rainfed agriculture under changing climate scenario and it also helps in the maximization of productivity and profitability by efficient utilization of natural resources like land, light and water (Chandra et al., 2010 b). Evaluating and promoting millet-legume intercropping systems in Andhra Pradesh (Nandyal district) could prove transformative.

Methodology

Trails were conducted with different intercropping systems i.e. Little millet + Pigeon pea (5:1), Proso millet + Pigeon pea (5:1) , Foxtail millet + Pigeon pea (5:1) and Pearl millet+ Pigeon pea (2:1) during 2018-19 , 2019-20 and 2020-21 along with sole crops in rainfed medium soils with 60 locations in KVK operational villages during *kharif* season. The mean seasonal rainfall distribution was 407 mm during southwest monsoon (June-September) and 151 mm during northeast monsoon (Oct - Dec), 15.0 mm rainfall during winter (Jan-Feb) and 70 mm in summer (March – May). The percentage season-wise distribution of rainfall was 64.29% from southwest monsoon, 23.85 % from northeast monsoon, 2.36 % in winter and 11.05 % in summer. The amount of rainfall received in 2018, 2019 & 2020 was 540.8 mm, 969.6 mm and 584.4 mm with deviation of -14.5 %, + 53.17 % and – 7.67 % respectively compared with average annual rainfall (633.0 mm) [Table 1].

Climatic constraints of villages based on long term data, assessment of natural resources, identification of major farming situations, constraints of crop production, climatic vulnerabilities, yield gaps and opportunities for climate change adaptations were analyzed. Based on the detailed analysis, on farm testing with appropriate intercropping systems to meet climate vulnerability (drought) was prepared on participatory mode with the help of farmers. At the time of harvest, the yields of intercropping systems and sole crops were recorded. The economic analysis of input and output relationships and grain equivalent yields were worked out to quantify the benefits of intercropping systems for the last three years.

Results

The results showed (Table 2) that intercropping of millets with pigeon pea i.e. foxtail millet + pigeon pea (5:1), recorded highest pigeon pea equivalent of 1681kg/ha followed by proso millet + pigeon pea (1629 kg/ha) little millet + pigeon pea (1551kg/ha) and pearl millet+ pigeon pea (1276 kg/ha.) while the sloe crop yields of pigeon pea , foxtail millet , proso millet, little millet and pearl millet were 1076 kg/ha, 785 kg/ha, 814 kg/ha , 776 kg/ha 699 kg/ha respectively. Similar results were reported by Sashidhara et al. (2000) which showed that small millets performed better even under drought and erratic rainfall, both as sole and intercropping systems probably due to their drought tolerant capacity. The results were in conformity with the findings of Basavarajappa (2003) who reported that highest foxtail millet equivalent yield was recorded when foxtail millet was grown with pigeon pea where 100 per cent pigeon pea population was maintained.

The gross returns, net returns and C: B ratio were substantially higher in all intercropping treatments foxtail millet + pigeonpea (5:1), proso millet + pigeon pea (5:1), little millet + pigeon pea (5:1) and pearl millet+ pigeon pea (2:1) respectively compared to the sloe crop of pigeon pea, foxtail millet, proso millet, little millet and pearl millet. The lowest gross returns (52,492 Rs. /ha) was recorded with peral millet (sole crop). All intercropping treatments recorded the land equivalent ratio more than unity (1.00). Among the various intercropping Foxtail millet + Pigeon pea (5:1) system recorded higher land equivalent ratio (1.79) followed by Proso millet + Pigeon pea (1.72) , little millet + pigeon pea (1.68) and pearl millet+ pigeon pea (1.38) .

Table 1. Rainfall pattern from 2018-19 to 2020-21

Month	Normal(mm)	Monthly Rainfall distribution (mm)		
		2018-19	2019-20	2020-21
Jan	11.0	28.8	00	18.30
Feb	4.0	00.0	00	6.80
March	7.0	00.0	49.0	00
April	16.0	42.4	28.0	51.5
May	37.0	26.1	39.9	45.20
June	65.0	26.1	156.5	68.9
July	107.0	57.6	247.10	104.6
August	115.0	89.3	133.60	69.40
September	120.0	271.1	167.7	63.70
October	117.0	96.7	86.4	49.80
November	26.0	00	53.1	106.2
December	8.0	00	8.3	00
Total	**633.0**	**540.8**	**969.6**	**584.40**

Table 2. Mean Grain yield (kg/ ha), pigeon pea Equivalent Yield (kg/ha) and LER of different millet based inter cropping systems

Treatments	Yield (q/ha)*		Pigeon pea Equivalent Yield (kg/ha)	LER	BC Ratio
	Pigeon pea	Millet			
Little millet + Pigeon pea (5:1)	875	1336	1551	1.68	3.24
Sole Little millet		1532	776	1.0	2.45
Proso millet + Pigeon pea (5:1)	915	1531	1629	1.72**	3.40**
Sole Proso millet		1746	814	1.0	2.57
Foxtail millet + Pigeon pea (5:1)	976	1890	1681	1.79	3.51**
Sole Foxtail millet		2105	785	1.0	2.40*
Pearl millet+ Pigeon pea (2:1)	867	1397	1276	1.38	2.76
Sole Pearl millet		2386	699	1.0	1.96
Sole Pigeon pea	1076	-	1076	1.0	2.70

*Significant at 5 % level** significant 1 % level

Conclusion

The intercropping system is potentially important today for the efficient utilization of available resources such as water, sunlight, nutrients, atmospheric carbon, and energy. In an assessment of different intercropping systems in red soils of Nandyal district of A.P, foxtail millet + pigeon pea (5:1), Proso millet + Pigeon pea (5:1**),** Little millet + Pigeon pea (5:1) and Pearl millet+ Pigeon pea (2:1) were found to be economical and climate resilient crops in rainfed situations. Hence, intercropping system offers solution to obtain higher productivity, diversified food products and reduced risk of crop failure under rainfed conditions.

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Assessment of Finger Millet Varieties and Method of Sowing under Rain-Fed Condition in Chatra District of Jharkhand, India

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Climate change impacts on agriculture are being witnessed all over the world, but situation in county like India is more vulnerable in view of the large population depending on agriculture, excessive pressure on natural resources, and poor cropping mechanisms. In Jharkhand within agriculture, rain-fed agriculture which contributes nearly 80% of the net cultivated area is excessively impacted for two reasons. First, rain-fed agriculture is practiced on fragile, degraded, and sloppy land which is thirsty as well as hungry and prone to erosion that impacts on food security at the household level, particularly for small and marginal farmers and wage labourers. In Jharkhand, finger millet is the second most popular crop besides rice. But most of the farmers using local varieties and traditional methods of sowing i.e. direct seeding with poor management practices reap them to harvest of 5-6 q/ha which is very low if compared to the potential yield of improved varieties. For increasing, the productivity of finger millet under the upland rain-fed situation transplanting method with line sowing of improved varieties and recommended packages of practices is very popular among the farmers. Finger millet crop addresses many issues such as water scarcity, labour requirements, high cost of production, and utilization of uncultivable land and fulfill nutritional securities of the farmers. Keeping this fact under consideration an on-farm trial was conducted to judge, the performance of two different finger millet improved varieties under direct seeded and transplanting with a recommended dose of fertilizer and improved management practices in the upland rain-fed situation in Chatra district of Jharkhand India.

Methodology

An On-Farm Trails (OFT) was conducted during the years 2020 & 21 to find out a suitable variety with appropriate methods i.e. direct seeding or transplanting in the bio-physical and socio-economic condition of Chatra district of Jharkhand. The experiment was conducted in Mardanpur village of Chatra Block in Chatra District of Jharkhand state where the NICRA Project was under operation. The trail was designed in randomized block design consisting of 20 replications with four technological options i.e. Farmers Practice: Desi Varieties (Chotki) Ragi with $N_{25}P_0K_0$ with direct seeding, TO-I: Improved varieties (A-404)with $N_{40}P_{30}K_{20}$ with direct seeding, TO-II: Improved varieties (A-404) with $N_{40}P_{30}K_{20}$) and transplanting 20 days old seedling in line sowing (PP 10cm and R to R 30cm) TO-III: Improved varieties (GPU-28) with ($N_{40}P_{30}K_{20}$) with direct seeding and TO-IV: Improved varieties (GPU-28) with ($N_{40}P_{30}K_{20}$) and transplanting 20 days old seedling in line sowing (PP 10cm and R to R 30cm). farmers' reactions with respect to intervention technologies for knowing the choice were also measured through 5 points rating scale.

Results

Yield attributers and yield of finger millet as affected by method of sowing and improved package of practices

Technology option	Effective tillers/m^2	finger length (cm)	Ear weight (g)	Number of grain/ear	Grain weight/ear/ gram	1000 grain weight (gram)	Grain yield (q/ha)	Straw yield (q/ha)
Farmers Practice: Desi Varieties (Chotki) Ragi with $N_{25}P_0K_0$ with direct seeding in upland rain-fed	49	3.86	3.73	5.32	2.21	2.98	9.86	23.48
TO-I: Improved varieties (A-404)with $N_{40}P_{30}K_{20}$ with direct seeding. in upland rain-fed	64	5.21	4.99	734	2.46	3.10	13.98	32.86
TO-II: Improved varieties (A-404) with $N_{40}P_{30}K_{20}$) and transplanting 20 days old seedling in line sowing (PP 10cm and R to R 30cm)	77.0	5.72	5.18	784	2.76	3.20	17.24	39.49
TO-III: Improved varieties (GPU-28) with ($N_{40}P_{30}K_{20}$) with direct seeding upland rainf-fed	86.6	6.0	5.61	998	3.31	3.44	18.42	47.12
TO-IV: Improved varieties (GPU-28) with ($N_{40}P_{30}K_{20}$) and transplanting 20 days old seedling in line sowing (PP 10cm and R to R 30cm). upland rainf-fed	89.3	6.38	6.36	938	3.21	3.28	23.46	59.64

The table above shows that Yield attributes and yield viz., effective tiller/m^2 (89.3), finger length (6.38cm), ear weight (6.38g), no of grains/ear (938) and grain weight/ear/gram (3.32g) and 1000 grain weight (3.28) were highest in technology option IV i.e. improved varieties (GPU-282) with ($N_{40}P_{30}K_{20}$) and transplanting 20 days sold seedling in line sowing (PP10 cm & RR 30cm). The maximum grain yield (23.46 q/ha) and straw yield (59.64 q/ha) were recorded in technology option IV followed by technology option III, TO-II & I. respectively. High yielding varieties with line sowing and recommended nutrient management increased the grain yield with increased nutrient supply on yield attributing the characters like effective tillers/m^2, finger length, ear weight, number of grain/ear and grain weight/ear. Application of recommended dose of nutrients and line sowing facilitate weeding to operate three times dry land weeder which lead to increase availability of nutrients and improve the soil properties, absorption and translocation of nutrient by crop resulting in increased yield. These results are in line with the finding of AK. Roy et al (2018).

The above table shows that cost of cultivation, gross return, net return and benefit cost ratio were influenced by the different technologies option under trail. Gross return and net return increased due to using improved varieties, recommended dose of nutrient under line sowing. Highest gross return (Rs. 82110/ha) and net return (Rs. 52410/ha) were recorded in technologies option IV followed by technology option III (Rs. 64470/ha) and (Rs. 37770/ha). Technology option II (Rs. 60340/ha) and (Rs.30640/ha) & Technology option-I (Rs. 48930/ha) & (Rs. 22230/ha) respectively. The benefit cost ratio was also high in technology option IV (2.76) followed by technology option III (2.41), technology option II (2.03) and technology option I (1.79) respectively.

Economics

Economic and benefit cost ratio comparison between farmers practice and intervent practices

Technology options	Cost of Cultivation (Rs/ha)	Gross Return (Rs/ha)	Net Return (Rs/ha)	B:C Ratio
Farmers Practice: Desi Varieties (Chotki) Ragi with $N_{25}P_0K_0$ with direct seeding in upland rain-fed	19200	34510	15310	1.79
TO-I: Improved varieties (A-404)with $N_{40}P_{30}K_{20}$ with direct seeding. in upland rain-fed	26700	48930	22230	1.83
TO-II: Improved varieties (A-404) with $N_{40}P_{30}K_{20}$) and transplanting 20 days old seedling in line sowing (PP 10cm and R to R 30cm)	29700	60340	30640	2.03
TO-III: Improved varieties (GPU-28) with ($N_{40}P_{30}K_{20}$) with direct seeding upland rainf-fed	26700	64470	37770	2.41
TO-IV: Improved varieties (GPU-28) with ($N_{40}P_{30}K_{20}$) and transplanting 20 days old seedling in line sowing (PP 10cm and R to R 30cm) upland rainf-fed	29700	82110	52410	2.76

Conclusion

Technology option IV i.e. improved varieties (GPU-28) ($N_{40}P_{30}K_{20}$) and 20 days old seedling transplant with line sowing (PP-10cm and R to R 30cm) and technology option II improved varieties (A-404) ($N_{40}P_{30}K_{20}$) with transplanting of 20 days old seedling in line sowing (PP-10cm and R to R 30cm) in upland rain-fed situation was highly accepted by majority of the farmers. So that technology option IV & II both are recommended in rain-fed upland & medium land situation in Chatra district of Jharkhand, India

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Performance of Contingent Crops under Delayed Monsoon in Scarce Rainfall Zone of Andhra Pradesh

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In India, rainfed agriculture occupies about 51% of net sown area and accounts for nearly 40% of the total food production. Whereas in Andhra Pradesh, nearly 57% of net sown area is under rainfed agriculture. Agricultural productivity in rainfed areas continues to remain low and unstable due to weather aberrations, nutrient disorder, and poor socio-economic status of farmers. Rainfall is the key variable influencing crop productivity in rainfed farming. Intermittent and prolonged droughts are a major cause of yield reduction in most crops. The productivity of *kharif* crops in dryland conditions varies to a great deal from year to year in response to the variability of climate, particularly the rainfall (Guled*et al*., 2013).The major challenge in dryland agriculture is to minimize yearly variations in crop yields due to aberrant weather conditions and to stabilize production at a reasonably acceptable level. Crops with wider sowing windows can still be taken up till the cut-off date without major yield loss and only the change warranted could be the choice of short duration cultivars. The performance of different contingent crops under delayed monsoon situations needs to be evaluated. Hence, an experiment is conducted to find out the suitable contingent crops and their performance under delayed sowing condition in scarce rainfall zone of Andhra Pradesh.

Methodology

A field experiment was conducted with an objective to identify the most suitable and profitable contingent crops under delayed monsoon for scarce rainfall zone of Andhra Pradesh. The experiment site is situated in Ananthapuramu district. The soil in the experimental area is red sand loam in texture. The experiment was conducted in Randomized Block Design (RBD) with 3 replications and 13 treatments comprising different crops viz. Groundnut(Var. K6), Greengram(Var. WGG-42), Horsegram(Var. CRIDA-1-1-18R), Cowpea(Var. TPTC-29), Foxtail millet(Var. SIA-3085), Pearlmillet(Var. ABV-04), Sorghum (Var. NTJ-5), Castor(Var. Haritha), Fodder Bajra(Var EC4216), Fodder sorghum(Var. MP Chari), Field bean(Var TFB-2), Redgram(Var PRG-176)and Blackgram(Var TBG-104) were sown on 10th of August, 2023. All the recommended agronomic and plant protection measures were adopted as per the package of ANGRAU. Yield of various contingent crops were recorded from net plot area and extrapolated to hectare basis. Economics of different treatments were estimated considering the prevailed market price of commodities during crop season. The level of significance used in 'F' test was at 5%. The critical difference (CD) values are given in the table at 5% level of significance (Gomez and Gomez, 1984).

Results

Among different crops tried under delayed sowing (Date of sowing: 10.08.2023), all the crops were affected by severe drought due to low rainfall (218.4) during crop growth period. Among the crops, greengram recorded significantly higher groundnut equivalent yield (490 kg/ha) followed by groundnut (470 kg ha^{-1}), cowpea (455 kg ha^{-1}) and horsegram(450 kg ha^{-1})(Table.1) . However, greengram recorded higher net returns (Rs. 17479/ha) followed by horsegram (Rs.1742/ha). Further, it was noticed that no seed yield was obtained in castor and sorghum crops as these crops were severely affected due to severe drought experienced during the crop growth period.

Conclusion

Contingent crops, viz. greengram, horsegram and cowpea were identified as a alternative to groundnut under delayed monsoon condition which were recorded higher yields compared to other crops in rainfed areas of scarce rainfall zone of Andhra Pradesh.

Table 1. Performance of contingent crops under delayed monsoon

Treatments	Pod/seed yield (kg/ha)	Haulm/ straw yield (kg/ha)	Net returns (Rs/ha)	*GEY (kg/ha)	B:C ratio	RWUE (kg/ha/mm)
Groundnut	469.6	2653	-2061	470	1.01	2.15
Greengram	363.0	1015	17479	490	2.45	2.24
Horsegram	488.9	2430	17452	450	2.82	2.06
Cowpea	318.5	2252	10017	455	1.66	2.08
Foxtail millet	361.5	1105	256	201	1.18	0.92
Pearlmillet	545.2	2652	-154	216	1.13	0.99
Sorghum	0.0	1707	-10129	81.2	0.34	0.37
Castor	0.0	667	-28666	21.2	0.04	0.10
Fodder bajra	0.0	1837	-6339	87.5	0.42	0.40
Fodder sorghum	0.0	1926	-6222	91.7	0.42	0.42
Field bean	41.8	844	-14960	80	0.25	0.37
Red gram	265.2	2681	-710	295	1.04	1.35
Blackgram	130.4	844	-3329	144	0.77	0.66
			S.Em.±	26.36		--
			C.D. at 5 %	76.93		--
			C.V. %	21.58		--

*Groundnut equivalent Yield (GEY)

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Response of Ajwain (*Trachyspermum ammi*) genotypes to different planting time under rainfed conditions

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Ajwain, also known as carom seed (*Trachyspermum ammi* L.) belongs to family Apiaceae is native of Egypt and is a popular seed spice crop in India. It is a cold loving crop and mainly grown during *rabi* season in India. In some pockets of the country, it is also sown as *kharif* crop. In India, its production is concentrated mainly in Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh, Bihar, Uttar Pradesh, Tamil Nadu and West Bengal. It has been introduced for cultivation in northern part of Karnataka very recently. But farmers are unaware of its cultivation and there is a lack of information regarding production technologies like suitable varieties and sowing window of this crop. Scientific information on the effect of sowing date in different varieties of Ajwain to optimize the seed yield is lacking, especially for northern dry zone of Karnataka. There is a need to generate the basic data on different agro-techniques for Ajwain cultivation and which helps to develop suitable production technologies by optimizing the sowing time for different varieties to get higher yield. Hence, the study was planned to evaluate Ajwain genotypes under different sowing time.

Methodology

A field experiment was carried out during the *Kharif* 2022-23 to identify the suitable Ajwain genotype and optimum planting time for northern dry zone of Karnataka. (Zone -3) at All India Coordinated Research Project for Dryland Agriculture, Vijayapura centre. The experiment was laid out in a Split Plot Design with three replications and 18 treatment combinations *viz.*, The 6 main plot with date of sowing (D_1- I fortnight of August, D_2- II fortnight of August, D_3- I fortnight of September , D_4- II fortnight of September, D_5- I fortnight of October and D_6- II fortnight of October and 3 Sub plots with Genotypes (G1 – Ajmer Ajwain-1, G2 – Ajmer Ajwain-93 and G3 – Kadapa local-1).

Results

The Results indicated that the date of sowing and genotypes have significantly influenced on the growth, yield parameter and yield of Ajwain (Table)

The Ajwain genotypes performance was better when it was sown on August first fortnight to September first fortnight. Significantly higher plant height , branches /plant, number of umbels , seed yield /plant and seed yield/ha obtained with sowing during II FN of August (95.5 cm, 11.8, 199, 13.76 and 592 kg/ha, respectively) . However, which was on per with the I FN of

August and I FN of September. Significantly Lower Yield parameter and yield (282 q/ha) noticed in II FN of October. Similar Results are also obtained by Chaitanya *et. al* 2023. Among the genotypes Kadapa local produced significantly higher yield parameters and yield (622 kg/ha) compared to AA-1 (496 kg /ha) and AA-93 (298 kg/ha). The Results are in conformity with the findings of Ranjeetha *et. al* 2023. Soil moisture data at different growth stages indicated that, moisture availability during flowering and seed filliping stage was more in early sown crop than delayed sown crop (Fig).

Among the interaction effects, the genotype Kadapa local with I FN of August produced significantly higher seed yield (924 kg/ha), net return (Rs. 1,40,010/ha) and BC ratio (6.33) as compared to all other treatment combination. Significantly lowest seed yield (288 kg/ha), net return (Rs. 25530/ha) and BC ratio (0.67) as compared to all other treatment combination. Similar Results are also obtained by Susha *et. al* 2023.

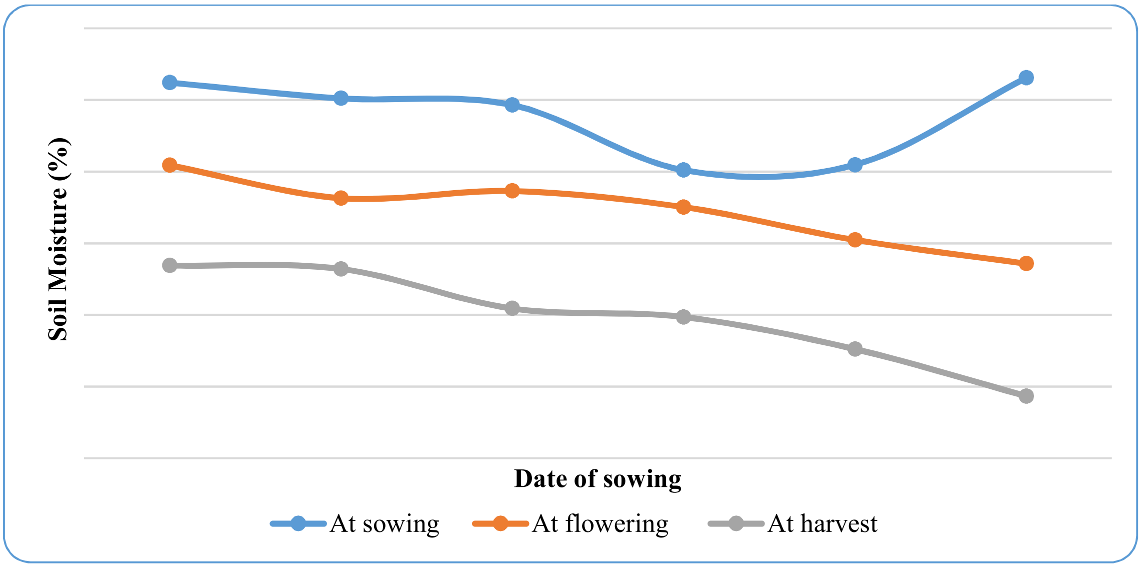
Growth and yield parameters of Ajwain genotypes under different sowing dates

Treatment	Seed yield (kg/ha) 2022-23	Plant height (cm)	Branches / plant	No. of Umbels / plant	Seed yield /plant (g)	Net return (Rs/ha)	BC ratio	RWUE (kg/ha -mm)
Date of Sowing (D)								
D1- I FN of Aug	533	97.5	12.1	168	10.73	69690	3.65	1.23
D2- IIFN of Aug	592	95.7	11.8	199	13.76	80290	4.06	1.37
D3- I FN of Sept	524	92.1	11.6	165	11.82	68050	3.59	1.21
D4- II FN of Sept	455	92.7	9.2	114	7.8	55590	3.12	1.05
D5- I FN of Oct	447	96.2	8.6	103	6.98	54150	3.06	1.03
D6- II FN of Oct	282	38.4	4.9	37	4.84	24450	1.93	0.65
Mean	472	85.4	9.7	131	9.32	58703	3.24	1.09
SEm+	29	2.9	0.3	5.1	0.31	5297	0.2	0.07
CD (5%)	88	8.6	1.0	15.4	0.92	15834	0.6	0.20
CV (%)	18.7	10.0	9.9	11.8	9.9	17.1	18.7	18.70
Genotype (G)								
G1 – Ajmer Ajwain-1	496	84.5	9.9	133	9.24	63000	3.40	1.15
G2 – Ajmer Ajwain-93	298	85.3	9.8	118	8.66	27420	2.04	0.69
G3 – Kadapa local	622	86.5	9.3	142	10.07	85690	4.26	1.44
Mean	472	85.4	9.7	131	9.32	58703	3.23	1.09

**RWUE – Rain water use efficiency   NS: Non significant

Conclusion

Sowing of Ajwain from first fortnight of August to first fortnight of September is ideal for expressing its potential and Kadapa local genotype performed better than AA-1 and AA-93 in Northern Dry Zone of Karnataka under rainfed condition.



Soil moisture content at different growth stages of Ajwain (60 cm soil depth)

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QTL mapping for late leaf spot disease resistance in groundnut (Arachis hypogaea L.)

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Groundnut (*Arachis hypogaea*) is one of the major oilseed crop that contributes 35% of the total oil production in India. Production and productivity of groundnut are affected by so many biotic and abiotic stresses. The foliar fungal disease Late leaf spot (LLS) is a major constraint that is causing significant 70 % yield losses worldwide. Breeding of the improved resistance varieties is one of the important remedies to control LLS disease in groundnut. Classical breeding procedures for developing cultivars are complex, time-consuming and labor-intensive. The genomic approaches such as marker-assisted selection (MAS) and QTL (Quantitative trait loci) mapping is one of the potential approaches to enhance the efficiency and precision of developing groundnut cultivars with improved resistance to LLS. Keeping the importance of MAS to develop LLS resistant varieties a BC1F1 mapping population (47 plants) was derived from the late leaf spot (LLS) susceptible parent TMV 2 and resistant parent ICGV 86699 in groundnut. Which was genotyped using 122 SSR markers across 18 linkage group and phenotyping was carried out against LLS disease under natural field conditions at 60, 75, 90, and 105 days after sowing. Genotyping and phenotyping data were analyzing with 'QTL IciMapping' software version 4.0. During the study eight QTLs resistant to LLS were identified at different stages of screening. Out of these two QTLs viz. qLLS105TH-5-1 flanked by marker TC2E12 and GM1615 and qLLSs105th-5-1 flanked by marker TC9H19 and PM217 were showed highest and lowest phenotypic variance of 28.25% and 10.34% respectively. The markers flanked with these QTLs may be used in precision breeding program for the development of LLS resistant varieties in groundnut. Further to make more robust these QTLs may be validated in different mapping population in different environment because the stable expression of these QTLs across the different environments highlights their potential for improving groundnut resilience to biotic stress, ultimately contributing to food security and economic sustainability in groundnut-growing regions.

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Identification of contingent crops for delayed sowing under changed climate in dryland situations

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Agriculture supports nearly two-thirds of India's population, with rainfed agriculture playing a vital role in the economy and rural livelihoods. Covering 55% of the net cultivated area, it contributes over 39% to national agricultural production and supports 42% of the population. Key crops like coarse cereals, pulses, oilseeds, and cotton are predominantly cultivated under rainfed conditions (Nagaraj, 2013). However, rainfed agriculture faces significant challenges, including low productivity due to weather variability, nutrient deficiencies, and poor socio-economic conditions of farmers. Climate variability, especially rainfall, is the most critical yet unpredictable factor affecting crop planning in dryland regions. These areas experience frequent weather aberrations, including delayed monsoons, uneven rainfall distribution, and dry spells, which make crop production highly uncertain. The variability in monsoon rainfall, with coefficients of variation ranging from 40-55% in arid and semi-arid zones, exacerbates drought risks. Monsoon failures severely impact small and marginal farmers, threatening rural livelihoods (Lodh and Haldar, 2024). To address these challenges, adopting resilient cropping systems and identifying contingency plans for delayed sowing is essential. Developing strategic measures tailored to specific agro-climatic conditions can help mitigate the risks of monsoon failures and ensure sustainable dryland agriculture.

Methodology

The field experiment was conducted during the rainy seasons (June–September) of 2019–2022 at the University of Agricultural Sciences, GKVK Campus, Bengaluru, Karnataka, under the All India Coordinated Research Project for Dryland Agriculture. The site, located at 12.97°N and 77.59°E with an elevation of 920 m, comprised a semi-arid Alfisol with a sandy clay loam texture, pH of 5.5–6.0, and organic carbon content of 0.45%. Annual rainfall averaged 922 mm, primarily in August and September. The study employed a Factorial Randomized Complete Block Design (FRCBD) with two factors: sowing windows (August 2nd fortnight, September 1st fortnight, and September 2nd fortnight) and Crops (foxtail millet, finger millet, field bean, french bean, and quinoa). The gross plot size was 4.2 m × 3.6 m, with all recommended agronomic and plant protection practices followed. Crop yields were recorded from net plot areas (3.6 m × 3.2 m), with straw or haulm yield calculated as the difference between above-ground dry matter and seed yield. Finger Millet Equivalent Yield (FMEY) was computed using the formula by Verma and Modgal (1983), converting economic yields of other crops into their finger millet equivalents based on market prices. Rain Water Use Efficiency (RWUE) was calculated as grain yield per hectare divided by rainfall in millimeters (kg ha-mm^{-1}). Data were analyzed using ANOVA to assess the effects of sowing windows, crops, and their interactions at a 5% significance level, with critical difference (CD) values presented in tables. Results, based on pooled data from four years, provide insights into yield parameters and the adaptability of contingent crops to delayed sowing in dryland conditions

Results

The Results of the field experiment on the identification of contingent crops for delayed sowing under changing climatic conditions are summarized in Table 1. The pooled data from 2019–2023 highlights the influence of sowing windows and crop types on Finger Millet Equivalent Yield (FMEY), straw/haulm yield, and Rain Water Use Efficiency (RWUE).

Finger millet equivalent yield (FMEY): Sowing windows significantly affected FMEY, with the highest yields observed during the first sowing window (S_1: August 2nd fortnight) across all crops. French bean (C_4) exhibited the highest FMEY under S_1 (3962 kg ha^{-1}), followed by finger millet (C_2) at 2759 kg ha^{-1}. Delayed sowing to S_2 and S_3 resulted in a reduction in FMEY for all crops, with French bean (C_4) still maintaining relatively higher yields (3816 kg ha^{-1} in S_2 and 2953 kg ha^{-1} in S_3). Foxtail millet (C_1) and quinoa (C_5) were more sensitive to delayed sowing, showing significant reductions in FMEY by S_3 (713 kg ha^{-1} and 1322 kg ha^{-1}, respectively). The mean FMEY across all sowing windows was highest for French bean (C_4) at 3577 kg ha^{-1}, while foxtail millet (C_1) had the lowest mean yield (1079 kg ha^{-1}). This highlights the potential of French bean as a resilient contingent crop under delayed sowing conditions. The yield reduction in delayed sowing was attributed to greater biotic and abiotic stresses *viz*., moisture stress, high temperature and decreased moisture availability and moisture stress that resulted in lesser total dry matter production and its translocation from vegetative parts to reproductive structures. It was attributed to reduced productive tillers per plant, number of pods per plant, panicle weight and pod weight as well as reduced translocation from source to sink with delayed sowing. Similar Results have been reported by (Rao *et al*., 1991) in finger millet.

Straw/Haulm Yield: Straw/haulm yield followed a similar trend to FMEY, with the highest values recorded in the first sowing window (S_1). Finger millet (C_2) achieved the highest mean straw yield (3099 kg ha^{-1}), while french bean (C_4) produced the least (788 kg ha^{-1}). The impact of delayed sowing was more pronounced for crops like foxtail millet (C_1) and quinoa (C_5), which saw sharp reductions in straw yield from S_1 to S_3. These findings corroborate the Results of Sharma *et al*. (2021), who reported that optimal sowing time enhances straw productivity due to favourable vegetative growth conditions.

Effect of different sowing windows on Finger Millet Equivalent Yield (FMEY) (kg ha^{-1}) and Rain water use efficiency (RWUE) (kg ha-mm-1) of contingent crops (pooled data 2019-20 to 2022-23)

Treatment	Finger Millet Equivalent Yield (FMEY) (kg ha^{-1})				Straw yield/haulm yield (kg ha^{-1})				Rain water use efficiency (RWUE) (kg ha-mm^{-1})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
C_1	1389	1135	713	1079	1594	1160	766	1173	2.40	2.81	1.65	2.29
C_2	2759	2484	2054	2432	3498	3111	2688	3099	5.10	6.33	5.94	5.79
C_3	1502	1604	1173	1426	1055	1040	650	915	1.90	2.78	2.32	2.33
C_4	3962	3816	2953	3577	792	952	620	788	8.26	27.04	26.61	20.64
C_5	2550	1765	1322	1879	960	692	489	714	1.83	1.54	1.36	1.58
Mean	2432	2161	1643		1580	1391	1043		3.90	8.10	7.58	
	S	C	SC		S	C	SC		S	C	SC	
S.Em±	76.23	59.05	34.09		114.81	88.93	51.35		76.23	59.05	34.09	
CD (5%)	132.50	171.05	98.76		199.56	257.63	148.74		132.50	171.05	98.76	

Note: S_1: Aug 2nd fortnight (27th Aug); S_2: Sep 1st fortnight (14th Sep); S_3: Sep 2nd fortnight (24th Sep)
C_1: Foxtail millet; C_2: Finger Millet; C_3: Field bean; C_4: French bean; C_5: Quinoa

Rain water use efficiency (RWUE): RWUE was significantly influenced by sowing windows and crop type. The mean RWUE was highest for French bean (C_4) at 20.64 kg ha-mm^{-1}, demonstrating its superior ability to utilize available water efficiently under dryland conditions. Delayed sowing to S_2 and S_3 significantly reduced RWUE for all crops except French bean, which maintained high efficiency (27.04 and 26.61 kg ha-mm^{-1}, respectively). Foxtail millet (C_1) and quinoa (C_5) had the lowest RWUE, averaging 2.29 kg ha-mm^{-1} and 1.58 kg ha-mm^{-1}, respectively. These Results suggest that these crops are less suitable for delayed sowing under dryland conditions, primarily due to their lower water-use efficiency. The interaction between sowing windows and crops (S × C) was statistically significant for all measured parameters, emphasizing the importance of selecting appropriate crop types for specific sowing windows. French bean emerged as the most adaptable crop, with consistent performance across different sowing windows, while crops like foxtail millet and quinoa showed substantial declines in performance under delayed sowing conditions.

Conclusion

The study demonstrates that french bean is a promising contingent crop for delayed sowing under changing climate scenarios in dryland situations, with superior yields and water-use efficiency. Early sowing during the first window (August 2nd fortnight) is critical for maximizing productivity and resource use efficiency across all crops. However, further research into the physiological responses of these crops to varying sowing windows is recommended to refine recommendations for dryland farming systems.

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Evaluating the Crop Efficiency Using Productivity Indices of Different *Rabi* Crops Grown Under Rainfed Situation in Chhattisgarh State

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Rabi crops are sown in winter and harvested in the spring in India. An effort is required to increase farmers' profitability, agricultural income and cropping intensity in Chhattisgarh state. There are around 37.46 lakh farm families in the state with about 80% farmers falling under small and marginal category. *Rabi* crops are not only affected directly by winter precipitation alone but summer season precipitation also influences the *rabi* crops through water and soil moisture availability over many parts of India (Prasanna 2014). The best index of the suitability of an area for a particular crop is its relative yield as well as its stability from year to year as judged from co-efficient of variability (CV) regardless of the area under the crop (Singh et al., 1995).

Methodology

Area and production data of major crops of CG state were collected from the Dept. of Agriculture, Co-operation and Farmers' Welfare site for a period of 2000-2023. That was analysed to work out the relative yield and coefficient of variation in the yield with methods:

$$\text{Relative Yield of Crop X} = \frac{\text{Average yield of crop x in a district}}{\text{Average yield of crop x in Chhattisgarh state}} \text{x} 100$$

$$\text{Coefficient of Variability of Crop X} = \frac{\text{Standard Deviation of Crop X Yield in a district}}{\text{Average yield of crop x in the state}} \text{x} 100$$

The relative yield and CV for each crop in each district was classified as follows:

Criteria	High	Medium	Low
Relative Yield	Above 120%	80-120%	Below 80%
CV: Threshold varied crop to crop on the basis of the range in values and frequency of their distribution			

Results

The table shown for each *rabi* crop is drawn on the basis of the result obtained from the analysis.

a. **Wheat:** According to the analysis conducted, the results for Chhhattisgarh state are in the Table 1. Table states that criteria of efficiency was fully fulfilled by few districts that are Baloda bazar, Dantewada, Kondagaon, Mungeli, Sarguja with high stable productivity.

b. **Lathyrus:** It can be said that high stable productivity for lathyrus crop is found in only one district viz., Mungeli with efficient criteria (Table 2).

c. **Rapeseed and Mustard:** The result recorded after the analysis of productivity and efficiency level of rapeseed and mustard is tabulated in Table 3. Efficient region with high stable productivity was found in Kondagaon district.

d. **Linseed:** According to the analysis conducted, the results were interpreted in Table 4. The category of highest efficiency with high stable productivity was seen in Kondagaon district.

Table 1. Productivity and efficiency level of different districts producing wheat

Sl. No.	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/ High CV	Low productivity	Inefficient	Bijapur
2	Districts with medium yield and medium/ High CV	Medium unstable productivity	Less efficient	Kabirdham, Korea,Sukma
3	Districts with medium yield and low CV	medium stable productivity	Moderately efficient	Balod, Bematara, Dhamtari, Durg, Korba, Surajpur
4	Districts with high yield and medium/High CV	high unstable productivity	Potentially efficient	Balrampur, Bastar, Bilaspur, Gariaband, Janjgir-champa, Jashpur, Kanker, Mahasamund, Narayanpur, Raigarh, Raipur, Rajnandgaon
5	Districts with high yield and low CV	high stable productivity	Efficient	Baloda-bazar, Dantewada, Kondagaon, Mungeli, Surguja

Table 2. Productivity and efficiency level of different districts producing Lathyrus

Sl. No.	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/ High/CV	Low productivity	Inefficient	Kabirdham, Korea, Surajpur
2	Districts with medium yield and medium/High/CV	Medium unstable productivity	Less efficient	Balod, Gariaband, Jashpur, Naranyanpur and Surguja
3	Districts with medium yield and low/CV	medium stable productivity	Moderately efficient	Bilaspur, Dhamtari, Durg, Jangir-champa, Kanker, Kondagaon, Korba, Mahsamund, Raigarh, Raipur, Rajnandgaon
4	Districts with high yield and medium/High CV	high unstable productivity	Potentially efficient	Baloda-Bazar, Balrampur, Bastar, Bemetara
5	Districts with high yield and low CV	high stable productivity	Efficient	Mungeli

Table 3. Productivity and efficiency level of different districts producing Rapeseed and mustard

Sl. No.	Category	Productivity	Efficiency level	Districts
1	Distrcits with low yield and low/medium/ High CV	Low productivity	Inefficient	Kabirdham, Korba
2	Districts with medium yield and medium/High CV	Medium unstable productivity	Less efficient	Balrampur, Bijapur, Bilaspur, Dantewada, Dhamtari, Durg, Jangir-Champa, Jashpur, Kanker, Mungeli, Narayanpur, Raipur, Rajnandgaon, Surajpur
3	Districts with medium yield and low CV	Medium stable productivity	Moderately efficient	Balod, Baloda-Bazar, Bemetara, Gariaband, Korea, Mahasamund, Raigarh, Sukma, Surguja
4	Districts with high yield and medium/ High CV	High unstable productivity	Potentially efficient	Bastar
5	Districts with high yield and low CV	High stable productivity	Efficient	Kondagaon

Table 4. Productivity and efficiency level of different districts producing Linseed

Sl. No.	Category	Productivity	Efficiency level	Districts
1	Districts with low yield and low/medium/High CV	Low productivity	Inefficient	Kabirdham, Korba
2	Districts with medium yield and medium/High CV	Medium unstable productivity	Less efficient	Balrampur, Bijapur, Bilaspur, Dantewada, Dhamtari, Durg, Janjgir-Champa, Jashpur, Kanker, Mungeli, Narayanpur, Raipur, Rajnandgaon, Surajpur
3	Districts with medium yield and low CV	Medium stable productivity	Moderately efficient	Balod, Baloda-Bazar, Bematara, Gariaband, Korea, Mahasamund, Raigarh, Sukma, Surguja
4	Districts with high yield and medium/High CV	High unstable productivity	Potentially efficient	Bastar
5	Districts with high yield and low CV	High stable productivity	Efficient	Kondagaon

Conclusion

The analysis result showed that Chhattisgarh state includes all the criteria of efficiency of *rabi* crops at different levels. After the analysis of crop productivity and their efficiency, it can be suggested that districts recorded with efficient and high stable productivity are highly suitable districts. The area recorded with low efficiency can be either taken for diversification or it should be identified with major problems regarding their low productivity.

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Influence of Various Establishment Methods for Climate Resilience in Different Agro-Climatic Zones of Madhya Pradesh and Chhattisgarh

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Rainfed agriculture plays a crucial role in ensuring food security, particularly in regions like Madhya Pradesh and Chhattisgarh, where a significant portion of the agricultural land relies on monsoon rainfall. However, the erratic nature of rainfall, prolonged dry spells, and the increasing effects of climate change pose serious challenges to crop productivity and sustainability in these areas. To mitigate these risks and enhance the resilience of farming systems, the adoption of suitable crop establishment methods is essential (FAO, 2019). Establishment methods, such as zero tillage, broad bed furrow (BBF), ridge and furrow, and relay cropping, offer innovative solutions to optimize water-use efficiency, improve soil health, and increase crop yields (Hati *et al*., 2006; Challa and Tilahun, 2014; Jat *et al*., 2019;). These methods are particularly effective in rainfed conditions as they reduce soil erosion, enhance water retention, and minimize the impact of rainfall variability. Additionally, providing the life-saving supplemental irrigation during long dry spells has the potential to further stabilize agricultural productivity under challenging climatic conditions (Singh *et al*., 2018). This study evaluates the influence of various crop establishment methods across different agro-climatic zones of Madhya Pradesh and Chhattisgarh. It aims to quantify their influence on crop productivity and economic returns under rainfed conditions. The findings provide valuable insights for promoting climate-resilient agriculture, contributing to sustainable development goals while improving the livelihoods of small and marginal farmers in the states of Madhya Pradesh and Chhattisgarh.

Methodology

The demonstrations were conducted in the farmers' fields, where specific agricultural interventions were applied. These include soil and water conservation practices like Broad Bed and Furrow system, Zero tillage, and ridge and furrow method, alongside life-saving supplemental irrigation during long dry spells. The climate resilient varieties of major crop of particular agro-climatic zone were selected for demonstration and to assess yield improvement. The number of demonstrations and farmers involved in each intervention varies. The detailed data on the crop yields before and after the interventions and the economics of the demonstration including gross cost, gross returns, and net returns is given in Table below. The percentage increase in yield and profitability of each intervention is calculated using the formula given by Rana *et al*., 2014.

Influence of establishment methods on crop yield and economics in different agro-climatic zones

Agro-climatic Zone wise intervention	Average Crop Yield (q/ha)		Cost of Cultivation (Rs./ha)	Gross returns (Rs./ha)	Net Returns (Rs./ha)
	Famers practice	Demo			
Bundelkhand region (BBF in Soybean)	7.1	12.2	32500	56120	23620
Bundelkhand region (BBF in Blackgram)	5.1	8.3	29700	57685	27985
Bundelkhand region (ZT in Wheat)	28.3	43.5	43200	98963	55763
Grid region (ZT in Wheat)	34.1	43.8	29500	91078	61578
Chhattisgarh Plains (R&F in Cauliflower)	184	242	54600	363000	308400
Chhattisgarh Plains (R&F in Brinjal)	176	285	58900	285000	226100
Grid region (R&F in Mustard)	12.73	13.95	30100	82003	51903
Grid region (R&F in Bajra)	22.95	29.67	24550	69423	44873
Chhattisgarh Plains (Relay cropping in Lathyrus)	11.14	11.88	20336	38016	17680

Results

The influence of various establishment methods on crop performance and economic returns under rainfed conditions was assessed across different agro-climatic zones of Madhya Pradesh and Chhattisgarh (Table 1). The Broad Bed and Furrow method showed significant yield improvements for soybean and black gram in Bundelkhand region of Madhya Pradesh. Soybean yield increased from 7.1 q/ha (local practice) to 12.2 q/ha (BBF), representing a 71.8% increase, while yield of blackgram improved from 5.1 q/ha to 8.3 q/ha, with a 62.7% increase over farmers practice. In Grid and Bundelkhand regions, Zero tillage in wheat crop showed considerable improvement in yield (43.5 q/ha), with 53.7% higher yield over control (28.3 q/ha), with similar trends observed in other districts of Madhya Pradesh. Ridge and Furrow system in Chhattisgarh plains, showed significant higher yield improvements in cauliflower, with increment in yields by 31.5% (from 184 q/ha to 242 q/ha), and brinjal yields rose by 61.9% (from 176 q/ha to 285 q/ha). Whereas in Grid region of Madhya Pradesh, ridge and furrow system showed yield enhancement by 9.6% and 29.3% in mustard and pearl millet crop, respectively. Relay cropping with Lathyrus in plains of Chhattisgarh led to a slight yield increase of 6.6% compared to farmers practice, highlighting its potential in marginal rainfed areas. The introduction of improved establishment methods led to significant economic gains in improved establishment methods (Table 1).

Conclusion

The establishment methods proved effective in mitigating the impacts of erratic rainfall and prolonged dry spells. Practices like Zero tillage and BBF reduced soil erosion and preserved moisture, while relay cropping enhanced land use efficiency in low-rainfall areas. These results underscore the importance of adopting climate-resilient establishment methods tailored to specific crops and agro-climatic conditions, enabling sustainable agricultural practices in rainfed regions.

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UID: 1185

High throughput Phenotyping of Millet Species for Drought tolerance

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Drought stress is a significant constraint in agricultural productivity, particularly in regions where water scarcity is prevalent. Millets, being hardy and drought-tolerant crops, have gained attention as potential alternatives to address food security challenges. This study aimed to assess the drought tolerance of seven millet species including Browntop millet (Urochloa ramosa), Proso Millet (Panicum meliaceous), Kodo millet (Paspalum scrobiculatum), Little millet (Panicum sumatrense), Barnyard millet (Echinochloa esculenta), finger millet (Eleusine coracana) and foxtail millet (Setaria italica) using a high throughput phenotyping approach. The millet species were grown in pots and subjected to four different levels of drought stress, including 100% field capacity (FC), 75% FC, 50% FC, and 25% FC. At regular intervals, visible (RGB) images of the plant were captured by using a visible camera (400-700nm) at the Plant Phenomics facility, and the related parameters such as digital leaf area, convex hull area, calliper length, circumference, compactness, and eccentricity were derived after image analysis by LemnaTec software. The Results demonstrated significant variations in digital leaf area pixels and other derived parameters among the different millet species under varying levels of drought treatments. Under 50% FC, Finger millet (38.34%) showed the least reduction in the digital leaf area pixel, followed by Proso Millet (43.04%), Kodo millet (47.65 %), Barnyard millet (57.36%), Foxtail millet (60.65%), Little millet (63.42%). Browntop millet (78.44%). In calliper length also foxtail millet showed only a 2% reduction and Browntop millet (48.39%). Our findings highlight the potential of utilizing phenotyping techniques to evaluate drought tolerance in minor millet species. The identified traits, such as leaf area dynamics and other growth-related parameters under drought response can serve as potential selection criteria for breeding programs targeting improved drought resilience.

UID: 1187

Characterization and Identification of Nutritionally Superior Landraces of Rainfed Rice through Farmer Participation in Tarikhet Block of Uttarakhand

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Rainfed rice cultivation in mountainous regions, such as the Tarikhet block of district Almora, Uttarakhand, plays a pivotal role in ensuring food security and biodiversity conservation. Despite their resilience and adaptability, traditional landraces of rice are often overlooked in favor of high-yielding commercial varieties. This study focuses on characterizing and identifying nutritionally superior landraces of rainfed rice through a participatory approach involving local farmers, ensuring relevance and practicality in real-world agricultural settings. The research aimed to (1) Characterize diverse landraces of rice cultivated in the Tarikhet block under rainfed conditions (2) Assess their nutritional superiority in terms of macronutrient and micronutrient content and (3) Involve farmers in the evaluation process to incorporate indigenous knowledge and encourage adoption of superior varieties.

Methodology

A participatory rural appraisal (PRA) approach was adopted to identify and document the traditional landraces grown in the region. Farmers were engaged throughout the process, from seed selection to field trials and final evaluation. Key steps included:

- **Collection of Germplasm**: Seeds of various paddy landraces were collected from farmers of the target area. These comprised named landraces like *Chwardhan, Halmunji, Gyarsu, Ratinia, Sitolia, Saloni, Shyawdhan, Laldhan, Khazia, Bakula, Gita, Kavthuni, Jhusiyao, Maildhan, Pantoli, Bakul, Lambgudiya, Jaulia, Dudh* and *Bateshu* etc.
- **Field Trials**: Experiments were conducted in farmer-managed plots under rainfed conditions in tricot design to simulate real-world cultivation practices. Each farmer was given 3 varieties to grow and thus total 176 varieties were tested over three years that included landraces, farmer's varieties, improved cultivars and germplasm accessions from the National Gene Bank. Farmers were actively scoring landraces based on agronomic performance, taste, and culinary preferences.
- **Phenotypic and Agronomic Characterization**: Traits such as plant height, grain yield, pest and disease resistance, drought tolerance, taste etc were documented.

- **Nutritional Analysis**: Laboratory analysis was performed to quantify the rice varieties' protein, iron, zinc starch and amylose content.

Results

1. **Genetic Diversity**: The study identified a wide range of rice landraces, many of which demonstrated remarkable resilience to abiotic stresses such as drought and poor soil fertility.
2. **Nutritional Superiority**: The nutritional analysis of the rice landraces reveals promising traits for promoting health benefits, particularly for populations vulnerable to metabolic disorders and micronutrient deficiencies. The study reveals that high-amylose landraces like *Gita* (30.66% amylose) and *Kavthuni* (27.49% amylose) are likely to have a low glycemic index (GI), as higher amylose content slows starch digestion and glucose release (Table). These findings align with previous research indicating that rice varieties with amylose content above 25% are associated with lower GI values, beneficial for metabolic health and managing diabetes. Additionally, *Gita* emerged as a standout variety due to its high nutritional profile, including 15.16% protein, 42.63 µg/g zinc, and 68 µg/g iron. Micronutrient-rich rice varieties have been recognized for their potential to combat malnutrition, as supported by findings that biofortified and iron- and zinc-dense rice can improve dietary intake in nutrient-deficient populations (Bouis et al., 2003; Al-Daez, 2022). The study underscores the dual role of traditional rice landraces in promoting metabolic health through low-GI diets and addressing micronutrient deficiencies. The combination of low GI and high nutrient content in these landraces demonstrates their potential as functional foods, particularly in dietary strategies targeting diabetes and undernutrition.

Table 1: Nutrient composition of superior rice landraces

Landrace	Amylose (%)	Starch (%)	Protein (%)	Zn (µg/g)	Fe (µg/g)
Gita	30.65	76.10	15.16	42.63	68.0
Batesu	22.07	70.98	11.65	28.28	36.3
Dudh	23.08	78.66	10.22	28.72	53.0
Jaulia	26.88	74.55	11.97	39.27	51.3
Kavthuni	27.48	72.68	11.75	38.75	50.6
Lambgudi	25.69	74.98	9.87	37.27	38.7

1. **Farmer Preference**: The analysis of traditional rice landraces highlights their unique agronomic and nutritional attributes, making them valuable for both food security and cultural preservation. For instance, *Lambgudiya* is noted for its long grains and high yield, making it a staple variety in the region. *Bateshu dhan*, with its white, soft grains and sweet taste, is particularly appreciated for its ease of dehulling, enhancing its appeal for local consumption. *Jauliya dhan* is distinguished by its bold grains and is considered ideal for preparing the traditional dish "Jaula," which is consumed during recovery from

jaundice, while *Shyawdhan*, with its blackish husk and tall straw, is recognized for its role as a dietary supplement for lactating mothers, owing to its high iron content. Additionally, *Laal dhan*, characterized by its red husk and grains, is not only rich in iron but also contains antioxidants, offering both nutritional and sensory benefits with its buttery texture when boiled.

2. **Cultural and Ecological Significance**: These landraces were found to be intricately linked to local traditions and agroecosystem stability. These landraces illustrate the intersection of nutrition, tradition, and sustainable agriculture, emphasizing their potential in both health-focused diets and biodiversity conservation.

Conclusion

This study highlights the untapped potential of traditional rice landraces in addressing nutritional and agricultural challenges in the Tarikhet block of Uttarakhand. The nutritionally superior landraces identified in this study hold potential for addressing malnutrition and enhancing dietary diversity in rural communities. Furthermore, promoting these landraces can support sustainable agriculture in rainfed and marginal areas, contributing to ecological resilience.

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Integrated Approach for Management of Cyperus spp. in Maize (Zea mays L.) under Rainfed Conditions of North West Himalayas

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Among many factors that adversely influence resource use efficiency and crop production, severe weed infestation is the most important. Weeds have the ability to survive under adverse conditions, as they extract more water and nutrients from the soil, thereby reducing crop yield by 37 to 79 % under rainfed agriculture. Weeds being more aggressive, adaptive, and persistent pose a serious threat to crop production and are difficult to control below the economic threshold level with a single weed management practice. Hence, more emphasis is needed to develop multiple and integrated weed control strategies in a holistic manner for sustainable crop production and livelihood security in rainfed areas.

Methodology

The present investigation entitled, "Integrated Approach for Management of *Cyperus* spp. in Maize (*Zea mays* L.) under Rainfed Conditions of North West Himalayas" was conducted at Dryland Agriculture Research Station (DARS), Rangreth, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during *Kharif* seasons of 2022 and 2023 with the objective to study the effect of different weed control methods on growth and development with special reference to management of *Cyperus* spp. in maize. The experiment consisted of eleven treatments, viz; Halosulfuron methyl 75% WG @ 67.5 g a.i. ha^{-1} as POE, Halosulfuron methyl 75% WG @ 90.0 g a.i. ha^{-1} as POE, Topramezone 33.6% SC @ 67.5 g a.i. ha^{-1} as POE, Topramezone 33.6% SC @ 90.0 g a.i. ha^{-1} as POE, Halosulfuron methyl 75% WG @ 67.5 g a.i. ha^{-1} at two leaf stage of weed, Halosulfuron methyl 75% WG @ 90.0 g a.i. ha^{-1} at two leaf stage of weed, Topramezone 33.6% SC @ 67.5 g a.i. ha^{-1} at two leaf stage, Topramezone 33.6% SC @ 90.0 g a.i. ha^{-1} at two leaf stage, hand weeding at 30 and 60 DAS, weedy check and weed free. The experiment was laid out in randomized block design and replicated thrice. The soil of the experimental field was silty clay loam in texture, neutral in reaction, medium in organic carbon, available nitrogen and potassium and low in phosphorus.

Results

Experimental Results revealed that the research area was dominated by weed species like *Cyperus* spp., *Xanthium strumarium*, *Trianthema* spp., *Echinochloa* spp., *Cynodon dactylon, Amaranthus viridis, Sorghum halepense,* etc. The highest weed density (No./m^2) and drymatter accumulation (g/m^2) were recorded in the weedy check than rest of the treatments at 80 days of crop growth stage. Significantly lower weed density (No./m^2) and drymatter accumulation (g/m^2) was observed in weed free treatment as compared to the rest of treated plots. The weed count showed that herbicide halosulfuron methyl 75% WG @ 90.0 g ha^{-1} at two leaf stage of weed was significantly more effective at controlling grasses and broad-leaved weeds than halosulfuron methyl 75% WG @ 90.0 g ha^{-1} as POE whereas topramezone 33.6% SC @ 90.0 g ha^{-1} at two leaf stage of weed proved significantly superior at controlling grasses and broad-leaved weeds than topramezone 33.6% SC @ 90.0 g ha^{-1} as POE. Different weed control treatments registered significant increase in yield attributes and grain yield of maize compared to unweeded control. The highest grain yield (4.91 t/ha) was recorded in weed free treatment and lowest in weedy check (2.27 t/ha). Unchecked weed growth resulted in a 53.74% yield loss of maize.

Effect of different weed management practices on weed dynamics of maize at 60 DAS

Treatment	Weed Density (No./m^2)			Weed drymatter (g/m^2)			WCE (%)	WI (%)
	2022	2023	Pooled	2022	2023	Pooled		
T_1:- HS methyl 75% WG @ 67.5 g ha^{-1} POE	7.95 (62.9)	8.00 (64)	7.99 (63.6)	7.76 (59.8)	7.49 (56.1)	7.69 (58.9)	61.62	26.00
T_2:- HS methyl 75% WG @ 90 g ha^{-1} POE	6.78 (45.5)	7.10 (50.4)	6.91 (47.5)	7.14 (50.6)	6.84 (46.8)	7.07 (49.7)	59.62	23.36
T_3:- Tpz 33.6% SC @ 67.5 g ha^{-1} POE	7.00 (48.5)	7.23 (53.7)	7.14 (50.7)	7.32 (53.1)	7.15 (51.1)	7.29 (34.7)	65.64	26.25
T_4:- Tpz 33.6% SC @ 90.0 g ha^{-1} POE	7.28 (52.5)	7.57 (57.2)	7.50 (54.5)	7.38 (54.0)	7.96 (63.3)	7.60 (57.5)	62.56	23.18
T_5:- HS methyl 75% WG @ 67.5 g ha^{-1} at 2LS of weed	6.72 (44.9)	6.98 (48.8)	6.84 (46.5)	7.83 (60.8)	7.95 (63.3)	7.90 (62.0)	67.64	22.97
T_6:- HS methyl 75% WG @ 90 gha^{-1} at 2LS of weed	5.71 (32.2)	6.01 (36.1)	5.84 (33.9)	6.12 (37.1)	5.91 (35.0)	6.08 (36.7)	76.11	12.49
T_7:- Tpz 33.6% SC @ 67.5 g ha^{-1} at 2LS	7.72 (59.5)	7.63 (58.2)	7.71 (59.5)	7.97 (63.1)	7.78 (60.5)	7.93 (62.6)	59.83	24.80
T_8:- Tpz 33.6% SC @ 90.0 gha^{-1} at 2LS	6.45 (41.2)	6.24 (38.9)	6.41 (40.8)	6.92 (47.5)	6.11 (37.3)	6.68 (44.5)	71.08	22.88
T_9:- Hand weeding at 30 and 60 DAS	7.56 (56.9)	7.80 (60.8)	7.57 (58.6)	7.89 (61.7)	7.78 (60.5)	7.88 (61.7)	59.23	23.54
T_{10}:- Weedy check	12.73 (161.5)	12.98 (168.0)	12.83 (164.1)	12.38 (152.8)	12.38 (152.7)	12.39 (153.1)	0.00	54.17
T_{11}:- Weed free	2.93 (8.1)	2.91 (8.5)	2.99 (8.6)	2.20 (4.3)	2.73 (7.4)	2.46 (5.8)	96.35	0.00
CD (P=0.05)	0.60	0.52	0.59	0.53	0.58	0.45		

Figures in parentheses are original values

Conclusion

It was concluded that highest weed population (No./m^2) and dry matter accumulation (g/m^2) was recorded in weedy check and the lowest population was observed in the hand weeded plot at 60 days of crop growth. The weed count showed that herbicide halosulfuron methyl 75% WG @ 90.0 g ha^{-1} at two leaf stage of weed (T_6) was significantly premium to control grasses and broad-leaved weeds than halosulfuron methyl 75% WG @ 90.0 g ha^{-1} as POE (T_2) whereas topramezone 33.6% SC @ 90.0 g ha^{-1} at two leaf stage of weed (T_8) proved significantly superior to control grasses and broad-leaved weeds than topramezone 33.6% SC @ 90.0 g ha^{-1} as POE (T_4)

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In vitro management of seed borne disease in chickpea (Cicer arietinum (L.))

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Chickpea [*Cicer arietinum* (L.)] is a member of Fabaceae family, and it is a cool season crop. Its cultivation is mainly concentrated in semi arid environment. Chickpeas are widely grown in Northern Karnataka, with Gulbarga taking first place, followed by Vijayapura, Bidar, Gadag, Dharwad, Belagavi, Bagalkot, Raichur, and Yadgiri districts.

Seed borne diseases are regarded as major constraints in chickpea production. Seed infection affects the import and export adversely because the seed affected with microbes is not acceptable in the international market. Infected seeds fail to germinate, or seedlings and plants grown from infected seeds in the field may avoid early infection, but at the later stage of growth they may also be affected. In addition, pathogens may spread over a long distance, and the seeds in which various pathogens are present will invade uninfected fields (Fakir *et al.,* 2001). The seed treatment with bioagents is safe, economical, eco-friendly and cheap it can be done easily with locally available materials and is non-harmful to seed, animals and human beings (Singh *et al*., 2003) and seed treatment with fungicide has helped to protect seeds from mycoflora not only in storage but also to protect the germinating seedling and promote good establishment (Kumar *et al.,* 2019). Hence, study on *in vitro* management of seed borne diseases in chickpea.

Methodology

A lab experiment was carried out in the Department of Seed Science and Technology, College of Agriculture, Vijayapura during *rabi* 2021-22 to study the *in vitro* efficacy of three combi-product fungicides at three concentrations (100, 200 and 500 ppm) against seed borne fungus *Rhizactonia bataticola* isolated from the seed by using the poisoned food technique for the management of seed borne disease in chickpea. Four replications were maintained for each treatment.

Five bioagents were tested to evaluate the antagonistic activity against *Rhizactonia bataticola* by dual culture technique. Antagonistic activity was calculated by using the formula developed by Skidmore and Dickinson (1976).

$$PIRG = \frac{RI\text{-}RII}{RI} \times 100$$

Where,

RI: Radius of fungal colony in control plate.

RII: Radius of fungal colony in dual culture plate

Per cent inhibition of growth over control was calculated by using the formula given by (Nene and Thapliyal, 1979).

$$I = \frac{C - T}{C} \times 100$$

Where,

I = Per cent inhibition in growth of pathogen
C = Radial growth (mm) in control
T = Radial growth (mm) in treatment.

Results

In vitro efficacy of three combi-product fungicides against *R. bataticola* was evaluated at 100, 200 and 500 ppm concentrations. The data revealed that all the fungicides at each concentration reduced the mycelial growth of fungus when compared to control. Among the three combi-product fungicides evaluated against *R. bataticola*, carbendazim 25 % + mancozeb 50 % WS, and thiophanate methyl 45 % + pyraclostrobin 5 % FS, were found to be the most effective and found significantly superior over other fungicides in all concentration, which inhibited cent per cent growth of *R. bataticola* at all the concentrations tested. This was followed by carboxin 37.5 % + thiram 37.5 % DS (59.36 %). Least inhibition of mycelial growth was observed in carboxin 37.5 % + thiram 37.5 % DS and at 500 ppm concentration with the inhibition of 100 % (Table 1).

Table 1. ***In vitro*** **evaluation of different combi-product fungicides against** ***R.bataticola***

Sl. No.	Treatment details	Inhibition of mycelial growth (%)			
		Concentration (ppm)			Mean
		100	200	500	
1	Carboxin 37.5%+ Thiram 37.5% DS	34.00 (35.66)*	44.08 (41.60)	100.00 (90.00)	59.36 (55.75)
2	Thiophanate Methyl 45%+ Pyraclostrobin 5% FS	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
3	Carbendazim 25% +Mancozeb 50% WS	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
4	Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Mean	78.00 (71.88)	81.36 (78.36)	100.00 (90.00)	
		S.Em ±		CD at 1%	
	Fungicides	0.278		0.565	
	Concentration	0.278		0.565	
	Fungicides x Concentration	0.481		0.979	

*Figures in the parentheses are arcsine transformed values

In vitro efficacy of four bioagents against *R. bataticola* was evaluated. The data revealed that some bioagents reduced the mycelia growth of fungus when compared to control. Among the five bioagents evaluated against *R. bataticola*, *Trichodrema harzianum* (82.70%), *Pseudomonas fluorescens* (74.05%), *Bacillus thuriengenisis* (62.41%) were found to be the most effective and found significantly superior, which inhibited cent per cent growth of *R. bataticola*. This was followed by *Bacillus cereus* (32.13%) (Table 2). Least inhibition of mycelial growth was observed in *B. cereus* and *B. subtilis.*

Table 2. *In vitro* evaluation of different bioagents against R. Bataticola.

Sl. No.	Treatments	Inhibition of mycelial growth (%)
1	*Trichoderma harzianum*	82.70 (65.44)*
2	*Pseudomonas fluorescens*	74.05 (59.40)
3	*Bacillus cereus*	32.13 (34.47)
4	*Bacillus thuringenesis*	62.41 (52.21)
5	*Bacillus subtilis*	16.92 (24.29)
6	Control	0.00
	S.Em±	1.458
	CD @ 1%	4.231

*Figures in the parentheses are arcsine transformed values

Conclusion

Seed treatment with Carbendazim 25%+ Mancozeb 50% WS @ 3.5 g /kg of seed followed by Thiophanate methyl 45%+ Pyraclostrobin 5% FS @ 4ml /kg of seeds have a good inhibitory effect and increased the seed quality parameter and among bioagents, *Trichoderma harzianum* followed by *P. fluorescence* shown good antagonistic effect compare to other bioagents.

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UID: 1202

Assessment of Genetic Variability Parameters and Divergence for Yield Attributes and Nutrient Traits in Indigenous Finger Millet (*Eleusine Coracana* L.) Germplasm

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Finger millet (*Eleusine coracana* (L.) Gaertn) belongs to the Poaceae family, sub-family Chloridoideae. It is a self pollinated, allotetraploid with chromosome number 2n=4x=36. It is believed that finger millet originated in the Ethiopian highlands and was introduced to India approximately 3000 years ago (Babu *et al*., 2017). It is grown extensively in Africa and India after wheat, rice, sorghum, maize and bajra. It is the sixth most produced crop in India. It is a traditional staple millet crop grown mostly under irregular rainfall or marginal soils in dry land agricultural systems. In India, finger millet is grown in an area of 11.14 lakh hectares, with a production of 16.69 lakh tonnes and a productivity level of 1497 kg ha^{-1} (Directorate of Economics and Statistics 2022-2023). In Andhra Pradesh, finger millet is cultivated on 0.3 lakh hectares of land and produces 0.35 lakh tonnes with a productivity of 1167 kg ha^{-1} (Directorate of Economics and Statistics 2022- 2023).

Ragi is a "Nutritious Millet" because it has a good amount of proteins, minerals, calcium and vitamins compared to major food grains. The nutritive values for every 100 g of finger millet are protein (7.7 g), fat (1% - 2%), carbohydrate (72 g), minerals (2.7 g), calcium (344 mg), fibre (3.6 g), energy (328 kcal), iron (6.3 mg), Zinc (2 mg), manganese (3.5 mg), magnesium (130 mg) and ash (2.7 g) (Thapliyal and Singh, 2015). Exploiting existing genetic variability and diversity in the germplasm is very important for a successful crop improvement programme. Such genetic studies on yield and yield related characteristics along with iron and zinc contents will aid in the development of nutrient rich high yielding finger millet varieties. With this objective, the present study was carried out to assess the variability parameters and genetic divergence among finger millet indigenous germplasm lines to determine the genetic potential of these materials for future use in the breeding programme.

Methodology

One hundred and seven genotypes of finger millet were evaluated during Kharif 2022 in two replications under a randomized block design at Agriculture Research station, Perumallapalle. The spacing adopted was 22.5 cm × 10.0 cm and each genotype was raised in a single row. The crop management techniques were uniformly adopted for the entire experiment. Five random plants in each replication for each genotype were tagged for making observations, and the mean of five plants was used for statistical analyses. Observations were recorded for thirteen characteristics *viz.,* days to maturity, flag leaf length, flag leaf width, ear head length, finger length, finger width, fingers per ear, tillers per plant, plant height Fe content, Zn content, fodder yield and grain yield. The assessment of iron and zinc content was carried out using the Di-acid method, and the readings were recorded using an Atomic Absorption Spectrophotometer (AAS). The estimates of GCV and PCV were computed according to the method suggested by (Burton, 1952). Heritability in broad sense was calculated as per the formula given by (Lush, 1940). Genetic advance was estimated according to the method suggested by (Johnson et al., 1955). Genetic divergence between the genotypes was estimated by multivariate analysis using Mahalanobis D^2 statistics and grouping of genotypes into different clusters was done using Tocher's method.

Results

Analysis of variance for 107 finger millet indigenous germplasm lines revealed significant differences for all traits studied, indicating the presence of considerable genetic variability among the genotypes studied. High GCV and PCV for iron content, zinc content, grain yield and fodder yield indicated that these characters have a very large extent of genetic variation among indigenous germplasm lines for these traits. Therefore, simple selection would be effective for further improvement of these characters. This was in conformity with the findings of Madhavilatha *et al*. (2021). For the iron content, zinc content both heritability and genetic advance were high indicating that these characters were controlled by additive gene action. Therefore, phenotypic selection would be more effective for improvement of these characters.

Table 1. Genetic parameters for yield attributes and nutritional traits in indigenous finger millet germplasm

Character	Mean	Genotypic Coefficient of variation	Phenotypic Coefficient of variation	Heritability (Broad sense) %	Genetic advance (GA)	Genetic advance as percent of mean (%)
Days to maturity	114.4	7.9	7.9	99.2	18.5	16.2
Flag leaf length (cm)	32.9	10.6	12.6	70.8	6.0	18.3
Flag leaf width (cm)	1.0	8.0	13.2	36.4	0.1	9.9
Ear head length (cm)	8.5	15.4	17.6	77.0	2.4	27.9
Finger length (cm)	6.3	20.1	21.3	88.7	2.4	38.9
Finger width (cm)	0.9	11.2	14.6	58.8	0.2	17.7
Fingers per ear	7.4	10.1	13.2	58.0	1.2	15.8
Tillers per plant	2.8	25.2	32.1	61.7	1.1	40.8
Plant Height (cm)	103.7	10.7	11.6	83.9	20.8	20.1
Fe content	192.1	47.2	47.2	99.8	186.6	97.1
Zn content	36.3	43.4	43.8	97.9	32.1	88.4
Fodder Yield (g/plant)	84.3	33.5	34.2	95.9	56.9	67.6
Grain Yield (g/plant)	9.8	38.4	41.0	87.8	7.3	74.1

The 107 genotypes were divided into nine clusters using the clustering technique by Tocher's method. The third and the biggest cluster was represented by 43 genotypes. The first and second clusters consisted of thirty-five and two genotypes, respectively. The fourth, fifth and sixth clusters consisted of eight, six and ten genotypes respectively. Clusters seven, eight and nine were solitary represented by one genotype each. The average intra and inter cluster distances between the nine clusters were presented in Table 2. Cluster 6 (436.14) recorded the maximum intra cluster distance and the minimum intra cluster distance was shown by cluster 2 (17.7). Clusters 6 and 9 had the maximum inter cluster distance (5532.66), followed by cluster 2 and 6 (5328.24). Cluster 8 and cluster 9 had the minimum inter cluster distance (268.85). Among the thirteen characters studied, iron content contributed more towards genetic diversity (62.7) followed by days to maturity (21.27).

Table 2. Average Intra (diagonal) and Inter Cluster distances in indigenous finger millet germplasm

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9
Cluster 1	**164.39**	469.8	676.75	508.43	1333.05	3171.28	475.65	600.6	762.19
Cluster 2		**17.7**	1722.51	1233.16	2474.91	5328.24	419.54	497.15	546.31
Cluster 3			**247.42**	713.9	557.05	1349.87	1188.61	1410.91	1926.44
Cluster 4				**217.47**	1762.39	2832.77	1460.08	1111.94	960.83
Cluster 5					**323.49**	1109.45	1334.77	2034.2	3098.71
Cluster 6						**436.14**	3921.69	4462.76	5532.66
Cluster 7							**0**	544.74	1162.79
Cluster 8								**0**	268.85
Cluster 9									**0**

Conclusion

In the present study, Results indicated that all the genotypes are having a wide array of variation for yield components and nutrient traits. So, these genotypes could be further utilized for crop improvement through simple selection procedures for these traits. Based on cluster means and divergence crossing of the genotypes in cluster VI with genotypes in cluster IX and cluster II genotypes with cluster VI is suggested in order to generate a wide spectrum of variability for obtaining superior genotypes, which helps in finger millet yield improvement.

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Crop-Weather Relationships: Impact of Sowing Windows and Genotype Variability on AGR, CGR, Seed and Straw Yield in Pigeonpea

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Pigeonpea (*Cajanus cajan* L.) is commonly known as red gram / arhar / tur and its origin is in South Africa. It is an important grain legume that belongs to the fabaceae (Leguminaceae) family and is a widely cultivated pulse crop in India. The growth and development of pigeonpea vary from location to location due to variability in agro-climatic and soil-water related parameters. Even in the same location, variability in growth takes place due to different growing environments created by sowing dates, cultivars and other cultural and management practices (Ahlawat and Rana, 2005). A study on phenological changes under varying weather scenarios is required to determine optimum sowing windows and suitable genotypes under different weather scenarios and evaluate their subsequent effect on pigeonpea productivity. It is, therefore, important to study how pigeonpea genotypes perform in changing weather scenarios through sowing windows, especially in the Northern Dry Zone of Karnataka. Keeping this in view, the experiment entitled "Crop-weather relationship of pigeonpea under changing weather scenarios" was executed at Regional Agricultural Research Station, Vijayapura, during *Kharif* 2021.

Methodology

The experiment was conducted at the Regional Agricultural Research Station (RARS), Vijayapura and it is located at latitude of 16^{0}46' 15.16" North, the longitude of 75^{0}44' 53.78' 'East and an altitude of 593.8 meters above the mean sea level. The soil of the experimental site is medium deep black and the texture of the soil is a clayey loam belonging to the order

Vertisols. The experiment was laid out in split plot design that consisted of 12 treatment combinations. Treatments included main plots with four sowing windows *viz*., first fortnight of June (23-24th Standard Meteorological Week), second fortnight of June (25-26th SMW), first fortnight of July (27-28th SMW) and second fortnight of July (29-30th SMW) and subplots with three genotypes TS-3R, GRG-152 and GRG-811 and replicated thrice.

Results

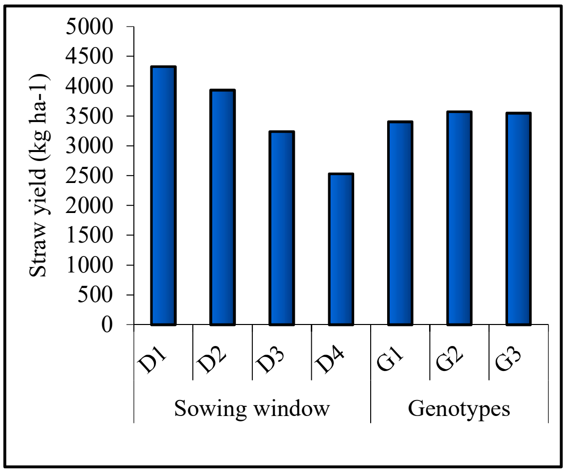
The sowing windows differed significantly for AGR at S_2-S_3 and S_3-S_5. The pigeonpea sown in 1st fortnight of June recorded significantly higher AGR at S_2-S_3 and S_3-S_5 (48.97 and 104.04 g day^{-1}, respectively), followed by 2nd fortnight of June sowing (46.14 and 94.05 g day^{-1}, respectively) and a lower value (35.50 and 67.54 g day^{-1}, respectively) in 2nd fortnight of July sowing. Variation in AGR was influenced significantly among the genotypes. GRG-152 recorded significantly higher AGR at S_2-S_3 and S_3-S_5 (44.11 and 88.49 g day^{-1}, respectively), followed by GRG-811 (43.38 and 86.70 g day^{-1}, respectively) and TS-3R (40.76 and 81.80 g day^{-1}, respectively). The CGR differed significantly due to different sowing windows. At both stages, a significantly higher CGR was observed in 1st fortnight of June sowing (1.96 and 4.16 g dm^{-2} day^{-1}, respectively), followed by 2nd fortnight of June sowing (1.84 and 3.76 g dm^{-2} day^{-1}, respectively).

Absolute growth rate (AGR) and crop growth rate (CGR) at different stages of pigeonpea genotypes as influenced by the growing environment

Treatments	AGR (g day^{-1})		CGR (g dm^{-2} day^{-1})	
	S_2 - S_3	S_3 - S_5	S_2 - S_3	S_3 - S_5
Sowing window				
D_1: 1st fortnight June	48.97	104.04	1.96	4.16
D_2: 2nd fortnight June	46.14	94.05	1.84	3.76
D_3: 1st fortnight July	40.39	77.01	1.62	3.08
D_4: 2nd fortnight July	35.50	67.54	1.42	2.70
Genotype				
G_1: TS-3R	40.76	81.80	1.63	3.27
G_2: GRG-152	44.11	88.49	1.76	3.54
G_3: GRG-811	43.38	86.70	1.74	3.47
LSD (*P=0.05*)				
Sowing window	2.43	4.79	0.11	0.19
Genotype	0.54	1.32	0.02	0.05
Sowing windows x Genotypes	1.07	2.64	0.04	0.11

S_2: Initiation of primary branch; S_3: Initiation of secondary branch; S_5: 50% flowering

The pigeonpea sown in the 1st and 2nd fortnight of June produced significantly higher seed yield (1539 and 1535 kg ha^{-1}, respectively) and were on par with each other. And we observed that each consecutive 15 days delay in the sowing from 1st fortnight of June sowing caused a reduction in seed yield by 10.01% under 1st fortnight of July and 23.61% under 2nd fortnight of July sowing. Under late sown, the plant could not accumulate sufficient photosynthates due to the short vegetative growth period, hence a less strong sink, *i.e*., the number of pods plant^{-1}, which was also reported by Singh *et al.* (2012). TS-3R, produced significantly higher seed yield compared to the rest of the genotypes. On the contrary, straw yield was higher in GRG-152 (3570 kg ha^{-1}) compared to other genotypes, which was 4.90% higher than TS-3R (3402 kg ha^{-1}). The improvement in straw yield might be due to higher biomass production and its distribution in different plant parts in GRG-152 compared to other genotypes. The genotypic variation for straw yield was also noticed and reported by (Tigga *et al.*, 2017).



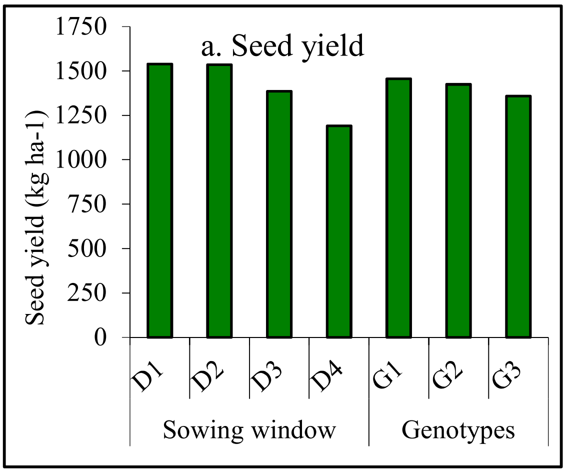


Fig. Seed yield (a) and straw yield (b) of pigeonpea as influenced by sowing windows and genotypes

Conclusion

It can be concluded that early sowing of pigeonpea in the first fortnight of June sowing recorded higher AGR, CGR, seed and straw yield. However, among the genotype GRG-152 recorded higher AGR, CGR and straw yield. Whereas TS-3R recorded a higher Seed yield.

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Performance of Black gram Varieties for Physio-biochemical and Yield Traits Under Well-water and Water-stress Conditions

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Abiotic stresses such as drought, salinity, extreme temperatures, and nutrient deficiencies significantly hinder agricultural productivity, particularly in arid and semi-arid regions. Among these, drought stress is the most severe, contributing to over 34% of global agricultural losses, with increasing instances of "hot droughts" exacerbating the problem. These conditions severely restrict water availability during critical crop growth stages, causing substantial yield losses. Pulse crops like black gram (Vigna mungo L.), an essential protein-rich staple in South Asian diets, are highly vulnerable to drought, especially during flowering stages, resulting in yield reductions of 20-30%. Despite its role in sustainable agriculture through nitrogen fixation, black gram's dependence on rainfed conditions makes it particularly susceptible to water scarcity. Black gram employs various strategies to mitigate drought stress, such as proline accumulation and changes in canopy temperature depression, which help maintain cellular stability during stress. These adaptations allow the crop to survive periods of water scarcity, albeit with a reduction in growth and yield. Understanding these mechanisms is crucial for identifying drought-tolerant genotypes and improving cultivation practices under water-limited conditions.

Methodology

The study aimed to evaluate drought responses in three black gram varieties (IPU94-1, PDU-1, and WBG108) by assessing traits indicative of drought tolerance. The experiment was conducted at ICAR-CRIDA, Hyderabad, using a pot trial in a completely randomized design with three replicates. Two watering regimes were employed:

1. **Well-watered (control):** Consistent irrigation throughout the experiment.
2. **Water-stressed:** Irrigation was withheld for five days at the pre-flowering stage until visible drought symptoms appeared, after which the plants were re-watered and grown to maturity.

The differences in soil moisture content between the well-watered and water-stressed treatments were maintained to ensure contrasting conditions. Data were collected on various morpho-physiological, biochemical traits, seed yield and yield-related traits. Statistical analyses were conducted using analysis of variance (ANOVA) and Tukey's tests to compare genotypic responses and identify key drought-resistant traits.

Results

The ANOVA showed significant genotypic differences ($p \leq 0.05$) for most traits, except for free amino acid, NDVI, days to 50% flowering, and branch number. Treatment effects were also significant for most parameters, and the genotype × treatment interaction was significant for traits such as RWC, MDA, proline content, TSS, pod weight, and seed yield.

Morpho-Physiological and Biochemical Responses

RWC declined significantly under water stress, with PDU-1 maintaining higher RWC levels compared to other genotypes, indicating better water retention and stress resilience. Membrane Stability Index (MSI) was reduced under stress, reflecting compromised cellular integrity. Chlorophyll content decreased under water stress, suggesting impaired photosynthetic efficiency. The proline accumulation increased significantly across all genotypes under stress, serving as an osmoprotectant and stabilizer of cellular structures. Total Soluble Sugars (TSS) increased under water-stress, contributing to osmotic adjustment. The malondialdehyde (MDA) content increased, indicating heightened lipid peroxidation and oxidative stress.

Yield traits

Drought stress significantly impacted yield-related traits, with reductions in pod weight, pod number, and seed yield per plant. Among the genotypes, PDU-1 showed superior performance under stress, maintaining higher yields and exhibiting resilience in physiological and biochemical traits. IPU94-1 and WBG108 showed greater yield reductions, indicating lower drought tolerance.

Under water-stressed conditions, PDU-1 exhibited the highest tolerance, followed by IPU94-1 and WBG108. This was evident in its ability to sustain physiological activities, minimize stress-induced biochemical changes, and maintain better yield parameters. PDU-1's resilience can be attributed to its efficient water-use mechanisms and better adaptation strategies under limited water availability.

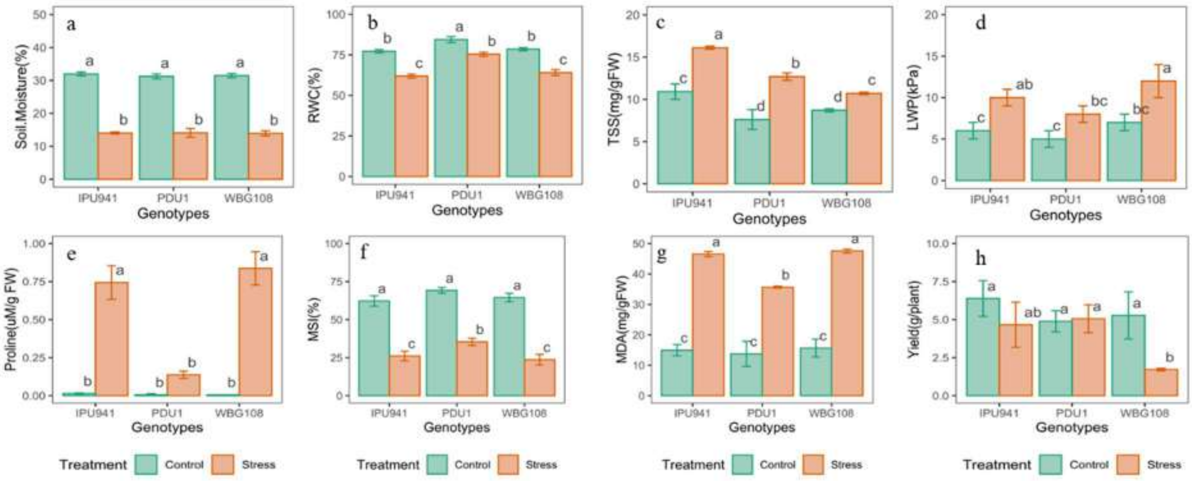
Conclusion

The study highlights the detrimental effects of water stress on black gram growth, physiology, and yield. While water stress leads to reduced growth in most morpho-physiological traits, biochemical responses such as increased proline and TSS accumulation suggest adaptive mechanisms at play. PDU-1 emerged as a promising drought-tolerant variety, demonstrating the potential for stable yields under water-limited conditions. The identification of key drought-tolerance traits, such as higher RWC, reduced MDA accumulation, and stable yield parameters, can aid in the genetic improvement of black gram. These insights can guide breeding programs and crop management strategies aimed at enhancing black gram productivity in arid and semi-arid regions. The findings underscore the importance of selecting genotypes with consistent physiological and biochemical performance under stress as potential candidates for cultivation in drought-prone areas.

Performance of black gram genotypes under well-watered and water deficit stress conditions

Treatment	Genotypes	Chlo	FAA	NDVI	DF	PH	BN	PW	PN	HSW	SY
Control	IPU94-1	2.49	0.36	0.76	26.33	19.67	3.67	10.47	36.11	3.95	6.39a
Stress	IPU94-1	1.66	0.61	0.69	27.00	19.33	4.67	5.44	21.11	3.33	4.67a
Control	PDU-1	2.71	0.41	0.79	25.67	20.00	5.00	7.06	23.67	3.85	4.89a
Stress	PDU-1	2.10	0.57	0.71	26.33	17.33	4.00	7.28	26.22	4.25	5.06a
Control	WBG-108	2.05	0.48	0.79	27.33	14.00	5.67	6.94	22.89	4.04	5.28a
Stress	WBG-108	1.48	0.51	0.67	26.00	16.67	3.67	3.50	12.00	3.43	1.72b
Control (Overall)		2.42	0.42	0.78	26.44	17.89	4.78	8.16	27.56	3.95	5.52a
Stress (Overall)		1.75	0.56	0.69	26.44	17.78	4.11	5.41	19.78	3.67	3.81b
Grand mean (Overall)		2.08	0.49	0.73	26.44	17.83	4.44	6.78	23.67	3.81	4.67
LSD 5%(Genotypes)		0.25	0.19	0.05	1.97	2.94	1.33	2.27	8.70	0.32	1.96
LSD 5%(Treatment)		0.15	0.11	0.03	1.14	1.69	0.77	1.31	5.02	0.19	1.13

Where, Tchlo=total chlorophyll content(µg/g), FAA= free amino acids (mg/g F.Wt), NDVI= normalized difference vegetation index, DF= days to 50% flowering, PH=Plant height(cm), BN=branches number/plant, PW= pod weight(g/plant), HSW=hundred seed weight (g), SY=seed yield(g/plant)



Responses of black gram varieties under well-water and water-stressed conditions

Where RWC= relative water content (%), TSS =total soluble sugar (mg/g FW), LWP = Leaf water potential (kPa), MSI= membrane stability index (%), MDA= Malondialdehyde (mg/gFW)

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Global Warming Potential of Major Crop Production Systems with Traditional and Climate Resilient Technologies in Central India

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Agriculture is a significant contributor to global greenhouse gas (GHG) emissions, accounting for approximately 14% of emissions worldwide (Smith et al., 2008). In India, traditional practices in staple crop production—such as rice, wheat, and maize—intensify emissions of methane and nitrous oxide. Mitigating these emissions is crucial for achieving India's climate goals under the Paris Agreement, which includes reducing emissions intensity by 33-35% by 2030 (Anon. 2015).Studies in South Asia, such as Bhattacharyya et al. (2012), demonstrate that conservation tillage and integrated nutrient management can cut GHG emissions by up to 40%, underscoring the potential of Climate Resilient Technologies (CRTs). This study evaluates the GWP of major crops production systems in central India under traditional and CRT based management to identify sustainable practices that balances productivity, mitigation, and climate resilience.

Methodology

Cultivation by various machines viz. Zero till drill, Zero till drill with straw handler, Happy seeder, Broad bed former, Rotary tiller assisted BBF, Slit till drill, Pre emergence zero till planter and Seed cum fertilizer drill were studied during 2021 to 2024 in Bhopal. Experiments were conducted on farmers' fields and experimental farm of CIAE in the plot of 0.2 ha each with six replications. Carbon input, output, and indices like carbon efficiency, productivity, and sustainability index were determined to evaluate Global Warming Potential (GWP) and environmental impact (Lal, 2004).

The GHG emissions were calculated for operations, inputs, and outputs, with coefficients for each source (diesel, electricity, fertilizers, and crop residues). ANOVA was used to analyze differences among treatments, and Duncan's Multiple Range Test (DMRT) identified significant variations at $P < 0.05$. SPSS software was employed for statistical analysis. Results aimed to identify efficient, climate-resilient practices minimizing emissions while maximizing productivity.

Results

The carbon footprint of cultivation with different machines is shown in Table 1. The evaluation of improved sowing machines for wheat cultivation showed significant differences in carbon efficiency and sustainability. Seed cum fertilizer drill has the highest carbon emissions at 775.4 kg CO_2/ha, indicating a significant environmental impact. Zero till drill emits 651.8 kg CO_2/ha, making it a more efficient choice. Zero till drill with straw handler carbon input was 702.5 kg CO_2/hawhile Happy seeder carbon emission was 608.1 kg CO_2/ha, most eco-friendly option among the machines. Broad bed former emitted 717.9 kg CO_2/ha, while the Rotary tiller assisted broad bed former has emissions of 685.4 kg CO_2/ha. Slit till drill (STD) proves to be the most environmentally sustainable machine, with the lowest carbon emissions at 521.5 kg CO_2/ha. Slit Till Drill, Happy Seeder, and Zero Till Drill with Straw Handler are the most sustainable choices. As no prior seed bed preparation is required during sowing with slit till drill and happy seeder which reduced the inputs and hence reduces the carbon footprints in wheat production, while the Seed cum fertilizer drill remains the least eco-friendly option.

Table 1. Carbon footprints of different improved machines for wheat production

Parameters	Improved machines						
	Seed cum Fertilizer Drill	Zero till Drill	Zero till Drill-Straw Handler	Happy Seeder	Broad Bed Former	Rotary Tiller Assisted Broad Bed Former	Slit Till Drill
Carbon input, kg CO_2/ha	812.3	706.5	702.5	608.1	717.9	685.4	558
Carbon output, kg CO_2/ha	4120.1	4292	4431.7	4360.7	4738.4	4884.8	4351.13
Carbon use efficiency	5.07	6.07	6.3	7.17	6.6	7.12	7.79
Carbon Productivity, kg/kg CO_2	5.37	6.5	6.77	7.65	7.43	7.88	8.3
GHG intensity, kg CO_2/kg	0.186	0.154	0.147	0.13	0.134	0.126	0.12
Carbon Sustainability Index (CSI)	4.07	5.07	5.3	6.17	5.6	6.12	6.79

Global Warming Potential (GWP) of different machines showed that the Seed cum fertilizer drill has the highest GWP (775.4 kg CO_2eq/ha). Slit till drill is the most environment friendly with lowest GWP (555 kg CO_2eq/ha). Zero till drills and other machines have intermediate GWP values. Hence slit till drill is most climate resilient machines. The carbon footprint of sowing soybean by different machines showed that the carbon input from Seed cum fertilizer drill was of 260.8 kg CO_2/ha and carbon output of 1837.2 kg CO_2/ha, with a carbon use efficiency of 7.04 and a Carbon Sustainability Index (CSI) of 6.04. Broad Bed Former has a higher carbon output (2268.8 kg CO_2/ha) and a CSI of 7.38. Pre-emergence herbicide zero till planter showed higher carbon sustainability index (8.14), reflecting better carbon productivity and lower GHG intensity. It occurred as herbicide is applied along with sowing operation in standing stubbles which reduces the energy input. This reduces the carbon input while sowing with pre-emergence herbicide zero till planter.

Table 2. Carbon footprints of different improved machines for soybean cultivation

Carbon footprint parameters	Improved machines		
	Seed cum Fertilizer Drill	Broad Bed Former	Pre-emergence herbicide zero till planter
Carbon input, kg CO_2/ha	260.8	270.6	266.7
Carbon output, kg CO_2/ha	1837.2	2268.8	2436.8
Carbon use efficiency	7.04	8.38	9.14
Carbon Productivity, kg/kg CO_2	5.63	7.14	7.39
GHG intensity, kg CO_2/kg	0.177	0.140	0.135
Carbon Sustainability Index (CSI)	6.04	7.38	8.14

Conclusion

The study demonstrated significant differences in the Global Warming Potential (GWP) and carbon footprints of various machines for wheat and soybean cultivation in central India. Seed cum fertilizer drill showed the highest carbon input and output, resulting in the highest GWP, while the Slit Till Drill (STD) emerged as the most eco-friendly option with the lowest GWP. Zero Till Drill and Happy Seeder also exhibited lower carbon emissions, highlighting their environmental benefits. These findings emphasize the importance of adopting climate-resilient technologies (CRTs) to reduce carbon footprints, enhance productivity, and support sustainable development goals.

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Studies on Productivity and Economics of Soybean + Millet Intercropping Systems under Dryland Condition of Akola

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Soybean is gaining popularity on account of its unique characteristics and adaptability to varied agro-climatic conditions. It has unmatched composition of 40 per cent protein and 20 per cent oil and nutritional superiority on account of containing essential amino acids, unsaturated fatty acids, carbohydrates, vitamins and minerals. Soybean is predominantly grown in Vertisols and associated soils of central India. Minor millets are the age-old crops cultivated in marginal and sub marginal lands for both food and fodder purpose. Small millets are drought tolerant crop, water requirement is very meager compared to other crops with high nutritional benefits and less susceptible to pests and diseases. Due to its wider adaptability it can be grown under varied climatic conditions. Sustainable yields can be expected from the crop even under adverse conditions and are popularly known as climate resilient crops. Intercropping of minor millets with legumes can be a viable option for the introduction of minor millets even in non-traditional areas. Hence, there is an urgent need of inclusion of minor millet crop in soybean based cropping systems. Initial slow growth of small millets will facilitate the better establishment of soybean crop. The main advantage of the intercropping is that the component crops are able to use the growth resources differently and make better overall use of growth resources than grown separately. The objectives of the experiment is to study the productivity and economics of soybean + millet inter cropping under rainfed condition.

Methodology

The experiment was conducted at the research farm of All India Coordinated Research Project for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during the *kharif* season of 2022-23. The experiment was laid out in split plot design with fourteen treatment combinations and replicated thrice. The main plot treatment comprised of seven cropping systems namely, CS_1- Sole Soybean, CS_2- soybean + foxtail millet (2:2), CS_3- soybean + foxtail millet (4:4), CS_4- soybean + finger millet (2:2), CS_5- soybean + finger millet (4:4), CS_6-soybean + barnyard millet (2:2) and CS_7- Soybean + barnyard millet (4:4). Sub plot treatment comprised of two *in-situ* moisture conservation practices *viz*., M_1- Broad Bed Furrow and M_2- non BBF (Flat bed sowing).

Results

Results regarding the yield and soybean seed equivalent yield is presented in Table 1. Soybean seed yield was recorded higher in treatment of sole soybean than other intercropping systems. In respect of soybean seed equivalent yield, significantly higher soybean seed equivalent yield was observed in treatment of Soybean + foxtail millet (4:4) inter cropping system and found on par with the cropping system of soybean + foxtail millet (2:2) intercropping system. Similar results was observed by Manjunath *et al.* (2023). In respect to i*n situ* moisture conservation practices, Broad bed furrow was recorded significantly highest soybean seed equivalent yield (1730 kg ha^{-1}).

Table 1. Yield and soybean seed equivalent yield (kg ha^{-1}) as influenced by different intercropping systems of soybean + minor millets and in situ moisture conservation practices

Treatment		Yield (kg ha^{-1})				
		Soybean	Minor millets: Foxtail millet	Minor millets: Finger millet	Minor millets: Barnyard millet	Soybean seed equivalent yield
Main plot - Cropping system						
CS_1 :	Sole soybean	1,577	-	-	-	1,577
CS_2 :	Soybean + foxtail millet (2:2)	954	918	-	-	1,717
CS_3 :	Soybean + foxtail millet (4:4)	947	1002	-	-	1,780
CS_4 :	Soybean+ finger millet (2:2)	918	-	796	-	1,580
CS_5 :	Soybean+ finger millet (4:4)	890	-	856	-	1,602
CS_6 :	Soybean+ barnyard millet (2:2)	834	-	-	728	1,439
CS_7 :	Soybean+ barnyard millet (4:4)	880	-	-	822	1,564
CD at 5 %		-	-	-	-	157.3
Sub plot - In situ moisture conservation practices						
M_1 :	BBF	1098	-	-	-	1730
M_2 :	Flat bed	902	-	-	-	1487
CD at 5 %		-	-	-	-	61.1
Interaction CD		-	-	-	-	NS

Economics of the cropping systems and *in situ* moisture conservation practices are presented in Table 2. In cropping system, gross monetary returns and net monetary returns was found significantly higher in treatment of soybean + foxtail millet (4:4) cropping system (Rs. 80911 and 46,524 ha^{-1}, respectively) and found on par with soybean + foxtail millet (2:2) intercropping system (Rs. 77959 and 43,678 ha^{-1}, respectively). In respect of moisture conservation practices, BBF (Broad bed furrow) recorded significantly highest gross monetary returns and net monetary returns (Rs. 78341 and 43776 ha^{-1}, respectively). Interaction effect of cropping system and in situ moisture conservation was found non-significant. Maximum

B:C ratio of 2.35 was observed in of Soybean + foxtail millet (4:4) intercropping system and followed by Soybean + foxtail millet (2:2). Higher B:C ratio of 2.27 was observed in BBF *in situ* moisture conservation practices. Maximum rain water use efficiency of 1.96 was observed in intercropping system of Soybean + foxtail millet (4:4) and followed by Soybean + foxtail millet (2:2). In respect of *in situ* moisture conservation practices higher rain water use efficiency of 1.91 was observed in BBF.

Table 2. Economics and rain water use efficiency (kg ha^{-1}mm^{-1}) influenced by different intercropping systems of soybean + minor millets and in situ moisture conservation practices

Treatment		Economics			Rain water use efficiency (kgha^{-1}mm^{-1})
		Gross monetary returns (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C ratio	
Main plot - Cropping system					
CS_1 :	Sole soybean	70238	34,242	1.95	1.74
CS_2 :	Soybean + foxtail millet (2:2)	77959	43,678	2.27	1.89
CS_3 :	Soybean + foxtail millet (4:4)	80911	46,524	2.35	1.96
CS_4 :	Soybean+ finger millet (2:2)	71602	37,533	2.10	1.74
CS_5 :	Soybean+ finger millet (4:4)	72656	38,544	2.13	1.77
CS_6 :	Soybean+ barnyard millet (2:2)	65516	31,653	1.93	1.59
CS_7 :	Soybean+ barnyard millet (4:4)	71223	37,170	2.09	1.72
CD at 5 %		7237	7237	-	-
Sub plot - In situ moisture conservation practices					
M_1 :	BBF	78341	43776	2.27	1.91
M_2 :	Flat bed	67403	33179	1.97	1.64
CD at 5 %		2718	2719		-
Interaction					
CD		NS	NS	-	-

Conclusion

Soybean + foxtail millet (4:4) intercropping system was found superior in respect of soybean seed equivalent yield, gross monetary returns, net monetary returns, B:C ratio and Rain water use efficiency and followed by Soybean + foxtail millet (2:2) intercropping system. In moisture conservation practices, Broad bed furrow was recorded higher soybean seed equivalent yield, gross monetary returns, net monetary returns, B:C ratio and Rain water use efficiency.

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Tillage and Weed Management Influences Weed Dynamics, Productivity and Soil Health in Maize-Wheat-Greengram Cropping System

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Crop production is a vital part of agriculture, ensuring global food security. Effective crop production starts with proper soil management, the cornerstone of agronomy. Conventional tillage (CT), characterized by deep primary tillage and secondary cultivation, is commonly used. It prepares the soil for optimal seedbed conditions, supporting seed emergence by ensuring adequate water, light, and nutrients. However, CT has significant drawbacks, including soil degradation, reduced fertility, high production costs, and environmental harm . Conservation agriculture (CA) is emerging as a sustainable alternative, especially in rainfed areas, addressing natural resource limitations and climate change . The CA involves minimal soil disturbance (no-till), permanent soil cover (mulch), and crop diversification (rotations), gaining global traction. However, weed management is a critical challenge in CA, as weeds affect crop quality and yield by harboring pests and diseases. Effective weed control in CA relies on minimal tillage, herbicide use, and innovative agronomic and engineering practices (Mishra et al. 2022). Weeds can cause yield loss ranging from 25-79% based on weed aggressiveness (Chhokar et al. 2021). Since there is an inverse relationship between weed pressure and crop yield, effective weed management in CA is crucial to achieving optimal yields. Therefore, effective weed management in CA is important to obtain good crop yields. Maize-wheat-greengram is an important cropping system that is significantly affected by weed infestation. Though, prevalence of weed is largely dependent on management practices.

Methodology

A field experiment was conducted during 2017-2023 on the *vertisol* of ICAR-Directorate of Weed Research, Jabalpur, Madhya Pradesh, India to evaluate the performance of crop establishment methods and weed management practices on weed dynamics, productivity, profitability and soil health on maize-wheat-greengram system. The soil of the study area was medium in organic carbon, available nitrogen, low in phosphorus, and high in potash with a neutral pH. The study was executed in a split-plot design with three replications. The main plot comprised six tillage practices (CT-CT-CT, CT-ZT-ZT, ZTR-ZT-ZTR, ZT-ZTR-ZTR, ZTR-ZTR-ZTR, ZT-ZT-ZT) and four weed management practices (recommended herbicides, herbicide rotation, integrated weed management and control) (detailed in table 1) comprising twenty-four treatments. The crops were sown with a happy seed drill and supplied with 120: 60: 40 kg N, P_2O_5 and K_2O/ha in maize and wheat while 20:60:40 kg N, P_2O_5 and K_2O/ha in greengram. Rest of the management practices were followed as per the recommendation for the crop in the study area. Species-wise weed density and weed biomass were recorded at 60 DAS. Data were subjected to square root transformation (√x+0.5) to normalize their distribution. ANOVA was performed using SAS window version 9.3.

Results

Results revealed that there was a clear shift in weed flora under CA, in CA, grassy weeds were more dominant over others in maize-wheat-greengram system. In maize, there was dominance of *E. colona, D. sanguinalis* and *D. annulatum*, while in wheat, there was *A. ludoviciana, C. dactylon, D. sanguinalis* and *D. retroflexa*, in greengram *E. colona, D. sangionalis, C. dactylon* and *D. annulatum*.

Table 1. Tillage and weed management practices on weed control efficiency, system crop and water and energy productivity and profitability in maize-wheat-greengram system

Treatment	Weed control efficiency (%)			System crop and water productivity			Energy productivity			Economics	
CEM	Maize	Wheat	Green gram	SP (t/ha)	IWP (kg/ha/ mm)	WP (kg/ha/ mm)	NE (104 MJ/ha)	EP (kg/ MJ)	Energy profitability	NR (Lakhs/ ha)	B:C
CT-CT-CT	-	-	4	10.94d	33.7d	6.3d	23.19b	0.66b	20.36b	1.07d	2.18d
CT-ZT-ZT	19	-	-	11.53c	45.7c	7.0c	25.11a	0.77a	24.42a	1.21c	2.38c
ZTGR-ZT-ZTWR	43	38	5	12.17b	52.9b	7.5bc	16.91c	0.41c	11.05c	1.34b	2.56b
ZT-ZTMR-ZTWR	49	3	21	12.45b	55.3b	7.7ab	11.67d	0.40c	11.35c	1.39b	2.61b
ZTGR-ZTMR-ZTWR	55	48	27	13.16a	59.8a	8.1a	11.37d	0.17d	3.19d	1.52a	2.77a
ZT-ZT-ZT	21	1	10	11.52c	46.5c	7.0c	25.12a	0.80a	25.71a	1.22c	2.42c
					Weed management						
W1	50	81	84	11.70b	46.8b	7.1b	18.58b	0.53b	15.72b	1.24b	2.40b
W2	74	95	98	15.66a	62.6a	9.5a	27.82a	0.71a	22.01a	1.94a	3.20a
IWM	87	99	95	16.01a	64.0a	9.7a	28.63a	0.70a	22.34a	1.97a	3.11a
Weedy check	-	-	-	4.48c	17.9c	2.7c	0.54c	0.20c	3.99c	0.03c	1.03c

Regardless of crop adoption of ZTR-ZTR-ZTR recorded a reduction in weed density by 9.6-16.9%, whereas biomass reduction was 16.8-22.5% over CT-CT-CT system. Among weed management practices, the adoption of HR and IWM was comparable, controlling weed density by 73-90.3% and biomass by 87-99% over weedy check. System productivity in ZTR system was higher [13.16 t/ha of maize equivalent yield MEY)] while it was only 10.94 t/ha in conventional system. System irrigation and water productivity were higher with ZTR system over CT system. System profitability was also measured more with ZTR system than that of CT system. In the maize-wheat-greengram system, adoption of herbicide rotation and IWM controlled large groups of weeds. Among weed management practices, adoption of IWM obtained highest system productivity in terms of MEY, system irrigation and water productivity and system profitability these were followed by HR. All system indices were recorded as the lowest with weedy check. Therefore, it can be concluded that the adoption of ZTR system with either herbicide rotation or integrated weed management will provide better weed control, higher system crop-water and energy productivity and profitability in maize-wheat-greengram cropping system.

Conclusion

Weed control is one of the greatest impediments for successful crop production and especially for the application of CA systems. Appropriate and judicious management of weeds is needed to make the CA a successful and profitable one. Based on the findings, triple ZT with retention of full crop residues along with integrated weed management and sequential application of herbicides provided excellent weed control, better crop and water productivity. Similarly, higher energy productivity and profitability were also obtained under ZTR-ZTR-ZTR with IWM.

UID: 1231

Performance of Bt. Cotton (*Gossypium Hirsutum* L.) Hybrids Under High Density Planting in Rainfed Condition

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Cotton is considered as one of the most important fiber and cash crop and plays a dominant role under rainfed conditions but the constraints of rainfed agriculture make it difficult for optimum use of resources. Practicing High Density Planting System (HDPS) is now being conceived as an alternate production system having potential for improving productivity and profitability. With these objectives a field experiment was conducted at AICRP on Dryland Agriculture farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during kharif 2021-2022. In all twelve-treatment combinations, consisting of three Bt cotton Hybrid (RCH-608, ACH-5 and NCS-9011) in and four plant spacings (90 cm x 15 cm, 90 cm x 22.5 cm, 90 cm x 30 cm and 80 cm x 20 cm) were evaluated in split plot design with three replications. The results showed that High Density Planting System (HDPS) produces fewer bolls/plant than conventional planted cotton but yield maximization is due to higher percentage of the total bolls/ha. The Bt. Cotton Hybrid ACH-5 recorded significantly higher values of growth attributes, bolls/plant (20.27), boll weight (3.52 g), seed cotton yield/plant(64.85 g) and seed cotton yield/ha (2794 kg/ha). The plant spacing 90 cm x 15 cm (74,074 plants/ha) recorded significantly lower values of growth attributes, bolls/plant(16.40), boll weight (2.69 g), seed cotton yield/plant (43.10 g) but significantly higher seed cotton yield/ha (2790 kg/ha) recorded due to a greater number of plants/ha. In direct comparison with RCH-608 and NCS-9011, Bt. Cotton hybrid ACH-5 demonstrated exceptional performance across various parameters including growth attributes, lint yield, seed cotton yield, and net monetary returns.

A plant density of 37,037 plants/ha exhibited notable advantages, showcasing enhanced growth with a well-balanced pattern. This density efficiently allocated dry matter to fruiting bodies, resulting in higher yield attributes, including picked bolls and seed cotton yield per plant, when compared to other plant densities (74,074, 62,500, and 49,382 plants/ha). A plant density of 74,074 plants ha-1emerged as particularly advantageous, recording elevated seed cotton yield, stalk yield, biological yield, as well as gross and net monetary returns per hectare. Notably, this plant density also exhibited the highest benefit-to-cost ratio among the tested densities. Based on the one-year trial, the conclusion suggests that adopting Bt. Cotton hybrid ACH-5 with a plant density of 74,074 plants/ha (using a 90 cm x 15 cm spacing) is not only productive but also proves to be remunerative and profitable, especially under the rainfed conditions prevalent in the Marathwada region. This result underscores the potential for enhanced cotton cultivation outcomes in this specific agro-climatic context.

UID: 1234

Effect of Sowing Time on Yield of Black Gram under Varied Environmental Conditions

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Sowing time is a non-monetary input and a key factor influencing the yield potential of Black Gram, particularly in dryland agriculture. In regions where water availability is limited, and rainfall is erratic, precise timing of sowing is essential to maximize yield and minimize cultivation costs. Black Gram, a pulse crop grown primarily in the *kharif* season, is highly sensitive to temperature, rainfall, and soil moisture during its growth stages. The timing of sowing can significantly influence the crop's ability to capitalize on available water resources and optimal temperature ranges for germination, vegetative growth, flowering, and pod formation. This research focuses on the importance of sowing time and its effect on the productivity of Black Gram in dryland farming systems, with a particular emphasis on climatic parameters and seasonal variations. The objectives of this study are to study the effect of sowing time on growth and yield of black genotype; to work out the agrometeorological indices of black gram genotype under varying environmental conditions to better understand how these factors influence soybean productivity.

Methodology

The field experiment was conducted at the research farm of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in Vidarbha region of Maharashtra, during the *kharif* season of 2023-24. The experiment was laid out in a Factorial Randomized Block Design with 9 treatment combinations comprising 3 dates of sowing viz., D1- 28 MW (10th July), D2- 29 MW (17th July) and D3- 30 MW (24th July) and three genotypes viz., V1- PDKV Black gold, V2- AKU-15 and V3- AKU 23/5, replicated three times.

Results

The study highlights the critical role of sowing time and genotype selection in optimizing Black Gram yield. Early sowing at 28 MW (10th July) accumulated the highest heat units (1139°C days), leading to superior crop performance in terms of seed yield and biological yield. The early sowing benefitted from favorable temperature and moisture conditions during the initial growth stages, which supported better crop development. Conversely, delayed sowing in 30 MW (24th July) accumulated only 1030°C days, resulting in lower yields. The shorter growth cycle in delayed sowings was likely due to temperature stress during reproductive stages, which reduced the time for crop development. The Growing Degree Days (GDD) required from pod initiation to physiological maturity were higher in early sowing and lower in late sowing, indicating the impact of temperature stress in later sowing. Among genotypes, PKDV Black gold (V1) accumulated the highest heat units (1160°C days) and performed the best in terms of seed yield and biological yield, followed by AKU-15 (V2) and AKU-23/5 (V3). This suggests that PKDV Black gold is better adapted to the growing conditions and can utilize resources more efficiently. In terms of photothermal units (PTU), early sowing (28 MW) accumulated the most 15369°C day hrs, reflecting its longer growth period. PKDV Black Gold required the most PTU, indicating its longer growth duration. Overall, early sowing and selecting high-performing genotypes like PKDV Black gold is crucial for maximizing Black Gram yield, especially in dryland conditions. The Results indicate a clear impact of sowing time and genotype on Black Gram yield. Early sowing at 28 MW (10th July) resulted in the highest seed yield (957 kg ha-1) and biological yield (2763 kg ha-1), followed by sowing at 29 MW (17th July), with seed yield of 793 kg ha-1 and biological yield of 2293 kg ha-1. Late sowing at 30 MW (24th July) resulted in the lowest seed yield (693 kg ha-1) and biological yield (2067 kg ha-1), likely due to reduced growth duration and temperature stress during reproductive stages.

Among the genotypes, PDKV Black gold (V1) outperformed the others, producing the highest seed yield (872 kg ha-1) and biological yield (2516 kg ha-1). AKU-15 (V2) followed closely with a seed yield of 854 kg ha-1 and biological yield of 2459 kg ha-1, while AKU-23/5 (V3) recorded the lowest yields, with 717 kg ha-1 for seed yield and 2148 kg ha-1 for biological yield. These findings suggest that early sowing, particularly at 28 MW, combined with high-yielding genotypes like PDKV Black gold, is crucial for maximizing Black Gram productivity under dryland conditions.

Accumulated GDD, HTU, PTU from sowing to physical maturity and seed yield and biological Yield

Treatment	GDD (^{0}C day)	PTU ^{0}C day hrs	HTU (^{0}C day hrs)	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Factor A: Sowing windows					
D1 - 28 MW (10th July)	1139	15369	3874	957	2763
D2 - 29 MW (17th July)	1078	14522	3896	793	2293
D_3 - 30 MW (24th July)	1030	13843	4142	693	2067
Factor B: Genotypes					
V1 – PDKV Black gold	1160	15526	4393	872	2516
V2 – AKU-15	1054	14232	3818	854	2459
V_3 – AKU-23/5	1033	13976	3702	717	2148

Conclusion

This study demonstrates that both sowing time and genotype selection significantly affect the yield of Black Gram. Early sowing at 28 MW (10th July) resulted in the highest seed yield (957 kg ha^{-1}) and biological yield (2763 kg ha^{-1}), benefiting from optimal temperature and moisture conditions. In contrast, late sowing at 30 MW (24th July) led to lower yields due to temperature stress and a shortened growth cycle. Among the genotypes, PDKV Black gold (V1) performed the best, yielding 872 kg ha^{-1} of seed and 2516 kg ha^{-1} of biological yield. Overall, early sowing and selecting high-yielding genotypes like PDKV Black gold are essential for optimizing Black Gram yield, especially in dryland farming.

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Effect of Elevated Temperature and Carbon Dioxide on Rice Growth and Soil Quality in Acid Soils of Northeast India

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Since Earth's creation, climate change has been unavoidable. Greenhouse gas emissions (CO_2, CH_4, and N_2O) are accelerating global climate change. CO_2 concentration rose from 280 ppm in pre-industrial times (1750 AD) to over 410 ppm today, causing a 0.84 ºC atmospheric warming. Global warming will reduce crop output, yet high CO_2 levels may boost photosynthesis and carbon fertilization. Thermal stress causes physiological changes, water stress, and increased respiration, reducing agricultural performance (IPCC, 2014). Due to rising temperatures of 1.0 to 2.0 °C, tropical and subtropical countries, including India, will produce 30% less food grain. The most stable food in India is rice, which it produces and exports the most. Rice output in India is 43.86 million acres and 137.8 million tonnes, contributing 26% to global food grain production (upag.gov.in). Roy et al. (2012) and Sing et al. (2013) found that ambient CO_2 and temperature affect rice growth and yield. Nutrient and hydrologic cycles affect physical, chemical, and biological qualities and crop yield in complicated and sluggish soil responses to climate change. For food security, it's crucial to precisely analyse how rising atmospheric CO_2 and temperature effect rice crop productivity. The aim of the present study was to investigate the effect of elevated CO_2 and temperature on maize growth parameters and its interplay with changes in soil fertility in acid soils of Meghalaya under Carbon dioxide Temperature Gradient Chamber (CTGC).

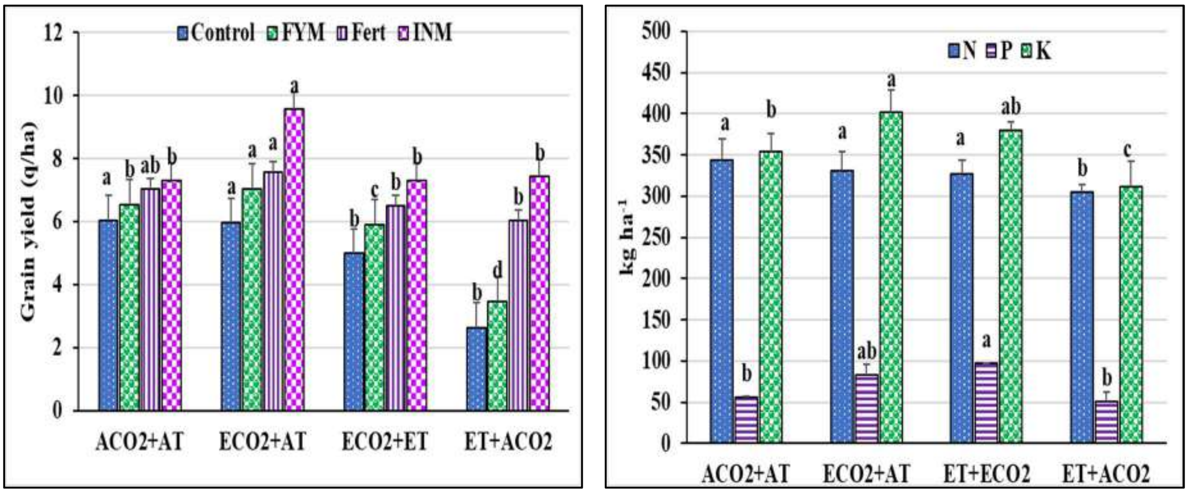
Methodology

An experiment utilizing CTGC was conducted at the NICRA Research Farm of the ICAR Research Complex for the NEH Region in Umiam, Meghalaya. The research station is located at 25°41'21" N latitude and 91°55'25" E longitude, at an elevation of 980 m above mean sea level, with an average slope ranging from 32% to 53%, in the East Khasi Hills in North-East India. The average annual precipitation is approximately 2208 mm, with a low temperature of 6.8 °C and a maximum of 29.7 °C. The main treatments were (i) ambient temperature (AT) and ambient CO_2 (ACO_2), (ii) AT and ECO_2 (550 ppm), (iii) ET (+3 ºC) and ACO_2 and (iv) ET and ECO_2. The sub-treatments were (a) Control, (b) inorganic fertilizer, (c) FYM and (d) integrated nutrient management (INM). FYM was applied at the rate equivalent to nitrogen content in FYM and P was supplemented through rock phosphate in T2 and T4, accordingly.

At the end of the harvest, plant parameters including yield were recorded as per the standard procedures. Soil pH was estimated in 1:2 ration soil: water suspension, available nitrogen (AN) by alkaline permanganate oxidation method (Subbiah and Asija, 1956), available phosphorus (AP) by molybdenum blue colour method and available potassium (AK) by using flame photometry after 1 mol L-1 NH_4OAc extraction (Jackson, 1973).

Results

The results showed that amongst the four CO_2 and temperature combinations, AT+ECO_2 combination recorded the highest value of most of the studied parameters. Highest biomass yield was observed under AT+ECO_2 (5.25 t/ha) which was 50-107% higher than other treatment combinations. Similarly, AT+ECO_2 recorded the maximum grain yield (7.53 q/ha) and showed a 12-54% increase in grain yield over other treatments. ET significantly decreased root dry weight (RDW), shoot dry weight (SDW) and grain yield about, on average, 54, 53 and 38%, respectively when compared to the ambient condition. However, the decreases were slightly less when ECO_2 was added to ET alone treatment. INM showed a significant increase in RDW (21-50%), SDW (19-65%) and grain yield (16-61%) over other nutrient management practices. ECO_2 alone and ECO_2+ET increased the soil microbial biomass carbon (SMBC) by about 11.1 and 10.7%, respectively; on the other hand, the SMBC was reduced by 8% under the ET treatment. Increase in temperature and CO2 reduced the exchangeable Al (12.1%) and exchangeable acidity (11.9%) significantly. However, increase in CO2 alone increased the total acidity and pH-dependent acidity, but ET alone and ET+ECO2 resulted in 16-61% and 10-65%% decreased the total acidity and pH-dependent acidity. Further, ET alone statistically reduced the soil quality parameters including soil enzymes activity.



Effect of elevated CO_2 and temperature on rice grain yield and NPK content in acid soils of Meghalaya

Conclusion

The study showed that rice responded positively to elevated CO_2 with respect to plant growth parameters. On the other hand, elevated temperature decreased the biomass and grain yield components of maize. ET alone decrease the HI significantly however; addition of CO_2 with ET further decreased the HI significantly. The integrated nutrient management and FYM application could be better adaptation strategies for significant recovery of the yield loss caused by the elevated temperature. Further, these adaptation strategies could also improve the soil fertility under the changing climatic scenario.

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UID: 1246

Comparative Study of Maize Varieties under Various Planting Techniques in Tarai Region during Kharif Season

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Crop management practices are critically important for increasing yield. A field trial was conducted at GB Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India, during the *Kharif* season of 2022 and 2023 to study the performance of maize varieties under different planting techniques. The two maize varieties, PSM 1 and DKC 9144, were tested using five planting techniques: flat, bed, ridgetop, ridge mid-slope, and broad ridge mid-slope on both sides of the planting methods. Growth parameters such as plant height (cm), number of leaves, and dry matter accumulation (g/plant) were recorded, with the highest values observed under the broad ridge mid-slope method. In contrast, the flat sowing method resulted in the lowest plant height, number of leaves, and dry matter accumulation.

Periodic growth parameters, including plant stand per hectare at harvest, plant height, and dry matter accumulation, were significantly higher for the hybrid DKC 9144 than the composite PSM 1. In conclusion, broad ridge mid-slope on both sides of the planting method with hybrid DKC 9144 significantly increased grain yield, stover yield, and biological yield. In conclusion, the broad-ridge mid-slope on both sides of the planting method combined with the hybrid DKC 9144 resulted in the highest growth and yield parameters. This study highlights the critical role of optimal planting techniques and cultivar selection in maximizing maize productivity during *the Kharif* season in the Tarai region.

UID: 1249

Evaluation of Groundnut Genotypes for Physio-Biochemical and Yield Traits under Water-Deficit Stress Conditions

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Groundnut (*Arachis hypogaea* L.), commonly known as peanuts, is an important leguminous plant that is widely cultivated in the tropics and subtropics spanning latitudes between 40°N and 40°S. Globally, groundnut is cultivated on 327 lakh hectares with the production of 539 lakh tonnes yielding 1648 kg per hectare (FAOSTAT, 2021). Global warming, an increasing threat, is expected to increase the water scarcity in the environment, affecting plant growth and metabolism (Abady et.al., 2021; Wang et.al., 2021). Over two-third of global peanuts are grown mainly in seasonally rainfed regions across arid and semi-arid zones where drought is a major yield limiting factor (Ravi et.al., 2010).

This study focused on assessing the responses of groundnut genotypes to water-deficit stress by analysing traits associated with stress tolerance. The goal was to elucidate the mechanisms underlying stress resilience to support the development of strategies for improving groundnut cultivation in water-limited environments.

Methodology

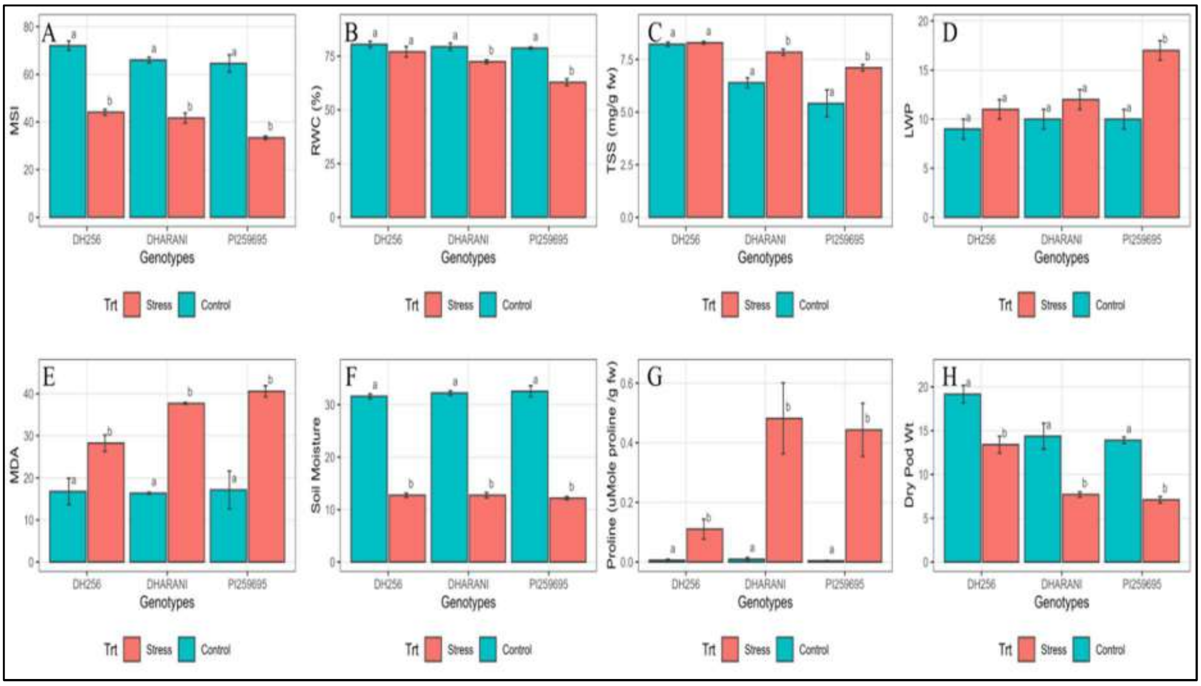
A pot experiment was conducted at the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, to evaluate drought responses in three groundnut genotypes: DH256, Dharani, and PI259695. The experiment was designed in a Completely Randomized Design with three replicates and included two watering regimes: well-watered (control) and water-stressed. In the stress regime, irrigation was withheld for five days during the pre-flowering stage until visible drought symptoms appeared, after which plants were re-watered and grown to maturity. Data on morpho-physiological, biochemical, and yield traits were collected.

Statistical analysis (ANOVA and Tukey's tests) identified drought-resistant traits, aiding the evaluation of genotypic responses and drought tolerance in groundnut genotypes.

Results

The study revealed significant reductions in soil moisture under water stress compared to well-watered conditions. ANOVA showed notable genotypic differences ($p \leq 0.05$) for most traits except days to 50% flowering and plant height. Significant genotype × treatment interactions were observed for traits like relative water content (RWC), membrane stability index (MSI), proline, total soluble sugars (TSS), and pod number, indicating that both genetic and environmental factors influenced these traits.

Water stress decreased RWC, MSI, and dry pod weight while increasing TSS, leaf water potential (LWP), proline, malondialdehyde (MDA), and free amino acids. DH256 demonstrated higher resilience, maintaining better RWC and showing less pronounced stress-induced increases in proline, TSS, and MDA compared to Dharani and PI259695. Yield-related traits were significantly impacted under stress, with greater reductions in Dharani and PI259695. Overall, DH256 exhibited superior drought tolerance, followed by Dharani and PI259695, highlighting its potential for cultivation in water-limited environments.



Conclusion

Water stress significantly reduced the growth of agro-morphological traits and adversely affected physiological traits, with genotypic responses varying due to inherent tolerance mechanisms. While adequate water is essential for optimal crop growth, water stress alters physiological and biochemical processes, hindering performance. This study highlighted diverse morpho-physiological and biochemical responses among groundnut genotypes under stress. Traits like TSS, LWP, proline, and MDA increased under stress, suggesting their potential as indicators of drought tolerance. Genotypes maintaining stable physiological activities, such as DH256, which showed superior performance under stress, can aid in identifying drought-tolerant varieties. These findings emphasize the value of morpho-physiological characterization for selecting and improving genotypes in water-limited environments

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UID: 1267

Performance of Millets-based Intercropping Systems under Organic and Integrated Production Systems

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The productivity of rainfed agriculture constituting about 51% of the cultivated area in India is already constrained by the aberrant monsoon, low and unstable yield, small farm size, degraded soil and resource-poor farmers. Climate change may further severely impact the food production and livelihoods of smallholders in these areas. Millets, also known as 'Nutri-cereals' due to their high nutritional value, are among the oldest foods known to humans and have been an integral part of Indian diet since centuries. Millets are hardy crops, mostly grown under rainfed conditions with low rainfall (200-800 mm) and perform better than other crops even during extreme weather events and in the low fertile soils. Millets also form an important source of fodder for the livestock in rainfed areas. India is the leading producer of millets in the world. About 16.9 million tonnes of millets food grains are produced in India from 12.7 million ha area, constituting about 6% of the national food grain basket. Rajasthan, Maharashtra and Karnataka are the major states in millets cultivation with a share of 35, 23 and 14% to total millets area. However, the productivity of millets is low due to various reasons such as unavailability of seeds of improved varieties, cultivation under low-fertile soils and rainfed conditions with low input use, and poor adoption of agronomic practices. Cultivation of millets can help to address some of the challenges such as nutrition and health needs, climate change mitigation and adaptation, and livelihoods of smallholders particularly in resource-constrained rainfed areas. Identification of millets-based cropping systems and appropriate production technology is one of the researchable issues to enhance millets productivity in rainfed areas.

Methodology

A field experiment was conducted during *kharif* 2023 at Gungal Research Farm of ICAR-CRIDA, Hyderabad to evaluate the performance of finger millet (*Eleusine coracana*) + pigeonpea (*Cajanus cajan*) (2:1), foxtail millet (*Setaria italica*) + pigeonpea (2:1) and little millet (*Panicum sumatrense*) + pigeonpea (2:1) under organic, control (chemical) and integrated crop management systems. The experiment was laid out in a strip-plot design with three production systems and three intercrop ping systems. In the plots under organic management, gliricida (harvested from research farm) was applied on the N equivalent basis to all the three cropping systems. In the plots under integrated management, 25% of equivalent recommended N (10 kg/ha) was applied through gliricidia. The remaining 75% N (30 kg/ha) and 100% P (20 kg/ha) and K (20 kg/ha) was applied through chemical fertilizers. The plots under control (chemical) received recommended dose of chemical fertilizers (40:20:20 kg NPK/ha) for all the three intercropping systems.

Results

In general, among the three intercropping systems, finger millet + pigeonpea (2:1) system produced 16.1 and 24.6% higher finger millet equivalent yield (FMEY) (1755 kg/ha) than foxtail millet + pigeonpea (2:1) and little millet + pigeonpea (2:1) systems, respectively. Among the three production systems, averaged across three intercropping systems, organic and integrated management being on par with each other produced significantly higher FMEY than control (chemical). Similarly, organic management produced about 240 and 310 kg/ha higher FMEY of foxtail millet + pigeonpea (2:1) and little millet + pigeonpea (2:1) system compared to control, respectively (Fig 1). Ashokh *et al* (2020) also better performance of finger millet under organic nutrient management.

In general, among the three intercropping systems, the net returns were higher from finger millet + pigeonpea (2:1) system than others. Integrated management of finger millet + pigeonpea (2:1) system gave marginally higher net returns (Rs 42300/ha) than organic management (Rs 40350/ha). However, organic production system gave higher net returns from both foxtail millet + pigeonpea (2:1) and little millet + pigeonpea (2:1) systems than that of integrated management and control.

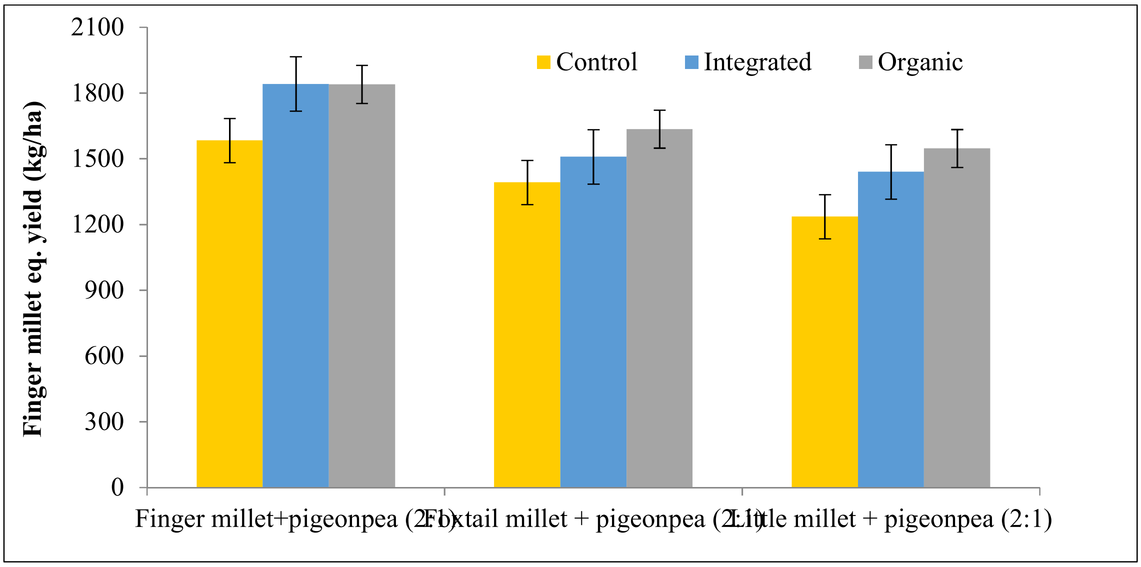

Fig 1: Performance of millets-based intercropping systems under different production systems

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UID: 1268

Broad bed + Mulch and Foliar Spray Can Alleviate Dry Spell Impact on Rainfed Maize

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Rainfed agriculture plays a pivotal role in global food security, but it remains highly vulnerable to climatic aberrations, especially dry spells. Maize (*Zea mays* L.), a critical crop for food and fodder, often suffers from productivity losses due to water stress. Employing innovative agronomic practices like improved planting methods and foliar nutrient sprays can enhance the resilience of rainfed maize against dry spells. By minimizing the cumulative impact of dry spells, yield reduction can be reduced in more than 55%, 49% and 42% areas of pearl millet, pigeon pea and groundnut growing regions of India, respectively (Bal et al., 2022). There are many foliar spray recommendations for adapting. However, these recommendations need to be compared against each other to find out the best performing one. Hence a field experiment was conducted during the kharif season to evaluate the impact of planting methods and foliar sprays on the growth, productivity and antioxidative defence system.

The study was carried out at the Gungal Research Farm of ICAR- Central Research Institute for Dryland Agriculture (17º05' N, 78º39'E) between 2023-2024. The study comprised three planting methods: conventional sowing, broad beds without mulch, and broad beds with mulch, along with five foliar spray treatments: 1% KNO_3, 0.2% nano urea, 2% urea, water spray, and a control (no spray). Foliar sprays of 1% KNO_3 and water were applied after 5–7 days of dry spells, whereas nano urea and urea were applied after the crop recovered from the dry spell.

Results showed a significant impact of both planting methods and foliar sprays on maize grain physiological parameter and yield. The results show that the effects of the dry spell were most pronounced under normal sowing, while the Broad Bed Furrow (BBF) method with mulch (91.1%) showed the highest recovery, highlighting its effectiveness in mitigating stress (Fig 1). Among foliar treatments, potassium nitrate (KNO_3) significantly improved the Relative Leaf Water Content (RLWC), aiding rapid recovery (89.2%) compared to other treatments. Urea and nano sprays enhanced nitrate reductase (NR) activity (2.7 umoles/g fw/hr) and chlorophyll content (1.7 mg g^{-1} FW), supporting better physiological resilience and recovery during the stress period (Fig 2).

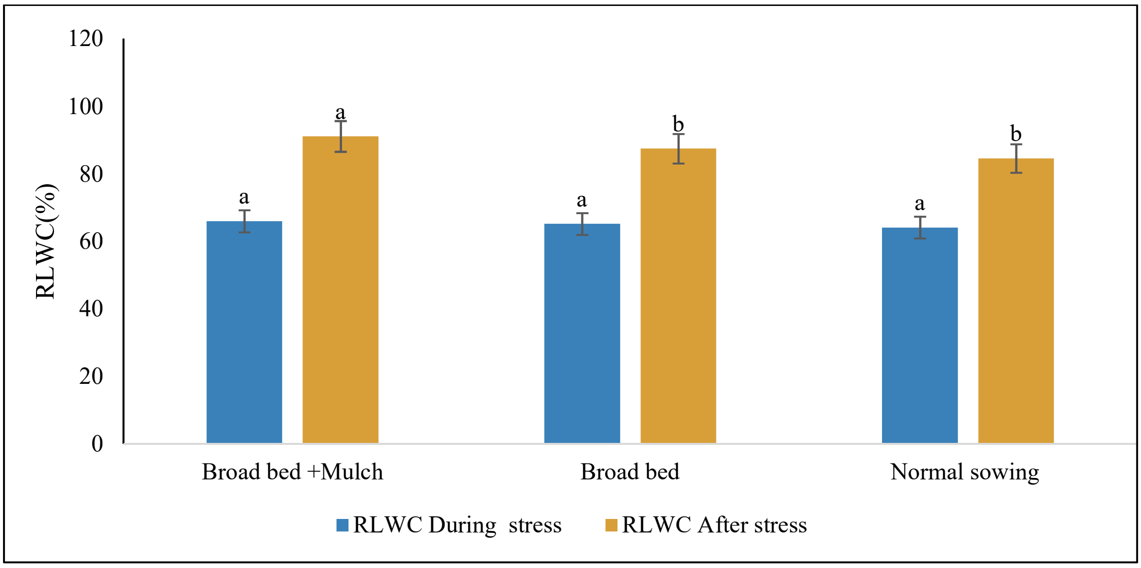

Fig 1. Relative leave water content in main plot treatments

Broad beds with mulch demonstrated the highest grain yield of 3314 kg/ha, followed by broad beds without mulch at 2908 kg/ha. Conventional sowing, recorded the lowest yield of 2048 kg/ha. The use of mulch in broad beds likely improved soil moisture retention, reducing the adverse effects of dry spells. Among the foliar spray treatments, the application of 1% KNO_3 proved most effective, resulting in the highest grain yield of 4194 kg/ha. This can be attributed to the immediate availability of potassium and nitrate ions, which enhance osmotic regulation and photosynthesis during water stress (Fig 3). Foliar sprays of 0.2% nano urea and 2% urea were equally effective in alleviating dry spell impacts, indicating their potential as alternative nutrient sources during drought conditions. The water spray treatment provided a minor benefit by reducing surface temperature and improving crop conditions, though its impact was significantly lower than nutrient-based sprays.

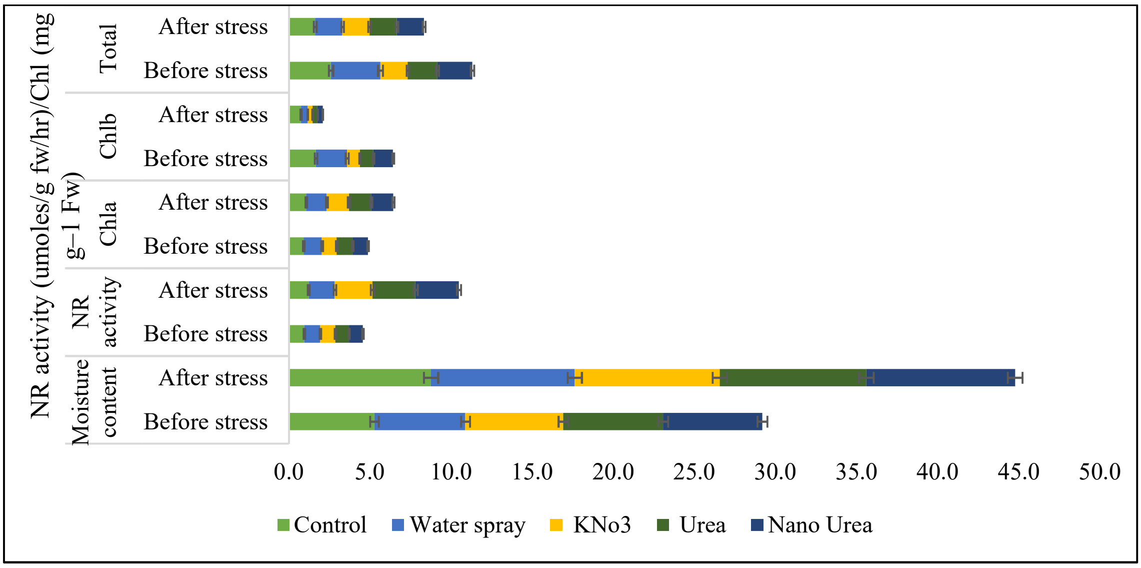

Fig 2: Physiological parameter in sub plot treatments

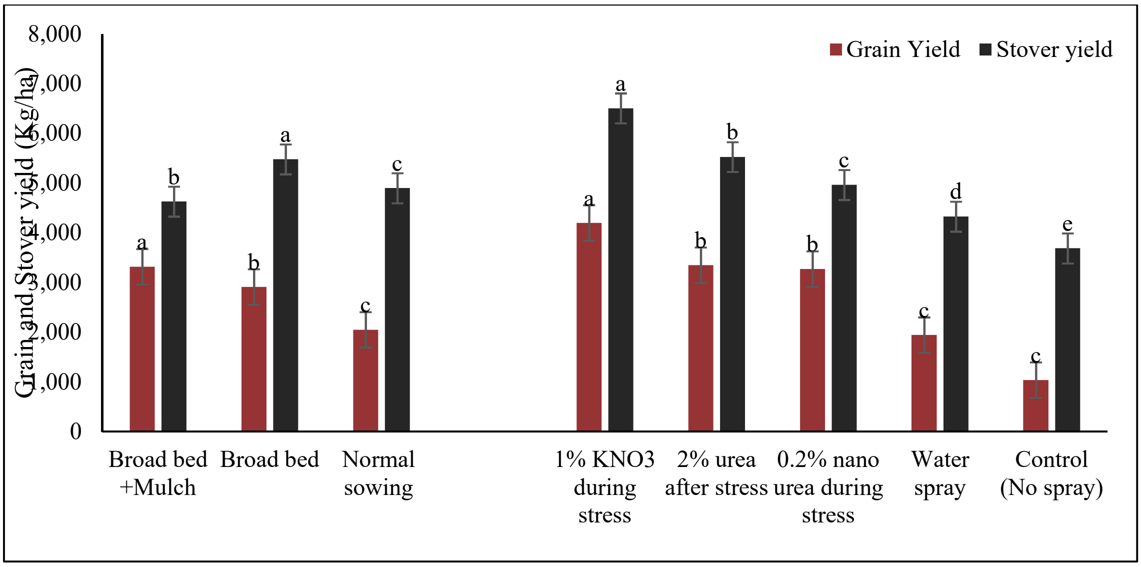

Fig 3: Grain yield and stover yield in main and sub plots

Conclusion

Based on the findings, the combination of broad beds with mulch was highly effective in enhancing maize grain yield. Additionally, the foliar application of 1% KNO_3 proved to be the most effective in maximizing grain yield, while both 0.2% nano urea and 2% urea sprays were equally efficient in mitigating the effects of dry spells, highlighting their potential for stress management.

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UID: 1270

Independent and Interactive Effects of elevated CO_2 and Temperature on Aphis craccivora on groundnut

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Global Mean Surface Temperature (GMST) and Global atmospheric CO_2 concentrations have been increasing significantly since the last 19th century, and climate change is evident in influencing agriculture. An increase in temperature and elevated CO_2 (eCO_2) influence crop growth significantly and affect the insect herbivores directly and indirectly. The impacts of climate change are spatially variable, species-specific, and complex, and comprehension of their impacts is vital in developing a suitable pest management strategy. The two dimensions of climate change i.e., elevated temperature (eTemp.) and elevated CO_2 (eCO_2), influence herbivore insect pests, and the interactive effects of both are not studied much.

Aphis craccivora Koch. is a major insect pest of leguminous crops, including groundnut. Sap removal and physiological reactions of plants to aphid feeding cause direct damage and act as an important vector of plant viral disease, transmitting over 30 plant viruses. The growth and development of insect pests are temperature-driven and termed a direct effect, and the result of elevated CO_2 on the performance of insect herbivores is an indirect effect and host-mediated. The influence of temperature and CO_2 on insect growth and development is documented individually or independently, whereas the information on their interactive effects is very scarce or poorly known. It was hypothesised that *e*Temp and eCO_2 would influence the growth and development of *A. craccivora* in the climate change scenario, and the primary data obtained will be useful for pest model development and refining pest management.

With this background, experiments were conducted to study the independent and interactive effects of *e*Temp and eCO_2 on the growth, development, and performance of *A. craccivora* on groundnut using a new facility, i.e., Carbon dioxide and Temperature Gradient Chambers. The concept, philosophy, and details of the facility are documented (Srinivasa Rao *et al* 2018). Several feeding trials were conducted by obtaining the crop foliage from respective set conditions and the treatment associations were maintained in conducting the feeding experiments by collecting the leaves from the respective CO_2 and temperature conditions.

The cut leaf method was followed in conducting feeding trials of *Aphis craccivora*. The aphids were reared individually in petri dishes and feeding trials were conducted adopting the 'cut leaf' method (Brisson *et al*., 2007). Three different sets containing ten replications (n=10) were kept for each CO_2 level, making a total of 90 aphids. The groundnut leaves with the petiole tips wrapped in a moist cotton swab were used for trials. Before placing the aphids, a moist filter paper was kept at the bottom of the petri dish to maintain the leaf turgidity and freshness. The cotton swabs were moistened daily to keep the leaf fresh, and the leaves were changed on alternate days. The fully expanded leaves were collected and used for the feeding trials. The data on development time, fecundity, and total life cycle were recorded for *A. craccivora.*

Bio chemical analysis of the groundnut leaves was done to estimate the dilution of carbon, nitrogen (C:N ratio), and polyphenol content at 30 and 60 DAS. The biochemical constituents varied in peanut foliage at two CO_2 levels, and nitrogen content (2.95%) was significantly ($F_{1,28}$ = 21.19; $P < 0.01$) reduced under eCO_2 than ambient (3.20%). In contrast, carbon content was found higher in eCO_2 foliage (39.8% and 41.1%) compared to ambient (38.8%) and did not vary significantly ($F_{1,28}$ =1.78; $P > 0.05$). However, the change in the relative proportion of carbon to nitrogen (C:N ratio) was considerably higher (13%) in eCO_2 than in ambient. Polyphenol content measured in terms of TAE was significantly ($F_{1,28}$ =13.15; $P < 0.05$) higher under elevated conditions (1.90% and 1.69%) than in ambient conditions (1.66%).

The adults produced more offspring when fed on groundnut leaves from eTemp+*e*CO_2 condition. The number of nymphs laid per female was significantly higher at *e*CO_2 than that of the *a*CO_2 and *a*Temp. The increased mean fecundity was found to be 33.3 % under *e*CO_2 than *a*CO_2.A significant reduction in longevity and development time of *A. craccivora* was noticed at 550 CO_2 over ambient, and the reduction was in the range of 9-26%. The average weight of adults and Mean Relative Growth Rate, MRGR increased significantly when reared on eTemp+eCO_2 grown leaves. The increase in average weight of adults was 116 % at 550 *e*CO_2 conditions and of MRGR was by 22.41% respectively.

The impact of *e*CO_2 on aphid species is divergent and complex. Under the influence of *e*CO_2, fecundity increased across most aphid species, albeit host crop dependency is significant. The reduced developmental time of *A. craccivora* and higher weights were noticed in our Results, and a similar result with B. *brassicae* and *Amphorophora idaei* were reported. (Martin *et al.,* 2011). The present experimental Results showed that the fecundity of *A. craccivora* increased significantly with higher MRGR at *e*CO_2 and more alate forms were produced under *e*CO_2 + *e*Temp conditions.

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UID: 1272

Nutritional Evaluation of Maize Genotypes Grown under Rainfed conditions

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Maize (*Zea mays* L.) is an important cereal crop (FAO, 2016) that belongs to family Poaceae. Maize is a rich source of macro and micronutrients, along with many phytochemicals that contributes to 8% in food basket. Phytochemicals plays an important role in our health; maize is an essential source of various phytochemicals. Due to their potent antioxidant activities phytochemicals in grains plays a significant role in reducing the risk of many diseases. The stable production of this cereal becomes a critical task for food security and also nutritional security. Its grains are important source for the production of oil, starch and glucose. Protein is one of the major requirements as many people suffered from different health issues due to protein deficiency in their diets in many of the developing countries. Maize kernels contain albumins, globulins, prolamins and glutelins. The maize embryo contains globulin and the endosperm, the major site of storage protein accumulation contains predominantly prolamins, the so called zein fraction. Agriculture plays a key role towards mitigating deficiencies of iron, zinc, vitamin A and other micronutrients So, it is considered as a sustainable solution towards mitigating micronutrient malnutrition elimination through enhancing the micronutrient density in edible parts. So, the first step is the germplasm screening/evaluation for micronutrient content. It provides the information of content in edible portions that in turn depends on the genetic makeup of the germplasm. This genotypic variation may be exploited in breeding programs to develop staple traits across the environment with enhanced ablility to maintain higher micronutrient concentration in grains.. Yet, there is little information on the mineral composition of maize germplasm grown in rainfed conditions.Thus, the present study was focused on evaluation of nutritional quality in maize genotypes.

Methodology

The metallic cations were determined in the di-acid digest of plant tissues using Atomic Absorption Spectroscopy (AOAC 1990). Nitrogen content was estimated by Kjeldahl method and crude protein was calculated by using the formula (N x 6.25). The crude protein content was calculated with conversion factor (N X 6.25). Crude fiber was estimated by using ANKOM system. Ash content was estimated by weighing of 1 g of maize seed sample in crucibles and burned in muffle furnace between 500 to 600°C to destroy all organic material. The difference in weights gives the total ash content and is expressed in percentage. Statistical analysis was done with help of SAS programme by using one way ANOVA (Version - 4.2 (4.22.0.14311) A53013) and all determinations were done in three replications and the average values were reported.

Results and Discussion

Iron content was found in the range of (3.52 - 10.40%) with mean of 5.54%. Higher iron content (10.40%) was found in genotype G37 followed by (9.24%) in G59, whereas lower iron content (3.52%) was found in genotype G5. Higher zinc content (6.14%) was found in genotype G39 followed by (5.95%) in genotype G34, whereas lower content (1.29%) was found in genotype G48. The range of phosphorus content was found in 0.96 – 2.37% with a mean of 1.48%. P content was higher (2.37%) in G74 followed by G25 (2.01%), whereas lower content (0.96%) in G29 & G37. Protein content is the second largest chemical component of the corn kernel. Protein content was found in range of (6.16 - 15.22 %) with a mean of 9.36%. Higher protein content (15.22 %) was found in genotype G95 followed by (12.11 %) in G69, whereas lower (6.16 %) was found in genotype G70. Crude fiber content was found in range of (1.60 – 4.35 %) with a mean of 2.28%. Higher crude fiber content (4.35 %) was found in genotype G53 followed by (4.20 %) in G52, whereas lower crude fiber content (1.60 %) in genotype G4. Ash content was found in the range of (0.89 –1.99 %) with a mean of 1.34%. Higher ash content (1.99 %) was found in genotype G10 followed by (1.80 %) in G74, whereas lower ash content (0.89 %) was found in G4.

Conclusion

The data indicate that seeds of maize genotypes vary greatly in term of their nutritional and mineral contents. This study helped in providing substantive nutritional information on maize, that revealed the nutritional composition of maize germplasm that helps in nutritional planning. The observed variation may be attributed to the maize variety used, environmental factors and agronomic practices as well as genetic factor. These results will be useful to know about the nutritional properties of the local maize varieties. Hence, the study is attributed to genotype and different genetic makeup since all other factors were similar to all the genotypes during cultivation. The significant variation in mineral concentration by genotypes was reported in other studies too. It can be concluded that the genotype effect was much larger than environment factors

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UID: 1274

Mutation Breeding in Chia (Salvia hispanica L.): Gamma Irradiation for Enhancing Genetic Variability of Newly Introduced Climate-resilient Crop

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Chia (Salvia hispanica L.) is recognized globally as a major plant-based source of omega-3 fatty acids and is being introduced as an alternative crop in India. Considering the lack of high-yielding varieties and genetic variability, a mutation breeding program was initiated by exposing seeds of white (Champion) and black (Local) chia varieties to gamma irradiation at 400, 500, and 600 Gy. Evaluation of the M1 generation showed that higher irradiation doses reduced germination rates, delayed seedling emergence, and stunted growth, with the Local Black variety being more severely affected than Champion White. At 5 days after sowing, Champion White's germination decreased from 88.50% (0 Gy) to 57.75% (600 Gy), while Local Black decreased from 86.25% to 56.50%. Root and shoot lengths at 30 days also declined with increased irradiation in both varieties, besides observing only 25% mortality. Novel traits such as purple pigmentation, bold seeds, altered foliage, spike shapes and pigmentation were observed in M2 and M3 under higher doses (500 and 600 Gy). In M4, a reduction in segregation for days to flowering, seed sizes, pigmentation, crinkled foliage etc. indicated stabilization of mutant lines. Interestingly, in M5, robust, extra-dwarf plants with dark green, thicker, crinkled foliage were observed in phenotypically stable lines (52-3-2). An extra-early flowering plant was also observed within a stable line (142-1-1-2) in M6. The Results highlight the optimum dose and the critical role of delayed selection in gamma radiation-induced mutation breeding to maximize the potential for genetic variability of newly introduced climate-resilient alternative crop.

UID: 1275

Pre- breeding Lines of Sunflower as Sources of Resistance to Leafhopper (*Amrasca biguttula biguttula*)

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The leafhopper (*Amrasca biguttula biguttula*) is a significant sucking pest that predominantly affects Sunflower during the *rabi* and summer seasons in India, causing yield losses of up to 40% (AICRP Sunflower, 2023), 2014). While chemical control methods are commonly used, they adversely impact pollinators. An ecologically and economically sustainable alternative is host plant resistance, which can effectively reduce the reliance on chemical insecticides. However, none of the currently available hybrids exhibit resistance to leafhoppers. Developing resistant cultivars can significantly lower plant protection costs, highlighting the urgent need to identify stable sources of resistance. Leafhopper resistance in the currently available germplasm is limited and creating variability may produce such sources. Attempts have been made to produce inter-specific crosses between *Helianthus annuus* and *H. argophyllus* through introgression. Such lines were evaluated for their reaction to leafhopper.

Methodology

A total of 60 sunflower introgression lines, derived from *H. annuus* X *H. argophyllus* and R gene pool lines (RGP) including a susceptible check, were evaluated during 2022 – 2023. In the second year (2023-24), 44 lines comprising those that exhibited resistant or moderately resistant reactions in the previous year were tested again to confirm their reaction to leafhoppers. In both years, the trials were sown on 30 January using a 60x30cm spacing and two replications. Each entry was raised in a single 3 m row in each replication. Test entries were sandwiched between susceptible check, NDCMS-2B in 2:1 ratio to increase pest density. Leafhopper counts were recorded from three leaves (top, middle and bottom) of five randomly selected plants in each replication. Injury ratings were assigned one week after the peak infestation. The ratings assessed followed a 0-5 scale. 0-Free from leafhopper injury; 1-yellowing on leaf edges up to 30%; 2-yellowing and browning up to 40%; 3-yellowing and browning up to 60%; 4-yellowing and browning up to 80%; 5- yellowing and browning of leaves up to 100%. Mean Scale Index (MSI) was calculated and entries were categorized as: Highly resistant (MSI, 0); Resistant (MSI, 0.1-1.0); Moderately resistant (MSI, 1.1-2.5); Susceptible (MSI, 2.6-3.5); Highly susceptible (MSI, 3.6-5.0) (Tabassum et al, 2021).

Results

Leafhopper population was 1.1-8 3 leaves/plant during 2022-23 and 3.0-6-11.6/ plant during 2023-24, the highest being on the susceptible check in both years. Thirty-five introgression lines/RGP lines, RGP 215, PB 1224, PB 1231, PB 1646, PB 1461, PB 1225, PB 1241, PB 1343, PB 1384, PB 1403, RGP 162, IR-1, PB 1333, PB 1456, CMS 1010B, PB 1627, RGP 236, PB 1228, PB 1232, RGP 178, PB 1343 Bold, PB 1424, PB 1429, PB 1457, PB 1462, PB 1356, PB 1617, PB 1644, PB 1349, PB 1240, PB 1425, PB 1556, RGP 252, PB 1226 and PB 1645 were found consistently resistant to leafhoppers with MSI of 1.0. Susceptible checks showed susceptible reaction in all the years. One line, RGP-306 was found resistant to leafhopper. However, it needs confirmation of its reaction to leafhopper.

Reaction of sunflower lines to leafhopper during summer, 2022-23

Sun flower entries	LH/plant	MSI	Reaction
PB 1224, PB 1225, PB 1226, PB 1228, PB 1231, PB 1232, PB 1240, PB 1241, PB 1244, PB 1343, PB 1343 Bold, PB 1349, PB 1356, PB 1384, PB 1389, PB 1403, PB 1424, PB 1425, PB 1429, PB 1432, PB 1443, PB 1456, PB 1461, PB 1599, PB 1600, PB 1609, PB 1530, PB 1537, PB 1549, PB 1617, PB 1643, PB 1644, PB 1645, PB 1649, IR 1, RGP 186, RGP 189, RGP 215, RGP 236, RGP 252, RGP 306, CMS 1010B	1.1-8.0	1.0	R
PB-1233, PB 1355, PB 1355 Bold, PB 1442, PB 1462, PB 1477, PB 1525, PB 1528, PB 1538, PB 1542, PB 1556, PB 1627, PB 1646, PB 1647, PB 1333, RGP 184, RGP-162	2.8-6.6	1.1-2.5	MR
Nil			S
NDCMS-2B (Susceptible check)	7.9	4.3	HS
Summer, 2024			
RGP-306	2.6	1.0	R
RGP 215, PB 1224, PB 1231, PB 1646, PB 1461, PB 1225, PB 1241, PB 1343, PB 1384, PB 1403, RGP 162, IR-1, PB 1333, PB 1456, CMS 1010B, PB 1627, RGP 236, PB 1228, PB 1232, RGP 178, PB 1343 Bold, PB 1424, PB 1429, PB 1457, PB 1462, PB 1356, PB 1617, PB 1644, PB 1349, PB 1240, PB 1425, PB 1556, RGP 252, PB 1226, PB 1645	3.0-10.2	1.1-2.3	MR
PB-1528, PB-1530, PB-1477, PB-1355, PB-1389, PB-1355 Bold and PB-1537.	2.9-7.2	2.6-3.4	S
NDCMS-2B (Susceptible check)	11.6	4.0	HS

LH- Leafhopper/3leaves/plant; MSI- Mean Scale Index; R- Resistant; MR-Moderately resistant; S- Susceptible; HS- Highly susceptible

Conclusion

In rain fed crops like Sunflower, the development of leafhopper resistant cultivar saves cost on plant protection, besides offering ecologically and economically pest management. The identified pre-breeding lines may be utilized in resistance breeding programmes of Sunflower against leafhopper.

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UID: 1276

Integrated Management of Charcoal Rot and Anthracnose in Soybean: Harnessing Endophytic Bacteria for Sustainable Agriculture

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Soybean (Glycine max L. Merril) is a vital oilseed crop rich in protein, widely grown in India. Charcoal rot and anthracnose diseases have recently emerged as significant threats, causing substantial global economic losses. Charcoal rot, especially, poses a critical threat, resulting in severe yield reductions. Anthracnose contributes to approximately 16-25% of soybean yield losses in India. This study explores the potential of endophytic bacteria as cost-effective, eco-friendly biological control agents for integrated disease management. Seven endophytic bacteria were evaluated in vitro against M. phaseolina, C. truncatum, and S. rolfsii. Results showed substantial inhibition of mycelial growth, with strain EB-111 exhibiting the highest inhibitory effect. Additionally, EB-53 demonstrated the highest cell wall degrading enzyme activity, including chitinase, protease, amylase, cellulase, and B-1,3-glucanase. Plant growth-promoting activities, such as nutrient solubilization and ndole-3-acetic acid (1AA) production, were also assessed. EB-53 exhibited notable capabilities in phosphorous, zinc, and potassium solubilization, while EB-24 displayed the highest IAA production. Furthermore, secondary metabolite production, including hydrogen cyanide (HCN) and siderophores, were evaluated. EB-53 showed the highest HCN production, while EB-11, EB-24, and EB-111 exhibited comparable siderophore production. The effectiveness of these potential bacterial endophytes in managing anthracnose and charcoal rot diseases was evaluated under both epiphytotic and field conditions. Seed treatment with EB-11 was most effective in managing charcoal rot, while EB-111 demonstrated superior efficacy against anthracnose. In field evaluations, EB-53 emerged as the most effective endophytic bacterial strain, resulting in significant improvements in yield attributes. In conclusion, this study highlights the potential of endophytic bacteria as valuable components of an integrated disease management strategy for soybean. The findings provide crucial insights into the biocontrol capabilities and plant growth-promoting attributes of these endophytic bacteria, offering a sustainable and eco-friendly approach to combat charcoal rot and anthracnose diseases in soybean cultivation.

UID: 1281

Impact of Temperature on Growth and Development of Sorghum Aphid, Melanaphis sacchari (Homoptera: *Aphididae*)

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Temperature-driven development and survival rates of the aphid, Melanaphis sacchari (Homoptera: Aphididae) were examined under laboratory conditions at seven constant temperatures (15, 18, 20, 25, 27, 30 and 32°C) on sorghum (Sorghum bicolor). The development duration of each nymphal instar linearly decreased with the increase in temperature from 15 to 30°C. The oviposition period showed a decreasing trend with an increase in temperature from 15°C (13.6 days) to 32°C (2.5 days). The highest mean fecundity per female per day was 4.2 offspring at 20°C. The survival ratio was the highest (95.5 to 100%) at 20 and 18°C and lowest (18.2%) at 32°C. Two linear and four nonlinear models were fitted to describe developmental rates of M. sacchari as a function of temperature and for estimating thermal constants and bioclimatic thresholds (lower, optimum and upper temperature thresholds for development: Tmin, Topt and Tmax, respectively). Estimated thresholds between the two linear models revealed that the Ikemoto-Takai linear model fit was better than the Campbell model across all the nymphal instars, except for the total nymphal developmental rate, which was fitted better by the Campbell model with an R2 of 0.8. Thermal constants required for completion of cumulative development of nymphal instars and for the total nymph were significantly lower in the Ikemoto-Takai linear model (10.9 to 17.6 and 98.9 degree-days, respectively) compared to the Campbell model. Three nonlinear models viz., Lactin-2, Briere and simplified β type distribution function performed better in describing the developmental rate for nymphal instars and total nymph based on goodness-of-fit criteria. The Lactin-2 model estimated Topt values closer to the observed maximum rates across all the nymphal instars and total nymphal development. The non-linear thermodynamic SSI model estimated the intrinsic optimum temperature which indicated no significant differences in the estimates for different geographical populations of M. sacchari. The temperature dependent growth and development of M. sacchari helps in understanding its field abundance, distribution and implications for management in sorghum.

UID: 1293

Physio-biochemical, Biomass and Yield responses of maize (*Zea mays* L.) genotypes under elevated temperature and its interaction with CO_2

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Climate change impacts crop production and productivity primarily through increased atmospheric CO_2 levels and rising temperatures. Elevated CO_2 (eCO_2) and temperature (eT) impact the growth and productivity of maize (*Zea mays* L.) crop (Ganigara *et al*., 2021). High temperatures, particularly those exceeding 35°C during pollination, can significantly reduce maize productivity by causing pollen dehydration (Hatfield *et al*., 2011). However, stress-tolerant genotypes experience less growth retardation due to their adaptive mechanisms, allowing for more stable seed yields under stress conditions. Understanding genotype-level tolerance to high temperatures is crucial for identifying resilient varieties with satisfactory productivity. While elevated CO_2 is expected to increase growth and yield, especially with C3 crop plants, some studies with C4 crops revealed that they also recorded positive responses (Ghannoum *et al*. 2000, Ira Khan *et al*. 2018). The present investigation was conducted with four maize genotypes to assess the impact of eT and its interaction with eCO_2 on phenological, physio-biochemical, biomass, and yield traits under the FATE facility.

Methodology

A pot experiment was conducted to evaluate the performance of four maize genotypes *viz*., M-22, M-24, DTL-4-1 and Harsha under Free Air Temperature and carbon dioxide Elevation (FATE) facility during *Summer* 2022. The crop experienced more than 40°C during flowering and grain filling stage. Elevated temperature (eT) was maintained as 3.0 ± 0.5°C above ambient canopy temperature (aT) and its interaction with eCO_2 ($eT+eCO_2$) was maintained at 550 ± 50ppm.

Results

The phenological parameters of flowering were early under both eT and $eT+eCO_2$ conditions except with M-24 as compared with aT condition. Increased ASI was observed with M-24 at both eT, $eT+eCO_2$ conditions due to the delay in silking being higher than anthesis, while less impact of these conditions was recorded with DTL-4-1, M-22 and Harsha (Fig. 1).

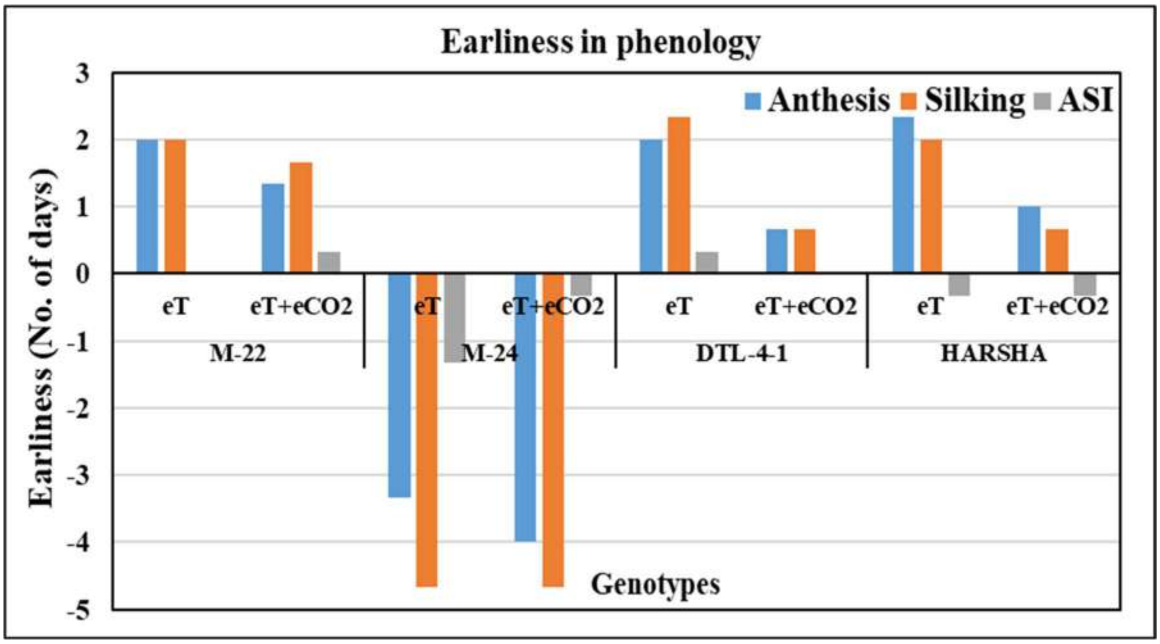


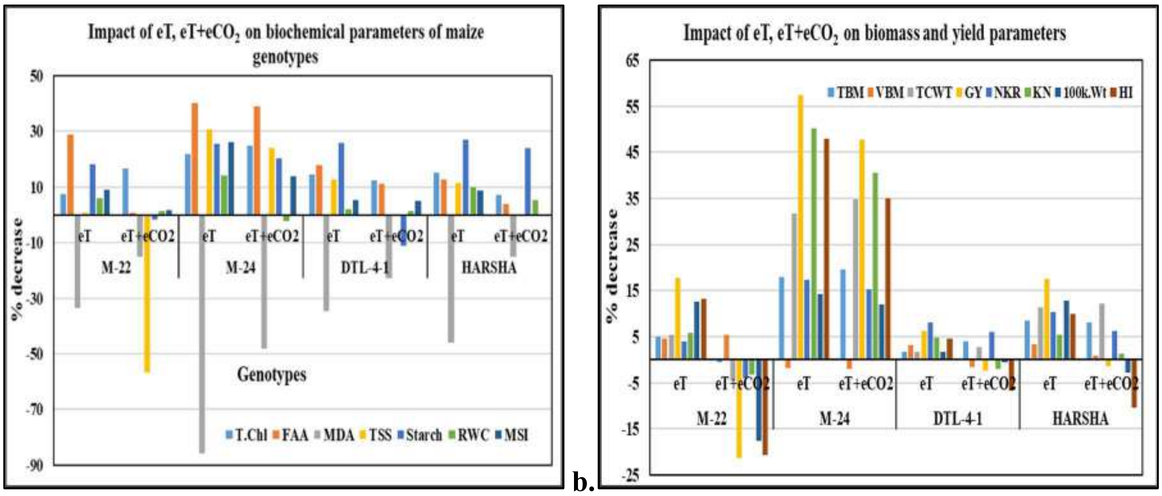
Fig. 1. Earliness in phenology of anthesis and silking under aT, eT & eT+eCO_2

Anthesis=days to 50% anthesis; Silking=days to 50% silking; ASI=anthesis silking interval

The physiological parameters- Anet, gs, Tr, WUE, RWC and CMSI decreased under eT condition, except an increase in gs and Tr was recorded with M-24. However, in the presence of eCO_2 of eT+eCO_2 treatment, the ill effects of eT on these parameters were reduced to some extent. While chlorophyll, free amino acids, TSS and starch decreased with eT and increased under eT+eCO_2 condition. The content of MDA and proline increased under eT and decreased with eT+eCO_2 condition in all the maize genotypes (Fig. 2a). The maize genotypes, DTL-4-1, M-22 and Harsha recorded less reduction of grain yield under eT however, the presence of eCO_2 reduced its impact, though maize is a C4 crop. The elevated temperature drastically reduced the grain yield of M-24 as both kernel number and filling were impacted and it could not recover even in the presence of eCO_2 of eT+eCO_2 condition (Fig. 2b).

Conclusion

Under eT condition, the maize genotype- M-24 showed increased ASI, reduced Anet, RWC, MSI, MDA, TSS, starch and accumulation of proline with a lower grain yield as compared with ambient control. In contrast, genotypes- M-22, DTL-4-1 and Harsha demonstrated better stress tolerance under eT. Their higher accumulation of proline, TSS, and starch likely protected metabolic processes from oxidative damage, helping to maintain RWC, MSI, and lower MDA levels, resulting in improved grain yields. However, in the presence of eCO_2 of eT+eCO_2 treatment, the ill effects of eT were reduced to some extent. Predominantly, M-22 was highly responsive to eCO_2 for both biomass and grain yield even at higher temperatures as compared to other genotypes. This makes M-22 a promising donor for developing new hybrids with improved biomass and grain yield under future predicted climate change conditions.



a. b.

Fig. 2. The percent reduction of a. biochemical b. biomass and yield parameters in four maize genotypes at eT and eT+eCO$_2$ over a T condition

T. Chl=total chlorophyll; FAA=Free amino acid; MDA= malondialdehyde content; TSS=total soluble sugars; RWC=relative water content; CMSI= cell membrane stability index; TBM=total biomass; VBM= vegetative biomass; TCWT= Total Cob weight; GY=grain yield; NKR=number of kernel rows; KN=kernel number; 100 K wt.= 100 kernel weight; HI= harvest index

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UID: 1296

Quinoa (*Chenopodium quinoa*) for enhancing food and nutritional security while promoting environmental sustainability in shallow basaltic semi-arid regions of India

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Recently, global agriculture is emphasizing on adopting climate resilient and environmentally sustainable practices while aiming to reduce low greenhouse gas and carbon emissions. However, the dilemma lies between feeding a growing population and depletion of its natural resource base, particularly in water scarcity environments of semi-arid and arid regions. In this context, encouraging climate-smart, nutritious crop production systems is crucial for providing accessible, affordable, safe, and nutritious diets for communities. In recent years, quinoa (*Chenopodium quinoa* Willd.) is gaining global attention as highly nutritious agro-industrial crop, capable of thriving in adverse soil and climatic conditions (Langyan et al., 2023). Due to its stress avoidance mechanism, the crop is considered highly suitable for arid and semi-arid regions with minimum supplementary irrigation (Bhargava et al., 2006). Compared to dominant cereals such as rice, wheat, and maize, quinoa stands out as a gluten-free pesudocereal rich in protein, well-balanced amino acids, essential vitamins, minerals and bioactive compounds (Sindhu and Khatkar, 2019). Its resilience and superior nutritional profile have positioned quinoa as a promising crop to combat silent hunger and malnutrition while reducing the global food environmental footprint (FAO, 2011). Since the United Nation's declaration of International Year of Quinoa in 2013, there has been rapid expansion in the cultivated area dedicated to this crop, shifting perceptions and elevating its status from a minor to a potentially major crop (Bazile et al., 2016). Bhargava et al., 2006 highlighted quinoa's potential for both agricultural and industrial applications, particularly in India. Given that a substantial portion of the Indian population lacks access to protein-rich diets, quinoa's proteinaceous seed could significantly contribute to addressing hunger. However, to date, there have been limited developments in terms of quinoa's adaptation in India, despite the country's arid and marginal environments. As with any new crop, successful introduction and establishment depend on adopting best management practices. Hence, our study focused on optimizing the sowing date, irrigation and nitrogen management to ensure successful quinoa production in water scarce marginal environments. The specific objective of our study was to assess the impact of these crop management strategies on quinoa yield, water productivity, quality and environmental sustainability in shallow basaltic semi-arid regions.

Methodology

During 2021-22 and 2022-23, a field experiment was conducted at ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra with hot and semi-arid climate. Majority of agricultural area is rainfed with low annual rainfall (584 mm) received mostly in June-December restricted to south-west (70%) and retreating (21%) monsoons. The soil of the experimental site is originated from parental basaltic rocks and characterized as shallow murrum (up to 40 cm depth) with 30% stones (> 2 mm); 48% sand, 15% silt and 7% clay. At the beginning of the experiment, the pH (1:2.5 soil: water), electrical conductivity (EC), Walkley-Black carbon (C), KMnO4 oxidisable nitrogen (N), 0.5 M NaHCO3 extractable phosphorous (P) and 1 N NH4OAc extractable potassium (K) were 7.2, 0.18 dS m^{-1}, 0.14%, 98.32 kg ha^{-1}, 2.51 kg ha^{-1} and 207 kg ha^{-1}, respectively. The experiment was laid out in a split-split plot design with four sowing dates (D1: 1st November; D2: 15th November; D3: 1st December, D4: 15th December) in main plots, two irrigation practices (I1: 40% ETc; I2: 80% ETc) in sub plots, and three nitrogen doses (N1: 100 kg N ha^{-1}; N2: 150 kg N ha^{-1}; N3: 200 kg N ha^{-1}) in sub-sub plots having three replications. The crops were irrigated based on actual crop evapotranspiration (ETc) approach. The crop yield, water productivity, carbon budgeting and sustainability parameters were determined for the crop production. Statistical analyses were executed with general linear models (GLMs) using the "Agricolae" package of R (R Development Team, 2011).

Results

Quinoa seed yield and water productivity

The seed yield was significantly higher in plots sown on 1st November (1446 kg ha^{-1}) which was reduced by 50% for sowings on 15th November and 1st December sowing, and the lowest yield was recorded for December 15th sowing (345.61 kg ha^{-1}) ($P < 0.05$) (Fig. 3). There were no differences in seed yield between the two irrigation levels. However, nitrogen levels had a significant effect on quinoa seed yield ($P < 0.05$) with maximum value under N3 (916.58 kg ha^{-1}) and N2 (815.04 kg ha^{-1}), and the latter being at par with N1 (723.50 kg ha^{-1}). The water productivity of quinoa production ranged between 0.85 kg m^{-3} to 0.18 kg m^{-3} for our study (Fig. 4). Water productivity was maximum for November 1st sowing (0.85 kg m^{-3}) followed by 15th November (0.52 kg m^{-3}), 1st December (0.37 kg m^{-3}), and was minimum for 15th December (0.18 kg m^{-3}). Providing irrigation at 40% ETc was 69.38% higher water productive than that of 80% ETc (0.36 kg m^{-3}). However, water productivity was not significantly influenced by the nitrogen levels.

Carbon budgeting, efficiency and sustainability index

Averaged over two years, the carbon budgeting and related indices differed among the treatments (Table 1). Early sowing dates i.e. 1st November sowing (S1), had lowest C footprint (0.19 kg CE kg^{-1} seed), highest C efficiency (3.69) and was more sustainable (CSI; 2.69) (P <

0.05). This might be due to improved biomass production leading to higher C output (1018.26 kg CE ha^{-1}) and moderate C input (276 kg CE ha-1) in S1. Sowing during 15th Dec (S4) resulted in highest C footprint (0.80 kg CE kg^{-1} seed), lowest C efficiency (0.88) and was not sustainable (CSI; -0.12) which was due to significantly less C output (243.31 kg CE ha^{-1}) as proportionate to the quantity of C input (279.53 kg CE ha^{-1}). Similarly, irrigating the crop at 40% ETc proved to be more C efficient and sustainable as compared to irrigating them at 80% ETc. Among the nitrogen levels, application of 100 kg N ha^{-1} (N1) registered lowest C footprint (0.33), higher C efficiency (2.14) and CSI (1.14) which was comparable to N2 i.e. 150 kg N ha^{-1}. However, higher N levels i.e. application at 200 kg ha^{-1} (N3) resulted in higher C output (632.07 kg CE ha^{-1}) but at the cost of efficiency and increased C footprint; therefore was less sustainable (CSI; 0.86).

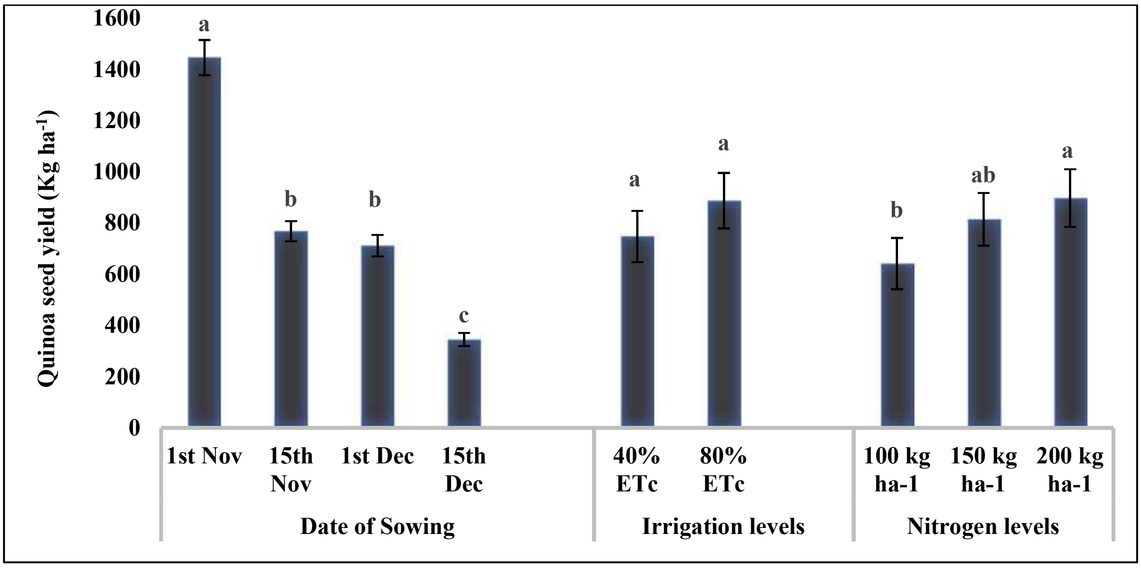

Fig 1. Effect of date of sowing, irrigation and nitrogen levels on quinoa seed yield (kg ha^{-1}).

Vertical bars represent mean ± SE of the observed values. Values followed by different lowercase letter are significantly different at $p < 0.05$ within the treatment levels according to LSD test.

Conclusion

In shallow basaltic semi-arid regions, sowing quinoa on first November with irrigation at 40% ETc and application of 100 kg N ha^{-1} were more C efficient and sustainable. Our study also confirmed quinoa's adaptability to water-scarce marginal environments and its potential for cultivation in India’s 26 million hectares of shallow basaltic *murram* soils and other similar agro-ecologies, where other food crops are less economically viable.

Table 1. Effect of date of sowing, irrigation and nitrogen levels on carbon input output parameters

Treatments	Total C output (kg CE ha^{-1})	Total C input (kg CE ha^{-1})	Carbon footprint (kg CE kg^{-1} seed)	Carbon efficiency	CSI
Date of sowing (D)					
D_1: 1st November	1018.26^{a}	276.02^{a}	0.19^{c}	3.69^{a}	2.69^{a}
D_2: 15th November	541.30^{b}	274.00^{a}	0.36^{b}	1.94^{b}	0.94^{b}
D_3: 1st December	501.68^{b}	276.21^{a}	0.38^{b}	1.85^{c}	0.85^{c}
D_4: 15th December	243.31^{c}	279.53^{a}	0.80^{a}	0.88^{d}	-0.12^{d}
LSD ($p < 0.05$)	48.7	NS	0.05	0.03	0.06
Irrigation levels (I)					
I_1: 40% ET_c	526.59^{a}	254.70^{b}	0.32^{b}	2.18^{a}	1.18^{a}
I_2: 80% ET_c	625.15^{a}	286.68^{a}	0.35^{a}	1.99^{b}	0.99^{b}
LSD ($p < 0.05$)	NS	15.7	0.01	0.01	0.01
Nitrogen levels (N)					
N_1: 100 kg N ha^{-1}	452.14^{b}	210.92^{c}	0.33^{b}	2.14^{a}	1.14^{a}
N_2: 150 kg N ha^{-1}	573.79^{a}	275.50^{b}	0.34^{b}	2.08^{ab}	1.08^{ab}
N_3: 200 kg N ha^{-1}	632.07^{a}	340.64^{a}	0.38^{a}	1.86^{b}	0.86^{b}
LSD ($p < 0.05$)	67.32	21.5	0.02	0.028	0.006

Means followed by different lowercase letters within a column are significantly different at $p < 0.05$ according to LSD test.

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Response of Rainfed Groundnut in Intercropping to Supplemental Irrigation for Alfisol Tracts of Southern Tamil Nadu

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Unpredictable dry spells and rainfall shortages present significant challenges to rainfed crop production. While in-situ rainwater harvesting techniques help retain soil moisture and meet crop water demands, they often prove inadequate during prolonged dry periods lasting 2–3 weeks. In such situations, supplemental irrigation (SI) through ex-situ rainwater harvesting, such as farm ponds, offers a reliable strategy to mitigate the negative effects of these dry spells and reduce yield losses (Reddy et al., 2012). Applying SI at small depths using micro-irrigation devices helps maintain sufficient moisture in the root zone of rainfed crops during periods of inadequate rainfall (Nangia and Oweis, 2016). Research has shown that providing SI during critical stages of crop growth during dry periods can enhance crop yields by 29% to 114% across different crops (Wani et al., 2008) and improve water productivity (Narsimlu et al., 2024). However, challenges remain in determining the optimal timing and amount of water application, as well as the practical feasibility of storing and retaining water in farm ponds, particularly in the face of significant seepage and evaporation losses (Oweis and Hachum, 2012). To address these challenges, this study aims to assess the water availability in the farm pond and evaluate the feasibility of utilizing stored water for SI of groundnut and intercrops.

Methodology

Experimental site

This research was conducted in AICRPDA Kovilpatti main centre at red soil farm, Agricultural Research Station, Kovilpatti, Tamil Nadu, India,during2021- 2023. The soil at the site is sandy loam in texture, with a field capacity of 24%, a wilting point of 9%, and an infiltration rate of 19.5 mm/hr. Long term (1974-2023) annual average rainfall was 720.2 mm (41 rainy days), with respect to seasonal rainfall, the main contribution was by North East Monsoon rainfall (NEM) i.e. 388.8 mm (21 rainy days). The maximum and minimum temperature recorded is 35.4°C and 22.4°C, respectively. The agroclimatic condition of the site is characterized by semi-arid tropics.

Experimental details

The experiment consist ofthree main plot treatments: pure rainfedcrop, crops with SI using drip system, and crops with SI using sprinkler system. The five subplottreatments (intercrops) contains of Groundnut (VRI 8) + Black gram (VBN6) (4:2), Groundnut + Cowpea (CO 7) (4:2), Groundnut + Clusterbean (Pusa Navbahar) (4:2), Groundnut + Radish (4:2), and Groundnut + Lablab (Hebbal Avare) (4:2). The experiment was laid in a split-plot design with three replications. Crops were grown with 30 X 10 cm spacing in compartmental bunding method of in-situ rainwater harvesting system.

Farm pond and irrigation equipment

A rectangular farm pond (20 m x 10 m x 2 m), lined with a 500-micron thickness, was used to harvest runoff from a 1 ha catchment area (Fig 1). A 3 HP diesel engine was used to pump water from the pond. A sprinkler with 3.5 lps discharge rate and 20 m throw radius was used for sprinkling water. Drip laterals were spaced 1 m apart, with drippers placed 60 cm apart, each delivering 4 liters per hour. Water levels, along with evaporation and seepage losses, were monitored in the pond to assess its water availability. SI at airrigation depth of 50 mm was applied during dry spells using both the sprinkler and drip systems.

Fig 1. Farm Pond at full storage capacity

Yield, Rainwater use efficiency and economics

The yield was recorded for both the main crop and intercrops, with the intercrop yields converted into main crop equivalent yield. Since, the crops are grown in rainfed regions, there was no irrigation to the crop other than rain water, the total rainwater utilized by the crop throughout the crop season to calculate rainwater use efficiency (RWUE). In case SI was given, the depth of SI would be added to cumulative depth of rainfall. The treatment-wise benefit-cost ratio was calculated based on cultivation expenses, including the cost of irrigation equipment, and the prevailing market price of groundnut to estimate income.

Results

Rainfall details and water storage in the farm pond

Water storage in farm pond during crop growth period for 2022-23 and 2023-24 is presented in Fig 2. During 2022–23, the NEM rainfall was 210.1 mm over 16 rainy days, with 4 runoff-causing rainfall of 106.2 mm generating 28.0 mm of runoff, resulting in a runoff coefficient of 0.26. A total of 280 m³ of runoff water was harvested, adding to initial pond storage of 120 m³, bringing total storage to 450 m³. SI of 50 mm was applied on 16-12-2022 and 10-01-2023 at 40 m³ each, so the total water availability at the end of the crop period reached to 148 m³ after accounting for losses.

During 2023–24, the NEM rainfall was 714.5 mm over 25 rainy days, with 11 runoff-causing events generating 299.6 mm of runoff from 583.4 mm of rainfall, giving a runoff coefficient of 0.51. A total of 2996 m³ of runoff was harvested, with an initial pond storage of 30 m³, bringing total storage to 400 m³ after overflow. SI of 50 mm was applied on 13-01-2024 and 08-02-2024 at 40 m³ each, so the total water availability at the end of the crop period reached to 160 m³ after accounting for losses.

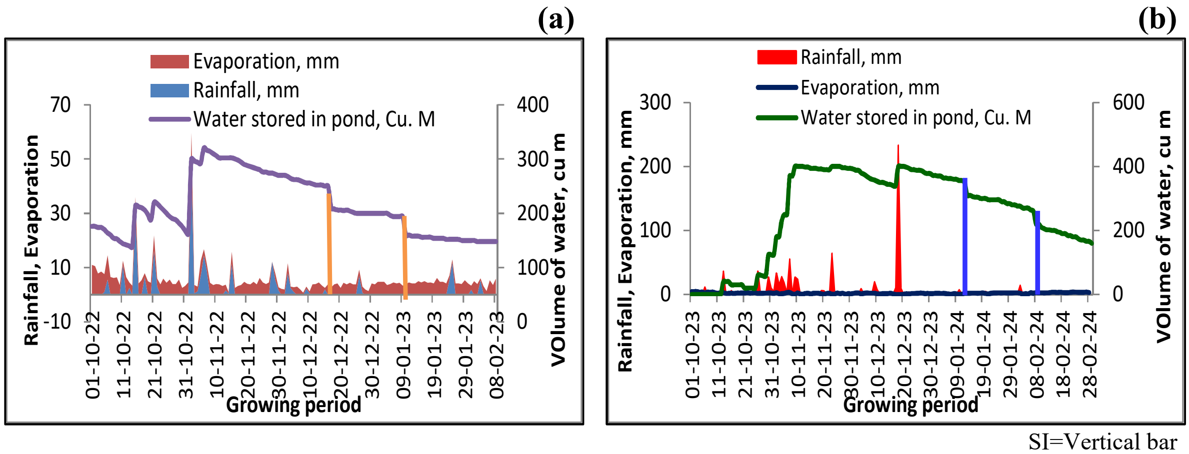

Fig 2. Water storage in farm pond during crop growth period for (a) 2022-23 and (b) 2023-24

Groundnut response to SI

Groundnut showed a positive response to the integrated use of rainwater and SI during dry spells in both years (Table). Moisture stress was observed during the 50th and 3rd SMW of 2022-23, and the 2nd and 5th SMW of 2023-2024, coinciding with the crop's maturity stage. By applying SI during this stage, certain amount of moisture required for completing maturity was refilled by both irrigationsystem. Though SI was given by sprinkler system, sufficient amount of moisture was retained in drip system. Hence, the drip system recorded the higher pod yield (1,731 kg/ha) in groundnut + black gram, with a higher RWUE of 3.95 kg/ha mm, a net return of Rs. 47,545, and a Benefit-Cost (BC) ratio of 2.23.

Response to SI on Yield, RWUE and Economics in rainfed groundnut production

Sl. No.	Main Plot	T1 - Pure rainfed			T2 - Crop with drip			T3 - Crop with sprinkler		
	Sub Plot	Yield kg/ha	WUE, kg/ha mm	B-C ratio	Yield kg/ha	WUE, kg/ha mm	B-C ratio	Yield kg/ha	WUE, kg/ha mm	B-C ratio
1	Groundnut+ Black gram	1105	3.42	1.54	1731	3.95	2.23	1580	3.63	2.09
2	Groundnut+ Cowpea	1009	3.10	1.41	1532	3.52	1.97	1408	3.23	1.86
3	Groundnut+ Clusterbean	956	2.94	1.32	1495	3.40	1.90	1374	3.13	1.79
4	Groundnut +Radish	852	2.63	1.18	1212	2.81	1.54	1174	2.74	1.53
5	Ground nut +Lablab	935	2.89	1.31	1442	3.33	1.86	1299	3.00	1.72
		T	M	T@M						
	S.Ed.	21.9	45.9	74.2						
	C.D.(P=0.05)	61.4	94.9	157.2						

Conclusion

The combined use of in-situ rainwater harvesting (compartmental bunding) and SI through the drip method using ex-situ harvested water from a farm pond offers higher production and better economic returns for groundnut intercropped with black gram. At the farm level, runoff water harvesting in a pond, along with reusing harvested water through SI and in-situ rainwater management, presents a highly effective option with significant potential to increase productivity in the rainfed alfisol of Southern Tamil Nadu.

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Uptake of major nutrients as influenced by varieties and different levels of NPK nutrients of Finger millet (*Eleusine coracana* L.) under scarce rainfall zone of Andhra Pradesh

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Finger millet (*Eleusine coracana* L.) is an important small millet grown in India and has the pride of place with the highest productivity among millets. In Andhra Pradesh, Finger millet is a prominent crop among small millets and occupies third place in production next to Karnataka and Tamil Nadu. However, the yields are low in Andhra Pradesh due to different production constraints like lack of improved varieties, prevalence of diseases like blast and banded sheath blight, lodging, moisture stress, and little research emphasis given to crop, etc. All the finger millet varieties will not respond similarly to chemical fertilizers due to their extensive genetic diversity. The productivity of finger millet can be increased through the adoption of improved varieties and the use of different levels of NPK nutrients. Knowing the fertilizer responsiveness of a variety is useful for its efficient fertilizer management.

Among all the modern agro-management practices, nutrient management is imperative for boosting the growth and production of finger millet especially under *rain fed* conditions. This aims at efficient and judicious use of the major sources of plant nutrients to get maximum economic yield without any deleterious effect on physio-chemical and biological properties of the soil.

Methodology

A field experiment was conducted at Agricultural College, Mahanandi of Acharya N.G. Ranga Agricultural University during *kharif* season from August to November, 2018 to evaluate the response of finger millet (*Eleusine coracana* L.) varieties to different levels of nutrients under the scarce rainfall zone of Andhra Pradesh. The experiment comprised four finger millet varieties *viz.,* V_1: VR-762, V_2: VR-847, V_3: Vakula and V_4: PPR-1012 and three fertility levels *viz.,* F_1: 60-30-20 N, P_2O_5 and K_2O kg ha^{-1}, F_2: 90-45-30 N, P_2O_5 and K_2O kg ha^{-1} and F_3: 120-

60-40 N, P_2O_5 and K_2O kg ha^{-1}. The experiment was laid out in randomized block design with a factorial concept (FRBD) having twelve treatments and three replications.

Results

At 30 DAS, the nitrogen uptake was significantly higher in VR-847 (24.12 kg ha^{-1}) variety followed by VR-762, PPR-1012 and Vakula (22.63, 19.12 and 18.26 kg ha^{-1}) varieties. At 60 DAS, higher nitrogen uptake was produced in VR-847 (210.01 kg ha^{-1}) variety when compared over rest of the varieties. At harvest (straw and grain), significantly higher nitrogen uptake was observed in VR-847 (178.06 kg ha^{-1} in straw and 38.71 kg ha^{-1} in grain) variety compared with VR-762, Vakula and PPR-1012 (161.22, 132.41 and 136.17 kg ha^{-1} in straw and 37.83, 35.75 and 33.46 kg ha^{-1} in grain) varieties. The higher nitrogen uptake might be due to better availability of nutrients that increase uptake of nutrients (Nigade and More., 2013, Saraswathi *et al.,* 2017 and Basavaraja *et al.,* 2017).

At 30 DAS, higher phosphorous uptake was observed with finger millet variety VR-847 (2.98 kg ha^{-1}) when compared to other varieties. However, the PPR-1012 (2.08 kg ha^{-1}) was statistically at par with Vakula (2.07 kg ha^{-1}) variety. At 60 DAS, phosphorous uptake was higher with finger millet variety of VR-847 (34.09 kg ha^{-1}) whereas, the variety Vakula (21.20 kg ha^{-1}) was statistically at par with PPR-1012 (20.54 kg ha^{-1}) variety. At harvest (straw and grain), phosphorous uptake was higher with finger millet variety of VR-847 (31.31 kg ha^{-1} in straw and 6.79 kg ha^{-1} in grain) whereas, the Vakula variety (21.36 kg ha^{-1}) was statistically at par with the PPR-1012 (20.68 kg ha^{-1}) at harvest in straw. The higher P uptake in grain might be due to increased drymatter production in reproductive parts (panicles) and nutrient content which was due to favorable environment and increased fertilizer levels that made sufficient quantities of P available in the rhizosphere which in turn helped the plants to uptake more nutrients (Vajantha *et al.,* 2017 and Prakasha *et al.,* 2018).

Among the finger millet varieties, higher potassium uptake was recorded with VR-847 (33.19 kg ha^{-1}) variety at 30 DAS, when compared to the rest of the varieties. However, lower potassium uptake was observed in Vakula (25.19 kg ha^{-1}) variety. At 60 DAS, potassium uptake was higher in VR-847 (292.53 kg ha^{-1}) variety which was superior over the rest of the treatments. At harvest (straw and grain), potassium uptake was higher in the treatment VR-847 (335.71 kg ha^{-1} in straw and 18.20 kg ha^{-1} in grain) when compared to other treatments. The increase in the potassium uptake might be due to direct fertilizer application, which solubilize the native *i.e.,* fixed and non-exchangeable form of potassium ions at later stages of crop growth that caused higher potassium uptake in straw (Nigade and More., 2013, Basavaraja *et al.,* 2017 and Saraswathi *et al*., 2017. The higher potassium uptake by grain might be due to increased growth parameters and yield parameters due to favorable environments and increased fertilizer levels available throughout the root zone that helped to uptake more nutrients (Vajantha *et al.,* 2017).

Conclusion

The nutrient uptake of nitrogen, phosphorous and potassium at 30, 60 DAS and at harvest (straw and grain) was significantly superior in the finger millet VR-847 variety. The uptake of nitrogen, phosphorous and potassium by varieties increased significantly and progressively with each increment in the level of fertilizers. Higher nutrient uptake (N, P and P) was recorded with the fertilizer level *i.e.,* application of 120-60-40 N, P_2O_5 and K_2O kg ha^{-1} at all the stages of crop growth when compared to 90-45-30 and 60-30-20 N, P_2O_5 and K_2O kg ha^{-1}, respectively.

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Performance of Pigeonpea under Rainfed Condition through Nipping Technology

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Pigeonpea is the fifth legume in the world and second in India after Chickpea. The pulses are an integral part of the cropping system all over the country. Pulses are considered the lifeblood of agriculture because they occupy a unique position in every known system of farming as a main, catch, cover, green manure, intercrop, relay and mixed crop. Modification of plant canopy architecture can strongly affect light distribution in the canopy, and total photosynthetic efficiency in turn greatly determines crop yield and yield attributes. Aslam *et al., (*2008) witnessed an increase in height and number of pods bearing branches with respect to topping of chickpea at various levels under water deficit systems. In general, when the vertical growth of plant *i.e.* apical bud is arrested or restricted, the growth of lateral branches gets induced. Above all, in the district predominantly noticed problems for pigeonpea cultivation are that, the terminal buds are usually removed in crops like cotton, castor, field peas and chickpea. Among them, optimum plant population and the number of reproductive sink/plants are the key factors determining the yield. In normal farmers practice, pigeonpea crop grows taller and plant height coupled with branching pattern Results in interlocking effect, excessive flower drop and decreased pod set which effects yield. Removal of the apical bud induces branching as a trained canopy, which influences setting and yield. Hence, while recommending nipping in pigeonpea, the details such as time of nipping, numbers and economic feasibility for higher yielding need to be verified. With this background, on farm testing were conducted to investigate the worth of high yielding and high yielding BDN 13-41 improved variety of pigeonpea with nipping operation.

Methodology

On farm testing was conducted at the adopted village of Krishi Vigyan Kendra khamgaon Beed II on nipping technology in pigeonpea variety BDN 13-41 during 2021, 2022 and 2023 in the district of Beed. The total 15 number of trials was conducted on 06 ha area each year. In general, soil of the area under study was medium to heavy and medium fertility status. The component demonstration technology in pigeonpea was comprised i.e. university recommended improved variety BDN 13-41 which was high yielding, medium duration and wilt resistant. In the on farm trial, one control plot was also kept where farmers practices was carried out. The yield data were collected from both the trial and farmers practice by random crop cutting methods and analyzed by using simple statistical tools. The percent increase yield was calculated by using following formula as per *Samui et al.,* (2000), as given below-

$$\text{Percent increase in yield} = \frac{\text{Trial yield} - \text{farmers practice yield}}{\text{farmers practice yield}} \times 100$$

Results

On farm trial studies were carried out in Beed district of Maharashtra state in *Kharif* season from 2021 to 2023. During three years of technology Results obtained are presented in Table 1. The Results revealed that the on farm trial on pigeonpea had an average seed yield recorded of 2073 kg/ha under experimental plots as compared to farmers practice of 1670 kg/ha. The highest seed yield in the experimental plot was 2220 kg/ha during 2022. The average yield of pigeonpea increased 19.27 per cent (Table 1). These Results clearly indicated that the higher average seed yield in experimental plots over the compare to farmers practice due to nipping practices and awareness of high yielding of BDN 13-41 variety. Adoption of scientific package of practices like seed treatment with bio-fertilizers and need based right plant protection practices resulted in higher yields. The above findings are similar in lines with Veeranna *et al.,* 2020. The cultivation of pigeonpea on farm trial gave higher net returns of Rs.101100, Rs. 107520 and Rs. 99000 per hectare as against to farmers practices i.e., Rs. 76400, Rs. 78860 and Rs 78000 per hectare during the years 2021, 2022 and 2023 respectively. Similar Results were observed with Zade *et al.*,2020, Singh *et al.,* 2014 and Raj *et.al.,* 2013 findings.

The Benefit: cost ratio of pigeonpea observed during different years 2021, 2022 and 2023 under on farm trial cultivation practices were 3.69, 3.75 and 3.66 respectively while it was 3.06, 3.13 and 2.88 under farmers practice for the respective years. The highest Benefit: cost ratio in OFT plots is because of higher yields obtained under improved technologies compared to farmers practices during all the three years. Similar Results were observed with Raju. G. T *et. Al.,* 2015

Yield and economic impact of pigeonpea cultivated under OFT and Farmers practice during 2021, 2022 and 2023.

Year	Average seed yield (Kg/ha)		Percent increase	Gross Income Rs./ha.		Net Income Rs./ha.		B: C Ratio	
	OFT	FP		OFT	FP	OFT	FP	OFT	FP
2021	2200	1800	18.18	138600	113400	101100	76400	3.69	3.06
2022	2220	1710	22.97	146520	112860	107520	78860	3.75	3.13
2023	1800	1500	16.66	126000	105000	99000	78000	3.66	2.88
Mean	2073	1670	19.27	137040	110420	102540	77753	3.70	3.02

*OFT-On farm testing, *FP-Farmers practice

Conclusion

The present investigation concluded that the nipping practice at 45 days after sowing in pigeonpea variety BDN 13-41 gave higher seed yield, gross monetary returns, net monetary returns and B: C ratio under rainfed condition over farmers practice in Beed district of Maharashtra.

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UID: 1301

Impact of a Rice-Based Cropping System on Biological and Chemical Properties of Soil

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Rice is also one of the key staple grain, accounting for more than 20% of their daily calorie intake for more than 3.5 billion people worldwide. The yield of the rice-rice cropping technique has reportedly stagnated or even declined according to reports of earlier studies of long-term continuous cropping in Asia. Rice productivity is declining due to decrease in soil quality, irregular rainfall and poor farming practices adopted by the farmers (Srinivasan et al. 2022). The two main strategies for rice-based agricultural systems to increase productivity per unit of resource are diversification and intensification. Additionally, it reduces pests and diseases, effectively manages human resources, lowers weather-related risks by planting and harvesting crops at different periods, and increases profitability. Including maize, pulses, and oilseeds in the R-R system is seen to be a distinct strategy for achieving improved production, profitability, and soil quality (Neogi et al. 2014). Legumes have the potential to restore soil fertility because of their deep roots, root exudation, N-fixation ability, and power to mobilise insoluble P and Zn. Rice-fallow production systems occupy the majority of cropped land across Odisha's various agro-climatic zones. Here, we hypothesized that insertion of maize, legumes and oil seed during winter season would alter soil quality. To examine the impacts of the cropping strategy on the soil's labile carbon pool, nutrient content, and microbiological characteristics, we took soil samples from the experimental field to test this hypothesis.

Methodology

The experimental site was conducted at Mahanadi delta region of Odisha, India. The experiments were designed in randomized complete block design with five treatments and four replications in a plot of 10 × 10 m. The treatments included five rice based cropping systems (i) rice-rice (R-R); (ii) sunflower-rice (S–R); (iii) maize-rice (M–R) (iv) Green gram-rice (GG-R) and (v) Black gram-rice (BG-R). Urea, di-ammonium phosphate (DAP) and muriate of potash (MOP) were applied as sources of inorganic N, P, and K fertilizers, respectively.

Composite soil sampling was performed in every season at the time of harvesting. The soil samples were in laboratory using standard procedures. For soil organic carbon, readily mineralizable carbon (RMC), microbial biomass carbon (MBC), permanganate oxidizable carbon (POC), water soluble carbohydrate carbon (WSC), available nitrogen, phosphorus and potassium were determined by using standard protocol. Total bacteria, fungi and actinomycetes population were estimated by following the serial dilution and plating. All the data analyzed for analysis of variance (ANOVA) technique as applicable to randomized complete block design.

Results

The soil labile carbons and major nutrients (N, P, K) were found to be significantly varied amongst cropping systems. After 3 cropping cycles, all the cropping systems recorded increased SOC over initial level of 0.54%. The BG–R system recorded the highest (0.59 g kg^{-1}) SOC which was 9.92, 8.02 and 8.02 % more compared to that of M–R, S-R and R-R systems, respectively. The soil labile carbon pools, mainly RMC, POC, WSC and MBC, were significantly varied among the rice based cropping system (Table 1). The RMC, POC, WSC and MBC contents of different rice based cropping system was varied from 106-145, 102-137, 14.6-25.1 and 192-234 µg C g^{-1}. The soil under the BG-R and GG-R cropping sequence had the higher labile C pool followed by S-R while the lowest was observed in the soil under the M-R cropping sequence. Legumes may increase the quantity of different C fractions in the soil by being included in the cropping sequence. This may be because legumes emit fathomable chemicals and provide microorganisms with new, protein-rich biomass, which increases the amount of various C fractions and MBC in the soil (Ghosh et al. *2020)*. In terms of available N, P, and K status of postharvest soil after a three-year crop cycle was significantly affected by different cropping systems. After balancing the nutrient removal by crop, the BG–R system recorded a significantly higher available nutrient over rest of the systems. The lowest available N (224 kg ha^{-1}) and P (15.25 kg ha^{-1}) was recorded in M-R, whereas, the lowest K (226.0 kg ha^{-1}) was recorded in R-R system. In general, the BG–R system improved available N by 9.25

% and P by 24.9 % over M-R system. The availability of N was greater in legume-based cropping system due to biological N_2 fixation in soil (Ghosh et al. *2020*). The available P was greater in GG and BG–R system due to the highest microbial activity and acid phosphatase facilitating solubilization of insoluble P. A similar result were reported by Singh et al. (2020). The GG/BG–R system augmented available K due to lower K removal by green gram and black gram.

Soil enzymes and microbial properties

Among the cropping systems, significant differences were recorded for total counts of bacteria, actinomycetes, fungi. In general, the highest microbial counts were recorded in legume-rice based cropping system, whereas the lowest in M–R system. The highest bacteria and actinomycetes counts were recorded in BG-R followed by GG–R and R-R, whereas, total counts of was the highest in BG-R, GG-R followed by R–R. The M–R system recorded the lowest counts of bacteria and actinomycetes (Fig. 1b). For fungi, the total counts showed a quiet different trend; it was the highest in R-R closely followed by S–R system. The highest microbial diversity under legume-rice systems might be associated to nutrient rich crop residue added by green gram and black gram, created more dynamic soil ecology which supported higher microbial counts and activitie. The results indicate that a cropping system having legume in a rotation exhibited better influence on such parameters. The BG–R system recorded the highest (40.4 µg g^{-1} h^{-1}) DHA activity, whereas the lowest (27.42 µg g^{-1} h^{-1}) for M–R system. The BG-R system recorded the highest urease (31.1 µg g^{-1} h^{-1}), ACP (89 µg g^{-1} h^{-1}) and ALP (88.0 µg g-1 h^{-1}) activity, which was the lowest (20.3, 75.9, 55.4 µg g^{-1} h^{-1}, respectively) in M–R system (Fig. 1c and 1d). In general, the M–R system recorded the lowest DHA, urease, ACP and ALP compared to other cropping systems. Legume-based cropping systems improve microbial and enzymatic activity due to quality biomass (low C: N ratio) addition into the soil through vigorous root growth and exudation, nodule degeneration and leaf shedding. The results of present study show that inclusion of legume in cereals increased microbe's activities and soil enzyme activities (*Ghosh* et al. *2020*; Singh et al., 2020). This could be associated with replenishing higher quality tissues, amount of biogenic materials like mineralizable nitrogen, water soluble carbon and carbohydrates from legume crop.

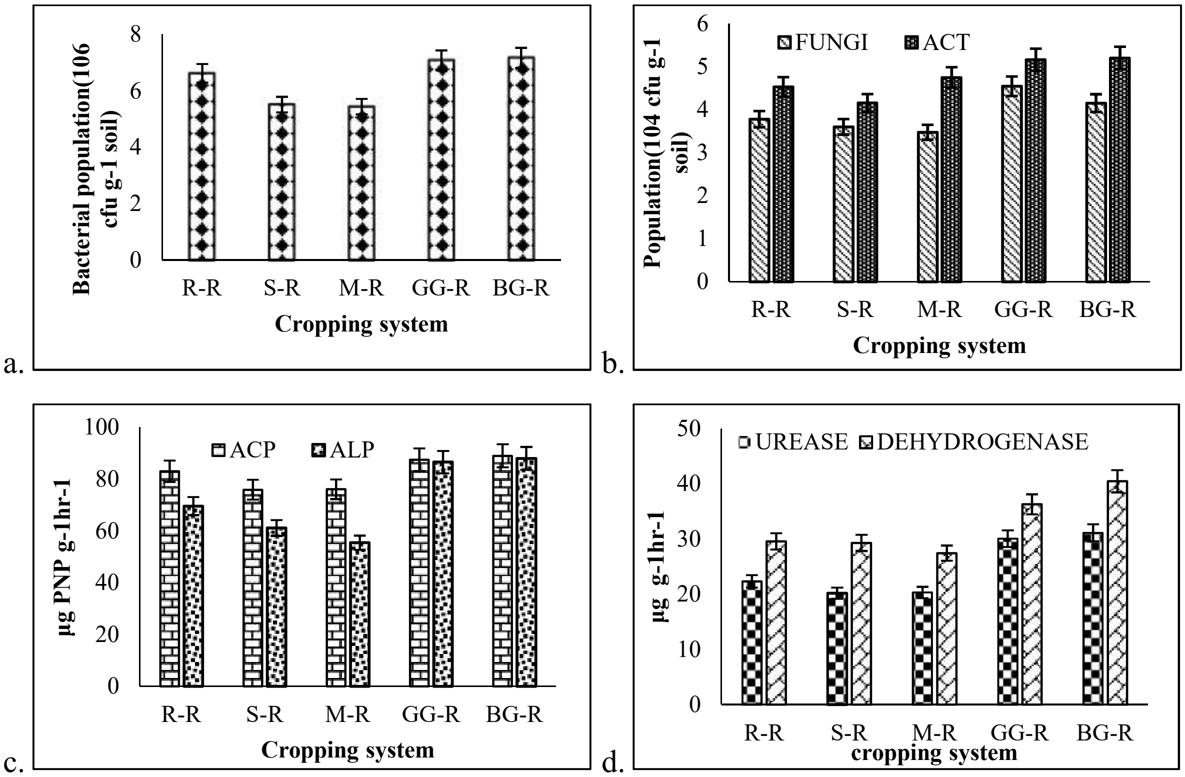
Soil carbon labile pool and major nutrient content as affected by different cropping systems, after completion of three cycles of crop harvest

Cropping system	SOC (%)	RMC (µg C g^{-1} soil)	POC (µg C g^{-1} soil)	WSC (µg C g^{-1} soil)	MBC (µg C g^{-1} soil)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
R-R	0.55	137	128	22.5	227	227	15.73	226
S-R	0.55	113	105	15.5	201	228	15.60	228
M-R	0.54	106	102	14.6	192	224	15.25	227
GG-R	0.58	145	137	23.1	234	232	17.65	257
BG-R	0.59	143	137	25.1	233	245	19.05	248
SEM(±)	0.02	2.14	1.21	0.64	1.47	4.54	0.48	22.1
LSD (P< 0.05)	0.06	6.33	3.57	1.91	4.34	13.5	1.43	65.5

Note: R-R: Rice-Rice, S- R: Sunflower-Rice, M- R: Maize-Rice, GG- R: Green Gram-Rice, BG-R: Black gram:

Conclusion

It was also observed that with rice legume followed by rice oilseed cropping led to significant improvement in soil health. A significant higher population of microorganisms was detected in rice green gram and rice black gram cropping system. Among the rice-based crop rotations, Rice–legume system proved to be the best for the soil microbial activity and organic carbon status of the soil.



Microbial counts and soil enzymes affected by different cropping systems

a; bacterial population, b; fungi and actinomycetes population, c; Acid phosphatase (ACP) and alkaline phosphatase activity (ALP); d; urease and dehydrogenase activity under different cropping system.

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UID: 1304

Assessing Soybean Genotypes for Anthracnose Resistance under Controlled Conditions

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Soybean (Glycine max), renowned for its high protein and oil content, suffers significant yield losses due to anthracnose, primarily caused by Colletotrichum truncatum. This disease impacts all parts of the plant at every growth stage, particularly in warm, humid conditions and when infected seeds are reused. Symptoms include damping off, stem cankers, veinal necrosis, leaf rolling, and premature defoliation. Existing control methods—such as rapid diagnosis, crop rotation, biological control, pathogen-free seeds, and fungicides—are costly and environmentally harmful. This study focuses on identifying resistant genotypes through advanced screening techniques. A new in vitro screening method was used, providing better control over biotic and abiotic factors, resulting in more accurate assessments. The study screened 145 elite soybean genotypes for pod blight resistance based on percent disease index (PDI) under controlled conditions using the detached pod inoculation method. Detached pods were soaked in a pathogen spore suspension and incubated under controlled conditions to observe disease progress. Various disease parameters, such as PDI and AUDPC, were used to classify the genotypes for resistance. PDI ranged from 14.67% in PUSA 37 to 92% in EC 341115. JS 9560 (Check) showed no significant difference in PDI compared to 10 genotypes among the 145 genotypes, while the remaining genotypes exhibited significantly lower PDI values than the check. The lowest AUDPC value was 2.42 in PUSA 37. Among the 145 genotypes, none were immune or highly resistant to anthracnose. However, 80 genotypes were resistant, 51 were moderately susceptible, 12 were susceptible, and 3 were highly susceptible. These findings are vital for detailed phenotyping of soybean genotypes and for identifying resistant genotypes, which can be used in breeding programs to develop anthracnose-resistant soybean cultivars.

UID: 1305

In-Vitro Assessment of Soybean Genotypes for Anthracnose Resistance

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Soybean (Glycine max), native to eastern Asia, is a valuable crop known for its economic significance, often referred to as the 'Golden bean' or 'Miracle bean.' However, its production is heavily affected by anthracnose, a fungal disease caused by Colletotrichum truncatum, which can lead to yield losses of 10% to 50%. Anthracnose thrives in warm, humid conditions, causing symptoms such as damping-off, dark spots on stems, petioles, and pods, and premature defoliation. While various control measures exist, host plant resistance provides a cost-effective, environmentally friendly solution. Traditional field-based screening methods have limitations, highlighting the need for advanced techniques to identify resistant genotypes. In this study, an in vitro evaluation using the detached pod inoculation method was employed to assess 146 soybean genotypes for resistance to anthracnose. Disease severity ranged from 2.078% (AGS 110) to 43.222% (TGX 702-4-8), with AGS 110 showing the lowest Area Under Disease Progress Curve (AUDPC) of 3.85% and TGX 702-4-8 the highest at 81.12%. Genotypes such as TGX 702-4-8, AGS 25, TGX 302A-68 D, and EC 389163 exhibited significantly higher AUDPC values, while AGS 110, BRAGG, EC 602288 (CAT 3293), and EC 241310 showed the lowest AUDPC values. Thirteen genotypes did not show significant differences from the check (JS 9560), while the remaining 133 genotypes had significantly different AUDPC values. AGS 110 consistently showed the lowest Percent Disease Index (PDI), indicating the highest resistance. Among the 146 genotypes, none were immune or highly resistant to anthracnose; however, 72 genotypes were resistant, 48 moderately susceptible, 21 susceptible, and 5 highly susceptible. These findings highlight resistant genotypes that can be utilized in breeding programs to develop anthracnose-resistant soybean cultivars.

UID: 1316

Effect of Weather Parameters on Growth and Yield of Wheat (*Triticum aestivum*) Varieties under Varied Sowing Dates

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The sowing dates of the *rabi* crops fluctuate based on the harvesting of the preceding *kharif* crop in northern India due to varying weather conditions. Therefore, to study the effect of weather parameters on the performance of wheat varieties in Jammu, field experiments were conducted at the research farm of the Agrometeorology Section, SKUAST-J, Chatha during 3 consecutive *rabi season* 2020-21, 2021-22, and 2022-23 with 3 wheat varieties (HD-2967, RSP-561, RAJ-3077) sowing on 03 different dates (05th Nov., 20th Nov. and 05th Dec.) with three replication laid in randomized block design. The three-year pooled data revealed that the wheat crop sown on 5th November took more days to complete the vegetative and reproductive stages. The significantly higher dry matter accumulation, yield attributes, and yield were recorded under the 5th November sowing as compared to the sowing done on the 20th November and 5th December. The positive correlation has been also observed between GDD and plant height, yield attributes, grain, and biological yield of wheat, resulting in higher dry matter accumulation at various stages which contributed to better yield attributes and consequently into more grain yield (35.14 q ha^{-1}) than the variety RSP-561 and RAJ-3077. The crop weather relationship developed between accumulated dry matter at different phenophases and weather parameters predicted the rate of increase in dry matter production with accumulated GDD, HTU, and PTU with an accuracy of 78, 62, and 70 percent, respectively.

Methodology

Field experiments were conducted on the research farm of Agrometeorology at SKUAST-Jammu during three consecutive *rabi* seasons from 2020-21 to 2022-23. The soil of the experimental field was sandy loam in texture with organic carbon of about 0.34 % and low in available nitrogen (214 kg/ha) but medium in available phosphorus (13.8 kg/ha) and potassium (129.8 kg/ha). The experiments were conducted with three wheat varieties *viz.* HD-2967 (V_1), RAJ 3077 (V_2), and RSP-561 (V_3) and three different sowing dates *i.e.,* 5th November (D_1), 20th November (D_2) and 5th December (D_3) during *rabi* 2020-21, 2021-22 and 2022-23 in factorial randomized block design with 9 treatment combinations and three replications. The agrometeorological indices like accumulated growing degree days (GDD), Heliothermal units (HTU), photothermal units (PTU), and Heat use efficiency (HUE) were calculated at different phenophases in wheat crops during the three years.

Accumulated GDD (°C day) = $\sum_{i=1}^{i-n} \frac{T_{max} + T_{min}}{2} - T_b$

Where, T_{max} = Maximum temperature, T_{min} = Minimum temperature, and T_b = Base temperature was taken 4.5 ^{O}C

Accumulated PTU (°C day hrs) = $\sum_{i=1}^{i-n} GDD \times N$

where, N = Day length

Accumulated HTU (°C day hrs.) = $\sum_{i=1}^{i-n} GDD \times n$

where, n = Bright sunshine hours

Heat Use Efficiency (g/m²/°C day) = $\frac{\text{Dry matter yield (g/m}^2)}{\text{AGDD (°C day)}}$

Results

The data showed that accumulated GDD accurately (R^2= 0.78) related to the dry matter at the tillering stage and the accumulation at the rate of 0.474 g/m^2 /^{0}C days, while, the rate of 0.429, 0.528, and 1.124 g/m^2 /^{0}C with very less accuracy (R^2= 0.16, 0.04 and 0.15) at jointing, flag leaf, and spike emergence, respectively. However, at later stages (anthesis and milking) the accumulated thermal time significantly plays the contribution in accumulation of dry matter at rates of 1.519 and 1.229 g/m^2/ ^{0}C with an accuracy of 0.62 and 0.70, respectively.

The seed yield of wheat crops was found significantly affected by dry matter accumulation at various phenophases (Table). The conversion efficiency of dry matter into seed yield of 2.3368 g/m^2 with better accuracy of 76 percent at the tillering stage showed that the increased number of tillers also impacted the seed yield of wheat crops. The other vegetative stages such as jointing and flag leaf stage were found non-significant in the contribution to the seed yield of wheat. While the reproductive stages viz; spike emergence, anthesis, and milking have been found to significantly affect the conversion efficiency from dry matter (source) to grain yield (sink) of wheat with the rate of 0.3234, 0.3438, and 0.3966 g/m^2 with accuracy of 69,71 and 86 percent, respectively. Out of these phenophases, the milking stage was found very crucial for the conversion of dry matter into the seed yield under optimum soil moisture, mean temperature, and photoperiod. Moreover, the anthesis and milking stages were also affected by the photoperiod significantly and accumulated dry matter @ 0.107 and 0.097 g/m^2 /^{0}C days hours with an accuracy of R^2= 0.24 and 0.30, respectively.

Conclusion

It can be safely concluded that the mean temperature above base temperature and photoperiod were found prominent weather parameters were affected the initial and reproductive phenophases of wheat crop. The variety HD 2967 was recorded the superior concerning RAJ

3077 and RSP 561, when sown on the first fortnight of November month compared to the delay in sowing dates and the milking stage observed crucial for dry matter conversion into seed yield of wheat crop under subtropics of Jammu region.

Correlation between agro meteorological indices growth, yields attributes and yield of wheat during *rabi* 2020-21 to 2022-23 (Pooled data of 3 years)

Parameters	GDD (°C days)	HTU (°C Day)	PTU (°C Day hour)
Plant height (at harvest)	0.499	-0.064	-0.082
No. of spike /m^2	0.890**	0.568*	0.576*
No. of grains/m^2	0.704**	0.432	0.391
1000 grain weight (g)	0.209	-0.262	-0.378
Grain yield (q/ha)	0.704**	0.298	0.262
Biological yield (q/ha)	0.667*	0.081	0.048

*Significant at 0.05, ** Significant at 0.01

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Management of Dry Spell Effect in *Bt* Cotton Through Land Configurations and PGR

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Cotton, the 'white gold' is cultivated on 124.69 Lakh ha in India and on 42.34 lakh ha in Maharashtra state with low productivity of 441 kg and 331 kg lint per ha, respectively (Anonymous, 2024). Major reason for low productivity in India and state as well is major area under rainfed cultivation where quantum of rainfall and its distribution doesn't favour the optimum vegetative and reproductive growth. Prolong dry spell during growth period and early cessation of rainfall are major issues creating moisture stress at critical stages of cotton. Hence an experiment was conducted to evaluate response of land configurations and plant growth regulators on growth and yield of *Bt* cotton under rainfed condition.

Methodology

The experiment was conducted at Cotton Research Station, Nanded (VNMKV, Parbhani), Maharashtra under AICRP on Cotton. The experiment was conducted on black cotton soil having 0.29% OC, low in available nitrogen, medium in P_2O_5 and high in K_2O content. Three land configurations *viz.*, Broad bed and Furrow (BBF), opening of furrow (OF) and Flat bed (FB) *i.e.* farmers' practice were evaluated in main plot and four treatments of PGR *viz.*, Glycine betain @ 100 ppm (GB), Salicylic acid @ 100 ppm (SA), control and Potassium nitrate @ 2% spray were evaluated in sub plot. The experiment was laid out in split plot design and replicated thrice. *Bt* cotton hybrid was sown on 6th July, 2024 and recommended practices for the region were followed. Excess rainfall (8.27%) was received over normal of the station (871 mm) in 42 rainy days which was more by 8 days than normal. Thus, wet spell was observed during vegetative growth (29-30 SMW) and dry spell during 31-32 SMW followed by early cessation rainfall from 40 SMW. Single foliar spray of plant growth regulator treatments was given at 75% moisture deficit.

Results

Sowing on broad bed and furrow recorded significantly higher seed cotton yield (1539 kg ha^{-1}), yield plant^{-1} (86.93 g), number of bolls m^{-2} (39.42) and boll weight (4.10 g) than sowing on flat bed (1274 kg ha^{-1}, 73.65 g, 34.75 and 3.88 g, respectively). Ridges and furrows system was found at par with sowing on broad bed and furrow for seed cotton yield and yield contributing characters. However, land configuration didn't influence the plant height and number of monopodia plant^{-1}. The number of sympodia plant^{-1} and plant population ha^{-1} at harvest were increased in sowing on BBF (14.03 and 18467 plants ha^{-1}, respectively) over flat bed (13.12 and 18004 plants ha^{-1}, respectively). The BBF recorded significantly highest GMR (` 105665 ha$^{-1}$), NMR (` 21749 ha^{-1}) and BCR (1.26) and was superior over flat bed. BBF has increased 16.61 per cent moisture over Flat bed at 60 DAS whereas, ridges and furrows has improved soil moisture content (15.54 per cent) significantly over farmers practice at 150 DAS. The increased soil moisture in BBF and RF was efficiently utilized at the flowering and boll development period of crop. It has benefited in increasing number of bolls and seed cotton yield (Asewar et al, 2008 and Pandagale et al, 2022).

The Glycine Betain (1517 kg ha^{-1}) and Salicyclic acid (1467 kg ha^{-1}) spray had significantly increased seed cotton yield, yield plant^{-1} and boll weight over control (1313 kg ha^{-1}). PGR spray treatments didn't influence the plant growth characters. Glycine Betain spray @ 100 ppm recorded significantly higher GMR (` 104162 ha$^{-1}$) whereas spray of Salicyclic acid was more profitable in terms of NMR (` 21351 ha^{-1}) and BCR (1.27). Application of glycine betaine can be used to improve seed cotton yield and economic returns under deficit irrigation (Emrah et al., 2024). Salicyclic acid is considered a signaling molecule that plays a key role in plant growth, development and defense responses under stress conditions (Dong et al., 2015).

Effect of land configuration and PGR spray on yield, plant growth character, economics and soil moisture content

Treatment	Seed cotton yield (kg ha^{-1})	Yield $plant^{-1}$ (g)	Bolls m^{-2}	Boll weight (g)	Sym-podia $plant^{-1}$	Plant population ha^{-1} at harvest	GMR (` ha^{-1})	NMR (` ha^{-1})	B:C ratio	Soil moisture content (%)	
										60 DAS	At harvest
A) Main : Land configuration											
A_1: Broad bed & Furrow	1539	86.93	39.42	4.10	14.03	18467	105665	21749	1.26	28.49	12.56
A_2: Ridge & Furrow	1431	79.83	37.33	4.03	13.26	18364	98266	16527	1.20	27.20	13.08
A_3: Control (FP) - Flat bed	1274	73.65	34.75	3.88	13.12	18004	87516	12343	1.16	24.43	11.32
SE±	38.83	1.32	0.73	0.02	0.37	66.38	2669	2281	0.03	1.03	37
CD at 5%	156.56	5.30	2.93	0.06	0.53	189.23	10762	9165	N.S.	2.94	1.06
B) Sub : PGR spray											
D_1: Glycine Betaine @ 100 ppm	1517	86.11	39.22	4.09	13.87	18313	104162	19314	1.23	26.82	12.26
D_2: Salicylic acid @ 100 ppm	1467	80.69	37.33	4.05	13.53	18244	100739	21351	1.27	26.77	12.30
D_3: Control	1313	74.76	35.33	3.87	13.01	18244	90133	12368	1.15	26.71	12.29
D4 : KNO_3 spray @ 2%	1362	79.00	36.78	4.00	13.47	18313	93562	14458	1.18	26.52	12.43
SE±	29.66	2.63	1.13	0.04	0.36	213.15	2036	1739	0.02	0.64	0.52
CD at 5%	88.83	7.87	N.S.	0.13	N.S.	N.S.	6096	5208	0.06	N.S.	N.S.
Interaction A x B											
SE±	77.67	2.63	1.45	0.03	0.75	369.18	5339	4561	0.06	1.11	0.89
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	2.02
GM	1415	80.14	37.17	4.00	13.47	18278	97149	16873	1.21	26.71	12.32

Conclusion

Sowing on broad bed and furrows has increased seed cotton yield significantly over farmers practice by 21.62 per cent. Salicylic Acid spray was most profitable with highest NMR and BCR.

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Integrated weed management in lentil (*Lens culinaris* Medik)

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Lentil (*Lens culinaris* Medik.) is one of the oldest valuable human foods that is consumed as dry seed mainly (whole and split). It is a semi-arid grain legume crop that is usually grown in rotation with cereals (mainly rice) in winter season. In India, lentils are primarily consumed in the form of dal, as well as in snacks and sweets. After harvest, the straw and pods serve as valuable fodder due to their high nutritionalcontent. Despite their high nutritional value, lentils are often cultivated on marginal lands with minimal inputs. Among several reasons, the prominent is that lentil is a weak competitor against weeds because of its short height, slow establishment, and limited vegetative growth. The crop fails to develop a dense canopy due to its relatively low plant density and slow early growth, making it vulnerable to weed competition and resulting in reduced availability of resources (Karimmojeni *et al*., 2015). Mishra (1997) reported that the most critical period of weed competition in lentil is first 4-8 weeks. In lentil crops, weeds are particularly detrimental as they deplete the soil of nutrients and moisture. Lentils, with their weak stems, short height, slow initial growth, and extended growing period, struggle to compete against many weed species. Reports indicate that weeds can lead to yield reductions of up to 70% in lentil crops. To ensure sustainable lentil production, it is essential to implement effective weed management strategies that incorporate various herbicides for controlling diverse weed species, which could minimize the risk of developing herbicide-resistant weeds. In view to develop or evolve suitable weed management options in lentil crop, the present experiment entitled "Integrated weed management in lentil (*Lens culinaris* Medik.)" was planned and conducted.

Methodology

The field experiment was conducted during the *rabi* season of 2023-24 at the experimental farm of the Division of Agronomy, IARI, New Delhi. The experiment was designed in a randomized block design with three replications. The experiment consisted of ten treatments of weed control measures (T1 - Pendimethalin @ 1000 g/ha (PE); T2 - Pendimethalin @ 750 g/ha + Imazethapyr 50 g/ha (PE) (ready mix-Valor 32% EC); T3 - Pendimethalin @ 750 g/ha as PE + 1 hand weeding at 30 DAS; T4 - Pendimethalin @ 750 g/ha as PE + maize straw mulching (4t/ha); T5 - Imazethapyr @ 50 g/ha at 20 DAS; T6 - Quizalofop- ethyl @ 50 g/ha at 20 DAS; T7 - Quizalofop-ethyl @ 40 g/h at 20 DAS + 1 hand weeding at 40 DAS; T8 - Pendimethalin @ 750 g/ha (PE) + Quizalofop-ethyl 50 g/ha at 30 DAS; T9 - Weedy check; T10 - Weed-free check). The soil of the experimental plot was sandy loam in texture, slightly alkaline in reaction. The variety used in the experiment was *L-4717*, which was extra-large seeded lentil released by IARI in 2019. The required amount of herbicides were applied using 500 litres /ha of water with a knap-sack sprayer fitted with a flat – fan nozzle. Normal crop husbandry practices were followed for the successful raising of lentil crop.

Results

The major weed species (weed flora) recorded in weedy check plots were Phalaris minor, Chenopodium album, Melilotus indica and Rumex dentatus. All weed control treatments resulted in significant reductions in the density and dry weight of all classes of weeds both individually as well as together, over weedy check at all observation stages. Pendimethalin @ 750 g/ha as PE + 1 hand weeding at 30 DAS brought the highest reduction in the growth of all weeds resulting in higher weed control efficiency over all other weed control treatments. This treatment produced a 92.95 % higher grain yield of lentils over the weedy check. Pre-emergence application of pendimethalin @ 750 g/ha as PE + maize straw mulching (4t/ha) achieved the lower weed density and dry weight of weeds at 30 DAS. Post-emergence application of quizalofop-ethyl was found inferior in reducing weed growth amongst herbicidal treatments. There was a significant effect of weed control measures on crop growth parameters like plant height, crop dry matter accumulation and no. of branches at all stages of observation. Season long weed free condition brought a higher increase in growth parameter and yield attributes, grain yield and stover yield of lentil which were statistically similar with pendimethalin @ 750 g/ha as PE + 1 hand weeding at 30 DAS and pendimethalin @ 750 g/ha as PE + maize straw mulching (4 t/ha). Herbicide treatments provided a yield advantage of 36.61% to 92.95% over weedy check. Highest net return (Rs 62,200/ha) was obtained in pendimethalin @ 750 g/ha as PE + 1 hand weeding at 30 DAS closely followed by pendimethalin @ 750 g/ha as PE + maize straw mulching (4 t/ha) (Rs 55600/ha). The B:C was highest in pendimethalin @ 750 g/ha (PE) + 1 hand weeding at 30 DAS owing to high gross return (: 92,000) as compared to the cost of cultivation (: 29,800) than other treatments, which was comparable to pendimethalin @ 750 g/ha as PE + maize straw mulching (4t/ha). Application of imazethapyr @ 50 g/ha at 20 days after sowing showed toxicity to crop plant to an extent of 30-40%.

Conclusion

The Conclusion from the present investigation may be drawn that either the pre-emergence pendimethalin application at a rate of 750 g/ha (PE) followed by one hand weeding at 30 DAS or pre-emergence application of pendimethalin @ 750 g/ha supplemented with maize straw mulching (4t /ha) soon after herbicide application may be practiced for successful weed management in lentil crop.

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UID: 1330

Genetic Variation for Rancidity and Grain Yield Components in Pearl Millet Seed Parents

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Pearl millet is an important staple food crop in India, but its flour is not properly utilised due to rancidity that develops during storage. The processing methods could be many, but they are not so effective. So, the best way to increase longevity in pearl millet flour is by identifying the best suitable genotypes and developing hybrids. Knowledge of genetic variability, genotypic and phenotypic coefficient of variation, heritability, correlation and analysis of path of yield contributing traits is important for efficient planning of crop improvement programmes. The present investigation was conducted to evaluate 60 seed parents of pearl millet in a Randomized Block Design with two replications. The analysis of variance revealed highly significant differences among genotypes for all the traits under investigation thereby indicating the existence of substantial genetic variation among genotypes for all the yield and its contributing traits. Vigour index exhibited high correlation coefficient, while comprehensive peroxide value on 10th day along with other traits had direct effects with respect

to grain yield, in the desired direction indicated that these traits could be effective in crossing programmes to develop promising maintainer lines with longer shelf life.

Pearl millet [*Pennisetum glaucum* (L.) R. Br.; 2n=14], is an important staple food and fodder crop grown in arid and semi-arid regions of Asia and Africa. Pearl millet has very high nutritional value, in terms of energy, proteins, fat, and minerals, equivalent to, if not superior to, major cereals (Qureshi *et al.,* 2000). In India, it ranks fourth in acreage next to rice, wheat and maize.

Methodology

The experimental material comprising 60 seed parents (maintainer lines or B-lines) of pearl millet were sown in a randomized block design in two replications at the Research Area of Bajra Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, Haryana during *kharif* 2021. In each replication, genotypes were sown in a single row of four-meter length with a row to row spacing of 45 cm and plant to plant distance was kept at 10-12 cm. The recommended agronomic practices were followed for raising a good crop of pearl millet.

The observations were recorded on five representative random plants in each replication for agro-morphological traits *viz*., plant height (cm), panicle diameter (cm), panicle length (cm), number of productive tillers/plants except for days to 50 per cent flowering, 1000-seed weight (g), grain yield/plant (g) and dry fodder yield/plant (g) which were recorded on plot basis. Two shelf-life traits *viz*., acid value (comprehensive acid value on the 1^{st}day and 10^{th} day and their difference *i.e.* CAV_0, CAV_{10} and CAV_{10}-CAV_0, respectively) and peroxide value (comprehensive peroxide value on the $1^{st}$and 10^{th}day and their difference *i.e.* CPV_0, CPV_{10} and CPV_{10}-CPV_0, respectively) were estimated from bulk open-pollinated grain samples of each genotype in both replications following AOAC (1990) method.

The comprehensive acid value (CAV) is defined as the number of milligrams of potassium hydroxide required to neutralize the free fatty acids present in 1 g of flour, while the comprehensive peroxide value (CPV) determines the concentration of hydroperoxide—the primary oxidation product in the flour and is an indication of the extent of oxidation suffered by the flour.

The formula to calculate CAV and CPV are:

$$CAV = 40 \text{ x } A \text{ x } N/W$$

where CAV is the comprehensive acid value, A denotes the volume of NaOH (mL), 40 is the constant value equivalence of mass of 0.1 N NaOH, W is the weight of the sample and N is the normality of the standard NaOH solution.

$$CPV = (A-B) \times N \times 1000/W$$

Where, CPV is the comprehensive peroxide value, A and B denote the titration volume of Na2S2O3 (mL) in the sample and blank, respectively, W is the weight of flour in grams and N is the normality of the standard Na2S2O3 solution.

The seed parameters *viz*., standard germination (%), seed vigour index I, Seed vigour index II, seedling length (cm) and seedling dry weight (mg), root length(cm) and shoot length(cm) were recorded on bulk open-pollinated seed samples of each genotype in both replications.

Results

The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters representing environmental impact on these characters for total variation. High GCV and PCV were observed for the traits *viz*., difference between CAV on 1st day (CAV_0) and 10th day (CAV_{10}), CPV diff- difference between CPV on 1st and 10thday, grain yield /plant (g), vigour index II, dry fodder yield/ plant, Comprehensive Peroxide Value on the 1st, CPV_{10} - Comprehensive Peroxide Value on the 10thday, seedling dry weight, vigour index I, Comprehensive Acid Value on the 1stday, number of productive tillers /plant, Comprehensive Acid Value on the 10thday, seedling length, germination per cent, 1000-seed weight while moderate GCV and PCV were observed for panicle diameter, panicle length, root length and seedling length. High estimates of GCV and PCV indicate that selection can be applied to these traits to isolate a more promising line. The high magnitude of the genotypic coefficient of variation indicated the presence of wide variation for the characters under study to allow further genetic improvement by the selection of the individual traits. Similar Results for GCV and PCV were also reported by Kaushik *et al*. (2018) for plant height, number of productive tillers/plants, panicle length and grain yield/plant.

Conclusion

From the Results of the present study, it is inferred that the material contains a wide range of genetic variations in which most of the traits showed a high PCV and GCV indicating the presence of a high degree of variation for these traits among the genotypes which could be improved through selection in the desirable direction. High heritability was observed for many traits such as the difference between the Comprehensive Peroxide Value on 1stand 10thday, seedling dry weight, seed vigour index and grain yield/plant indicated that these traits are governed by additive gene action. From the discussion on correlation and path coefficient analysis it could be concluded that for planning any selection criterion for improved grain yield, the main emphasis should be given on seedling length, vigour index-II, days to 50% flowering, 1000 seed weight, Comprehensive Peroxide Value on the 10thday and thus direct selection of these traits could be effective in the crop improvement programme of pearl millet. In terms of rancidity effects, it was found that the genotype has a longer shelf life if the difference between comprehensive acid value on day 1 and after 10 days after milling and comprehensive peroxide value between day 1 and after 10 days after milling is small as compared to other genotypes. Hence, efficient selection of pearl millet traits need to be carried out for the development of new variety with improved shelf life and better health benefits.

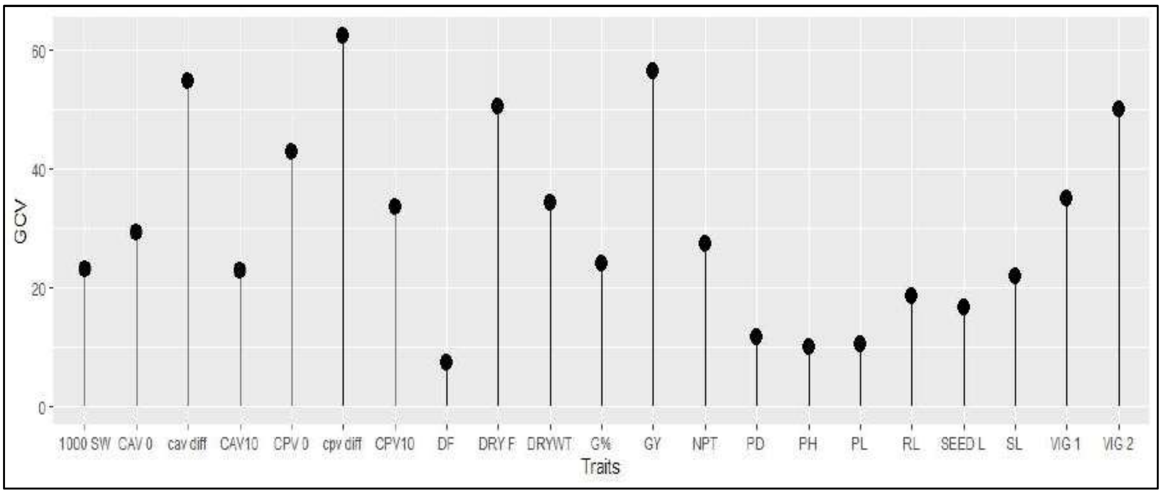

Fig 1. Estimates of GCV (%) for agro-morphological, seed and biochemical characters in pearl millet germplasm lines

DF- Days to 50% flowering, PH- Plant height(cm), PD- Panicle diameter(cm), PL- Panicle length(cm), NPT- Number of productive tillers/plant, 1000SW- 1000 seed weight(g), DryF- Dry fodder yield/plant(g),CAV 0- Comprehensive Acid Value on the first day, CAV10- Comprehensive Acid Value on the 10thday,CPV0- Comprehensive Peroxide Value on the first day, CPV10- Comprehensive Peroxide Value on the 10th day, CAV diff- Difference between CAV on 1st and 10thday, CPV diff- Difference between CPV on 1st and 10th day, G%- Germination per cent (%),RL- Root length(cm), SL- Shoot length(cm), SEEDL- Seedling length(cm), DRY wt- Seedling dry weight (mg), Vig-I- Vigour index I, Vig-II- Vigour index II, GY- Grain yield/plant(g)

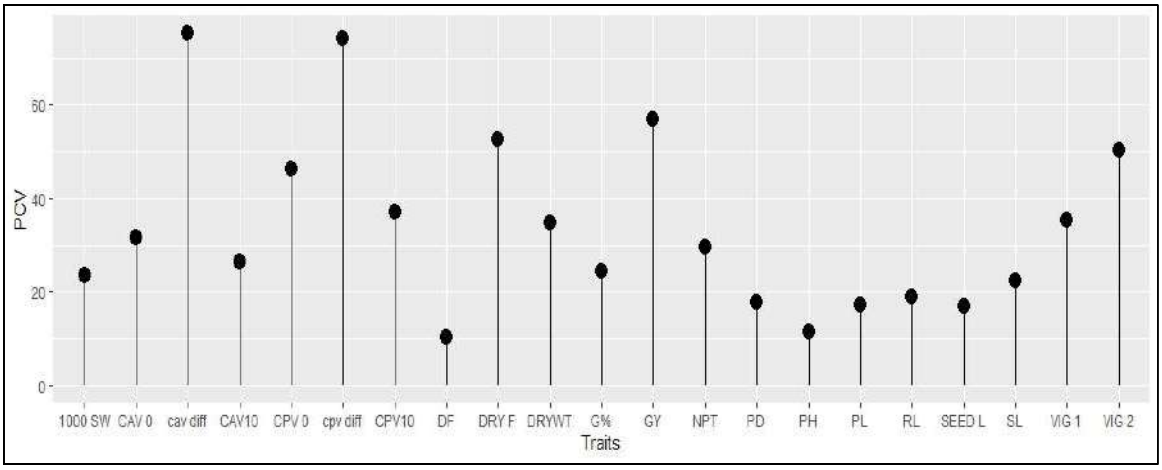

Fig 2. Estimates of PCV (%) for agro-morphological, seed and biochemical characters in pearl millet germplasm lines

DF- Days to 50% flowering, PH- Plant height(cm), PD- Panicle diameter(cm), PL- Panicle length(cm), NPT- Number of productive tillers/plant, 1000SW- 1000 seed weight(g), DryF- Dry fodder yield/plant(g), CAV 0- Comprehensive Acid Value on the first day, CAV10- Comprehensive Acid Value on the 10thday, CPV0- Comprehensive Peroxide Value on the first day, CPV10- Comprehensive Peroxide Value on the 10th day, CAV diff- Difference between CAV on 1st and 10thday, CPV diff- Difference between CPV on 1st and 10th day, G%- Germination per cent (%), RL- Root length(cm), SL- Shoot length(cm), SEEDL- Seedling length(cm), DRY wt- Seedling dry weight (mg), Vig-I- Vigour index I, Vig -II- Vigour index II, GY- Grain yield/plant(g)

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UID: 1332

Screening and Utilization of Abiotic Stress Tolerant Mother Palms for Hybrid Seed Production in Oil Palm (*Elaeis guineensis* Jacq.)

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Oil Palm (*Elaeis guineensis*) crop is the most significant determinant of the agricultural economy among oilseed crops. is also known as golden palm, the largest vegetable oil yielding perennial crop (4-6 t oil/ha/ year), one acre of oil palm (2n=32) plantation is able to produce up to ten times more oil than other leading oilseed crops. Large gap exists between availability and actual utilization of the oil palm germplasm. Extensive use of fewer and closely related parents in oil palm crop improvement could result in inbreeding depression and narrow genetic base. The evaluation and characterization of existing oil palm germplasm have resulted in identification of genetically diverse trait-specific germplasm lines meeting the needs of oil palm breeders for use in developing high yielding cultivars with a broad genetic base. Oil palms grown in their native habitats are frequently confronted with several stresses, both abiotic and biotic, that reduce crop output and provide significant challenges to satisfying world food demands. Stress-tolerant oil palm crops, which reduce the impact of abiotic pressures on crop output, are critical for agricultural production sustainability. The number of treatments is six, the number of crosses is thirteen, the number of replications is two, and the total number of plants is seventy-eight. T0: Control, no salt; T1: 0.2% salt, which is 2.922 grams per plant per 250 milliliters; T2: 0.4% salt, which is 5.844 grams per plant per 250 milliliters; T3: 0.6% salt, which is 8.961 grams per plant per 250 milliliters; T4: 0.8% salt, which is 11.688 grams per plant per 250 milliliters; T5: 1% salt, which is 14.61 grams per plant per 250 milliliters. Total thirteen different DxD crosses seedlings imposed different stress treatments, among different stress levels, treatment 4 (112 ml) observed as a better treatment. Out of 13 crosses, 5 crosses identified as tolerant to stress.

The selected genotypes may be utilized in hybrid seed production by crossing with promising male parent to produce elite progeny. The seedlings developed from promising abiotic stress tolerant palms are used to distribute to oil palm farmers and stakeholders. These selected palms are also being utilized by selfing and development of base population of Tenera X Pisefera and Tenera X Tenera for new generation seed gardens.

UID: 1334

Rhizobium spp. for improving yield of rainfed groundnut in semi-arid alfisols

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Nitrogen is a very important macronutrient required for plant growth and development. Indiscriminate use of chemical fertilizers is leading to deterioration of soil health and environmental quality (Das et al. 2023). Chemical nitrogenous fertilizers are also contributing to increased emissions of nitrous oxide, which has higher global warming potential (Cui et al. 2021). Many nations across the globe are pushing for reduction of chemical inputs usage in agricultural production (Brunelle et al. 2024). Biofertilizers are important means to minimize the use of chemical fertilizers. *Rhizobium* species are important symbiotic nitrogen fixing bacteria. They improve nodulation, nitrogen fixation, plant growth and yield of legumes. Rainfed areas are facing the problem of prolonged drought periods during the cropping season in recent years. Keeping this in view, a study was conducted to identify efficient *Rhizobium* isolates for improving yield of rainfed groundnut in semi-arid alfisols.

Methodology

A field experiment was conducted by following randomized block design with three replications at the Gungal Research Farm of ICAR-Central Research Institute for Dryland Agriculture. Inoculation of *Rhizobium* isolates was done through seed treatment. During the year 2023, groundnut crop (cv.K-9) was sown after the onset of monsoon. Recommended agronomic practices were followed to raise the crop under rainfed conditions. Analysis of the data was done using the Statistical Package for Social Sciences 16.0 (SPSS, 2016) for windows.

Results

Variation in plant growth and yield parameters were observed due to the inoculation of *Rhizobium* isolates. Inoculation of *Rhizobium* isolates GR1 and GR2 significantly (*p=0.05*) improved the pod yield of groundnut as compared to uninoculated control (Fig.1). Further, significant improvement in plant nitrogen content was observed due to the inoculation of *Rhizobium* isolates vis-à-vis uninoculated control. Higher plant nitrogen content was observed in *Rhizobium* spp.GR1+ *Bacillus* spp.VK7 inoculated treatment.

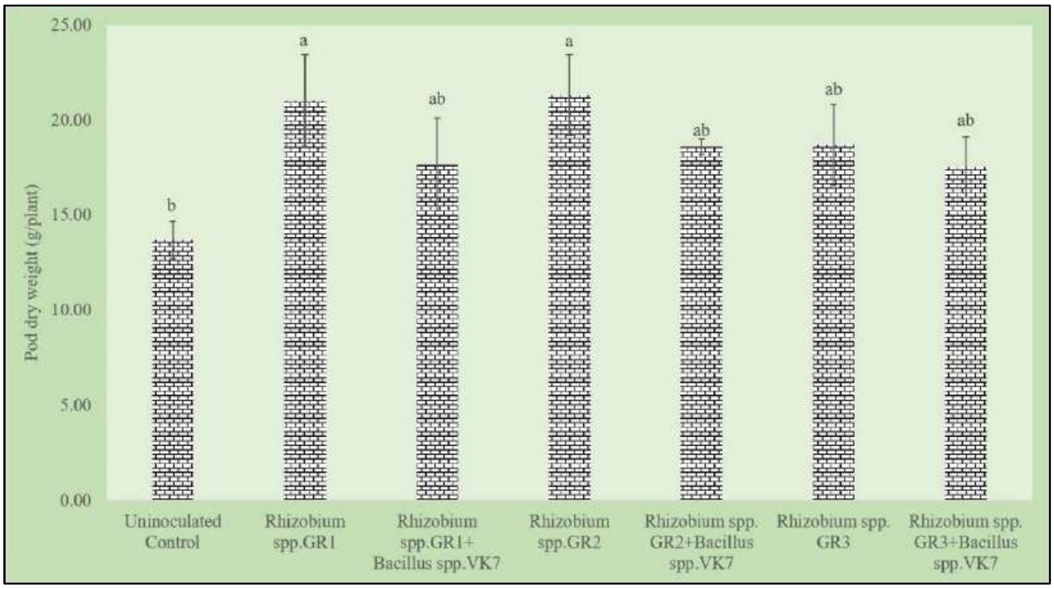

Fig 1. Effect of *Rhizobium* isolates on pod yield of groundnut

Conclusion

The results of the experiment suggest that, inoculation of *Rhizobium* isolates GR1 and GR2 significantly improved the pod yield of groundnut as compared to uninoculated control.

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UID: 1336

Effect of Different Mulches on Chickpea (Cicer arietinum L.) under Dryland Conditions

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Chickpea (*Cicer arietinum* L.) is India's most significant rabi pulse crop, contributing 40% of the country's pulse production. Grown on 10.91 Mha with a yield of 1260 kg/ha (Anonymous, 2022) chickpeas are rich in protein (18-22%), carbohydrates, and essential minerals, making them a vital dietary staple. However, productivity faces constraints like terminal drought, low soil moisture, and weed competition due to limited resources and changing climatic conditions which in turn effects productivity.

Mulching emerges as a promising solution for enhancing chickpea production (Deka *et al*., 2021) Organic mulches like rice straw, maize stubble, and Subabul trimmings reduce soil evaporation, retain moisture, suppress weeds, and regulate soil temperature. Additionally, mulches enrich soil organic carbon, improve structure, and foster beneficial microbial activity. They also enable in-situ moisture conservation, crucial in rainfed conditions where water availability is uncertain. Combining various mulch types can create synergies, improving both crop yields and soil health. Mulching also reduces dependency on chemical herbicides and manual weeding, making it cost-effective.

Research focuses on evaluating different mulch applications and their impact on chickpea growth, yield, and economic returns. It aims to address rainfed agricultural challenges like water stress, erratic rainfall. Sustainable mulching practices could enhance soil fertility, reduce climate risks, and ensure stable chickpea yields in India's semi-arid regions.

Methodology

A field experiment entitled ''Effect of different crop establishment methods and mulches on chickpea under dryland conditions''(*Cicer arietinum* L.) was carried out during the rabi (winter) Season of 2022-23 at the Agricultural Research Farm, Institute of Agricultural

Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India situated under North East plain zone of the country. Varanasi is situated between 25°18' North latitude and 83°03" East longitude and altitude of 75.7 meters above mean sea level situated in Northern Gangetic Alluvial plains. The Dryland Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi was chosen as the experimental site for the study. Varanasi is located in a semi-arid to subhumid climate belt with 1100mm of annual precipitation and 1520mm of potential evapotranspiration (PET). The yearly moisture deficit is thus about 420 mm. The Variety of chickpea used is RVG-202. The treatments used were No mulch, Dust mulch, Paddy straw mulch @5t ha^{-1}, Maize stover mulch @5t ha^{-1}, *Leucaena* twigs mulch @5t $ha^{-1,}$ Paddy straw @2.5t ha^{-1}+ *Leucaena* twigs mulch @2.5t ha^{-1}, Maize stover @2.5t ha^{-1}+ *Leucaena* twigs mulch @2.5t ha^{-1}. Soil Moisture is recorded by gravimetric method.

Results

The maximum soil moisture content has been recorded under T_3 (Paddy straw @ 5t ha^{-1}) followed by T_6 (Paddy straw @2.5t ha^{-1} + *Leucaena* twigs @2.5t ha^{-1}) which is at par with T_4 (Maize stover@5 t ha^{-1}) followed by T_7 (Maize stover @2.5t ha $^{-1}$ + *Leucaena* twigs @2.5t ha $^{-1}$, T_5 (*Leucaena* twigs @ 5t ha^{-1}),T_2 ((Dust mulch), and T_1 (No mulch). Among different mulching treatments, significantly the highest seed yield was recorded with the application of Paddy straw @2.5t ha^{-1} + *Leucaena* twigs@2.5t ha^{-1}(1749 Kg ha^{-1}). The second highest seed yield was recorded with the application of Paddy Straw@5t ha^{-1} (1567.7 Kg ha^{-1}). The No mulch treatment recorded with lowest seed yield (988 Kg ha^{-1}) i.e.,43% lesser.

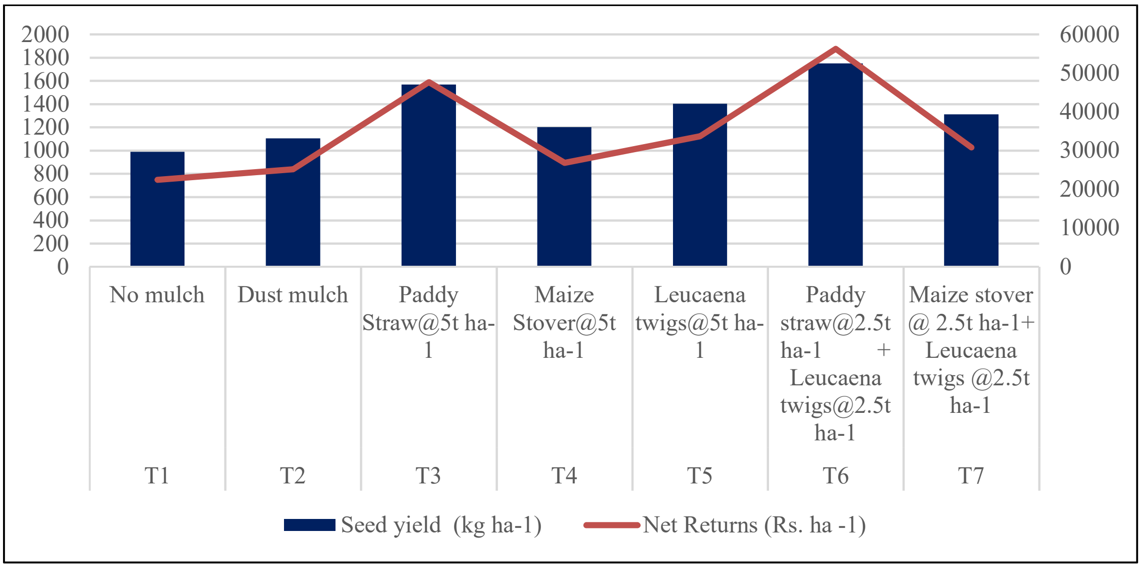

Fig 1. Effect of different mulches on Seed yield and Net returns of Chickpea

Among different mulching treatments, significantly the highest net returns were recorded with the application of Paddy straw @2.5t ha^{-1} + *Leucaena* twigs@5t ha^{-1}(56282 Rs. ha^{-1}) and the lowest was with No mulch treatment (22468 Rs. ha^{-1}). A higher B:C ratio was observed in T6 (paddy straw @2.55t ha^{-1} + Leucaena twigs @2.5t ha^{-1}) and a lower level in both no mulch and dust mulch treatments.

Conclusion

The maximum soil moisture content has been recorded under T_3 (Paddy straw @ 5t ha^{-1}) , Among different mulching treatments, significantly the highest seed yield was recorded with the application of Paddy straw @2.5t ha^{-1} + *Leucaena* twigs@2.5t ha^{-1}(1749 Kg ha^{-1}). The highest net returns were recorded with the application of Paddy straw @2.5t ha^{-1} + *Leucaena* twigs@5t ha^{-1}(56281 Rs. ha^{-1})

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UID: 1338

Evaluation of Different Pearl Millet Composites under Rainfed Agro-ecosystem of Jammu

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The changing climate is leading to an increase in global average temperature affecting agricultural production worldwide. Further, it directly influences biophysical factors such as plant and animal growth along with the different areas associated with food processing and distribution. Assessment of effects of global climate changes and deployment of new tools and strategies to mitigate their effect is crucial to maximizing agricultural production to meet out food demands of the increasing population. In this context, Pearl millet (Pennisetum glaucum L.) is considered to be most useful, as it is world's hardiest warm season crop among the cereals and well adapted to drought-prone areas, low soil fertility, and high temperature situations (Rinku et al., 2016, in comparison with other cereals It is more resilient to extreme climatic events such as drought and water scarcity and can play a vital role in ensuring food and nutritional security in changing climatic scenarios, which is mounting to frightening proportions. Globally, it is the sixth most significant cereal crop after rice (Oryza sativa), wheat

(Triticum aestivum), maize (Zea mays), barley (Hordeum vulgare) and sorghum (Sorghum bicolor). It is a staple food of 90 million poor people and extensively grown on 30-million-ha area in the arid and semi-arid tropical regions of Asia and Africa. It is also used for feed and fodder and accounts for almost half of the global millet production. It is a C4 plant with high photosynthetic efficiency, high dry matter production capacity and is successfully cultivated in the areas where agro-climatic conditions are adverse for crop production and even crops like sorghum and maize fail to produce economic yield. In India, pearl millet is the fourth most widely cultivated food crop after rice, wheat and maize. It occupies an area of 6.70 million ha with an average production of 9.62 million tonnes and productivity of 1436 kg/ha (Anonymous, 2022). The major pearl millet growing states are Rajasthan, Maharashtra, Uttar Pradesh, Gujarat and Haryana contributing to 90% of total production in the country. The union territory of Jammu & Kashmir occupied 13142 ha area with the total production of 58200 tonnes (0.06 % of the national production) (AICRP, 2020). Keeping the above facts in view, the problem was proposed.

Methodology

A field experiment was carried out at research farm of Advance Centre for Rainfed Agriculture, Rakh Dhiansar, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, UT of J & K (32° 39" N 74° 53" E, 332 m amsl) during *Kharif* 2023, to evaluate different pearl millet composites for their relative performance to cope with aberrant weather under rainfed Agro –ecosystem of Jammu region, comprising of nine pearl millet composite varieties viz: T_1-Dhanshakti, T_2-ICMV 221, T_3-Pusa Composite 701, T_4- Pusa Composite 383, T_5-JBV 2, T_6-Raj 171, T_7-MBC- 2, T_8-PC 443, T_9- Bajra (local). The soil of the experimental site was *Inceptisols* having sandy loam texture with low available nitrogen, medium phosphorus, low potash with *p*H value 6.58 and low organic carbon. Nitrogen, phosphorous and potash were applied as per package through Urea, DAP and MOP. The experiment was laid out in randomized block design with three replications.

Results

Nine pearl millet composites viz. *Dhanshakti, ICMV 221, Pusa Composite 701, Pusa Composite 383, JBV-2, Raj 171, MBC-2, PC-443 and Bajra (local)* were evaluated during *kharif* 2023 for their yield performance. Perusal of the data revealed that MBC-2 resulted in significantly higher grain yield (2735 kg/ha) and stover yield (10056 kg/ha) over all the other pearl millet composites. It might b because of Similarly, highest net returns, B.C ratio and RWUE values of Rs. 75384/ha, 4.17 and 3.46 kg/ha-mm, respectively was also recorded with *MBC-2*. Among the other pearl millet composites, *Pusa Composite 383*, *Pusa Composite 701* and *PC-443* performed well with the corresponding grain yield values of 2515 kg/ha, 2400 kg/ha and 2320 kg/ha, respectively. Whereas, Bajra (local) evinced the lowest values of grain yield 1780 kg/ha), net returns (Rs. 41074/ha), B.C ratio (2.74) and RWUE (2.25 kg/ha-mm).

Yield and economics of Pearl millet composites

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grains	Stover/ stalk				
Dhanshakti	2210	8000	23760	55911	3.35	2.79
ICMV 221	1885	7163	23760	45043	2.90	2.38
Pusa Composite 701	2400	9000	23760	63540	3.67	3.03
Pusa Composite 383	2515	9155	23760	67032	3.82	3.18
JBV 2	2150	7525	23760	53103	3.23	2.72
Raj 171	2075	7470	23760	50940	3.14	2.62
MBC 2	2735	10120	23760	75384	4.17	3.46
PC 443	2320	8816	23760	60920	3.56	2.93
Bajra (local)	1780	6639	23585	41074	2.74	2.25
CD(5%)	212.0	-	-	-	-	-

Conclusion

It may be concluded that the pearl millet composite *MBC-2* could be recommended for sowing under rainfed agro- ecosystem of Jammu region, having potential to increase income and food security of farming communities. Pearl millet being a climate resilient crop and can survive in a wide range of ecological conditions under water scarcity having high nutritional value, can be exploited for improving nutritional quality and combating malnutrition.

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Assessment of Soybean and Blackgram Based Cropping System in Rainfed Area of Rewa Region of Madhya Pradesh

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The cropping system is a pattern or order of crops taken for a given piece of land over a fixed period. Crops interaction with farm resources and farm enterprises available technology determines their makeup. Inclusion of legumes in crop sequence increases soil fertility and consequently the productivity of succeeding crops. The crop rotation, including leguminous crops like pulses or oilseed crops are the main mechanism for sustained productivity and profitability under a given agro-climatic region. Among the prevailing crop rotations, blackgram and soybean based rabi season crops including field pea, chickpea, linseed, lentil, and mustard are the well-known predominant cropping system. Vindhayan plateau is a potential area for kharif and rabi season pulses and oilseed crops which are grown by the farmers therefore development of most profitable double cropping system in needed.

Methodology

The present field experiment was conducted at research farm Rewa during 2022-23 and 2023-24. The experimental field was clayey in texture, neutral in soil reaction and low to medium in organic carbon, available nitrogen, phosphorus and potash. Ten cropping systems were taken in randomized block design under factorial concept. Soybean and blackgram were taken as factor (a) and while five crops like chickpea, linseed, lentil, mustard and field pea were taken as factor (b). Grain yield data of kharif and rabi crops were converted into soybean equivalent yield.

Results

Performance of kharif crops under different cropping system:

Yield data of different kharif crops were converted to soybean equivalent yield revealing that blackgram gave maximum soybean equivalent yield after lentil and field pea. Soybean equivalent yield under the influence of different rabi crops was maximum from blackgram which was 42.47% higher than soybean taken after chickpea, lentil, mustard and field pea. It may be due to higher yield of blackgram and higher market price that gave more soybean equivalent yield.

Performance of Rabi crops under different cropping system:

Pooled data of different rabi crops reveals that chickpea, lentil, linseed, mustard and field pea were taken after blackgram while linseed yield maximum after soybean. Mustard after soybean and blackgram gave a 29.60% higher soybean equivalent yield as compared to soybean, chickpea, and blackgram-chickpea. Cultivation of lentil after soybean and blackgram gave 17.21q/ha soybean equivalent yield. The residual effect of blackgram on lentil, mustard and field pea was more as compared to soybean. It may be due to luxurious growth of lentil, mustard and field pea after blackgram.

Conclusion

The present experiment on the assessment of soybean and blackgram based cropping system in rainfed area of the Rewa region of M.P. was taken. The study reveals that blackgram crop have a good residual effect on linseed, lentil, Mustard and Field pea as compared to soybean. Maximum soybean equivalent yield 36.88 q/ha was noted in Blackgram- mustard cropping system followed by 33.26q/ha in blackgram lentil. Blackgram based cropping systems gave 38.26% higher yield than soybean.

UID: 1342

Comparative Assessment of Direct Seeded Rice and Conventional Transplanted Rice in Western Undulating Zone of Odisha

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Direct-seeded rice (DSR) has emerged as an innovative climate-resilient strategy to address the challenges of water scarcity and drought stress in rice cultivation. Traditional transplanted rice requires continuous ponding and puddling, making it vulnerable to rainfall uncertainties and water shortages (Tyagi et al. 2020). In Kalahandi district of Odisha, where monsoon variability and recurring drought periods affect rice productivity, DSR offers a sustainable alternative. This method involves sowing rice seeds directly into the field, eliminating nursery preparation and transplanting operations. DSR modifies the crop establishment process, leading to better root development and improved soil physical conditions. The technique reduces water requirement during the critical crop establishment phase and allows earlier sowing to capitalize on monsoon rainfall. Under the NICRA (National Innovations on Climate Resilient Agriculture) project, KVK Kalahandi demonstrated DSR as an adaptation strategy to help farmers cope with climate-induced water stress while maintaining productive rice cultivation.

Methodology

The demonstration was conducted during *kharif* 2023 at Indramal village (20.03°N latitude, 83.34°E longitude, 282 m above MSL) under NICRA Project, KVK Kalahandi. The experimental site, characterized by medium-low land topography with clay loam soil of medium fertility, falls under the Western undulating zone of Odisha, India. The region receives an average annual rainfall of 1378.2 mm, predominantly (80-90%) during June-September through Southwest monsoon. The study was laid out in a randomized complete block (RBD) design comparing dry direct-seeded rice (DSR) with transplanted-flooded rice using cultivar Sahabhagi Dhan. Triple bunds were maintained between plots to prevent water seepage between DSR and transplanted rice treatments. Both systems followed recommended package of practices for optimal rice growth, including proper nutrient management, weed control, and plant protection measures as per standard guidelines. The meteorological data during the experiment period was collected from RRTTS, Bhawanipatna, OUAT

Experimental Findings

The statistical analysis of the collected data has been conducted and the findings are showcased in Table, accompanied by a thorough critical assessment. The presentation endeavors to offer a vivid depiction of the data, ensuring clarity and coherence for a comprehensive understanding of the Results.

Results

The comparative analysis of Direct Seeded Rice (DSR) and Transplanted Flooded Rice (TFR) highlights several key differences that showcase the advantages of the DSR method. In terms of plant height, TFR (98.6 cm) showed a marginally higher value compared to DSR (96.5 cm), but this difference (±1.05) is negligible. Maturity duration was shorter in DSR (105 days) compared to TFR (112 days), enabling faster crop turnover and reduced water demand. While panicle length and number of grains per panicle were slightly greater in TFR (22.3 cm and 123 grains, respectively) compared to DSR (21.8 cm and 115 grains), the differences are minimal (±0.25 and ±3.5) and do not significantly affect overall performance. Similarly, TFR outperformed DSR in panicles per m² (267 *vs.* 248) and flag leaf characteristics (length and area), but the variations (±3.8, ±0.65, and ±0.55) remain within a small range.

The test weight of grains was nearly identical, with TFR (22.8 g) slightly exceeding DSR (22.5 g) by a negligible margin (±0.15). While grain yield per hectare was higher in TFR (37.5 q/ha) than in DSR (35.8 q/ha), the difference (±0.85) is offset by the reduced input costs of DSR. The harvest index also showed a slight advantage for TFR (0.34) over DSR (0.32), though the variation (±0.01) is minimal. Importantly, the economic analysis reveals the profitability of DSR: while TFR had slightly higher returns from grain yield (Rs. 81,862 *vs.* Rs. 78,151) and straw yield (Rs. 17,300 vs. Rs. 16,780), DSR achieved comparable gross returns (Rs. 94,931 vs. Rs. 99,162) and net returns (Rs. 56,719 vs. Rs. 57,322) with lower input costs. The B:C ratio was notably higher for DSR (1.48) compared to TFR (1.35), emphasizing the cost-efficiency and profitability of the DSR method. Overall, the DSR system proves to be a more sustainable and economically viable alternative, offering comparable yields with significant efficiency in labor, water, and resource use.

Comparative experimental findings between DSR and TFR.

Sl. No.	Characters	Direct Seeded Rice (DSR)	Transplanted Flooded Rice (TFR)	Standard Error SEm (±)
1	Plant height	96.5 cm	98.6 cm	1.05
2	Maturity duration	105 days	112 days	2.48
3	Panicle length	21.8 cm	22.3 cm	0.25
4	Panicle per m^2	248	267	3.8
5	No. of grains per panicle	115	123	3.5
6	Flag leaf length	16.7 cm	18 cm	0.65
7	Flag leaf area	18.7 cm^2	19.8 cm^2	0.55
8	Test weight	22.5 g	22.8 g	0.15
9	Grain yield	35.8 q/ha	37.5 q/ha	0.85
10	Harvest index	0.32	0.34	0.01
11	Return from grain yield	Rs. 78151	Rs. 81862	-
12	Return from straw yield	Rs. 16780	Rs. 17300	-
13	Gross return	Rs. 94931	Rs. 99162	-
14	Net return	Rs. 56719	Rs. 57322	-
15	B:C ratio	1.48	1.35	-

Conclusion

The study demonstrates that Direct Seeded Rice (DSR) is a sustainable and economically viable alternative to the conventional Transplanted Flooded Rice (TFR) system in the Western Undulating Zone of Odisha. While TFR exhibited marginally higher performance in plant height, panicle length, number of grains per panicle, and grain yield (37.5 q/ha *vs.* 35.8 q/ha), these advantages were minimal and did not outweigh the benefits of DSR. DSR achieved faster maturity (105 *vs.* 112 days), enabling quicker crop turnover and reduced water requirements. Despite slightly lower gross and net returns, DSR exhibited a higher benefit-cost (B:C) ratio (1.48 *vs.* 1.35), reflecting its superior cost efficiency.

The economic and agronomic findings emphasize DSR's potential to address the challenges of water scarcity, labor shortages, and climate variability. By reducing water demand, eliminating the need for nursery preparation, and enabling earlier sowing, DSR enhances the resilience of rice cultivation in rainfed areas. Its reduced input costs and efficient resource utilization make it a favorable choice for farmers in drought-prone regions like Kalahandi district. Overall, DSR emerges as a climate-resilient strategy that maintains productivity while ensuring sustainability, particularly under medium lowland and rainfed conditions.

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Effect of row spacing and seed rate on growth and productivity of short duration pigeonpea varieties under rainfed conditions

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Pigeonpea, is one of the most popular pulses preferred in India and is typically consumed as 'dal'. It is highly nutritious protein rich crop, low in fat and sodium while high in digestible protein (68%) and dietary fibres. It contains 22-25% protein, which is almost double than that of wheat and three times more than rice. It has a well-developed tap root system which enables it to extract moisture and nutrients from deep soil layers and bring them to the upper surface, to be used by the succeeding crops. In the sub-montane *Kandi* region, where water resources are scarce, pigeonpea production may be encouraged due to its potential to provide profitable yields in deficit moisture conditions. Recently developed short duration pigeonpea varieties are short duration, semi-spreading and have determinate growth, require different cultivation practices than long duration varieties which were tall, spreading and occupy the field for about 250-270 days. Thus, to realise the full yield potential of new pigeonpea varieties is it necessary to find out optimum number of plants that can be accommodated per unit area particularly under rainfed conditions. Yield and yield contributing traits of pigeonpea are highly influenced by seed rate. Apart from these, crop geometry plays a key role in increasing growth and yield through better utilization of nutrients and moisture from the soil (root spread) and from above ground (plant canopy) through capturing solar radiation and promotes the formation of better photosynthates. Therefore, keeping in view the above stated facts the study was conducted to find out optimum row spacing and seed rate for short duration pigeonpea varieties

Methodology

A field experiment was conducted at PAU-Regional Research Station, Ballowal Saunkhri during kharif 2022 in factorial randomized complete block design having three replications with combination of three row spacings (30 cm, 45 cm and 60 cm), three seed rates (15 kg ha^{-1}, 22.5 kg ha^{-1} and 30 kg ha^{-1}) and two varieties (AL 882 and PAU 881). Manual sowing of seeds was done on 25 June by adjusting crop geometry according to treatment combinations at a depth of 5 cm. Biological and grain yields were recorded plot-wise and converted into kg/ha.. Gross returns, net returns as well as benefit:cost (B:C) ratio were worked out. Manual harvesting of crop was done from net plots at maturity, when three fourth pods changed their colour to brown.

Results

Pigeonpea variety AL 882 gave highest grain yield (11.5 q ha^{-1}) at 30 cm row spacing and PAU 881 gave highest grain yield at 45 cm row spacing (10.9 q ha^{-1}). Therefore, PAU 881 should not be sown at row spacing less than 45 cm because of its indeterminate growth habit. The interaction among seed rate and genotype was found to be significant in terms of grain yield. AL 882 variety gave maximum grain yield at 30 kg ha^{-1} (11.4 q ha^{-1}) and PAU 881 at 30 kg ha^{-1} seed rate performed poorer as compared to optimum seed rate (22.5 kg ha^{-1}) because of its large canopy size and indeterminate growth pattern. The highest benefit to cost ratio (1.46) was obtained with the variety AL 882 sown at 30 cm row spacing using 30 kg ha^{-1} seed. PAU 881 gave highest benefit to cost ratio (1.42) at 45 cm row spacing with 22.5 kg ha^{-1} seed rate.

Table 1. Interactive effect of row spacing and varieties on grain yield of rainfed pigeonpea

Treatment	Grain yield (q ha^{-1})		
	A_1: 30 cm	A_2: 45 cm	A_3: 60 cm
V_1: AL 882	11.5	11.0	10.3
V_2 : PAU 881	9.3	10.9	10.7
CD (p=0.05)		0.80	

Table 2. Interactive effect of seed rate and varieties on grain yield of rainfed pigeonpea

Treatment	Grain yield (q ha^{-1})		
	S_1: 15 kg ha^{-1}	S_2: 22.5 kg ha^{-1}	S_3: 30 kg ha^{-1}
V_1: AL 882	10.6	10.9	11.4
V_2: PAU 881	10.4	10.7	9.9
CD (p=0.05)		0.80	

Conclusion

AL 882 performed better in terms of seed yield at closer row spacing of 30 cm and also at higher seed rate of 30 kg ha^{-1} under rainfed conditions. While PAU 881 exhibited better seed yield at wider row spacing of 45 cm and at a lower seed rate of 22.5 kg ha^{-1} under rainfed conditions.

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Introduction of Drought Resistant and High Yielding Groundnut Variety (K-Lepakshi) in Anantapuramu District

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Anantapuramu is the southern most district of the Rayalseema region of Andhra Pradesh. Agriculture remains the most important economic activity of the district, it is characterized by high levels of instability and uncertainty. Being located in the rain-shadow region of Andhra Pradesh, the district is drought-prone. The district has a total geographical area of 19.13 lakh hectare. Groundnut is the main crop with 7.5 lakh ha which is purely rainfed. During the recent years, the yields of groundnut crop have been reduced drastically or the crop failed sometimes due to severe drought. Hence, there is a need to replace the groundnut crop with any other profitable and sustainable variety (Sivajyothi et al, 2023 and Sahaja et al, 2024). Groundnut is an important commercial crop of Ananthapuramu district is recommended to be grown during July to October. But due to frequent droughts occurring at different phenophases of the crop and also other biotic stresses such as red hairy caterpillar, leaf miner, PSND and rust etc., the yields are low and unstable.

In the study area, the farmers are experiencing lower yields than the district and national average productivity. It might be due to the majority of groundnut cultivating area being occupied by old and traditional varieties of groundnut (K-6) which was released during 2005-06 However, the variety lost its potential yield in the farmers field, and became more susceptible to the pest and diseases. Farmers preferred this old variety due to its appearance, tasty and light pink in color. Hence, awareness was there on various aspects, a minuscule of the farmers looking ahead for the high yielding, pest, disease, wilt-tolerant and attractive seeds (K-Lepakshi) that suit an average rainfall of 550mm and a growing period of 112 days.

NICRA, Ananthapuramu center since 2021 had been demonstrating introduction of drought resistant and high yielding groundnut variety (K-Lepakshi). The main focus had been the demonstration of real time contingency crop plan implementation (RTCP) under on farm situation in a participatory mode. The KVK has adopted Pothurajukaluva, Sodhanapalli and East Narsapuram villages for demonstrating this programme.

Methodology

NICRA village profile:

NICRA adopted villages Pothurajukaluva, Sodhanapalli and East Narsapuram falls under Singanamala mandal. They lie between 14.7995° N latitude and 77.7602° E longitude and 338 m above sea level at a distance of 30.3 km away from Ananthapuram district head quarters. The normal rainfall of the area 566.2mm. The total cultivated area of Pothurajukaluva, Sodhanapalli and East Narsapuram is 612 ha, 351 ha and 977.5 ha, respectively. Out of the total cultivated area of 128 ha, 238 and 349.4 ha falls under rainfed in the respective adopted villages. The major soil types are red soils (90%) and light black soils (10%). The soils are slopy (1-2 %) and shallow in depth (10-15cm) with low water holding capacity. The major rainfed crops cultivated during *Kharif* are groundnut, redgram, castor, greengram, jowar and paddy whereas during *Rabi* are groundnut, greengram, castor and jowar. The sources of irrigation are open wells and bore wells. The actual crop seasonal rainfall was less than normal seasonal rainfall in all the years (2011-2021) except in 2017, 2020 and 2021.

The treatment comprised of improved technology vs farmers practice. The improved technology comprised of short duration variety groundnut (K-Lepakshi). Farmer's practice comprised groundnut variety K-6. The cost of cultivation (Rs/ha) was determined taking into account the prevailing charges of agricultural operations and the market price of the involved inputs. During the course of studies, gross returns were obtained by translating the harvest into monetary terms at the prevalent market rate.

Gross Returns (Rs/ha) = (Pod yield x Sale Price)

Net returns were obtained by deducting total cost of cultivation from gross returns
Net Returns (Rs/ha) = Gross Returns (Rs/ha) – Cost of cultivation (Rs/ha)

The benefit: cost ratio was determined by dividing gross returns by the cultivation costs

$$\textbf{Benefit: Cost ratio} = \frac{\text{Gross Returns (Rs/ha)}}{\text{Cost of Cultivation (Rs/ha)}}$$

Results

A comparison of yield performance between groundnut variety (K-Lepakshi) and farmer's practice (K-6) is depicted in Table 2. From the perusal of table it was observed that, during 2022-23, K-Lepakshi resulted in a higher pod yield (1517 kg/ha) as compared to farmers practice (K-6) plot (781 kg/ha) with 92.7 per cent yield increase over the K-6. Similar Results were obtained in 2021-2022 with K-Lepakshi (Priya *et al.,* 2016). The K-Lepakshi plots recorded a higher mean pod yield (1284 kg/ha) as compared to FP plot (837.5 kg/ha) with 55.5 per cent average increase in pod yield over the farmer's practice.

Economic returns

During the two year period a higher average gross return was recorded with demonstration plots (59531 Rs/ha) as compared to FP plots (48274 Rs/ha). During 2022-23 improved technology produced higher gross return (60680 Rs/ha) compared to farmer's practice (47220 Rs/ha). Similar Results were obtained during 2021-22 where demonstration gave a higher gross return in comparison to FP plot due to higher pod yield obtained. The benefit: cost ratio during 2022-23 was 1.37:1 in demonstrated plot as compared to FP plot (0.93:1). Similarly, the average across years indicated that the demonstration plot gave higher (1.33:1) B:C ratio from farmer practices (1.02:1). The variability in benefit cost ratio throughout the two years can be attributed primarily to yield performance and cost of inputs in those specific years (Priya *et al*., 2016). However, favourable benefit-cost ratios showed the economic feasibility of the K-Lepakshi and persuaded the farmers on the effectiveness of intervention. These Results confirm with the Results of Sivajyothi *et al.* (2023) who reported the improved technology plots recorded higher mean productivity, gross returns, and B: C ratio than farmers practice plots, indicating improved technology's technical and economic feasibility of groundnut variety K-Lepakshi.

Conclusion

The findings of the study revealed that the groundnut variety (K-Lepakshi) was found efficient in productivity and profitability by recording significantly the highest pod yield with low pest and disease incidence.

Salient features of groundnut varieties assessed during the study period

Sl. No.	Variety	Duration (days)	Potential yield (q/ha)	Shelling %	100 seed weight (g)	Oil content %	Special features
1.	K-Lepakshi	110-115	20-25 (kharif) 45-50 (rabi)	70	40-45	51	Very high yielding, profuse bearing spanish variety, with high oil and high protein content. Multiple resistant to pest and diseases and drought
2.	K-6	100-105	20-22 (kharif) 40-42 (rabi)	72	40-45	48	Early, high yielding, spanish bunch, attractive kernel and synchronous maturity.

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Effect of Phalaris minor Retz. Emergence Time and Density on Productivity of Wheat (*Triticum aestivum* L.)

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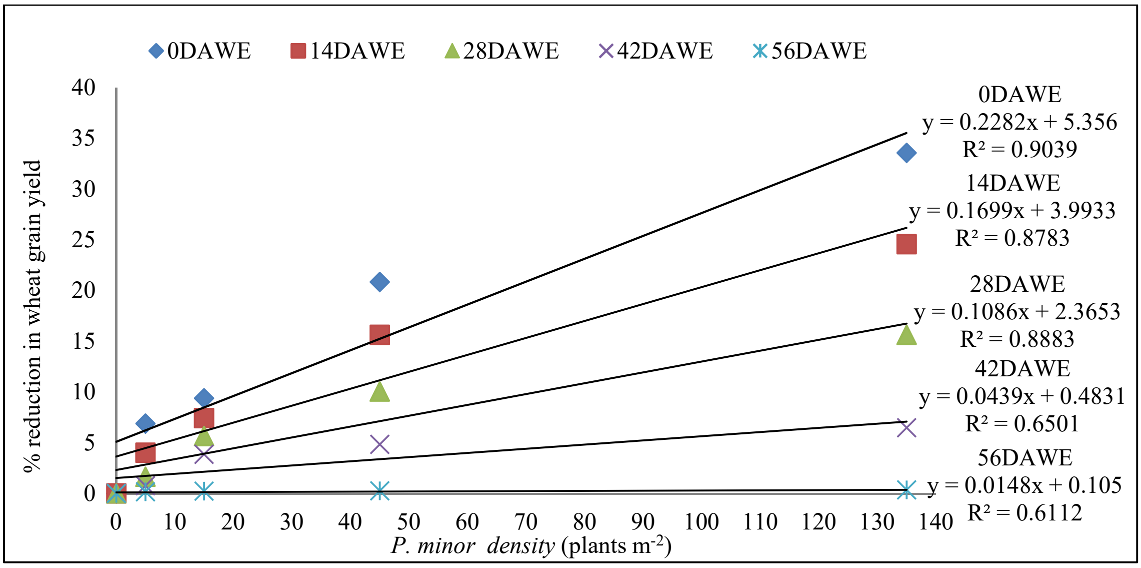
Phalaris minor has been a major threat to the productivity and sustainability of rice-wheat system in NW India. The yield losses in wheat due to *P. minor* competition could be up to 80% and under severe conditions, it can be a sole cause of complete crop failure (Malik and Singh, 1995) which was common during late 1970's due to the absence of effective herbicide and in mid-nineties, after it evolved resistance against isoproturon. With this perspective, the study was planned to estimate yield losses in wheat caused by *P. minor* competition as a function of its density and time of emergence.

Methodology

A field experiment was carried out on sandy loam soil during the winter season of 2019-20 and 2020-21 at Punjab Agricultural University, Ludhiana, India. The treatments consisted of five timings of emergence of *P. minor* (0, 14, 28, 42 and 56 days after wheat emergence) in main plots and five *P. minor* densities (0, 5, 15, 45 and 135 plants m^{-2}) in sub plots in a split plot design with three replications. Wheat variety (Unnat PBW 343) was sown manually using 100 kg seeds ha^{-1} in 22.5 cm spaced rows on 29 October 2019 and 6 November 2020. In 0 days after wheat emergence (d), *P. minor* seeds were sown as per density on the day of wheat sowing. In 14 and 28 d treatments, seeds were sown one week before due date of emergence while in case of 42 and 56 d treatments, *P. minor* seeds were sown 12-day before due date of emergence. The crop was raised as per standard package of practices except for weed control treatments. Data was analyzed using IBM SPSS Statistics 26 and pooled data of two seasons has been presented.

Results

Spike density of wheat increased when emergence of *P. minor* was delayed from 0 to 14, 28, 42 and 56 DAWE. Every successive increase in *P. minor* density from 0 to 5, 15, 45 and 135 plants m^{-2} significantly decreased spike density of wheat. At all times of *P. minor* emergence, weed free environment (0 *Phalaris minor* plant) recorded highest spike density. *P. minor* plants emerged at 28, 42 and 56 DAWE produced a similar number of wheat spikes at 5 *P. minor* plants m^{-2}. The highest wheat grain yield was recorded when *P. minor* emerged at 56 DAWE. It was at par with 42 DAWE and significantly higher than when *P. minor* emerged at 0, 14 and 28 DAWE in both years. Among *P. minor* density levels, every successive increase in *P. minor* density from 0 to 5, 15, 45 and 135 plants m^{-2} significantly decreased grain yield and weed free treatment (0 *Phalaris minor* plants m^{-2}) recorded the highest wheat grain yield in both years. Wheat crop under weed free environment (0 *Phalaris minor* plants m^{-2}) recorded highest grain yield irrespective of the time of emergence of *P. minor*. As compared to the weed free environment, grain yields at all densities of *P. minor* (from 5-135 plants m^{-2}) were at par with yield at 0 plants m^{-2} when *P. minor* emerged at 56 DAWE. When *P. minor* emerged at 0 and 14 DAWE, wheat grain yield was significantly reduced even at 5 *P. minor* plants m^{-2} compared to weed free treatment.



Correlation equations between *Phalaris minor* density & emergence time and wheat grain yield at Ludhiana, India (Mean data of 2019-20 and 2020-21); DAWE-days after wheat emergence

Conclusions

Wheat grain yield was highest when *P. minor* emergence delayed to 56 DAWE; grain yield reduced by 13, 9, 5 and 2%, respectively, when P. minor emerged earlier at 0, 14, 28 and 42 DAWE. Weed free treatment recorded highest wheat grain yield; grain yield reduced by 3, 6, 11 and 16% at 5, 15, 45 and 135 *P. minor* plants m^{-2}. Hence, any management practice for *P. minor* must delay its emergence and minimize its density till 42 days after wheat emergence for minimizing losses in wheat grain yield.

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UID: 1362

Recent trend in Millet Cultivation for improving Climate Resilience in Kalahandi District, Odisha

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Kalahandi district, located in the western undulating zone of Odisha, has long been recognized as a traditional hub for millet cultivation, encompassing approximately 10,500 hectares dedicated to diverse millet varieties such as Finger millet, Small millet, Kodo millet, Kangu, Jowar and Bajra millet. This region is characterized by a sub-tropical climate and a predominantly tribal population with rich traditional millet farming knowledge. The diverse topography, ranging from plains to undulating hills, supports the growth of these hardy crops, which are increasingly important for climate resilience amid challenges posed by erratic rainfall and climate variability. With over 70% of agriculture in Kalahandi being rainfed, initiatives under the NICRA (National Innovations on Climate Resilient Agriculture) project are vital for promoting sustainable practices that enhance food security and adapt to changing environmental conditions. In this context, millets have emerged as vital crops due to their drought tolerance, ability to thrive in poor soils, short growing season of three months (avg.), minimal incidence of insect and pests, and minimal input requirements. Nutritionally, millets are rich in protein (7-12%), vitamins, essential micronutrients like iron, calcium, and zinc, low glycemic index, and high in dietary fiber, contributing to food security and sustainable livelihoods. As per ICMR-NIN, the recommended amount of millet to be consumed per day is 33% of the total cereal requirement.

Methodology

The research carried out in the Kalahandi District of Odisha centers on rainfed agriculture, specifically millet farming, within a varied geographic region defined by a sub-tropical climate and different soil types. Data gathering includes structured surveys of farmers, field observations, and interviews with stakeholders, along with secondary data from agricultural department records and climate information. The quantitative analysis covers production trends, economic evaluations, and yield calculations over the last eight years, with rainfall data collected monthly and analyzed quarterly. This approach merges scientific precision with practical insights, providing a comprehensive understanding of millet cultivation trends and their effects.

Promotion of Millet Cultivation Under the Nicra Project

The NICRA project has implemented extensive demonstrations in selected villages to promote the cultivation of finger millet varieties. Key varieties include:

Arjuna: Recommended for its drought tolerance and high nutritional value, Arjuna has an average yield of 22 quintals per hectare and matures in 115 days.

Shreeratna: This variety is chosen for its adaptability to local soil and climatic conditions, offering an average yield of 23 quintals per hectare and tolerance to brown spot and foot rot diseases.

These demonstrations aim to highlight the advantages of these millet varieties in enhancing yields and improving climate resilience for local farmers.

Role of Kvk, Kalahandi in Scaling up and Value Addition

Millet Recipe Contest: Organized by KVK Kalahandi, this contest encourages the preparation of innovative millet recipes (like idli, dosa, ragi puri, millet cake, etc.) to increase consumer awareness, acceptance and demand for millet-based products.

Convergence Programs: Collaborations between KVK, different FPOs, the Odisha Millet Mission, the Department of Agriculture, and ITDA Kalahandi support millet cultivation through field days, awareness programs, and farmer training, promoting best practices and increasing production.

These initiatives effectively boost millet production, create added value in millet products, and support the economic well-being of farmers.

Results

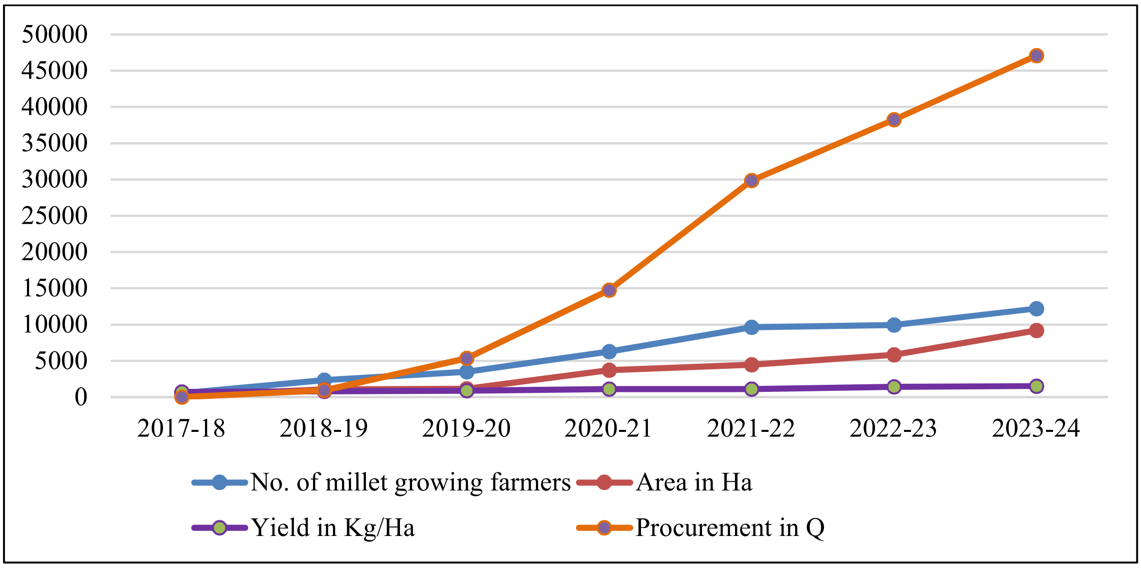
The promotion of Millet cultivation in Kalahandi has led to widespread adoption of finger millet, with the cultivated area expanding to 10081.25 hectares and contributing to a 45% increase in area under millet cultivation over the last five years. Enhanced farming practices, including improved seed varieties, the integration of traditional and modern techniques, and water management, have boosted yields and diversified crop varieties. These efforts have strengthened farmers' resilience against climate stresses, such as droughts while improving household food security and nutrition due to millet's nutrient richness. Value addition and recipe contests have generated economic benefits, providing farmers with better market access, increased income, and improved price realization. Millet cultivation has also fostered environmental sustainability by improving soil health, conserving water, and promoting biodiversity in farming systems.

Conclusion

The initiatives in Kalahandi have successfully revived millet cultivation, significantly expanding cultivation area and enhancing farmer resilience to climate stresses. Economic viability has been achieved through better market integration, providing a sustainable income source for farmers. These efforts showcase a potential model for other rainfed regions, highlighting the importance of millet as a resilient and nutritious crop. Continued policy support and further market development will be essential to sustain and scale these achievements. The millet cultivation approach in Kalahandi under the NICRA project represents a successful model of integrating traditional agricultural practices with modern climate resilience strategies. By leveraging collaborative efforts and innovative approaches, these programs are paving the way for sustainable food systems in the region.

The Trend in Millet Production Over Last 8 Years in Kalahandi

Year	No. of Millet growing Farmers	Area in Hectare	Yield (Kg/ha)	Procurement in Quintal	WSHG Support
2017-18	546	219.28	730	NA	NA
2018-19	2351	1074.45	810	920.29	NA
2019-20	3509	1163.94	900	5348.68	05
2020-21	6293	3707.47	1100	14767.73	16
2021-22	9651	4459.7	1100	29878.14	45
2022-23	9957	5812.3	1417	38231	92
2023-24	12213	9188.8	1525	47100	132



Trend in Millet Production in Kalahandi over last 8 Years

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UID: 1365

Integrated Strategies for Managing Chickpea Pests: Insights from Maharashtra

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The study, *"Evaluating IPM Modules for Sustainable Management of Chickpea Pests in Semi-Arid Maharashtra,"* aimed to assess the effectiveness of Integrated Pest Management (IPM) strategies in comparison to conventional farming methods. Chickpea, a vital legume crop in India, faces significant pest challenges, particularly from the Gram Pod Borer (*Helicoverpa armigera*), which drastically reduces yields. The increasing reliance on chemical pesticides to combat pests has raised concerns about environmental degradation, pesticide resistance, and health risks to farmers. This study investigates sustainable alternatives by employing IPM approaches.

Methodology

The primary objectives were to compare pest infestation levels, the abundance of natural enemies, crop yields, and economic returns between IPM-based and conventional farming practices. Field trials were conducted in Kumbharwadi village using the chickpea variety "Vishal." Eight treatment modules were developed and evaluated using a Randomized Block Design (RBD) with three replications. These modules included conventional pesticide usage and various combinations of botanical extracts, bio-pesticides, and mechanical controls.

Results

The Results revealed that while different pest control methods had minimal impact on plant height and spread, chickpea grain yields varied significantly. IPM modules M4, M5, and M6—incorporating botanical extracts, bio-pesticides, and mechanical controls—demonstrated yields comparable to those achieved with chemical treatments. Notably, these IPM modules produced 4% higher yields than chemical-based methods and over 65% higher yields than the untreated control group. Furthermore, the IPM modules effectively reduced Gram Pod Borer populations following the second pest control spray. While chemical methods remained effective, the integration of mechanical controls, botanical extracts, and bio-pesticides provided equivalent pest suppression with reduced environmental impact.

Effect of pest control modules on plant growth characteristics and grain yield

Modules	Modules	Plant height (cm)	Plant Spread (cm)	Grain yield (q/ha)
Botanical extracts	M1	39.0	24.3	17.06b
Botanical extract + Bio-pesticides	M2	40.7	25.3	17.63b
Botanical extract + Mechanical control	M3	43.3	31.3	16.44bc
Biopesticides + Mechanical control	M4	46.7	30.7	23.37a
Botanical +Biopesticides + Mechanical control	M5	46.0	29.3	23.43a
M5 + * ETL based Spray	M6	43.0	27.3	23.50a
100 % Chemical	M7	44.3	30.7	22.57a
Absolute control	M8	37.0	26.7	14.18c
CV		10.6	19.5	8.10
CD (0.05)		3	NS	2.81

Conclusion

The study highlights the adverse consequences of chemical pesticide overuse, including environmental harm, human health risks, and the emergence of pesticide-resistant pest populations. It underscores the potential of IPM as a sustainable alternative. By integrating natural pest control techniques such as botanical extracts, bio-pesticides, and mechanical interventions, IPM reduces chemical dependency while maintaining crop productivity. Mechanical control measures, such as sticky traps and bird perches, proved instrumental in naturally curbing pest populations. Similarly, botanical pesticides, derived from plants, emerged as eco-friendly alternatives to synthetic chemicals, mitigating resistance development and promoting long-term agricultural sustainability. The findings emphasize that no single pest control method is sufficient to achieve significant pest suppression or yield enhancement. Instead, combining methods in an integrated framework significantly improves pest control efficacy and crop performance.

Despite the benefits of IPM, its widespread adoption faces several challenges. These include the commercialization and formulation of botanical and bio-pesticides, regulatory hurdles, and the need for standardization in production. Additionally, large-scale cultivation of plants for botanical pesticides may compete with food crops for arable land, necessitating careful consideration of land use strategies.

UID: 1366

Evaluation of Land Configuration Techniques, Manures and Biostimulants on Yield and Economics of Ashwagandha-Rice intercropping under Rainfed Condition

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Ashwagandha (*Withania somnifera*), also known as Indian ginseng or winter cherry, is a medicinal plant native to central and north-western India. It belongs to the Solanaceae family and has been used for centuries across all age groups, including during pregnancy, without reported side effects (Paul *et al.,* 2021). Major producers of ashwagandha in India include Madhya Pradesh, Haryana, Gujarat, Punjab, Maharashtra, Uttar Pradesh, and Rajasthan, with Madhya Pradesh alone cultivating it on over 5,000 hectares (Moharana *et al.,* 2020).

Globally, rice (*Oryza sativa* L.) is a staple food for more than half the world's population, valued for its high nutritional and caloric content. However, challenges such as climate change and declining crop performance necessitate advanced agro-technological strategies to enhance productivity (Mishra *et al.,* 2013). The use of organic manures has proven effective in improving the quality of medicinal and aromatic plants, with growing international demand for organically certified medicinal herbs. Given ashwagandha's economic significance in domestic and global markets, organic nutrient management offers a sustainable alternative to chemical fertilizers, addressing both environmental and market concerns. Additionally, bio-stimulants have shown great potential in alleviating abiotic stresses caused by climate change, supporting crop productivity, quality, and food security (Bhupenchandra *et al.,* 2022). The aim of the present investigation was to evaluate the effect of organic fertilizers (Vermicompost and poultry manure) and bio stimulants on root yield and economics of treatments.

Methodology

The experiment was conducted during 2023-24 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. It is located at a distance of about 10 kilometers from Varanasi railway station in South-East direction. The geographically experimental field is situated at 25°18' N latitude, 83°03 E longitudes, and 75.7 meters above the mean sea level in the North Gangetic alluvial plain. The experiment was laid out at the All India Coordinated Research Project on Dryland Agriculture, of Agricultural Research Farm. The experimental site was homogeneously fertile with uniform textural makeup and had even topography. In this study, there is 4 main plot treatments, factor A (Broad bed furrow, Ridge & furrow), factor B (Poultry manure, Vermicompost) and four treatments

Seaweed extract, Humic acid, Seaweed extract and Humic acid mix and Control were kept in sub plot.

Results

Fig.-1 show that yield Kg/ha and economics of various treatments. Among the treatments, broad bed furrow with poultry manure along with humic acid was found superior over all the treatments followed by broad bed furrow with poultry manure along with Seaweed extract. Among the treatments, broad bed furrow with poultry manure along with humic acid was found higher gross return, net return and benefit cost ratio.

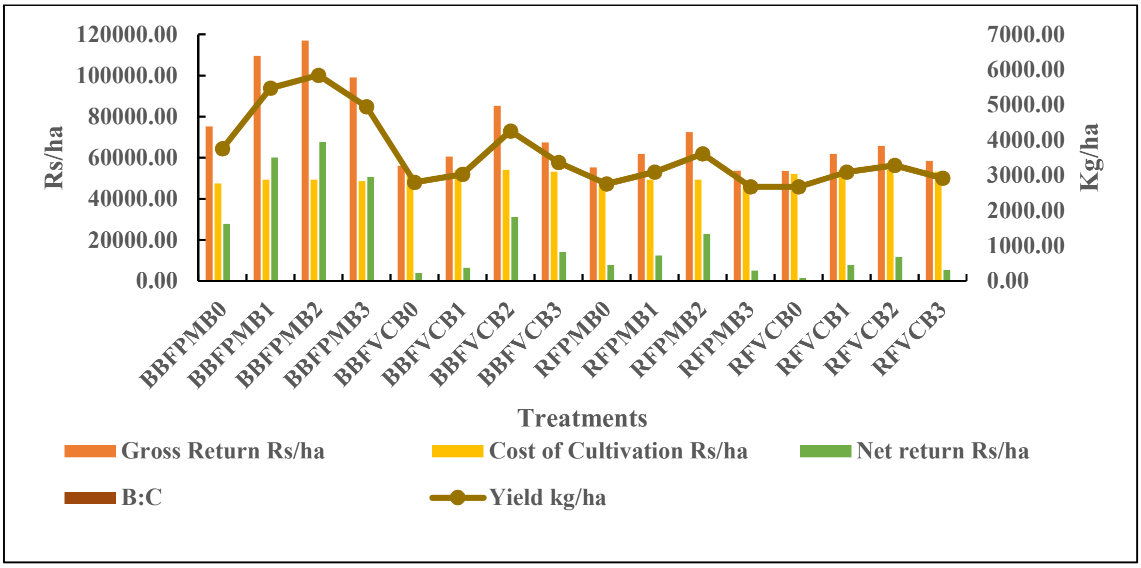

Fig 1. Yield and economics of various treatments

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UID: 1375

Integrated weed management in soybean (Glycine max L. Merill)

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Soybean (*Glycine max* L. Merill) is one of the India's major pulse and oil seed crops. It is rich in protein and vegetable oil. It is the only legume with ample amount of essential omega-3 fatty acid and alpha-linolenic acid. In addition, biotin, which is recognized as an essential nutrient factor, is included at a higher concentration in soybean compared to vegetables, fruits, and most meat products (Wang and Komatsu). During the year 2020-21 soybean sown on 12.81 million hectares and give the production of 12.90 million tonnes with the productivity 1007 kg/ha (Source- Directorate of Economics &Statistics, DA&Fw).

Early weed competition has a big impact on soybean yield. Soybeans are severely contaminated with broad-leaved weeds and other grasses during the wet season. Depending on the severity of weed infestation, soybean yield loss might range from 26 to 84%. In addition to yield loss, quality is also negatively impacted. The first 15 to 45 days are the most crucial for weed interference (Kumar et al.).

An integrated weed management approach to land management combines the use of complementary weed control methods such as grazing, herbicide application, land fallowing, and biological control. It uses knowledge of weed biology, (emergence, growth rate, fecundity) integrated with multiple weed control tools to manage weeds throughout the growing season (FAO).

Integrated Weed has been proposed to provide farmers with systematic approaches to reduce reliance upon herbicides, to decrease the density of weeds emerging in crops and to reduce their relative competitive ability.

Methodology

The field experiment was carried out during *kharif* 2021 at Experimental Farm of Agronomy Section, College of Agriculture, Latur to study Integrated weed management in soybean.

The experiment was laid out in randomized block design with three replications and nine treatments. The treatments are T1– Weedy check, T2 –Weed free, T3– Soybean + Green gram (2:1) intercropping, T4 – Diclosulam 84% WDG PE 26g/ha +1 Hoeing + Straw mulching, T5–

Diclosulam 84% WDG PE 26g/ha + POE Imazethapyr 10% SL @ 0.10 kg/ha at 20-25 DAS, T6 –Imazethapyr 10% SL @ 0.10 kg/ha POE at 20-25 DAS +1 Hoeing at 25 DAS + Straw mulching, T7 – Imazethapyr 10% SL @ 0.10 kg/ha POE + Quizalofop ethyl 5%EC @ 0.075 kg a.i/ha POE at 20-25 DAS (Tank Mix), T8 – Pendimethalin 38.7% CS @ 0.75 kg a.i/ha + Imazethapyr 10% SL @ 0.10 kg/ha POE at 20-25 DAS, T9– Pendimethalin 38.7% CS @ 1.0 kg a.i/ha + 1 Hoeing +Straw mulching.

Results

The data presented in Table. 1. Showed that highest Seed yield (Kg ha^{-1}), Gross monetary returns (₹ ha^{-1}), Net monetary returns (₹ ha^{-1}) and B:C ratio were found in treatments weed free (T2) i.e 2049, and 122940, 83275 and 3.0 respectively followed by Pendimethalin 38.7% CS @ 0.75 kg a.i/ha + Imazethapyr 10% SL @ 0.10 kg/ha POE at 20-25 DAS (T8) i.e 1890, 113400, 74095 and 2.89 respectively. Similar finding were reported by Samudre *et al.* (2019) and Yadav *et al*. (2017).

Mean seed yield (kg ha^{-1}), Economics (₹ ha^{-1}), Weed control efficiency (%) and weed index (%) as influenced by different treatments

Treatments	Seed yield (kg ha^{-1})	GMR	NMR	B:C ratio	WCE (%)	WI (%)
T1: Weedy check	950	57000	25035	1.78	0.00	53.63
T2: Weed free	2049	122940	83275	3.00	90.78	0.00
T3: Soybean + Green gram (2:1) intercropping	1462	87720	48755	2.25	30.26	28.64
T4: Diclosulam 84% WDG PE 26g/ha + 1 Hoeing + Straw mulching	1652	99120	57635	2.39	40.78	19.37
T5: Diclosulam 84% WDG PE 26g/ha + POE Imazethapyr 10% SL @ 0.10 kg/ha at 20-25 DAS	1840	110400	71635	2.85	82.23	10.20
T6: Imazethapyr 10% SL @ 0.10 kg/ha POE at 20-25 DAS +1 Hoeing at 25 DAS + Straw mulching	1718	103080	61435	2.48	59.86	16.15
T7: Imazethapyr 10% SL @ 0.10 kg/ha POE + Quizalofop ethyl 5%EC @ 0.075 kg a.i/ha POE at 20-25 DAS (Tank Mix)	1671	100260	59663	2.47	44.07	18.44
T8: Pendimethalin 38.7% CS @ 0.75 kg a.i/ha + Imazethapyr 10% SL @ 0.10 kg/ha POE at 20-25 DAS	1890	113400	74095	2.89	86.18	7.75
T9: Pendimethalin 38.7% CS @ 1.0 kg a.i/ha + 1 Hoeing +Straw mulching	1595	95700	53210	2.25	33.33	22.15
SE ±	107	6389	6389			
CD @5%	310	18572	18572			
G Mean	1647	98847	59415	2	51.94	19.59

GMR- Gross Monetary Returns, NMR- Net Monetary Returns, WCE- Weed Control Efficiency and WI- Weed Index

The highest weed control efficiency (%) recorded in weed free treatment (T2) i.e 90.78 % and lowest weed control efficiency (%) observed in weedy check plot. Among the chemical treatments, the highest weed control efficiency (%) observed in Pendimethalin 38.7% CS @ 0.75 kg a.i/ha + Imazethapyr 10% SL @ 0.10 kg/ha POE at 20-25 DAS (T8) i.e 86.18 % followed by diclosulam 84% WDG PE 26g/ha + POE Imazethapyr 10% SL @ 0.10 kg/ha at 20-25 DAS (T5) i.e 82.23 %. Similar finding was obtained by Samudre et al. (2019). The lowest weed index recorded in weed free plot followed by Pendimethalin 38.7% CS @ 0.75 kg a.i/ha + Imazethapyr 10% SL @ 0.10 kg/ha POE at 20-25 DAS (T8) i.e 7.75 %.

Conclusion

The study showed that the highest seed yield, Economics (₹ ha^{-1}), weed control efficiency, and lowest weed index were obtained in soybean crop kept with weed free condition followed by Pendimethalin 38.7% CS @ 0.75 kg a.i/ha + Imazethapyr 10% SL @ 0.10 kg/ha POE at 20-25 DAS (T8) and Diclosulam 84% WDG PE 26g/ha + POE Imazethapyr 10% SL @ 0.10 kg/ha at 20-25 DAS (T5).

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UID: 1378

Characterization and Evaluation of Sweet Sorghum (*Sorghum bicolor L. Moench*) Genotypes

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Sweet sorghum (*Sorghum bicolor* (L.) Moench) is an important bioenergy crop, that has the potential to accumulate sugars (10-23%) in its stalk like sugarcane but also produce grains. A field experiment was conducted at NBPGR, Hyderabad during *Kharif* 2022 and 2023 to study genetic diversity and identify promising parents in sweet sorghum for biofuel related traits like brix (%), green cane yield and related characters in 15 genotypes. Among all genotypes PSR-13243 and RJR-267 recorded significantly higher Brix (total soluble sugars (TSS) content than checks. Juice Brix content has shown very strong positive correlations with TSS. Sweet sorghum is a widely adapted sugar crop with high potential for bioenergy and ethanol production. It is a potential crop for ethanol production and also suitable for the sugarcane based cropping systems. It has rich soluble sugar in the stalk which can be converted into numerous products such as ethanol, syrup, fodder, jaggery and paper. It is an attractive crop for biofuel production and a good renewable feedstock suitable for cultivation under arid regions. It is similar to grain sorghum except for its juice-rich sweet stalk. The sugar is composed mainly of sucrose (70–80%), fructose and glucose. So, there is a need to develop promising parents in sweet sorghum for biofuel related traits like brix (%), green cane yield and other characters, which can be grown throughout the year with high stalk and sugar yields.

Methodology

The field experiment was conducted during the rainy (*kharif)* seasons of 2022 and 2023 at the NBPGR, Regional station, Hyderabad. A randomized block design was used to evaluate the performance of 15 sweet sorghum genotypes along with 4 checks for growth, yield and total soluble sugars production. Each genotype was raised in 2 rows of 4 m length spaced at 60 cm with inter plant distance of 15 cm. In each entry, five randomly selected plants were utilized to collect data on different characters viz., plant height (cm), days to 50 per cent flowering, number of leaves per plant, leaf length (cm), leaf width (cm), number of nodes per plant, stem girth (cm), green cane yield (t ha-1), juice volume (L/ha), brix content (%), juice extraction (%), 100 seed weight (g) and grain yield per plant (g) and the data was subjected to statistical analysis. The stalk juice was extracted with a sugarcane crusher and weighed to determine the juice yield. The brix in the cane was determined using refractometer.

Results

The analysis of variance revealed significant differences among the genotypes for all the traits. NSJ-098 (76 days) were recorded early flowering among the genotypes. Sweet sorghum cultivars being relatively photoperiod sensitive tend to delay flowering when planted under long day conditions. Differential phenology of sweet sorghum genotypes was also reported by Rao et al. (2013). The brix (total soluble sugar) content was found to be 18.5 per cent at physiological maturity. The maximum juice yield was recorded in PSR-13243 and RJR-267. The green cane yield showed positive correlation with plant height, number of internodes, total dry matter and fresh biomass. There is a positive correlation in green cane yield with the juice yield, brix. The sweet sorghum genotypes PSR-13243, RJR-267 and NSJ-367 were identified as more productive for brix, which can be utilized in further breeding programme.

UID: 1383

A Study on Screening of Sunflower Hybrids Against Pest: A Tool for Sustainable Pest Management

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Andhra Pradesh, Karnataka, Maharashtra, and Tamil Nadu are the states in India that grow sunflowers, accounting for over 90% of total acreage and 78% of total production (Chander Rao *et al*., 2015). According to Shankergoud *et al.* (2006), oilseeds make up the second-largest agricultural commodity after cereals, accounting for 14% of the nation's gross cultivated area, 5% of the gross national product, and 10% of the total value of all agricultural goods. There are many reasons for the low productivity of oilseeds crop among these attack of insect pest is a major one. A diverse assemblage of both beneficial and harmful insect species is associated with the sunflower ecosystem. cutworms (*Agrotis spp*.), sucking pests, leaf and plant hoppers (*Amrasca biguttula biguttula* Ishida, Empoasca spp.), thrips (*Thrips palmi*), whitefly (*Bemisia tabaci* Gennadius), defoliators (*Spilosoma obliqua* Walker, *Spodoptera litura* Fabricius, and *Plusia orichalcea* Fab.), and capitulum borer(*Helicoverpa armigera Hubner*) are major pests of economic concern. Different parts of the sunflower plant are damaged by different pests at different phonological stages. Soil insects damage roots and emerging seedlings. Defoliators and sucking pests cause losses in food reserves. Inflorescence pests like H. armigera destroy floral parts and developing seeds and cause direct damage (Basappa, 1998).

Resistant breeding against insect pest is of prime importance. In fact, even a moderate level of tolerance in plants can have a significant impact and lessen the need for insecticides. One of the most crucial strategies for maintaining insect populations below economic threshold levels is the use of resistant or less susceptible cultivars (Kavitha and Dharma Reddy, 2012, Sarwan Kumar and S. K. Dhillon 2014). The goal of the current experiment was to determine whether the 100 sunflower germplasm lines that were available were resistant to the capitulum borer (*Helicoverpa armigera* Hubner) and defoliators (*Spilosoma obliqua* Walker, *Spodoptera litura*

Fabricius, and *Plusia orichalcea Fab*.). This information could then be used to create resistant hybrids.

Methodology

A field screening experiment with Twenty-eight entries from IHT and AHT along with infester rows of susceptible check morden obtained from Indian Institute of Oilseeds Research and were screened for their resistance against defoliators and capitulum borer during Kharif, 2014-15 at Oilseeds Research Station, Latur, Maharashtra in Augmented Block design. Sunflower seeds were dibbled on the ridges at a spacing of 60 X 30 cm, fifteen plants. were maintained per row. A known susceptible check 'Morden' was maintained @ one row for every ten test accessions as infester rows. Two rows of the susceptible check were also sown around the experimental field as infester crop. Recommended agronomic practices were followed except plant protection measures. Observations on the number of defoliators and capitulum borer were made at weekly intervals by as follow

Head borer: Randomly 5 plants were selected, % seed damage head and the larval number flower bud -1and flower head-1 were recorded.

Defoliators: No. of defoliator population i.e. *Spilosoma obliqua* Walker, *Spodoptera litura* Fabricius, and *Plusia orichalcea* Fab were recorded by 5 randomly selected plants, counting the total number of larvae. Using these data, the mean population per plant and mean per cent was worked out and further analysis were made.

Sucking pest: Observations on the number of leaf hoppers, thrips and whiteflies were made at weekly intervals by counting the number of nymphs and adults present in six leaves two each from top, middle and bottom portions of three plants in a row.

Stem borer: infestation by Stem borer (*Nupserha vexator*) were recorded by 5 randomly selected plants, counting the total and affected stem and express their damage in percent

Results

Twenty eight entries from IHT and AHT along with susceptible check morden were evaluated for their reaction to major pest of sunflower. Defoliator incidence ranged between 0.73(AHT-8) to 4.33(IHT-988) larvae per plant, of which AHT-8 and AHT- 9 were promising. The incidence of capitulum borer (*Helicoverpa armigera*) ranged between 0.20 (IHT-989) to 2.13(IHT-1003) per plant, entry IHT-989 was found promising against capitulum borer. Stem borer (*Nupserha vexator*) was ranged from 07 to 67 per cent and it was found minimum in the entry IHT-989 and IHT-995.

Conclusion

The entries AHT-8 and AHT- 9 were promising for defoliators, IHT-989 was found promising against capitulum borer and stem borer similarly entry IHT-995 was also found promising for stem borer. Population of sucking pest was very low and uniformly distributed in all the tested entries.

Coordinated entries screened for pest resistance in sunflower (*Kharif*, 2014)

Sl. No.	Name of Entry	Leafhoppers / Pl	Thrips / Pl	Defoliators l/ plant	capitulum borer l/ plant	Stem borers (%)
1	AHT-1	0.53 (1.02)	0.47 (0.98)	1.87 (1.54)	0.67 (1.08)	17.00 (24.51)
2	AHT-2	0.73 (1.11)	0.67 (1.08)	2.00 (1.58)	0.53 (1.02)	18.00 (24.90)
3	AHT-3	0.60 (1.05)	0.20 (0.84)	1.27 (1.33)	0.87 (1.17)	19.00 (25.96)
4	AHT-4	0.73 (1.11)	0.53 (1.02)	1.93 (1.56)	1.60 (1.45)	16.00 (23.47)
5	AHT-5	0.33 (0.91)	0.93 (1.20)	1.00 (1.22)	0.93 (1.20)	19.00 (25.55)
6	AHT-6	0.47 (0.98)	0.87 (1.17)	1.53 (1.43)	0.73 (1.11)	22.00 (27.87)
7	AHT-7	0.53 (1.02)	1.40 (1.38)	1.93 (1.56)	0.53 (1.02)	26.00 (30.58)
8	AHT-8	0.47 (0.98)	0.87 (1.17)	0.73 (1.11)	0.67 (1.08)	14.00 (21.75)
9	AHT-9	0.60 (1.05)	0.67 (1.08)	0.80 (1.14)	1.00 (1.22)	29.00 (33.11)
10	Morden	0.80 (1.14)	1.60 (1.45)	1.80 (1.52)	0.93 (1.20)	64.00 (29.10)
SE at 5%		0.06	0.06	0.10	0.07	2.55
CD +		0.18	0.18	0.30	0.21	7.58
CV		10.60	9.05	12.59	10.54	15.20

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UID: 1384

Impact of Diurnal Variation in Vapor Pressure Deficit on Transpiration Rate in Blackgram Genotypes

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Blackgram or urdbean is a short duration grain legume. This crop is exposed to water stress at different stages of its growing period. Water stress drastically affects production and productivity of pulse crops if exposed to stress at flowering and post-flowering as compared to other phenophases. Traits such as restricted maximum transpiration (TR_{Lim}) reduce water loss under high vapor pressure deficit (VPD) conditions, typically experienced around noon, by decreasing stomatal conductance and delaying wilting. It may increase crop yield in drier atmospheric conditions and potentially conserve soil water to support crop growth later in the growing season. Therefore, water transpired and transpiration response to high VPD conditions were determined in four blackgram genotypes at peak vegetative stage.

Methodology

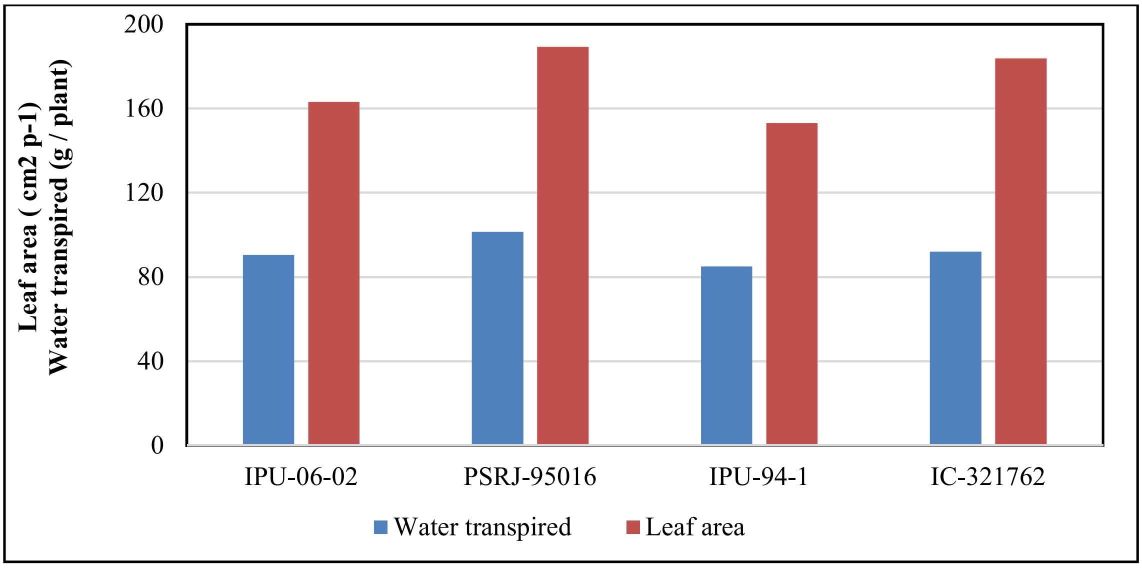
Whole plant transpiration response to increasing VPD of important rainfed pulse crop-blackgram genotypes (IPU-06-02, PLU-826, PSRJ 95016 and IPU-94-1) were determined at 34 days after sowing (DAS) when plants were at peak vegetative stage. Crop was sown in first week of February and transpiration response measurement was carried in first week of March. Plants were grown in plastic pots filled with approximately 7.5 kg of red soil (soil mixed with FYM in 4:1 ratio). Recommended dose of fertilizer and standard agronomic practices were adopted. Three seeds were sown in each pot and two weeks after sowing, plants were thinned to one plant per pot. Plants were grown under well-watered conditions for 33 days (vegetative stage). Pots were irrigated and left to drain overnight to reach field capacity. Moisture content was 18% at field capacity. Soil evaporation was restricted by covering the soil surface around the stem with a plastic sheet, on which a 2-cm layer of plastic beads were placed. Throughout a complete clear day in outdoor conditions, under natural variations in atmospheric vapor pressure deficit (VPD), potted plants were weighed gravimetrically every 60 min using 1 g precision weighing balance from 5:00 am to 6:00 pm. VPD tends to be low in the morning, gradually increasing until it reaches a peak around midday, after which it decreases during the afternoon. Plants were harvested at the end of the transpiration measurement to measure leaf area (LI-3100). The individual plant transpiration rates (TR) were obtained by dividing transpiration values by leaf area.

Results

The temperature was lowest in the morning (21.05ºC at 5 am) and reached a peak at 1pm (35.42ºC) and again decreased to 28.28 ºC at 5 pm) (fig 1). The relative humidity was highest in the morning (38.25% at 5 am) and lowest at 1 pm (17.62%) and again increased to 25.19 % at 5 pm. With variation in temperature and relative humidity there was variation in vapor pressure deficit (VPD). The VPD was lowest in the morning (1.54 K Pa at 5 am) and highest at 1 pm (4.73 K Pa) and decreased to 3.0 K Pa at 5.0 pm in the evening on the day of experiment.

There were significant differences among the blackgram genotypes for leaf area and water transpired. The leaf area of blackgram genotypes *viz;*IPU-06-02, PSRJ-95016, IPU-94.1 and IC 321762 was 163.1, 189.2, 153.1 and 183.8 and water transpired from morning to evening was 90.5, 101.3, 85 and 92.0 g/plant respectively (fig).

There was variation among the genotypes for transpiration rate with increasing VPD. The genotypes IPU-06-02, PSRJ-95016, IPU-94-1 increased the transpiration with increasing VPD while the genotype restricted the transpiration at mid-day. This restriction in the transpiration would save water and contribute potentially to drought adaptation. The genotypes IPU-06-02, PSRJ-95016, IPU-94-1 had a higher transpiration rate (TR) of 104.7, 112.6, 100.1 mg cm^2 hr^{-1}, while the genotype, IC 321762 restricted the TR to 74.4 mg cm^2 hr^{-1}The restriction in transpiration under high VPD allowed by partial stomata closure saves soil moisture at the early vegetative stage, which can increase moisture availability for reproductive stages under the rainfed condition and can enhance yield. The restricted transpiration rate is likely due to the result of low hydraulic conductance located in the leaves of this genotype between the xylem and into the guard cells.



Water transpired from morning to evening and leaf area in blackgram genotypes

Conclusion

In conclusion the genotype *viz*; IPU-06-02, PSRJ-95016, IPU-94.1 increased the transpiration with increasing VPD and had higher transpiration rate at midday when VPD was high while genotype, IC 321762 restricted the transpiration rate.

UID: 1385

Performance of Climate Resilient Pigeonpea Variety Pkv-Tara in Gadchiroli District

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Pigeonpea (*Cajanus cajan* L.) is also called arhar, red gram, and tur in different parts of the country. Globally, India ranks first in redgram production globally with 43.4 lakh tones cultivated under 49.8 lakh hectares with productivity of 871 kg/hectare in 2021-22 (Agricultural Statistics at a Glance. 2022). State wise redgram production in India in 2021-22, Maharashtra and Karnataka were the major producing states in an area of 12.98 and 12.40 lakh hectares, respectively. Andhra Pradesh produced 0.66 lakh tonnes of redgram cultivated in an area of 2.52 lakh hectares. Uttar Pradesh, Maharashtra and Telangana were found superior in terms of productivity of redgram. It is the second most important pulse crop in India after chickpea in terms of production and consumption. For the majority of the Indian population, pulses are the main source of supply high-quality proteins as compared to other crops. Pigeonpea contains 20-22% protein, 1.2% fat, 65% carbohydrate, and 3.8% ash and it is mainly used as split dal, green pod, and green seeds in the form of green vegetables (Anonymous, 2010). The pigeonpea is hardy, drought-tolerant, and water- susceptible and belongs to the family Leguminosae. Its cultivation involves less input due to the ability to fix atmospheric nitrogen by about 40kg/ha. It is generally cultivated in dry land and rainfed areas. There are several factors like unavailability of high- yielding varieties, quality seeds, bio-fertilizers, improper management, and non-adoption of suitable plant protection measures especially for pod borer and wilting which hamper Pigeonpea yield drastically. Kumar et al. (2014) observed that the low yield of pigeonpea was due to the poor quality of the seed, poor adoption of the package, and the practices of production. To overcome these challenges and to increase the productivity and profitability of pigeonpea there is a need to create awareness among the farmers about site-specific improved varieties and packages and practices of production. Thus, the present study was conducted with objective to examine the effect of CFLD by Krishi Vigyan Kendra, Gadchiroli (MH) during 2021-2022 and 2022-23 on the profitability of pigeonpea production.

Methdology

Demonstrations were conducted based on low-yield attributing causes identified from PRA and preliminary discussion. In control plots, the existing farmer's practices were followed. Critical inputs like seed, Chloropyriphos, Neem oil, biofertilizer and micronutrients were provided by Krishi Vigyan Kendra, Gadchiroli, and remaining inputs were arranged by farmers. Yield data were collected through random crop cutting in the presence of farmers and personnel from both plots of demonstration and existing farmers' practices and based on the data yield performance and economics were calculated by using standardized formulae.

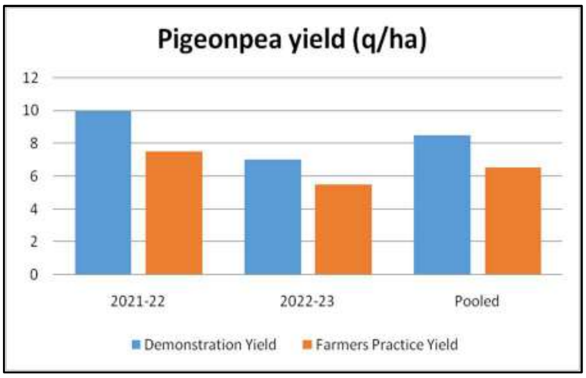
Results

The findings of investigation revealed that the transfer of developed technology under cluster frontline demonstration of pigeonpea resulted in a 10% higher yield as compared to existing farmers' practices. During years 2021-22 and 2022-23, the improved technology demonstrated under CFLD yielded pooled yield 8.87 q/ha of pigeonpea as compared to 6.50 q/ ha in existing farmers' practice. The higher yield received from the demonstration plot might be due to the inclusion of quality seeds of high- yielding variety, seed treatment, recommended dose of fertilizer, weed control, and pest control. The present finding tally with the findings of Kumar et al. (2014) in pigeonpea. Economic analysis of CFLD and existing farmers' practices is presented in Table 1 which revealed that the highest cost of cultivation (Rs. 42500/ha), gross return (Rs. 66000/ha), net return (Rs. 23500/ha), and benefit cost ratio (1.55) was calculated from CFLD with involvement of improved production technology as compared to existing common farmer practice. An average net return of CFLD demonstration was higher than existing farmers' practice, which may be due to the higher production under CFLD as compared to farmer's practice A similar result was also found by Dhuware et al., (2023).

Performance of Pigeonpea crop in Gadchiroli district (2021-22 & 2022-23)

Year	Demonstration plot (Var. PKV-Tara)					Farmer's practice (Local)				
	Avg. Yield (q/ha)	COC (Rs/ ha)	GMR (Rs/ ha)	NMR (Rs/ha)	B:C Ratio	Avg. Yield (q/ ha)	COC (Rs/ ha)	GMR (Rs/ ha)	NMR (Rs/ ha)	B:C Ratio
2021-22	9.93	16500	62600	55800	1:3.79	7.50	17300	42300	37100	1:2.44
2022-23	7.00	17800	42000	24200	1:2.35	5.50	22500	33000	10500	1:1.46
Pooled	8.47	17150	52300	40000	1:3.07	6.50	19900	37650	23800	1:1.95

COC- Cost of cultivation, GMR- Gross monitory returns, NMR- Net monitory returns, B:C- Benefit to Cost ratio



Demonstration on Pigeonpea crop in Gadchiroli district

Yield performance of Pigeonpea crop in Gadchiroli district

Conclusion

Based on CFLDs conducted during years 2021-22 and 2022-23, with 100 demonstrations in 40 hector area, it can be concluded that the intervention of improved varieties, technologies, balanced input resources, and capacity-building development programs of farming communities will be more helpful in reducing the technology gap and increasing the productivity and profitability of pigeonpea along with perception of technology.

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UID: 1399

Assessment on the Performance of Different Climate Smart and Bio-fortified Rice Varieties in NICRA and KVK Adopted Villages During kharif Season Under Rainfed Bunded Upland Situation in Red Lateritic Zone of Purulia District, West Bengal

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Rice (Oryza sativa) is the most important field crop of Purulia District in West Bengal for the bunded rainfed uplands during Kharif season. Non-adoption of improved technologies is one of the major constraints of traditional rice cultivation with low productivity. Technology Testing under NICRA-TDC were conducted in 15 locations at 5 adopted villages of Krishi Vigyan Kendra Kalyan, Purulia, West Bengal viz., Haramjanga, Jambad, Deoli, Arjunjora & Makrabera during three consecutive Kharif seasons from 2022 to 2024, to demonstrate the production potential and economic benefits of improved technology package comprised of newly released location specific suitable varieties viz., MTU-1153 (Chandra), CR Dhan-310 and CR Dhan-311; Improved technology for all Technology Option i.e. Seed rate-45kg/ha; seed treatment with Carbendazim @3gm/kg seeds; application of Fertilizer @ 30 kg N, 30 kg P2O5 & 30 kg K2O /ha as basal @ 30 kg N as top dressing; Plant Protection as & when necessary were remain same. Total 75 farmers in which five respondents from each variety from one adopted village were selected through random sampling method and each having 0.26 ha. of land being used for assessment of new rice varieties. The improved technologies i.e. Technology Option-1(MTU-1153), Technology Option-2(CR Dhan-310) & Technology Option-3 (CR Dhan-311) recorded significantly higher average yield of 51.40 q/ha (12.88 %), 48.49 q/ha (8.30 %) & 47.58 q/ha (6.26 %) respectively than the yield obtained under farmers practice (44.78 q/ha). The improved technologies i.e. Technology Option-1(MTU-1153), Technology Option-2(CR Dhan-310) & Technology Option-3 (CR Dhan-311) resulted higher mean net return of Rs. 55,654.00/ha (B:C-2.20), of Rs. 46,713.00/ha (B:C-2.02) & of Rs. 45,410.00/ha (B:C-1.99) respectively as compared to local check (Rs. 39,636.00/ha, & 1.82). Technology Option-1with variety: MTU-1153 performed best with some special characteristics i.e. High yielding, non-lodging, short duration, multiple resistance, 2 weeks dormancy and high HRR. It is concluded that the National Innovations in Climate Resilient Agriculture-Technology Demonstration Component (NICRA-TDC) is an effective programme for dissemination of climate smart technology with increasing area, production and productivity of rice coupled with increasing B:C ratio and changing the knowledge, attitude

and skill of farmers on the adoption of improved technologies. The percent increment in yield of rice to the extent of 12.88% over the check created greater awareness and motivated the other farmers to adopt the improved package of practices. These demonstrations also built the relationship and confidence between farmers and scientists. The beneficiaries of NICRA-TDCs also played an important role as source of information on the quality of seeds for wider dissemination of high yielding varieties of rice to the adjacent villages.

UID: 1412

Effect of Biostimulant: Platina on Growth, Yield Parameters and Yield of Cotton

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Cotton (*Gossypium hirsutum* L.) is one of the most important fibre crop of world which is also known as “white gold”. Cotton fibre is the backbone of textile and other industries and plays a prominent role in the rural, national and international economy. It is grown mainly in tropical and subtropical region of more than 80 countries in the world. It is grown mostly for fibre used in the manufacture of cloths for mankind. Besides fibre, cotton is valued for its oil and cotton seed cakes which is good sources of nutrients and used as manures. India plays a vital role in the global cotton landscape, accounting for around 25 per cent of the total cotton production, cultivated across 70.56 lakh hectares, which is estimated around 40 per cent of the world cotton area. At global level, although India occupies 40 per cent of the area, but able to produce just 21 per cent of the global cotton production. Use of bio stimulants in cotton is gaining importance due betterment of qualitative and quantitative parameters. Bio stimulants are natural or synthetic substances that can be applied to seeds, plants and soil. These substances cause changes in vital and structural processes in order to influence plant growth through improved tolerance to abiotic stresses and increase seed grain yield and quality. In addition, bio stimulants reduce the need for fertilizers, in small concentrations, these substances are enhancing nutrition efficiency, abiotic stress tolerance, crop quality traits, regardless efficient, of its nutrients content (Du Jardin, 2015).

Methodology

The present investigation was conducted during *kharif*- 2021 at Main Agricultural Research Station, UAS, Raichur. The cotton variety used for this experiment was ACH 1155 2 BG II. The soil type of experimental plot was medium black cotton soil. The experiment was laid out in randomized complete block design with seven treatments and each treatment was replicated thrice which includes T_1: Platina @ 50 ml per 100 liters of water, T_2: Platina @ 75 ml per 100 liters of water, T_3: Platina @ 100 ml per 100 liters of water, T_4: Platina @ 150 ml per 100 liters of water, T_5: Tata bahaar @ 200 ml per 100 liters of water, T_6: Isabion @ 200 ml per 100 liters of water and T_7: Untreated control.The spray was taken at three stages of cotton, first spray at flower initiation stage, second and third sprays were at 15 days interval using knapsack sprayer.

Results

The data on total dry matter production per plant, number of bolls per plant, boll weight and seed cotton yield differed significantly due to application of different bio- stimulants (Table 1). Among the different bio- stimulants application of platina @ 150 ml per liter water recorded significantly higher total dry matter production per plant (328.90 g plant^{-1}), number of bolls per plant (30.80), boll weight (5.18 g) and seed cotton yield (2999 kg ha^{-1}). However, they were found at par with application of platina @ 100 ml per liter of water. Whereas, application of platina @ 75 ml per 100 literof water, tatabahaar @ 200 ml per 100 liters of water and isobion @ 200 ml per 100 liters of water were found to be the next best treatments, respectively. Nevertheless, untreated control recorded significantly lower total dry matter production per plant (217.50 g plant^{-1}), number of bolls per plant (18.20), boll weight (3.85 g) and seed cotton yield (2238 kg ha^{-1}).

Growth, yield parameters and seed cotton yield as influenced by platina and other bio-stimulants

Treatments	Total dry matter production (g plant^{-1})	No. of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha-1)	Per cent increase over control
T_1: Platina @ 50 ml per 100 liter of water	259.14	21.43	4.50	2681	19.79
T_2: Platina @ 75 ml per 100 liter of water	292.10	23.20	4.52	2867	28.11
T_3: Platina @ 100 ml per 100 liter of water	313.12	27.84	4.90	2903	29.71
T_4: Platina @ 150 ml per 100 liter of water	328.90	30.80	5.18	2999	34.00
T_5: Tata bahaar @ 200 ml per 100 liter of water	306.20	26.30	4.90	2838	26.81
T_6: Isabion @ 200 ml per 100 liter of water	306.00	25.20	4.80	2802	25.20
T_7: Untreated control	217.50	18.20	3.85	2238	-
S. Em.±	13.09	1.09	0.21	123	-
CD @ 5%	38.51	3.21	0.62	361	-

This may be ascribed to the beneficial effect of platina as a bio-stimualant on physiology, growth of cotton, strong root growth and better use of water and soil nutrients. Due to increased photosynthetic activity in plants, they accelerate chlorophyll formation and dry matter production by the plant growth regulator (Wu *et al*., 1994). Thereby, increase the synthesis of substances such as carbohydrates, protein, sugar, oil *etc*., and resulted in increased number of bolls, boll weight and seed cotton yield. The similar Results were concluded by Patel (1992) and Sawan*et al.* (2006).

Conclusion

From the present study, it can be concluded that, application of bio- stimulant: platina @ 150 ml per liter water at flower initiation stage followed by second and third sprays at 15 days interval in cotton was found helpful in increasing the growth and yield attributing parameters and ultimately seed cotton yield in cotton.

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UID: 1419

Soil moisture conservation practices and foliar spray to enhance yield and water use efficiency of cotton in dryland

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Fifty-one percentage of India's net sown area comes under rainfed agriculture which contributes to nearly 40% of total food production. But constant fluctuations in total rainfall and its distribution, severely affects the yield of rainfed crops. Such an uncertainty in crop production necessitates the need to enhance the productivity from rainfed areas to meet the growing population demand by adapting suitable technologies. Considering these constraints, a field experiment was taken up to find out suitable in-situ moisture conservation and drought mitigation practices for cotton under dryland vertisols. Treatments comprised of T_1 – Control, T_2 - Application of super absorbent (Hydrogel) @ 2.5 kg ha^{-1}, T_3 - Mulching with crop residue

@ 5 t ha^{-1}, T_4 - Broad bed furrow (BBF), T_5 - BBF+ application of super absorbent 2.5 kg ha^{-1}, T_6 - BBF+ Mulching with crop residue @ 5 t ha^{-1}, T_7 - BBF+ Mulching with crop residue @ 5 t ha^{-1} + application of super absorbent 2.5 kg ha^{-1}, T_8 - T_7 + Foliar application of 2% KNO_3 at 60 and 75 DAS, T_9 - T_7 + Foliar application of Salicylic Acid 100 ppm at 45 and 60 DAS, T_{10} - T_7 + Foliar application of 1% PPFM at 60 and 75 DAS. The research trial was conducted in Randamized Block Design and replicated thrice. Among the different in situ moisture conservation practices, formation of broad bed furrow (BBF)+ application of crop residue @ 5 t ha^{-1} + application of super absorbent (hydrogel) @ 2.5 kg ha^{-1}+ foliar application of 2% KNO_3 at 60 and 75 DAS recorded significantly higher number of sympodial branches plant^{-1} (14.8), number of bolls plant^{-1} (12.5), boll weight (3.0 g) and kapas yield (1020 kg ha^{-1}) with higher Rainfall Use Efficiency (RUE) of 2.5 kg ha^{-1} mm^{-1}and higher gross return (Rs. 45900 ha^{-}1), net return (Rs. 15696 ha^{-1}) and B:C ratio (1.52).

UID: 1419

Cotton-Based Intercropping: A Climate-Smart Approach for Livelihood Security

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Field experiment was conducted during 2021-22 to study the effect of different intercropping system on yield and economics of cotton hybrid at ARS, Kovilpatti under rainfed condition. Experiment was laid out in randomized block design with three replications. The treatment combinations comprised of sole Bt cotton, paired row planting of Bt cotton with two rows of inter crop (A- Clusterbean), paired row planting of Bt cotton with two rows of inter crop (B-Radish), paired row planting of Bt cotton with two rows of inter crop (C- Onion), paired row planting of Bt cotton with one row (A) and one row (B), paired row planting of Bt cotton with one row (B) and one row (C), paired row planting of Bt cotton with one row C) and one row (A), paired row planting of Bt cotton with one row (A), one row (B) and one row (C), farmers practice and recommended intercropping. Among the different cropping system, sole Bt cotton recorded significantly higher number of symbodial branches plant^{-1} (15.2 nos.), number of bolls plant^{-1} (19.0 nos.) and boll weight (4.37 g). Significantly higher cotton crop equivalent yield (3557 kg ha^{-1}) was recorded by paired row planting of Bt cotton with one row cluster bean and one row radish and one row onion which was followed by paired row planting of Bt cotton with two rows of inter crop cluster bean.

Significantly higher LER (1.89) was recorded paired row planting of Bt cotton with two rows of inter crop cluster bean. With regard to economics higher gross return of Rs. 1,60,084 ha^{-1}

was recorded by paired row planting of Bt cotton with one row of cluster bean, one row of radish and one row of onion but higher net return (131143 kg ha^{-1}) and B:C ratio (5.9) were recorded by paired row planting of Bt cotton with two rows of cluster bean which was followed by paired row planting of Bt cotton with one row of cluster bean and one row of radish. From the experiment it was concluded that, intercropping of Bt cotton with two rows of cluster bean giving higher net return and B: C ratio under dryland condition.

UID: 1421

Plant Growth-Promoting Rhizobacteria (PGPR): A Sustainable Approach to Enhance Crop Productivity

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Plant Growth-Promoting Rhizobacteria (PGPR) are beneficial soil microorganisms that colonize plant roots and stimulate plant growth through multiple mechanisms. The increasing interest in PGPR application in agriculture stems from its potential to enhance crop productivity sustainably while reducing reliance on chemical fertilizers and pesticides. PGPR facilitate the uptake of essential nutrients such as nitrogen, phosphorus, and potassium via nitrogen fixation, phosphate solubilization, and potassium mobilization. They produce phytohormones, including auxins, gibberellins, and cytokinins, which promote root and shoot development. Additionally, PGPR help plants tolerate abiotic stresses like drought, salinity, and heavy metal toxicity by producing stress-alleviating compounds such as ACC deaminase. They also act as biocontrol agents, inhibiting plant pathogens through the production of antibiotics, siderophores, and enzymes that degrade pathogenic cell walls. The benefits of PGPR extend to enhancing seed germination, root elongation, and overall plant vigor, resulting in higher yields and improved crop quality. By reducing the need for synthetic inputs, PGPR align with eco-friendly farming practices and contribute to soil fertility by increasing organic matter content and microbial diversity. The integration of PGPR with biofertilizers, organic farming, and precision agriculture holds promise for amplifying their benefits. Advances in biotechnology can further enhance the efficiency and adaptability of PGPR strains. Increased governmental support and farmer education are pivotal for the widespread adoption of this sustainable agricultural practice.

UID: 1422

Effect of Halophilic Bioformulations (Halo-AZO and Halo-PSB) on yield of wheat crop Variety-KRL-283 under Sodic Soil condition

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A field experiment was conducted during Rabi season of 2021-22 and 2022-23 respectively, at the farmer's fields in NICRA villages Umachha and rasoolpur gircha, district Kaushambi to study the Impact of halophilic bio fertilizers - Halo Azotobacter (Halo-Azo) and Halo Phosphate Solubilising Bacteria (Halo-PSB) on the growth and productivity of salt tolerant variety of wheat (KRL-283). It is observed that potential salt tolerant variety of wheat KRL-283 in association with halophilic beneficial microbes together can play a important role to improve the productivity of wheat crop. These bioformulations showed significantly increased plant growth in terms of germination per cent, plant establishment per cent, plant height, no. of effective tillers/plant, no. of grains /Spike, length of spike, test weight grain and straw yield. Exploitation of azotobacter and phosphate solubilising bacteria as bio fertilization has enormous potential in improving the crop productivity and soil fertility in sodic soil condition.

UID: 1426

Effect of Climate Change on Growth and Yield of Rice under Submergence Conditions

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Submergence is one of the major constraints for Rice (*Oryza sativa* L.) production in India which is increasingly threatened by the erratic nature of onset of monsoon rain and climate change. Large variation in rainfall pattern affects the timing of nursery raising and transplanting later in the main field therefore, we adopted suitable varieties for rice production, which allows keeping rice seedlings in the seedbed for an extended period to synchronize with the onset of monsoon rain. So, the experiment conducted at 30 farmer's field of NICRA village, Khanabadi, Kishanganj, Bihar, India during 2023-2024 under the supervision Krishi vigyan Kendra, Kishanganj, the experiment was framed in randomized block design with ten replications. All plots of experiment were equally fertilized with recommended dose of fertilizers (120:60:40 kg ha^{-1} NPK). The source of nitrogen, phosphorus and potassium were urea, di-ammonium phosphate and muriate of potash respectively. To determine the growth parameter i.e., plant height (cm) at harvest stage, number of effective tillers per hill, LAI, Chlorophyll concentration

(SPAD) and days to 50% flowering were recorded at 90 DAS. Yield attributes *viz*., number of panicles per m^{-2}, number of grains panicle $^{-1}$, number of grains filled and unfilled panicle^{-1} test weight (g), and yield viz., grain yield, straw yield, biological yield (kg/ha) and harvest index (%) were recorded after harvest. The result of conducted field experiment revealed that both the climate resilient varieties, swarna sub-1 and Sabour sampann demonstrated at farmer field, 'Swarna Sub-1' was found significantly superior in all terms of plant characters viz. growth, yield attributing and yield characters under submergence condition of Bihar so that result was found significantly maximum grain yield (51 q ha^{-1}), straw yield (72 q ha^{-1}), biological yield (123 q ha^{-1}) and harvest index (41%) recorded in Swarna Sub-1.

UID: 1427

Performance of Climate Resilient Chickpea Variety Jaki-9218 in Gadchiroli District

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Chickpea (*Cicer arietinum* L.) popularly known as "Gram" or "Bengal gram" is most important and premier pulse crop of India. India rank first in area (73%) and production (75%) at global level. In major producing countries the highest productivity of 2170 kg/ha is observed in Ethiopia. India's productivity is 1261 kg/ha. In Maharashtra the chickpea contributed with area (29.56 lakh ha.), production (31.75 lakh tonnes) and productivity (1074 kg/ha). (FAO Stat., 2022). Chickpeas are one of the main crops used to produce rabi pulses, which contain significant levels of easily digesteable protein (17.21 %) and carbohydrates (55 %). In addition to being high in essential vitamins, calcium and iron, chickpea as also have maleic acid in their leaves. Chickpea meets 80% of its nitrogen (N) requirement from-symbiotic nitrogen fixation and can fix up to 140 kg N/ha from air. It leaves substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improve soil health and fertility. Because of its deep tap, root system, chickpea can avoid drought conditions by extracting water from deeper layers in the soil profile. It is generally acknowledged that, using chemical fertilizers is a necessary component of a set of procedures for increasing agricultural output. Chickpea is usually sown between mid-October to mid-November. However, sowings are often delayed when grown in sequence with kharif crops especially Paddy in Gadchiroli district. There are several factors like faulty sowing practices, unavailability of high- yielding varieties, quality seeds, bio-fertilizers, improper management, and non-adoption of suitable plant protection measures which affects the chickpea yield drastically. Kumar et al. (2014) reported that the low yield of chichpea was due to the poor quality of the seed, poor adoption of the package, and the practices of production. To overcome these challenges and to increase the productivity and profitability of chickpea there is a need to create awareness among the farmers about site-specific improved varieties and packages and practices of production. Thus, the present study was conducted with objective to examine the effect of CFLD by Krishi Vigyan Kendra, Gadchiroli, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during 2021-2022 and 2022-23 on the profitability of chickpea production.

Methdology

The cluster front line demonstration were conducted based on low-yield attributing causes identified from PRA and preliminary discussion with farmers, during the post rainy season at 150 farmers fields on 60 ha area, to demonstrate production potential and economic benefit of improved technologies consisting climate resilient variety of chickpea (Jaki-9218), integrated nutrient management, integrated pest management at villages viz. Jairampur and Rampur of Gadchiroli district during Rabi season 2021-22 and 2022-23. Critical inputs for demonstration plots were provided by Krishi Vigyan Kendra, Gadchiroli. In control plots, the existing farmer's practices were followed and for this inputs were arranged by farmers. The yield data were collected through random crop cutting in the presence of farmers and personnel from both plots of demonstration and existing farmers' practices and based on the data, yield performance and economics were calculated by using standardized formulae.

Results

The findings of demonstration revealed that the transfer of developed technology under cluster frontline demonstration of chickpea resulted in a 23.13% higher pooled yield as compared to existing farmers' practices. During years 2021-22 and 2022-23, the improved technology demonstrated under CFLD yielded pooled yield 15.6 q/ha of chickpea more than existing farmers' practice yield i.e. 6.50 q/ ha. These results clearly indicated that the higher average seed yield in demonstration plots over the compare to farmers practice due to integrated crop management practices and awareness of wilt resistant and high yielding Jaki-9218 variety. Adoption of scientific package of practices like seed treatment, integrated nutrient management, bio-pesticide and need based right plant protection practices resulted in higher yields. The above findings are similar in lines with Rupesh et al., 2017 and Rajan Kumar Ojha et al., 2020. The economic analysis of demonstrations taken under CFLD and existing farmers' practices is presented in table below which revealed that the highest gross return (Rs. 81120/ha), net return (Rs. 46770/ha), and benefit cost ratio (1:2.35) was recorded under the demonstrations through CFLD programme with involvement of improved production technology as compared to existing common farmer practice. An average net return of CFLD demonstration was higher than existing farmers' practice, which may be due to the higher production under demonstrations through CFLD programme as compared to farmer's practice. Similar results were also recorded by Rachhoya et al., 2018.

Performance of Chickpea crop in Gadchiroli district (2021-22 & 2022-23)

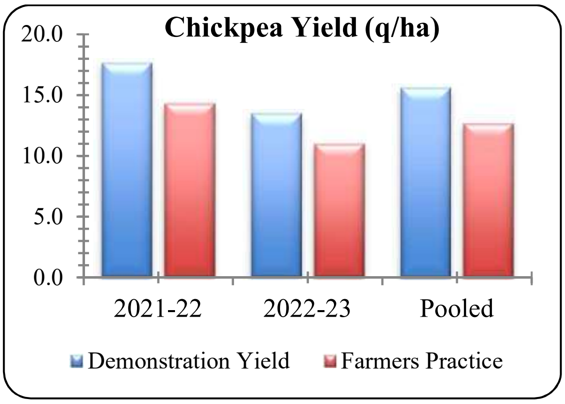
Year	Demonstration plot (Var. Jaki-9218)					Farmer's practice (Local)				
	Avg. Yield (q/ha)	COC (Rs/ha)	GMR (Rs/ha)	NMR (Rs/ha)	BC Ratio	Avg. Yield (q/ha)	COC (Rs/ha)	GMR (Rs/ha)	NMR (Rs/ha)	BC Ratio
2021-22	17.7	35000	92040	57040	1:2.63	14.35	38000	74620	36620	1:1.96
2022-23	13.5	33700	70200	36500	1:2.08	11.0	35100	57200	22100	1:1.63
Pooled	15.6	34350	81120	46770	1:2.35	12.67	36550	65910	29360	1:1.79

COC- Cost of cultivation, GMR- Gross monitory returns, NMR- Net monitory returns, B:C- Benefit to Cost ratio

Conclusion

Based on data obtained through CFLD programme conducted during years 2021-22 and 2022-23, with 150 demonstrations of chickpea in 60 ha. area, it can be concluded that the intervention of improved varieties, technologies, balanced input resources, and capacity-building development programs of farming communities will be more helpful in reducing the technology gap and increasing the productivity and profitability of chickpea along with perception of technology.

Demonstration on Chickpea crop in Gadchiroli district



Yield performance of Chickpea crop in Gadchiroli district

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UID: 1428

Synergistic improvement in growth and yield of legume-oilseed based double cropping system

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Dryland agriculture faces challenges such as variability of rainfall amount and intensity, high evaporation rate, soil loss, declining decreasing carbon (C) stock and reduced system productivity which resulted low cropping intensity (Kumar *et al.,*2023). Farmers typically grow crops during the monsoon, leaving fields fallow post-monsoon or conserving rainwater for short-duration crops. Enhancing productivity requires expanding cultivated land and intensifying crop production through higher yields and cropping intensity. Double cropping, growing two crops annually, increases productivity and stability in rainfed areas if suitable crops are selected. While double cropping involves higher risks due to weather variability, it improves crop diversification, nutrient cycling, and water-use efficiency, provided effective rainwater management is implemented. (Waha *et al*., 2013). Short-duration, high-yielding crops optimize the system, while legumes like cowpea, green gram and black gram enrich soil via nitrogen fixation, reducing fertilizer needs. Oilseeds like sesame and safflower enhance crop rotations and income with high-value oils. Scientific research on crop selection, pest control, and water conservation is essential to optimize the system. Efficient rainwater harvesting during the monsoon ensures water for rabi crops, making sustainable double cropping feasible in Alfisols.

Methodology

The field experiment was conducted at the Gungal Research Farm of ICAR- Central Research Institute for Dryland Agriculture (17º05’ N, 78º39’E) between 2022-2023 and 2023-2024 to find out the best possible double cropping system in rainfed region of alfisols. The treatments comprising of 6 legume - oilseed cropping systems with and without rainwater management were laid out in Randomized Block Design with three replications. The crops (both legumes and oilseed) used as treatments are presented in Table 1. During the *kharif* season legumes were sown and after harvesting of legume crops, oilseeds were sown in the month of October in both the years. The crops under rainwater management were given 2 supplementary irrigation (15 mm) from the water harvested during *kharif* season in the year 2022-2023 and 3 supplementary irrigation in the year 2023-2024. Nutrients were applied as per the recommended dose for each crop.

Results

Various crops grown with different rain water management practices resulted significant variation in crop growth parameters. Among the monsoon season grown crops, cowpea recorded the highest biomass (16.21 g plant^{-1} and 12.35 g plant^{-1}) and leaf area index (LAI) (1.58 and 1.52) at 45 DAS in 2022 and 2023, respectively (Table 1). Ability of cowpea to extract stored soil water from deeper layers and tolerate prolonged water deficits contributes to its better growth, higher biomass, and increased yield (Angus *et al*., 1983). In post monsoon season sesame with rainwater management showed highest growth in-terms of biomass (8.14 g plant^{-1} and 8.21 g plant^{-1}) and LAI (0.76 and 0.52) at 45 DAS in both years respectively. Initial growth of sesame was more compared to safflower and it is more prominent in comparatively dry year 2023. In terms of the green gram equivalent yield, cowpea-sesame system with rainwater management recorded the highest equivalent yield among the various double cropping systems, with 1655 kg ha^{-1} in 2022 and 1362 kg ha^{-1} in 2023 (Fig. 1). Superior performance of sesame in 2022 and 2023 is due to its drought tolerance, shorter duration, higher market value. The critical role of effective rain water management is prominent from the result of 2023 as crop was failed in the systems without rain water management which is aligning with findings of Bhatt *et al*. (2012).

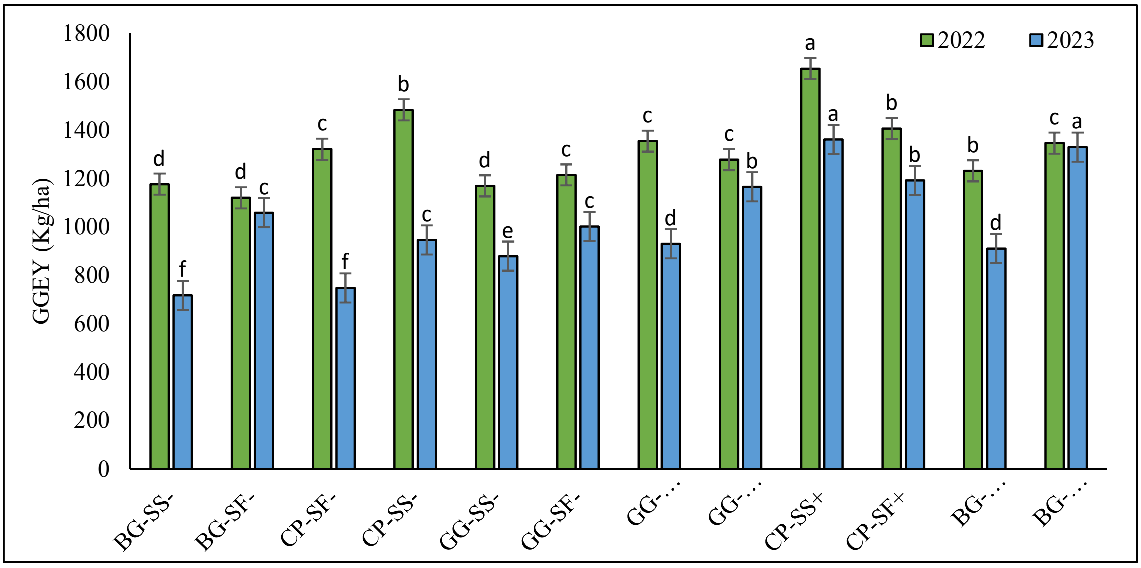

Fig 1. Green gram equivalent yield of cropping systems in the year 2022 and 2023

Table 2. Biomass and LAI at 45 DAS of various cropping systems (monsoon and post monsoon crops) in the year 2022 and 2023

Treat -ments	Year 2022				Year 2023			
	Biomass (g $plant^{-1}$)		Leaf area index (LAI)		Biomass (g $plant^{-1}$)		Leaf area index (LAI)	
	First crop	Second crop	First crop	Second crop	First crop	Second crop	First crop	Second crop
BG-SS-	5.00	3.56	1.15	0.54	4.25	2.34	1.37	0.22
BG-SF-	7.92	1.89	1.29	0.56	6.15	1.23	1.44	0.05
CP-SF-	14.91	1.90	1.55	0.54	12.25	0.95	1.50	0.03
CP-SS-	13.41	3.59	1.49	0.57	12.05	2.70	1.57	0.20
GG-SS-	6.35	3.45	1.39	0.54	5.29	2.56	1.47	0.25
GG-SF-	5.65	2.01	1.42	0.54	4.71	1.02	1.43	0.04
GG-SF+	6.27	3.65	1.46	0.62	5.11	3.09	1.46	0.28
GG-SS+	6.35	7.48	1.39	0.64	5.78	7.86	1.49	0.52
CP-SS+	15.12	8.14	1.53	0.76	12.12	7.89	1.58	0.48
CP-SF+	16.21	3.89	1.58	0.66	12.35	3.12	1.52	0.28
BG-SF+	5.48	3.89	1.31	0.64	4.75	3.68	1.46	0.31
BG-SS+	4.29	8.14	1.20	0.69	4.52	8.21	1.39	0.46
SE(m)	0.49	0.25	0.06	0.03	0.51	0.18	0.08	0.02
C.D. (P=0.05)	1.44	0.75	0.17	0.08	1.51	0.52	NS	0.06

Conclusion

Adopting effective rainwater management practices was found beneficial in identifying new double cropping system for rainfed region of Alfisols. The cowpea-sesame system was found as most efficient pulse -legume double crop system in terms of growth and yield.

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UID: 1434

Impact of Foliar Application of NPK Fertilizer on Productivity and Profitability of Green Gram: A Comparative Study in NICRA and NON-NICRA Village in Bolangir

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Green gram (*Vigna radiata*) is the most important pulse crop and provides a critical source of dietary protein besides improving soil health through biological nitrogen fixation, but its productivity is often threatened by climatic variability in soil nutrient deficiencies and traditional cultivation practices (Dhiraj and Kumar 2012). In this context, foliar nutrient application comes as a climate-resilient agronomic practice. Foliar feeding allows nutrients to be assimilated properly, reduces losses and fastens correction of nutritional imbalances, thus making it an ideal approach for increasing productivity and profit (Kuttimani and Velayutham 2011). This experiment focuses on assessing the response of foliar application of NPK 18-18-18 on green gram productivity, in comparison with its response against traditional granular application in Bolangir district, Odisha.

Methodology

The study was conducted in the NICRA-adopted village of Odiapali and a nearby non-NICRA village in the Bolangir district of Odisha during the kharif season. In the NICRA village, three farmers cultivated green gram over 1 ha each, applying two foliar sprays of NPK (18-18-18) water-soluble fertilizer (1%) at 30 and 40 days after sowing (DAS) (Kunjammal and Sukumar, 2019). In the non-NICRA village, three farmers cultivated green gram using granular fertilizers under similar conditions.

Productivity: Yield data was gathered from each farmer's field.

Economic Analysis: Gross returns were computed as yield times the minimum support price of ₹7755 per quintal. Net returns were determined by subtracting the gross cost of ₹32,000/ha with gross returns. BCR was computed as the gross returns to gross cost ratio.

Statistical Analysis: Standard deviation was calculated to analyze variability in productivity between the NICRA and non-NICRA villages

Results

Productivity

The productivity Results for the NICRA village showed higher yields compared to the non-NICRA village. The data is summarized in Table 1.

Table 1. Productivity of Farmers field in NICRA and Non-NICRA villages

Farmer	Location	Productivity (q/ha)	Average (q/ha)
1	NICRA Farmer-1	7.8	
2	NICRA Farmer-2	8.6	8.20
3	NICRA Farmer-3	8.2	
1	Non-NICRA Farmer-1	6.8	
2	Non-NICRA Farmer-2	7.2	7.13
3	Non-NICRA Farmer-3	7.4	

The standard deviation for productivity was 0.34 in the NICRA village and 0.31 in the non-NICRA village, meaning that the variability in the fields of NICRA farmers was slightly higher due to differences in efficiency in foliar application among farmers. However, the overall productivity in the NICRA village was significantly higher.

Economic Analysis

Table 2. The economic benefits of foliar and granular application in NICRA and Non-NICRA villages

Farmer	Location	Gross Return (₹)	Net Return (₹)	BCR
1	NICRA Farmer-1	60,489	28,489	1.89
2	NICRA Farmer-2	66,693	34,693	2.08
3	NICRA Farmer-3	63,591	31,591	1.98
1	Non-NICRA Farmer-1	52,734	20,734	1.64
2	Non-NICRA Farmer-2	55,836	23,836	1.74
3	Non-NICRA Farmer-3	57,387	25,387	1.79

Farmers adopting foliar application in the NICRA village achieved higher gross returns and net returns compared to those using granular fertilizers in the non-NICRA village. The average BCR in the NICRA village was 1.98, significantly higher than the 1.72 observed in the non-NICRA village.

Comparative Analysis

The improved performance in the NICRA village can be attributed to the benefits of foliar application:

1. **Nutrient Efficiency:** Foliar application ensured rapid and direct nutrient uptake, addressing deficiencies during critical growth stages.
2. **Climate Resilience:** The method minimized nutrient losses under variable weather conditions, particularly in rainfed areas.

3. **Economic Benefits:** Higher yields translated to greater profitability, with an average increase in net returns of ₹8,272/ha compared to granular fertilizer use.

Conclusion

The study demonstrates that foliar application of NPK (18-18-18) significantly improves the productivity and profitability of green gram compared to traditional granular fertilization. The average yield in the NICRA village was 15% higher, and net returns increased by 35.5 %. Moreover, the benefit-cost ratio was consistently superior with foliar application, highlighting its economic viability. This practice is particularly suitable for regions facing climatic uncertainties and nutrient-poor soils. Scaling up foliar nutrient application in green gram cultivation can contribute to enhanced productivity, better income stability for farmers, and greater climate resilience in pulse production systems.

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UID: 1435

Effect of Different Rice Establishment Methods on Microbial Diversity and Composition in Soil

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Traditional rice cultivation consumes more water per kg yield and new alternative strategies such as the aerobic method and Alternate Wetting and Drying (AWD) might be promising water-saving methods. However, they might have large impacts on the soil microbiology. In this study, we have analysed the microbial population in natural transplanting flooded (NTF), aerobic (AR) and AWD of water management methods. The highest microbial population; bacteria (290 x10^6 CFU/ gram of soil), actonomycetes (121 x10^5 CFU/ gram of soil) and fungi (24 x10^3 CFU/ gram of soil) were found at flowering stage and also, we compared the bacterial and archaeal communities in experimental field plots, cultivated under natural transplanting flooded , aerobic and AWD of water management. By high-throughput sequencing of the 16S rRNA gene, the Illumina MiSeq based 16S rRNA gene amplicon metagenomic analysis of rice rhizoshpre soil was carried out for different rice establishment methods. Illumina MiSeq method of sequencing revealed the various Phyla, with major Phyla belongs to the Proteobacteria, Acidobacteria, *Actinobacteria*, and *Bacteroidetes*. The major class belongs to the Alfaproteobacteria, Actinobacteria, Gammaproteobacteria, Anaerolineae, Thermoleophilia, Acidimicrobiia, Deltaproteobacteria, Planctomycecetacia, Bacteoidia and Acidobacteria. The Major genus like Anaerolineaceae, Rubrobacter, Burkholderiacease etc. Differential abundance analysis revealed the enrichment of potentially plant-growth-promoting bacteria under aerobic and AWD treatment, such as *Rubrobacter*, *Candidatus*, Betproteobacteriales and *Bacillus* microorganisms with an overall anaerobic lifestyle, such as various Delta- and Epsilonproteobacteria, and Firmicutes were depleted. Our study indicates that the AWD communities seems overall well adapted and more resistant to changes in the water treatment, whereas the other method microbiota seems more vulnerable.

UID: 1436

High-Yielding Soybean Varieties for Drought-Prone and Assured Rainfall Areas: Lessons from NICRA Trials

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The field investigation titled “Performance of Soybean Varieties in NICRA Adopted Villages” was initiated in 2023-24 at Itti village, Renapur taluka, and extended to Borgaon (N), Ausa taluka, Latur district, in 2024-25. The study aimed to evaluate the growth and yield performance of six soybean varieties under rainfed and varied climatic conditions, using both conventional and Broad Bed Furrow (BBF) methods. The varieties tested were V1-JS-335, V2-MAUS-158, V3-MAUS-162, V4-KDS-726 (Phule Sangam), V5-KDS-753 (Phule Kimaya), and V6-KDS-992 (Phule Durva).

During 2023-24, which experienced 349.8 mm of rainfall (50% below average), the year was classified as a drought year. Among the varieties, JS-335 (V1) under BBF technology exhibited superior performance with a plant height of 70 cm, 5 branches per plant, 45 pods per plant, and a yield of 22.60 qtl/ha compared to 17.5 qtl/ha under farmers’ practices. Physiological maturity was observed at 92 and 99 DAS. The Results indicated that JS-335 performed well in drought conditions when grown on medium black soil using BBF technology with a spacing of 45 x 5 cm.

In 2024-25, with an annual rainfall of 790 mm (meeting average rainfall levels), trials were conducted in Borgaon (N). V6-KDS-992 (Phule Durva) demonstrated the best performance under BBF technology, with a plant height of 89.25 cm, 6 branches per plant, 58 pods per plant, and a yield of 24.5 qtl/ha compared to 17.9 qtl/ha under farmers' practices. Physiological maturity occurred at 101 and 112 DAS.

The findings suggest that in drought-prone areas, JS-335 is suitable for achieving higher yields with BBF technology, while in regions with assured average rainfall, V6-KDS-992 (Phule Durva) offers maximum productivity and profitability. The adoption of BBF technology and appropriate high-yielding varieties can significantly enhance soybean production in varied agro-climatic conditions.

UID: 1441

Evaluation of Soybean-Maize strip cropping system under dryland condition

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Soybean, also known as wonder crop, is one of the furthermost significant legume as well as oilseed crop. It is the third largest oilseed crop of India after rapeseed mustard and groundnut and ranks first in edible oil in world. India ranks fifth in area and production of soybean in the world. Traditional non-fermented food uses of soybeans include soy milk from which tofu and tofu skin are made. Fermented soy foods include soy sauce, fermented bean paste, natto and tempeh. Together protein and soybean oil content account for 56% of dry soybeans by weight (36% protein and 5% ash).100 grams of raw soybeans supply 446 calories and 9% water, 30% carbohydrates, 20% total fat and 36% protein.

Maize, queen of cereals has the highest genetic yield potential among the cereals. It is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36 % (782 m t) in the global grain production. In India, maize is the third most important food crops after rice and wheat. Maize in India, contributes nearly 9 % in the national food basket and. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc.(Parihar *et al.,* 2011)

In haroti region of Rajasthan for improving crop yield and sustainability, incorporation of cereal crop maize along with pulse crop soybean in Soybean- Chickpea cropping system as strip cropping could help to improve crop production and productivity per unit area. Intercropping, the cultivation of two or more crop species on the same land, turns chances for sustainable crop production and agricultural intensification (Feng *et al.,* 2019).

In Kharif season under high variation in rainfall amount and intensity soybean maize strip cropping further sustain the production by reducing soybean crop failure risk. Intercropping of cereal and pulse crops is traditionally practiced in India as a risk coping mechanism for minimizing drought impact especially for small and marginal farmers (AICRPDA 2011). Maize and soybean produced larger relative grain yields in strip intercropping than in mono-cropping (Du et al., 2017). Therefore, this experiment was conducted to assess production and productivity and economic feasibility of soybean –maize strip cropping system under dryland condition.

Methodology

A field experiment was conducted under AICRPDA project, during *Kharif* season of two consecutive years from 2022-23 to 2023-24 at Agricultural Research Sub Station, Aklera, AU, Kota. Geographically, this is located in the south east part of the Rajasthan with 24.41^{o} Latitude and 76.56^{o} Longitude. According to Agro-climatic zones the domain comes in Humid South Eastern Plain, i.e. zone V of the Rajasthan. The Humid South Eastern plains (zone V) are popularly known as the Hadauti plateau. Summer temperatures reach up to 45^{o}C and in winter it falls to 2.4^{o}C. The relative humidity is generally high. The annual rainfall varies from 452 to 985 mm. The landscape is characterized by hills pediments and vast alluvial plain formed by the rivers Parbati, Parwan and their tributaries. The soil of experimental field was black of alluvial origin with pH 7.55, EC: 0.98, available N (238.60.57 kg ha^{-1}), available P (16.54 kg ha^{-1}), available K (206.20 kg ha^{-1}) and has about 0.33 % SOC.

The experiment was laid out in randomized block design consisting of seven treatments *i.e.* 1. Soybean (3.6) + Maize (3.6) at30 & 60 cm row spacing 2. Soybean (2.4) + Maize (4.8) at 30 & 60 cm row spacing, 3. Soybean (4.8) + Maize (2.4) at 30 & 60 cm row spacing 4. Soybean (3.6) + Maize (3.6) at 45 cm row spacing, 5. Soybean(5.4) + Maize (1.8) at 45 cm row spacing, 6. Soybean sole at 30 cm row spacing, 7. Maize sole at 60 cm row spacing.

The varieties were taken up as Soybean-JS-20-34, maize- PHM-3. The data recorded were statistically analyzed by using technique of ANOVA *i.e.* analysis of variance and significance was determined as given by Panse and Sukhatme (1978) by using computerized Programme.

Result

The data recorded regarding the effect of different soybean –maize strip cropping system under dryland condition on Soybean equivalent yield, System net return system, B: C Ratio and RWUE are presented in Table 1.

The results revealed that the soybean equivalent yield was significantly influenced due to effect of different strip cropping system. Treatment of Soybean (3.6) + Maize (3.6) @ 30 & 60 cm row spacing recorded significantly higher Soybean equivalent yield (1337 kg/ha), System net return (32249 Rs/ha), System B:C ratio (1.32) and RWUE (1.79 kg/ha-mm) over sole soybean and sole maize crop. This might be due to better utilization of resources like solar radiation, water and nutrient inputs under vagaries of monsoon. The interaction (below and above ground) of intercrops species has been reported to enhance the water and light utilization efficiency.

Treatment of Soybean (3.6) + Maize (3.6) at 30 & 60 cm row spacing was found at par with treatment of Soybean (2.4) + Maize (4.8) at 30 & 60 cm row spacing. Soybean (3.6) + Maize (3.6) sown at 45 cm row spacing in 8:8 rows results lowest Soybean equivalent yield (1119 kg/ha), System net return (25317 Rs/ha), System B:C ratio (1.12) and RWUE (1.49 kg/ha-mm)

Effect of different strip cropping system under dryland condition on soybean equivalent yield (SEY), system net return, B:C ratio & relative water use efficiency (RWUE)

Treatment	Soybean EY (kg/ha)	System Net return (Rs/ha)	System B:C ratio	RWUE (kg/ha-mm)
1. Soybean (3.6) + Maize (3.6) @30, 60 RS	1337	32249	1.32	1.79
2. Soybean (2.4) + Maize (4.8) @30, 60 RS	1310	30848	1.28	1.75
3. Soybean (4.8) + Maize(2.4) @30, 60 RS	1233	29919	1.27	1.66
4. Soybean (3.6) + Maize(3.6) @45 RS	1119	25317	1.12	1.49
5. Soybean(5.4) + Maize(1.8) @ 45 RS	1206	30826	1.27	1.61
6. Soybean sole at 30 cm row spacing	1140	27771	1.25	1.52
7. Maize sole at 60 cm row spacing	1232	30930	1.26	1.64
SEm±	31	789	0.03	0.04
CD (P=0.05)	102	1527	0.14	0.19

Conclusion

The results concluded that among soybean –maize strip cropping system Soybean (3.6) + Maize (3.6) at 30 & 60 cm row spacing recorded significantly higher Soybean equivalent yield (1337 kg/ha), System net return (32249 Rs/ha), System B:C ratio (1.32) and RWUE (1.79 kg/ha-mm) over sole soybean and sole maize crop. However, it was found at par with treatment of Soybean (2.4) + Maize (4.8) at 30 & 60 cm row spacing respectively under dryland farming situations.

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UID: 1444

Adaptation mechanism to address vulnerability of heat and drought in Bundelkhand region of Uttar Pradesh

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The Bundelkhand region is marked by its semi-arid climate, characterized by extreme temperature fluctuations, erratic rainfall patterns, and a recurrent vulnerability to heat waves and droughts facing severe water scarcity, particularly during the summer months when temperatures goes above 45°C. This region has experienced an average temperature increase of 0.5–0.9°C over the past decades, leading to reduced crop yield and heat stress on both humans and livestock (Gupta et al., 2021). The region faces recurrent droughts, with over 60% of the years between 2001 and 2020 experiencing below-average rainfall (Singh et al., 2020). Groundwater depletion and the drying of traditional water bodies have further aggravated water scarcity (Rathore et al., 2021). These climatic challenges have aggravated socio-economic distress, affecting agriculture, water availability, livelihoods, and human health. Adaptation mechanisms to cope with heat stress and drought conditions based on water scarcity, drought frequency and depletion of ground water are thus vital to the region's resilience and sustainable development

Methodology

Four districts namely Jhansi, Hamirpur, Chitrakoot and Sonbhadra were selected as per risk index assigned by ICAR-CRIDA, Hyderabad. Two villages from each district were adopted for demonstrating adaptive management practices for heat and drought vulnerabilities with major component of Natural Resource management (NRM), Crop Production, Livestock and Fisheries and institutional intervention. Under NRM component major emphasis were given on water conservation through check dams and implementation of micro irrigation facilities, under crop production heat tolerant varieties were introduced, under livestock component fodder availability was ensured with introduction of fodder crops, new varieties, under institutional interventions Custom Hiring Centres (CHCs), Village Climate Risk Management Committee (VCRMC), Seed bank and fodder bank were institutionalized in NICRA Villages.

Results

Adaptation Strategies for Heat and Drought Vulnerabilities

1. Water Conservation and Management

- **Rainwater Harvesting**: There has been a push to encourage the construction of rainwater harvesting structures such as ponds, check dams, and tanks to capture and store rainwater during the monsoon season. This stored water can be utilized during drought periods for irrigation and domestic purposes. Under Heat and drought vulnerability KVK Chitrakoot demonstrated a successful intervention for rainwater harvesting by creation of check dam. The constructed check dam has a water holding capacity of 2,063,799 liters which ensured at least two irrigation for 10 ha area in wheat, introduction of new crop and increasing the cropping intensity by 200% and increase in water level by two meters (Table1).

- **Water-efficient Irrigation Practices:** Farmers are being encouraged to adopt micro-irrigation systems, such as drip and sprinkler irrigation, which reduced water wastage and ensure more efficient use of water resources. These systems are particularly useful for crops like pulses, oilseeds, and vegetables, which are more drought-resistant. Total 10 demonstration were conducted in 25 ha area with sprinkler irrigation system, demonstration yield were recorded as 13.52 q/ha with 46.96% yield increase as compared to tradition irrigation flood system (13.52 q/ha) with B:C ratio of 3.54 was computed. The total 60% water saving was recorded under this practice (Table 2).

Table 1. Effect of Check Dam Intervention

Particulars	Before	After	Remarks
Collection of water catchment area (ha) surrounding area (km)	-	400 ha (4 rivulets)	
Depth of checkdam (m)	-	2	
Length of checkdam (m)	-	45	
Width of checkdam (m)	-	30	
Construction cost Rs. lakh	-	2.95 lakh	
Irrigated area (ha) by check dam	-	25	
Water holding capacity (lit)	-	2063799 (72900 cubic fit)	
Duration of water holding	Run off	Last February to Last March	
Irrigation method	Rain fed	Flood Irrigation of wheat crop	Use of water in wheat crop irrigation through lift of pumping set
Irrigated crops	Wheat and Chickpea	Wheat, moong Mustard, Chickpea, Field Pea etc.	
Status of water Level	Before 157m	After 155m	Water level increase by 2 m

Table 2. Demonstration of Sprinkler Irrigation System

Particulars	Before	After	Remarks
Sprinkler Irrigation System			
Crop	Chickpea/Barley	Gram/Field pea/ Wheat/Lentil	
Area (ha)	2 ha.	35 ha.	
Use of water in irrigation of crop (lit/ha)	6000000 Liters/ha through flood irrigation system	2100000 liter/ha through Sprinkler Irrigation system	
Water saving through sprinkler irrigation system (lit.)	3900000 lit		65.0 % Water saving in Field pea crop through Sprinkler irrigation
Cropping system	Sesame/ Barley /Chickpea/field pea/lentil	Sesame-Wheat/Chickpea/ Field pea/Lentil	
Land holding size (ha)	2.5	2.5	

2. Climate-resilient Agriculture

- **Crop Diversification**: Farmers are encouraged to move away from monoculture farming, particularly for water-intensive crops like paddy, and instead adopt drought-resistant and heat-tolerant crops like millets, sorghum, and chickpeas. These crops require less water and can withstand higher temperatures, making them more suitable for the region's climatic conditions. Mustard crop was demonstrated in Hamirpur Chitrakoot variety DRMR-541, Pitambari etc liked by the formers

- **Use of Drought-resistant Varieties**: The adoption of drought-tolerant crop varieties and improved seeds plays a critical role in enhancing agricultural productivity under water-scarce conditions. With replacement of drought tolerant varieties on an average 38 percent yield advantage was observed by KVK Jhansi.
- **In-Situ Soil Moisture Conservation**: *In situ* Techniques moisture conservation techniques were like Broad Bed and Furrow, mulching etc were demonstrated under the TDS-NICRA project at KVK, Jhansi, Hamirpur, Chitrakoot and Sonbhadra and 15- to 25 percent water saving was achieved through in-situ moisture conservation practices

3. Livelihood Diversification

- **Non-Agricultural Livelihoods**: Given the region's vulnerability to climate change, there is an increasing emphasis on diversifying livelihoods away from solely agriculture. Programs supporting livestock rearing, poultry farming, handicrafts, and small-scale industries are gaining traction to ensure that communities have a safety net during periods of drought.
- **Promoting Climate-smart Livestock Farming**: This includes the use of drought-resistant fodder crops, better veterinary care, and improved livestock management practices to reduce the vulnerability of the livestock sector to extreme heat and water scarcity.

4. Community-based Adaptation and Awareness

- **Village Climate Risk Management Committee (VCRMC):** A committee was constituted at village level for implantation and monitoring of the program. The committee was also empowered to take decisions for formation of Custom Hiring Services and procurement of Heavy machineries required for adaptation to the vulnerability of that area
- **Custom Hiring Services:** The machineries required for bunding, Levelling, Furrow maker, Sprinkler and drip irrigation facilities were created in adopted village assuring in-situ moisture conservation.

Conclusion

Adaptation to heat and drought vulnerabilities in Bundelkhand requires a multi-dimensional approach that combines technology, traditional knowledge, community participation, and policy support. The experiences of TDC –NICRA demonstrated for promoting climate-resilient agricultural practices and improving water management systems, may be utilized for making large scale programme for combating Heat and drought in Bundelkhand region.

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UID: 1447

Submergence tolerance varieties of rice and sowing of wheat by super seeder in NICRA village of basti district

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Rice-Wheat cropping system widely practiced in Basti district of Uttar Pradesh. Chando village of Bahadurpur block faced significant challenges for crop production due to prolonged waterlogging and flooding. About 60 hectares of farm land is affected due to waterlogging in kharif season. Rabi season crop also affected by high residual moisture content at the time of sowing due to prolonged flooding in monsoon season rendering to late sowing of rabi season crop. With regards above problem in NICRA village Krishi Vigyan Kendra, Basti played a vital role to implement scientific approach and solution for crop production in NICRA village for betterment of crop production in both season (kharif and rabi). Submergence-tolerant rice varieties and sowing of wheat by super seeder have been introduced to address the impacts of climate change.

Methodology

KVK Basti has selected village namely Chando of Bahadurpur block of Basti district in Uttar Pradesh to study the impact of front-line demonstration on submergence tolerant varieties of rice and sowing of wheat by super seeder. The Submergence tolerant variety Sambha Sub-1 and Super seeded wheat variety DBW-187 under demonstration had significant impact on production and productivity. Front line demonstrations were conducted during rabi season of 2023-2024 with sowing of wheat variety DBW-187 compared to sowing of wheat by conventional method. In kharif season of 2023-2024 frontline demonstration was conducted on submergence tolerant rice variety compared to local rice varieties.

Results

Front line demonstrations were conducted during kharif season of 2023-24 to compare submergence tolerant rice variety Sambha Sub-1 with local one. Study revealed that the sowing of submergence tolerant rice variety Sambha Sub-1 showed significant increase in yield and economics of rice crop. Submergence tolerant variety recorded additional yield 20.80 q/ha than local rice variety BPT-5204. Farmer with sambha Sub-1 var. recordeded Rs. 58440/ha net return along with B:C ratio of 2018 whereas local variety BPT-5204 recorded only Rs. 20446/ha with B:C ratio of 1.46. Sowing of wheat by super seeder recorded seed yield of 38.68 q/ha compared to wheat shown by broadcasting method (27.80 q/ha). Net return (Rs.43056/ha) and B:C ratios were also recorded higher compared to wheat sown by broadcasting method.

Treatment	Yield (q/ha)	Cost	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
Rice (Sambha Sub-1)	48.60	49200	107640	58440	2.18
Rice (BPT-5204)	27.80	44050	64496	20446	1.46
Wheat (Sown by super seeder)	38.68	38650	81706	43056	2.11
Wheat (Sown by broadcasting method)	31.50	37560	66725	30165	1.77

Conclusion

The combination of submergence-tolerant rice varieties and the use of super seeders for wheat sowing can have transformative impacts on the agriculture in NICRA village of Basti district. These technologies not only address immediate challenges like flooding and inefficient sowing methods but also contribute to long-term sustainability, climate resilience, and improved economic and social well-being for farmers. By promoting these innovations, Basti can potentially set an example for other flood-prone and resource-constrained areas to follow.

UID: 1453

Yield of Maize and Ahu rice based cropping sequence under rainfed and irrigated condition

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Maize-greengram / green manuring-potato cropping system involves growing maize as the primary crop followed by a green manure (*Sesbania aculeate*) / greengram to enrich the soil with nitrogen, and then planting potatoes. After incorporating of the green manure, creating a sustainable rotation that enhances soil fertility and crop yields while minimizing the need for chemical fertilizers. Farmers throughout the world are facing sustainability issues in crop production due to imbalanced and conventional practices (Bhardwaj, 2020) . The continuous cultivation of a cereal-based cropping system is severely affecting the crop productivity, income, and sustainability of the farm. "Ahu rice-greengram/greenmanure-toria" cropping sequence involves planting Ahu rice (a variety of rice grown in the early monsoon season) as the primary crop, followed by greengram/ green manuring and then sowing toria as a winter crop. As Assam is in high rainfall zone of India, stored harvested rainwater is used for supplemental irrigation to minimize water stress on vegetable crops particularly during high soil moisture deficit period (Ngigi, 2003). The small farm reservoir increased the intensity of vegetable cultivation, which resulted in increasing the farmer's income from marginal land by as much as 37.5% (Hafif and Murni, 2012). The objective of the experiment was to achieve maximum yield under rainfed and irrigated condition.

Methodology

The experiment was conducted in the field of All India Coordinated Research Project for Dryland Agriculture, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali ($26^{\circ}43^{/}32^{//}$ N and 93° $08^{/}01^{//}$ E) during 2018-19 and 2019-20. The experiment comprised 2 cropping sequence (Ahu rice-Maize); Ahu rice-greengram/green manuring-Toria) anyd Maize- greengram/green manuring- Potato, 2 irrigation level (R_0: Control, no irrigation i.e., rainfed ; R_1: Life saving irrigation (during dry spell) and 4 cropping system C_1: Potato - maize (kharif) – greengram; C_2: Potato - maize (kharif) - green manuring crop; C_3: Toria - Ahu rice - green gram and C_4: Toria - Ahu rice - green manuring crop. The experiment was laid out in Factorial RBD (Replicated Block Design) with eight treatments combination replicated thrice. As there were well distributed rainfall during both the kharif and pre-kharif crop growing periods, due to which no supplemental irrigation was applied and thus supplemental irrigation was applied during rabi (Toria and Potato) crops only. Soil texture was sandy loam and infiltration rate was considerably high (3.5 cm/h) with low water holding capacity (16.2 %). The field capacity, permanent wilting point and bulk density of the soil was 21.52 percent, 4.78 percent and 1.21 g cc^{-1}, respectively. The soil was acidic with a pH of 5.1 and EC of 0.001-0.026 dSm^{-1} and medium in available Organic carbon, N, P_2O_5 and K_20 (0.66%), (371.65 kg/ha), (26.65 kg/ha) and (144.11 kg/ha) respectively.

Results

Highest pooled system yield (21043 kg/ha), B:C(2.28) and RWUE (12.9 kg/ha/mm) were observed in the treatment R_1C_1 (Maize-Greengram-Potato with life saving irrigation) followed by R_1C_2 (Maize-Green Manuring –Potato) with life saving irrigation both treatment showed significant difference and minimum was recorded in R_0C_1 : Maize -Greengram-Potato without irrigation in Maize based cropping system whereas in Ahu rice based cropping system pooled system yield (9545 kg/ka), B:C (1.80) and RWUE (5.8 kg/ha/mm) were recorded in treatment

R_1C_3 (Ahu Rice-Greengram-Toria with life saving irrigation) followed by R_1C_4 : Rice- Green Manuring-Toria with life saving irrigation and minimum was recorded in R_0C_4 : Rice-Green manuring-Toria without irrigation. Amongst the sequence potato crop gives better system yield than the toria crop and both crop has a significant difference.

Conclusion

By including different crop types the cropping sequence provides a balanced nutrient intake for the soil and helps manage pests and diseases. Growing three crops on the same land within a year maximizes land productivity and provides a diverse income source for farmers.

Years (2018-19 & 2019-20) pooled system yield, RWUE, Benefit Cost ratio of various treatment of RWM

Sl. No.	Treatments	Grain yield (kg/ha)			BC ratio	RWUE (kg/ha/mm)
		2018-19	2019-20	Mean (kg/ha) Pooled Data		
1.	R_1C_1 : M-GG-P with life saving irrigation	20965	20122	21043	2.28	12.9
2.	R_1C_2 : M-GM-P with life saving irrigation	17211	16093	17292	1.48	10.6
3.	R_0C_1 : M-GG-P without irrigation	15452	14352	10534	2.01	6.5
4.	R_0C_2 : M-GM-P without irrigation	11896	1102	12213	1.91	7.5
5.	R_1C_3 : R-GG-T with life saving irrigation	9243	9777	9545	1.80	5.8
6.	R_1C_4 : R- GM-T with life saving irrigation	7789	8536	8195	1.70	5.0
7.	R_0C_3 : R-GG-T without irrigation	5267	5791	5517	1.75	3.4
8.	R_0C_4 : R-GM-T without irrigation	4030	4464	4257	1.46	2.6
CD (0.05) Irrigation		179	209	192	-	
CD (0.05) Cropping system		253	296	271	-	

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Assessment of mulching on vegetable crop production in drought prone Bundelkhand region

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Bundelkhand, a region encompassing parts of Uttar Pradesh and Madhya Pradesh, has a long-standing reputation as a drought-prone area in India. Agriculture in Bundelkhand is rainfed, diverse, complex, under-invested, risky and vulnerable. In addition, extreme weather conditions, like droughts, short-term rain and flooding in fields add to the uncertainties and seasonal migrations. The scarcity of water in the semi-arid region, with poor soil and low productivity further aggravates the problem of food security. However, over the past few decades, the frequency and intensity of drought conditions in Bundelkhand have increased. Jalaun is one of the districts of Uttar Pradesh comes under Bundelkhand region. The heat and drought like situation also prevailed in district Jalaun from past several years. Considering the situation, in 2021, the technology Demonstration Component under National Innovation in Climate resilient Agriculture (NICRA) started at KVK Jalaun to equipped farmers with the climate smart technologies. Since District Jalaun is bordered with various rivers like Yamuna, Pahuj, Betwa and its tributary river Noon, the undulated topography and poor management effected irrigation. Also, irratic and poor rainfall leads the district to rainfed situation. Farmers in these regions mainly dependent on dry land farming. Also, in dry land farming rain-fed cultivation is being stressed which needed more effective consumption of water resources by using water-saving technologies. Therefore, climate resilient technology like mulching could be an effective choice for saving water along with increasing production in rain-fed or dryland farming.

Methodology

The present study was conducted to assess the effect of mulching on Farmers field under existing agro-ecological situation (AES) through Front Line Demonstration (FLD) which was performed during 2022-23 & 2023-24 in NICRA adopted Village Piyaniranjanpur of block Dakore in district Jalaun. The Piyaniranjanpur comes under AES-II as per classified under Strategic Research Extension Plan (SREP) and situated at the bank of river Noon of district Jalaun. The village comprised of 429.46 ha cultivated area out of which 300.62 ha area is rainfed which computed as 70 percent of total area under, that was the purpose of selection of village under NICRA activities. In present study, vegetable growers were identified from the adopted village and front-line demonstration under 0.4 ha area each carried out at 3 farmer’s fields, those were selected randomly.

The demonstrations carried out on two vegetable crops viz. Sponge gourd and Bottle gourd during zaid and kharif season (Feb to Sept) in above said years. It was observed from the previous experience of researchers that the Seedling and Vegetative stage of cucurbitaceous crops affected due to heat waves and drought situation due to lack of required moisture. The specificity of demonstrated technology i.e. Plastic Mulch identified as to encourage moisture conservation and weed control which further increases the yield and indirectly protect the crop from extreme weather situations also.

Results

Climate Resilient technologies under Natural resource management component of NICRA project demonstrated in which Mulching on Bottle gourd carried out at 3 farmer fields with 0.4 ha each at adopted Village Piyaniranjanpur. The Results were compared with the farmers existing practice i.e. without mulching on same crop with same variety under same Agro-ecological situation. The Results showed an almost 82 percent of yield enhancement as average yield under farmers field observed as 165 q/ha bottle gourd whereas under mulching demonstrated farmers field yield obtained was 300 q/ha. Further, B:C ratio computed based on gross cost and net returns, it was observed that in Technology driven field with the investment of 1 rupee farmer could get an extra 1.22 rupee where without technology farmer can get only 74 paisa with the investment of 1 rupee.

Increase in Yield of Bottle gourd through Plastic Mulching

Specific Technology	Yield (q/ha)	Gross cost (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Farmer practices	165	94700	165000	70300	0.74
Demonstration (Plastic mulching)	300	134700	300000	165300	1.22
% Increase	81.8	42.2	81.8	135.13	

Also, the demonstration conducted on sponge gourd and yield observed the enhancement of 67.74 percent of growth while it was also observed the almost 86 percent of increment in the net income with the adoption of technology. (table 2)

Conclusion

The Results of above demonstrations showed a significant increase in yield which ultimately leads to higher returns to farmers who adopted the technology under NICRA program. Thus, mulching in cucurbitaceous crop under existing AES of Jalaun district of Bundelkhand region could be adopted at wider level and various demonstrations, training programs and other extension activities should be carried out at other villages than adopted one. Further, farmer's feedback for technology found satisfactory in terms of climate resilient technology

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DUS Characterization in sorghum (*Sorghum bicolor* (L.) Moench) germplasm accessions under rainfed conditions

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In India, sorghum (*Sorghum bicolour* (L.) Moench) is one of the most important cereal crops, behind wheat (Triticum aestivum) and rice (*Oryza sativa*). It is a vital staple meal for millions of people globally because of its adaptability to many soil types and climatic conditions (Mbulweand Ajayi, 2020). When it comes to any economically developed field crop, gathering germplasms and assessing them for DUS (Distinct, Uniform and Stable) features is crucial. Numerous sorghum genotype collections, characterizations, and assessments are being conducted globally (Henley *et al.* 2010).

A total of 100 sorghum germplasm accessions collected from different sources were used for study. The experiment was carried out at Agricultural Research Station (Tamil Nadu Agricultural University), Kovilpatti, Tamil Nadu, India, during 2023-24. Each germplasm line was sown in plot size of 1.35 m^2 with spacing of 45 cm x 15 cm. Ten randomly selected plants were taken for observations. DUS observations on leaf mid rib colour, time of panicle emergence (days), stem diameter (cm), length of leaf blade (cm), width of leaf blade (cm), panicle length without peduncle (cm), length of panicle branches (cm), panicle density at maturity and neck of panicle length (cm) were recorded. DUS characters were recorded based on the guidelines given by Protection of Plant Varieties and Farmers' Rights Authority (PPV & FRA), Government of India 2007.

Multivariate statistical tool Principal Component Analysis (PCA)(Oyelola, 2012) was used to differentiate and grouping the sorghum germplasm accessions based on variations present in the accessions. Statistical analysis was carried out using the software STAR 2.0. The proportion of variance, cumulative proportion and eigen values are given in Table 1.

Table 1. Proportion of variance, cumulative proportion and eigen values of sorghum germplasm accessions

Statistics	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Proportion of Variance	18.71	16.26	14.69	12.88	9.98	9.36	7.40	6.41	4.31
Cumulative Proportion	18.71	34.97	49.66	62.53	72.52	81.88	89.28	95.69	100.00
EigenValues	1.68	1.46	1.32	1.16	0.90	0.84	0.67	0.58	0.39

Out of nine PCs, four exhibited more than 1.0 eigen values and exhibited 72.52 % total variability among the characters studied.The maximum variation was observed in PC1 in comparison to other PCs. Hence, selection of germplasm accessions from this PC would be useful for further breeding programs. Eigen vectors of the PCs for different traits are presented in Table 2.

Table 2. Contribution of different traits towards total variance in sorghum germplasm

Traits	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Leaf mid rib colour	0.28	-0.16	0.39	-0.44	0.18	-0.47	-0.43	0.32	-0.04
Time of panicle emergence	0.39	0.02	-0.21	0.33	0.40	-0.59	0.34	-0.26	0.04
Stem diameter	-0.29	0.32	-0.50	0.11	-0.22	-0.39	-0.46	0.13	0.36
Length of leaf blade	0.44	0.39	0.08	-0.17	-0.39	0.04	-0.26	-0.62	-0.14
Width of leaf blade	0.47	-0.17	-0.23	0.39	-0.42	0.05	-0.07	0.47	-0.38
Panicle length without peduncle	-0.04	0.04	0.63	0.38	-0.44	-0.22	0.20	0.04	0.42
Length of panicle branches	-0.33	0.51	0.29	0.32	0.20	-0.13	-0.11	0.08	-0.61
Panicle density at maturity	0.39	0.40	0.10	0.23	0.41	0.45	-0.20	0.24	0.40
Neck of panicle length	0.10	0.52	-0.10	-0.47	-0.17	-0.09	0.57	0.37	0.01

The Results showed that width of leaf blade had highest positive value (0.47) followed by length of leaf blade (0.44), time of panicle emergence (0.39) and panicle density at maturity (0.39) in PC1. Neck of panicle length recorded highest positive value (0.52) followed by length of panicle branches (051), panicle density at maturity (0.40), length of leaf blade (0.39) and stem diameter (0.32) in PC2.Panicle length without peduncle (0.63) followed by leaf mid rib colour (0.39) recorded highest positive in PC3.

In the present investigation, the first two PCs (PC1 and PC2) were plotted against each other in biplot to observe the relation among the sorghum germplasm lines.

Germplasms *viz.*, IS 4201, IS 2952, IS 4010, IS 3160, IS 4139, IS 4419, IS 2938, IS 3400, IS 3933, IS 2871, IS 2938, IS 3964, IS 3668, IS 4065, IS 2859, IS 3722, IS 2852, IS 3790, IS 3932, IS 3399, IS 4065, IS 4009, IS 2417, IS 3172 and IS 2942 formed a group in right top corner of the biplot showed positive values of both the PCs and the traits *viz*., neck of panicle length, panicle density at maturity, length of leaf blade and time of panicle emergence placed in the same quadrant influencing the variation in the population.

In conclusion, the traits and accessions identified had large effects in the overall variation present in the germplasm and selection of these traits would be useful for further breeding programs.

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Studies on yield and quality traits in Karunganni cotton (*G. arboreum*) under rainfed condition

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Karrunganni cotton (*Gossypium arboreum*) is a native of India which is cultivated from time immemorial. It is a diploid species (2n=26) belongs to the family Malvauae. It is known for its resilience to variable climatic conditions, natural resistance to pest, diseases and drought tolerance. Karunganni cotton's unique cellulosic structure and lesser twist allows for higher permeability and absorption. Some varieties have coarse and short fibre with high moisture absorbency. Such varieties have great export value.

Methodology

The experimental material employed in this research comprises of ten genotypes and the research was conducted in Agricultural Research Station, Kovilpatti, Tamil Nadu during October to March 2023- 24, Rabi season. The genotypes were planted in three replications in Randomized Block Design (RBD) with three replications, six lines per genotype giving a spacing of 45 x 15 cm under rainfed condition. Agronomic practices and pest control measures were implemented through out the growing season as per the crop production guide 2020, Tamil Nadu Agricultural University. The observation recorded are no. of bolls per plant, boll weight (g), Ginning Out Turn (%), Seed Cotton Yield (kg/ha), Lint yield (kg/ha), UHML (mm), Uniformity ratio (%), Micronaire value (µg/inch), Bundle strength (g/tex) and elongation (%).

Results

All the cotton genotypes differed from each other for seed cotton yield per plant (Table-1.). The genotype CNA 1084 produced higher seed cotton yield (805 kg/ha) and lowest seed cotton yield was registered by the genotype DDCC 1 (CC) (381 kg/ha). The maximum seed cotton yield with CNA 1084 can be attributed to highest number of bolls per plant (17) and lint yield (312 kg/ha). These Results supported by the findings made by Hofs et al. (2006), Kaliyaperumal Ashokkumar and Rajasekaran Ravikesavan (2010). Boll weight is directly related to the seed cotton yield of cotton. An evaluation of data indicated that greatest boll weight was recorded in the genotype MDL 2674 (2.27 g) and lowest boll weight was recorded in CNA 1085 (1.29g). This was on line with the findings of Hofs et al. (2006).

The comparison of treatment means indicated that genotypes were differ in the bundle strength . The highest bundle strength was recorded by the genotype DLSa 17 (28.9) and the lowest bundle strength was found in the genotype DDCC 2151 (coloured) (21.1). Fibre finesses or micronaire is very important characteristic concerning in the fibre quality of cotton and is very useful for textile industry. The comparison of treatment means indicated that the genotypes differed from each other in fibre fineness. DLSa 17 had fine fibres (2.33 µg/inch) and CNA 1086 registered coarse fibre (4.46 µg/inch). Differences between the cultivars with respect to fibre fineness were also found by Copur (2006) and Ehsan et at. (2008).

Table 1. Mean performance of Karunganni cotton (*Gossypium arboreum*) for yield traits

Sl. No.	Genotypes	No. of Bolls/ Plant	Boll weight (g)	Ginning Out Turn (%)	Seed cotton yield (kg/ha)	Lint yield (kg/ha)
1.	CNA 1086	14	1.98	36.1	557	198
2.	DWDa 2251	10	1.54	37.2	387	143
3.	DDCC 1 (CC)	14	1.57	33.3	381	130
4.	CNA 1084	17	1.46	39.1	805	312
5.	DLSa 17	17	1.64	37.9	757	277
6.	MDL 2674	11	2.27	39.9	603	237
7.	CNA 1085	10	1.29	34.6	654	232
8.	DWDa 2252	8	1.83	37.6	616	230
9.	K 12	12	1.66	34.4	612	212
10.	DDCC 2151 (Coloured)	9	1.53	33.2	623	200
	SE	1.04	0.09	0.60	46.82	17.56
		3.08	0.30	1.62	139.04	52.14
		16.0	9.10	2.62	13.53	14.00

Table 2. Mean performance of Karunganni cotton (*Gossypium arboreum*) for quality traits

Sl. No.	Genotypes	UHML (mm)	Uniformity ratio (%)	Micronaire value (µg/inch)	Bundle strength (g/tex)	Elongation (%)
1.	CNA 1086	-	-	-	-	-
2.	DWDa 2251	27.2	83.1	4.46	26.6	5.5
3.	DDCC 1 (CC)	23.3	78.5	2.76	22.7	5.2
4.	CNA 1084	25.1	77.3	3.92	23.1	5.4
5.	DLSa 17	26.5	81.9	2.33	28.9	5.5
6.	MDL 2674	23.9	77.0	4.54	22.9	5.3
7.	CNA 1085	24.9	77.5	2.56	26.5	5.3
8.	DWDa 2252	25.4	79.5	3.11	27.1	5.5
9.	K 12	27.0	77.7	3.94	26.7	5.6
10.	DDCC 2151 (Coloured)	23.0	75.7	3.42	21.1	5.2

Conclusion

On the basis of yield and yield components, the genotype CNA 1084 was found to be the best. The use of genotype CNA 1084 seems to be better to get maximum yield of cotton.

The genotype DLSa 17 recorded higher number of bolls, higher seed cotton yield, lint yield, higher fibre finess and bundle strength may be used for developing high yielding cotton hybrids with higher bundle strength and fine fibre.

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Stress mitigation of rapeseed (*Brassica campestris var. toria*) using jasmonic acid under rainfed conditions of Assam

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Rapeseed (*Brassica campestris var. toria*) commonly known as sarson or toria, is a member of the Brassicaceae family and contains roughly 40–46% oil. India ranks third worldwide in the production of rapeseed and mustard with an annual production of 11.10 million metric tons (USDA, 2024). It is one of the main oilseed crops of Assam occupying an area of 2.86 lakh hectares with annual production of 1.85 lakh tonnes. The annual average productivity of the crop in the state is 6-7 q ha^{-1} which is quite low compared to the national average of 14.99 q per hectare (GoA, 2024). Poor nutrient management, delayed sowing and rainfed cultivation are some of the reasons for low yield in the state (Deka *et al.,* 2018). Out of all of these variables, delayed sowing may be one of the causes of biotic and abiotic stresses that harm crop growth which lowered the crop yield (Kumari *et al.,* 2011). Rapeseed being a thermo and photosensitive plant is highly influenced by both biotic and abiotic factors when the crop is grown under different micro-climatic regimes.

Plants produced jasmonic acid and its cyclopentanone derivatives referred together as jasmonate (JAs) which stimulates the signal pathway in response to abiotic stresses like drought, waterlogging, salt accumulation etc., (Raza *et al.,* 2020). Jasmonic acid plays a significant role in seed germination, flower development, seed formation and fruit ripening (Nafie *et al.,* 2011) etc. Under stress conditions due to delayed sowing, the exogenous application of jasmonic acid may help the plant to cope with various unfavourable conditions without much reduction in yield.

Methodology

A field experiment was carried out to evaluate the effect of exogenous application of jasmonic acid to alleviate the stress condition of rapeseed production under delayed sowing under rainfed conditions of Assam during the *rabi* season of 2022- 23. The rapeseed variety TS 67 was selected for the experimentation and lately sown on 30th December. The treatments were laid out in a randomized block design with three replications. The treatments comprised four different jasmonic acid (JA) concentrations *i.e.,* JA_1: Control, JA_2: 50 µmol JA, JA_3: 100 µmol JA, and JA_4: 150 µmol JA. The soil of the experimental site was sandy loam in texture, acidic in nature, medium in organic carbon content, low in available N, P_2O_5, K_2O.

Results

Results revealed that among different concentrations of jasmonic acid (JA), the application of 100 µmol JA (JA_3) significantly increased plant height and dry matter production at different growth stages. The physiological parameters including relative water content, proline content, leaf area, leaf area index (LAI), leaf area duration (LAD) and crop growth rate were also found to be maximum with the application of 100 µmol JA (JA_3). In the case of yield and yield attributes, significantly higher siliquae length (4.8 cm), number of siliquae per plant (56), number of seeds per siliqua (14) and seed, stover yield of 7.20 q ha^{-1} and 14.01 q ha^{-1} respectively were recorded with the application of 100 µmol JA (JA_3). In terms of economics the highest gross returns (₹ 40680 per ha), net returns (₹ 21050 per ha), and B-C ratio (2.1) were recorded with 100 µmol JA application (JA_3).

The significant increase in plant height, dry matter production, root-shoot ratio and leaf area with the application of jasmonic acid might be due to its role in promoting cell elongation, cell expansion and cell differentiation besides augmenting the action of auxin which might have increased the growth and development of the crop. The role of jasmonic acid in enhancing the growth and physiological parameters of the plants was also reported by Kaur *et al.* (2017) and Tayyab *et al.* (2020). The increase in growth and physiological parameters with the application of jasmonic acid might have increased the yielding characters the crop. These Results were in line with the findings of Ataei *et al.* (2013) and Awang *et al.* (2015).

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Oyster Mushroom Cultivation - A Climate Resilient Technology for Improving the Income of Ladakhi Farmers

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Mushrooms are edible fungi that belong to the genus Pleurotus and the Basidiomycetes class. It is a saprophyte because it lacks the ability to synthesize its own food due to a lack of chlorophyll. As a result, it is reliant on dead and decay, which also lacks roots. Instead, during the vegetative stage of growth, mushroom mycelia secrete enzymes that break down substrate compounds like cellulose and lignin. Oyster mushroom is sensitive to environmental factors such as temperature and humidity which plays crucial role in growth and yield.

Ladakh region is situated in the northernmost part of India and is characterized by extreme cold weather, low precipitation and high altitude. Ladakh experiences severe cold with temperature drops -20^0 C or even lower. Mushroom cultivation in the cold arid region of Ladakh presents an innovative and sustainable solution to diversify agricultural practices and provide a source of income for local communities. Farmers of Ladakh are very enthusiastic about the cultivation of mushroom but due to the climatic condition of Ladakh there is a big constrains in cultivating mushroom.

Constrains Faced during Mushroom Cultivation

- **Extreme climate condition**: Ladakh is marked with extreme cold climate specially during winter seasons when the temperature reaches below freezing point. The growing season for mushroom is limited for few months only.
- **Low Humidity**: Ladakh experiences a very low humidity making it challenging for cultivation of mushroom.

To overcome the challenges faced by farmers of Ladakh, KVK-Leh developed a low-cost mushroom unit which is attached with a local greenhouse. The Mushroom unit is constructed by using locally sourced material to promote mushroom cultivation as a sustainable agriculture practice. This low-cost mushroom unit attached with a local greenhouse is constructed based on the principle of heat and moisture exchange through pipes that help maintain required temperature and humidity for a successful crop and makes production possible for most part of the year.

Methodology

The research was conducted in the mushroom unit, at KVK-Leh, SKUAST-K. A Mushroom laboratory was setup at KVK-Leh, where oyster mushroom spawn was prepared, for own research purpose as well as for farmers training programmed.

The selected substrates used for mushroom cultivation were Wheat straw, Alfalfa straw, tree leaves and saw dust. These substrates were soaked in water for 12 hours in which formaldehyde 120 ml and carbendazim 7.5 gm were added for sterilization in big container separately then sterilized substrates were dried up to moisture retaining 50-60%.

Polypropylene bags were used for filling of substrates, where each treatment bags were filled different substrates mixed with mushroom spawn. After filling the bags, for each bag, pin holes were done to remove the excess moisture if present inside the substrate. These bags were incubated in low cost mushroom unit constructed at KVK-Leh. The humidity of 75-85% was maintained by wetting the room floor.

Results

Normally mushroom production in Leh is possible from May to September, but low-cost mushroom unit constructed by KVK-Leh resulted into production from April to November. This Mushroom Unit is Patented by the KVK-Leh, which is replicated by the farmers of different locations from Ladakh. Maximum Temperature inside the mushroom unit was recorded during July with 27.1^{0}C followed by June and August (26.5 and 25.5 ^{0}C) which is at par with September and October (25.4 and 25.1 ^{0}C) respectively. Minimum temperature was recorded in the month of January (1.7 ^{0}C) followed by march (2^{0}C).

Relative Humidity were recorded throughout the year in which maximum relative humidity was recorded during July (78%) followed by June (77%), whereas minimum was recorded in the month of January 50.7 %.

Effect of different substrate on harvesting duration

The harvesting duration was also statistically significant to the different substrate composition. The lowest time (45 days) for harvesting was recorded from wheat straw followed by alfalfa and tree leaves (48, 50 days) while in saw dust no growth is recorded. These findings are in conformity with Quimio (1978) who reported that fruiting bodies 3-4 weeks after inoculation of spawn. The crop of Oyster mushroom was harvested

Table. 1. Comparison of Temperature and Humidity both inside and outside the mushroom Unit.

Month	Temperature (0C)				Relative Humidity (%)	
	Maximum temperature outside the unit	Maximum temperature Inside the mushroom the unit	Minimum temperature outside the unit	Minimum temperature inside the mushroom unit		
January	4.5	8.5	-21.5	1.7	58.51	50.7
February	7.5	12.2	-21.5	2.1	50.51	52.9
March	18.5	22.4	-12.5	2	32.29	59.1
April	20.5	22.8	-3.5	10	32.76	68.4
May	24.5	25.4	0.5	4.9	36.88	70.1
June	33.5	26.5	4.0	18.4	34.5	77
July	34.5	27.1	9.0	20.5	45.63	78
August	30.5	25.5	7.5	18.8	48.73	70
September	27.0	25.4	1.0	12.5	46.47	68.3
October	22.5	25.1	-8.5	10.5	42.05	63.5
November	14.0	18.4	-14.5	9.5	41.25	62.2
December	10.0	12.1	-16.5	4.1	37.81	55.5

Effect of different substrates on yield of oyster mushroom

Different substrates were allowed for spawn running and results were recorded. The yield was measured during each harvest and the total yield was calculated finally. It was found highest from wheat straw (1.32 kg) followed by tree leaves and alfalfa (0.84 kg and 0.52 kg) while no growth was observed in saw dust (0.00 kg). Fanadzo *et al*., (2012) used the different substrate i.e. wheat straw, maize stover, thatch grass with 25% increase in biological efficiency of two oyster mushroom species (Pleurotus sajor-caju and P. ostreatus).

Table 2. Details of treatment and Composition

S. No.	Treatment	Composition
1	Substrate-1	Wheat straw
2	Substrate-2	Tree leaves (Popular and willow tree)
3	Substrate-3	Alfalfa hay
4	Substrate-4	Sawdust

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Package and Practices of Climate Resilient Crop Quinoa under Organically Grown Conditions

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Sikkim, one of India's smallest states, is located in the lap of the Himalayas. This region is distinguished by its extreme variation in elevation, ranging from 750 feet in the Teesta valley to the towering peak of Kanchenjunga at 28,200 feet. Approximately two-thirds of the state is covered by snow-capped mountains, and around 46% of its area is forested (Envis Centre, Sikkim). Despite the relatively small cultivable land area of only 11% (Census, 2011), Sikkim is renowned for being the world's first fully organic state, an achievement formally recognized by the UN FAO in 2019.

Agriculture in Sikkim faces significant challenges due to the region's mountainous terrain, climatic variations, and limited arable land. However, the introduction of climate-smart crops like quinoa (Chenopodium quinoa) holds promise for enhancing the food security of the state and promoting sustainable farming practices. Quinoa, originally from the Andes region of South America, is highly adaptable to diverse climatic conditions and is known for its nutritional value and resilience to environmental stresses, such as drought and extreme temperatures (Choukr-Allah et al., 2016). With growing interest in quinoa's health benefits and climate resilience, it has emerged as a potential crop for regions like Sikkim that face both climatic challenges and a need for sustainable agricultural solutions.

Quinoa has gained international recognition as a strategic crop for global food security, primarily due to its high nutritional content and adaptability to a variety of soil and climatic conditions (FAO, 2011). Quinoa is rich in proteins (ranging from 7.47% to 22.08%), oil (1.8% to 9.5%), and essential fatty acids, making it a highly nutritious grain. Its digestibility is over 80%, and it contains neutral antioxidants like phytoestrogens, which have been found to reduce the risk of chronic diseases, such as osteoporosis, heart disease, and breast cancer (Bhargava et al., 2006). Additionally, quinoa is gluten-free, which makes it particularly valuable for people with gluten intolerance or celiac disease.

Quinoa can be cultivated in a range of temperatures, but it thrives in cooler conditions, with an optimal temperature range of 4°C to 35°C (Srinivasa Rao, 2015). The crop requires relatively low humidity (40%-88%) and is well-suited to well-drained, sandy loam or clayey soils with a pH range of 4.5 to 9.5 (Jacobsen, Jensen, & Liu, 2011). Quinoa can be grown at altitudes ranging from sea level to 4,500 meters, with high-altitude varieties often yielding better results in colder conditions.

In Sikkim, where the weather is characterized by temperature extremes and erratic rainfall patterns, quinoa's resilience to such conditions positions it as a suitable option for farmers. The state's low cultivable land and dependence on organic farming make quinoa an attractive alternative to traditional crops like rice and maize, which are often vulnerable to climate change impacts, such as erratic rainfall and rising temperatures.

Quinoa's nutritional profile makes it an excellent source of food security. The seeds are rich in carbohydrates (55.7%), protein (13%), fat (5.3%), fiber (4.9%), and ash (3.0%), making quinoa comparable to wheat in terms of energy content (Bhargava et al., 2006). However, quinoa outperforms wheat in protein and fat content, and its high-quality proteins, containing all nine essential amino acids, make it a complete protein source.

Quinoa is a versatile crop that can be cultivated through direct seeding or transplanting. The seed rate for quinoa is typically around 15-20 kg per hectare, and seeds are often treated with Trichoderma dust at a rate of 10g per kg to prevent fungal diseases (Ramesh et al., 2019). The optimal sowing depth is between 1 and 2 cm, and spacing between rows should be 25-30 cm, with 10-15 cm between plants. Direct seeding or transplanting 20-25-day-old seedlings can both yield successful results.

Water management is also essential for quinoa cultivation, as it is a drought-tolerant crop that requires between 250 and 325 mm of water for optimal growth (Srinivasa Rao, 2015). While quinoa can survive with minimal irrigation, especially in sandy loam soils, excessive watering at the seedling stage can lead to root diseases, affecting crop establishment. Quinoa is typically ready for harvest when the plants begin to yellow, and the seeds shed from the plant.

Conclusion

Quinoa offers a promising solution to the agricultural challenges faced by regions like Sikkim, where climatic variability and limited arable land are major concerns. Its adaptability to a wide range of environments, combined with its high nutritional value and resilience to climate change, positions quinoa as a sustainable crop for small-scale farmers in marginal areas.

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Performance of Chickpea Varieties under Different Sowing Environments in Scarce Rainfall Zone of Andhra Pradesh

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To maximise productivity, each crop or variety has distinct optimal environmental needs, such as temperature, rainfall, relative humidity, and sunlight hours. Weather and climate have a considerable impact on agricultural productivity in all regions. Chickpeas flourish in cool, dry climates. However, strong cold and frost, especially during the flowering or pod initiation stages, might impede flower development and pod formation. The ideal daily temperature range for chickpea growth is 18 to 29 degrees Celsius. Temperature influences crop growth and development (Zinn *et al*., 2010). Seed yield, as a complex trait influenced by genetic and environmental factors, is strongly related to a variety of growth and physiological variables. Correlation studies are critical for understanding these correlations and choosing genotypes with favourable weather to increase chickpea yields (Sahu *et al.,* 2007). In the context of climate change, this study examined the effect of weather variables on chickpea production in Scarce Rainfall Zone of Andhra Pradesh.

Methodology

A field experiment was carried out from 2018 to 2023 at the Regional Agricultural Research Station (RARS), Nandyala, to investigate the crop-weather relationship of chickpea in Scarce Rainfall Zone of Andhra Pradesh. The experiment conducted in a split-plot design with three replications. The main plot treatments included three sowing dates: the first fortnight of October, the second fortnight of October and the first fortnight of November, and Three different chickpea cultivars were used as sub plot treatments. A recommended fertiliser dose of 20:50:0 kg ha^{-1} of N and P_2O_5 was applied at sowing, and all crop management practices were managed across treatments. To achieve unbiased results, both biotic and abiotic variables were carefully regulated throughout the crop growing period. Weather data were collected from the Class B meteorological observatory, located at RARS, Nandyala. Statistical analysis, including correlation coefficients and regression equations was used to determine relationships between weather parameters and seed yield of chickpea.

Results

Weather parameters recorded during different phenophases of chickpea under higher, normal, and lower yield situation were presented in table 1. The analysis revealed that rainfall of 32.6 mm up to 50% flowering stage is congenial for higher seed yield. Tmax upto 31 ºC throughout crop growth period is congenial for higher seed yield. It was further observed that seed yield was reduced when Tmax was above31ºC (Fig). Similarly, Tmin up to 18.2 ºC during pod initiation to pod maturity is optimum for higher seed yield. Morning relative humidity > 80 % during pod initiation is detrimental for higher seed yield as resulting in poor pod set.

Correlation and Regression

The correlation coefficients between seed yield of chickpea and weather parameters revealed that rainfall has significant positive influence on seed yield while Tmax has significant negative impact on seed yield upto 50 % flowering stage. Morning relative humidity has significant negative correlation with seed yield during pod initiation stage as poor pod set was noticed with higher morning relative humidity. Weekly relative humidity imparted a strong negative correlation with relative growth rate of biomass (Sah *et al.,* 2019). T max has significant negative correlation with seed yield during pod development stage to maturity. Evaporation and wind speed have significant positive correlation with seed yield during this corresponding stage table 2. The regression equations developed for prediction of seed yield in relation to weather parameters during different phenophases are best fit for the location table 3.

Table 1. Weather parameters recorded during different phenophases of chickpea for higher, normal and lower yields

Phenophase	RF (mm)	MAXT (°C)	MINT (°C)	RH1 (%)	RH2 (%)	WS (kmph)	EVP (mm)	Seed yield (Kg ha^{-1})
Sowing - Emergence	23.5	31.3	21.0	80.1	58.7	3.1	5.9	2344
Emergence _ 50%flowering	32.6	30.8	19.7	82.3	60.5	3.2	7.1	
Pod Initiation	0.4	30.9	18.2	79.5	53.2	3.7	7.4	
Pod Maturity	2.7	31.2	17.5	81.5	48.2	4.0	7.7	
Sowing - Emergence	2.8	32.9	22.1	79.9	52.4	2.9	6.2	1646
Emergence _ 50%flowering	2.6	31.9	19.9	82.4	49.3	3.0	5.7	
Pod Initiation	2.3	31.0	18.2	85.6	48.0	3.5	5.1	
Pod Maturity	2.1	32.6	19.0	84.0	46.2	3.2	5.6	
Sowing - Emergence	0.0	32.5	21.4	80.1	48.7	2.1	4.1	1082
Emergence _ 50%flowering	3.8	31.4	19.6	80.5	47.6	1.9	3.5	
Pod Initiation	0.0	32.7	20.2	81.1	47.0	1.6	3.5	
Pod Maturity	27.9	32.1	18.4	82.1	43.1	1.9	3.3	

Table 2. Pearson correlation coefficient (r) between seed yield and weather parameters during different phenophases of chickpea

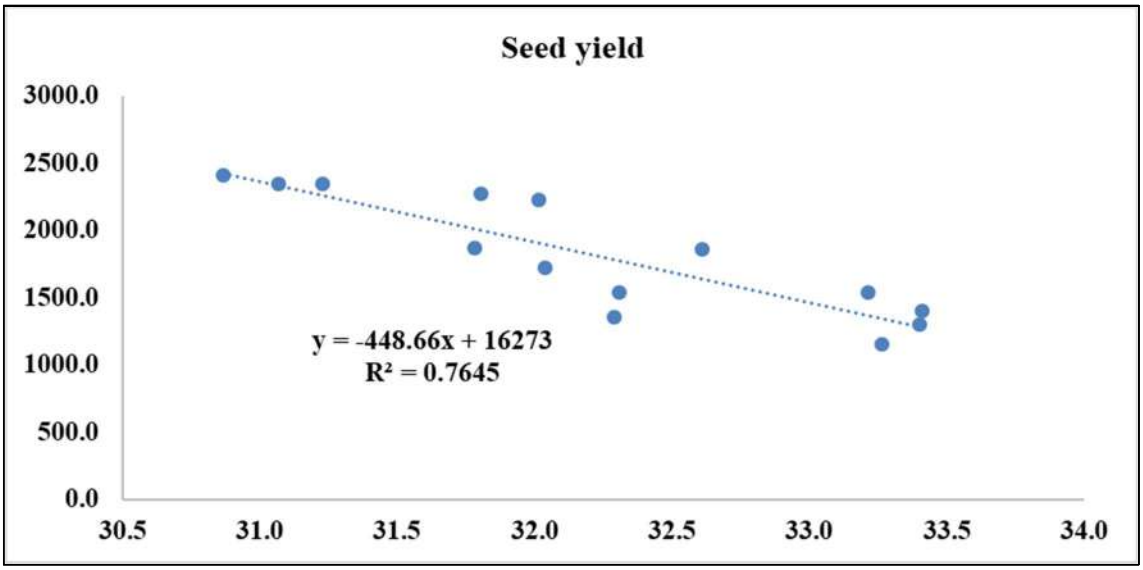
Weather parameters/Phenophase	Sowing – Emergence	Emergence-50% Flowering	Pod initiation	Pod Maturity
Rainfall (mm)	0.374	0.631**	0.018	-0.382
T_{max} (^{0}C)	-0.364	-0.502*	-0.372	-0.578*
T_{min} (^{0}C)	-0.308	-0.077	-0.083	-0.278
RH1(%)	-0.098	-0.083	-0.445*	-0.216
RH2 (%)	0.554*	0.624**	0.376	0.209
WS (kmph)	0.132	0.403	0.450*	0.655**
EVP (mm)	0.426	0.669**	0.712	0.784**

Correlation and Regression

The correlation coefficients between seed yield of chickpea and weather parameters revealed that rainfall has significant positive influence on seed yield while Tmax has significant negative impact on seed yield upto 50 % flowering stage. Morning relative humidity has significant negative correlation with seed yield during pod initiation stage as poor pod set was noticed with higher morning relative humidity. Weekly relative humidity imparted a strong negative correlation with relative growth rate of biomass (Sah *et al.,* 2019). T max has significant negative correlation with seed yield during pod development stage to maturity. Evaporation and wind speed have significant positive correlation with seed yield during this corresponding stage table 2. The regression equations developed for prediction of seed yield in relation to weather parameters during different phenophases are best fit for the location table 3.

Table 3. Regression equation developed to predict seed yield of chickpea in relation to weather parameters during different phenophases

Phenophase	Regression equation (Enter method)	R^2
Sowing - Emergence	Y = 8888.26 – 345.48 Tmax + 219.02 Tmin – 37.512 RH1 + 25.453 RH2 – 96.040 WS – 96.040 – 1.280 RF + 208.42 EVP	0.681
Emergence _ 50%flowering	Y = 2563.94 – 163.59 Tmax + 135.22 Tmin + 15.78 RH1 – 13.87 RH2 – 166.52 WS + 9.83 RF + 256.23 EVP	0.782
Pod Initiation	Y = 3362 – 124.32 Tmax – 55.52 Tmin + 7.91 RH1 + 14.12 RH2 – 124.90 WS – 18.29 RF + 189.20 EVP	0.834
Pod Maturity	Y = 11026.95 – 309.02 Tmax + 3.72 Tmin – 3.40 RH1 + 8.72 RH2 + 66.87 WS – 14.23 RF + 58.46 EVP	0.873



Relationship between T max and chickpea seed yield (Pod development stage)

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UID: 1509

Plant Hormonal Seed Priming: An Effective Technology to Tackle Climate Induced Vagaries and Maintain Sustainability in Crop Plants: Wheat as an Example

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Wheat (*Triticum aestivum* L.) is a major source of calories and dietary protein in India and globally it provides about 55% of the carbohydrates and 21% of the food calories consumed. Wheat outpaces all other grain crops, such as rice and maize, in both production and acreage, and is grown in a diverse range of climatic conditions. In recent times, climate change and rising temperature has caused a significant impact on plant growth, quality, and production of wheat. Among the various stressors, heat stress is a widespread concern that significantly lowers wheat yield and quality. In general heat stress brought on by high ambient temperatures is defined as an increase in air temperature that lasts long enough to damage or harm permanently crop plants. In wheat high temperature stress during grain-filling or terminal heat stress compromises photosynthesis through metabolic alterations and limitations and oxidative damage to chloroplasts which leads to hampered quality and yield reductions.

Methodology

To identify and assess the effects of plant hormones under high temperature, seeds of wheat cvHD2967 were primed with 50 mg/L of selected individual hormones with and without additional heat priming at 42 °C. The experiments were conducted in a field-based study where primed seeds were raised in season for two consecutive years and exposed to elevated temperature in an indigenously built heat trap chamber at anthesis for three consecutive days during maximum natural temperature conditions. The chamber-maintained temperature 4℃ to 5℃ above the prevailing ambient. Samples were collected and an extensive phenotyping comprising a series of morphological, agronomic, biochemical and physiological parameters were recorded. In the next year, to assess transgenerational effect of priming, the primed harvested seeds were sown in two staggered timings in season in similar field conditions and data collected. At the molecular level, ubiquitin proteasome system involved in protein turnover and hormonal signaling was analyzed.

Results

The generative or grain-filling stage is very sensitive to high temperature and thus very critical to the yield and quality of wheat. Improvement in seedling vigor was observed in the primed seedlings under KI (kinetin) and combined KI+HT (high temperature) priming. At vegetative and early generative stage under initial ambient condition, KI and KI+ HT increased shoot and root attributes; whereas under high ambient stress only KI primed plants exhibited enhanced plant architecture. Kinetin promoted wheat morphological attributes under ambient temperatures in absence of any high temperature stressor as well as under applied heat trigger. Beneficial impact on root system architecture (RSA) and the transgenerational effect of cytokinin priming was also very pronounced in late sown conditions at anthesis stage in the second year. Correlational analysis showed positive correlation between chlorophyll index and grain traits. Protein turnover and proteomic plasticity is very important for survival of plants under stress. Ubiquitin proteasome system (UPS) plays a major role in maintaining this plasticity and through their diverse interactions with plant growth regulators. The involvement of UPS in wheat terminal heat stress tolerance was analyzed by transcript expression profiling of SKP1(S-phase kinase ptein1), an essential component of SCF (SKP1-Cullin-F-Box) ubiquitin ligase. Differential and positive induction of SKP1 transcripts in the primed plants indicated intricate involvement of protein modifications, which reveals novel avenue for breeding heat tolerant wheat.

Conclusion

The comprehensive phenotyping under heat stress in seed primed and non-primed plants document that seed priming with plant hormones can be utilized as an alternative strategy to ameliorate adverse effects of high temperature in wheat production. Results demonstrate that towards sustainable crop productivity under changing climate scenario, seed priming is a cost effective and simple strategy. Utilizing the potential of seed priming with plant hormones to develop climate ready crop and thereby contributing to maintain food security is a realistic and promising technology.

UID: 1542

Demonstration of Short Duration Rice (*Oryza Sativa*) Variety Pusa Basmati 1509 as a Strategy to Cope with Climate Change in Bundelkhand

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Agriculture is the major user of the available fresh water the decline in water availability affects agriculture productivity. Among the agricultural crops, rice is a major consumer of water, and slight changing in the water resources of India affect the rice yield. The envisaged propagation of water-saving techniques will entail benefits for the resilience of rice production systems. Hence, the importance of the rice crop in the country can't be negated. Pusa Basmati 1509 is a cultivar characterised by its shorter duration with a maturity span of 120 days in addition to its exceptional grain and cooking qualities. It is highly popular among farmers because of its shorter growth period that saves a significant quantity of irrigation water by saving at least three to four irrigations.

Methodology

Krishi Vigyan Kendra, Datia, Madhya Pradesh conducted 100 demonstrations in 40 ha. on rice with varieties Pusa Basmati 1509 for five consecutive years from 2018 to 2023 at farmers' fields of village Kharag, Sanora, Barodi and Rajpur village in Datia district under NICRA project to find out the worth of this verity. The component demonstration of frontline technology in paddy was comprised of improved short duration variety PB 1509, Proper tillage, proper seed rate, sowing method, balance dose of fertilizer (100:50:50 NPK kg/ha), weed management and protection measures. Statistical tool like percentages was used in this study to analyze data. The technology gap, extension gap and technology index were calculated by using stabilised formulas.

Results

The results of five years of studies revealed that the yield under demonstration plots was 4508 kg/ha as compared to 3919 kg/ha in traditional farmer practices plots. This additional yield of 588.80 kg/ha and the increase in average rice productivity by 15.03 per cent may contribute to the present rice requirement on a national basis. The average technology gap, extension gap and technology index were found to be 292.00 kg/ha, 588.80.00 kg/ha and 6.08 per cent respectively. An additional net return of Rs. 6337 was received from this variety which is 11.00 per cent more to the farmer's practices. Fluctuating the sale price (Mandi rate) of rice during all years influenced the economic returns per unit area. Adoption of the improved package of practices in rice cultivation recorded a higher B:C ratio (2.51) as compared to farmers' practices (2.32). Yield enhancement and higher net returns were observed under FLDs of this improved variety of rice. Thus, the productivity of rice could be increased with the adoption of an improved variety. The present study resulted to convincing the farming community of higher productivity and returns.

Conclusion

There has been a significant change in the income of farmers owing to the adoption of paddy cultivation with variety P B 1509 through mechanisation. Both from the viewpoint of crop intensification drive as well as climate change, there is a need to have rice varieties that could mature early without much penalty on yield. Rice reduction in Bundelkhand is largely rain fed and with increased frequencies of weather extremes, the use of short maturity varieties should be emphasized and promoted. Growing short duration varieties of rice has other advantages like fitting other crops in between. It has been reported that the adoption of short duration rice varieties is one of the strategies to mitigate the emission of methane and nitrous oxide which are greenhouse gases. Since, the rice crop is said to be one of the major contributing factors to global warming, growing short duration varieties is one way of reducing such emissions.

UID: 1581

Evaluation of the Performance of DKC-9144 Maize Variety in NICRA Villages of KVK Kathua vs Local Varieties of Non-NICRA Villages: A Step Towards Climate-Resilient Agriculture

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The National Innovations on Climate Resilient Agriculture (NICRA) project, spearheaded by the Indian Council of Agricultural Research (ICAR), has highlighted the importance of climate-resilient hybrid varieties in improving the productivity and sustainability of rain-fed maize systems in India. According to NICRA's findings, the use of hybrid maize varieties has proven effective in increasing yield stability under erratic rainfall conditions, particularly in regions like Rajasthan, Madhya Pradesh, and Odisha, where maize production is highly vulnerable to climate variability (NICRA, 2021). Furthermore, NICRA emphasizes that integrating sustainable water and soil management practices alongside the use of hybrid varieties can enhance the overall resilience of maize farming systems to climate change (ICAR, 2020).

However, while hybrid maize varieties offer significant advantages, their adoption is not without challenges. The higher cost of hybrid seeds compared to local varieties, along with farmers' limited access to quality seeds and technological support, remains a barrier to widespread adoption, particularly in resource-constrained regions (Ghosh *et al.,* 2020). Additionally, hybrid varieties require annual seed procurement, which can increase financial pressure on smallholder farmers. Despite these challenges, the promotion of hybrid maize varieties as part of broader climate-resilient agricultural strategies is seen as a promising solution for enhancing maize productivity and resilience in rain-fed areas.

This research aims to observe the role of hybrid maize varieties in rain-fed systems, with a focus on their performance under climate variability, their socio-economic implications, agronomic practices, farmer adaptation strategies and their potential to improve food security and farmer livelihoods in India's rain-fed agricultural regions.

Methodology

The front-line demonstrations were carried out by Krishi Vigyan Kendra Kathua in different NICRA villages during the maize growing season from 2011 to 2023 in rain-fed farming situation. The variety demonstrated as per the region adaptability was DKC-9144 and compared with non-NICRA village farmer's practice/ local variety. For carrying out the front-line demonstrations, farmers were selected on the basis of interest towards adoption of improved varieties, and technical know-how of farmer. All the necessary inputs were provided to selected farmers and regular visits of scientist to the demonstrated field was carried out. Trainings, grouping meetings and field day were organized from time to time by the scientists of KVK Kathua for awareness of technologies among the farmers and to provide remedy to the problems faced by them. The sowing was done in first fortnight of June during all the years. All the improved cultivation practices like fertilizer, herbicide, irrigation and plant protection measures were demonstrated to the farmers as per the recommended guidelines (SKUAST-J package of practices). The yield data was recorded from demonstrated plots as well as farmers' practices plots from non-NICRA farmers. Yield, cost of cultivation, gross return, net return and benefit cost ratio were computed and analyzed as per the standard procedures (Dar et al., 2014).

Results

Growth Parameters

When examining the growth parameters year over year, the days to maturity and plant height were both positively influenced by the NICRA practices and showed clear trends favoring the NICRA region. Over the course of the study, plants in the NICRA region reached maturity approximately 113 days compared to 125 days villages than those in the non-NICRA villages. This trend became more pronounced in year 2022-23, where the difference was 10 days between the two regions. This indicates that the growth cycle in the NICRA region was more consistent, possibly due to better water management of monsoon and soil health.

Yield Performance

The average yield of DKC-9144 maize in the NICRA village was significantly higher compared to the non-NICRA villages. The maize yield in the NICRA area averaged 38 q/hec., while the yield in the non-NICRA area was 32 q/hec. The yield of DKC-9144 maize significantly varied between the NICRA and non-NICRA regions over the years from 2011 to 2023. Table 1 illustrates the year-wise comparison of maize yields in both areas. The average yield in the NICRA region consistently outperformed the non-NICRA region, with yields increasing by an average of 30% from year 2011 to year 2023. A t-test analysis confirmed that the difference in yields between the two regions was statistically significant ($p < 0.05$), suggesting that the NICRA interventions, such as better water management of monsoon and soil management practices, contributed to better maize productivity. Table 1 also illustrates the yield differences across various locations within both the NICRA and non-NICRA regions. The NICRA locations consistently outperformed the non-NICRA locations in terms of yield.

Economics

The economics during different year under front line demonstrations revealed that DKC-9144 maize was best net income in the NICRA villages compared to non-NICRA villages. The average net return of DKC-9144 maize in the NICRA villages were Rs. 80,00 per hectare in NICRA village, compared to local varieties used in non-NICRA villages was Rs 58000/- per hectare.

Conclusion

The yield of DKC-9144 maize consistently outperformed the non-NICRA regions across all the years. Growth parameters, such as plant height and days to maturity, showed stronger positive trends in the NICRA region, particularly in the later years of the study. Environmental conditions were more stable and supportive in the NICRA region compared to the non-NICRA region, which could explain the better performance in terms of yield and growth. Statistical analysis confirmed the significance of these differences year over year, suggesting that the climate-resilient practices under NICRA have contributed to improved maize production.

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UID: 1611

Climate Change *vis- a -vis* Invasion of New Pest Species: A Threat to Agriculture in North Western Himalayas

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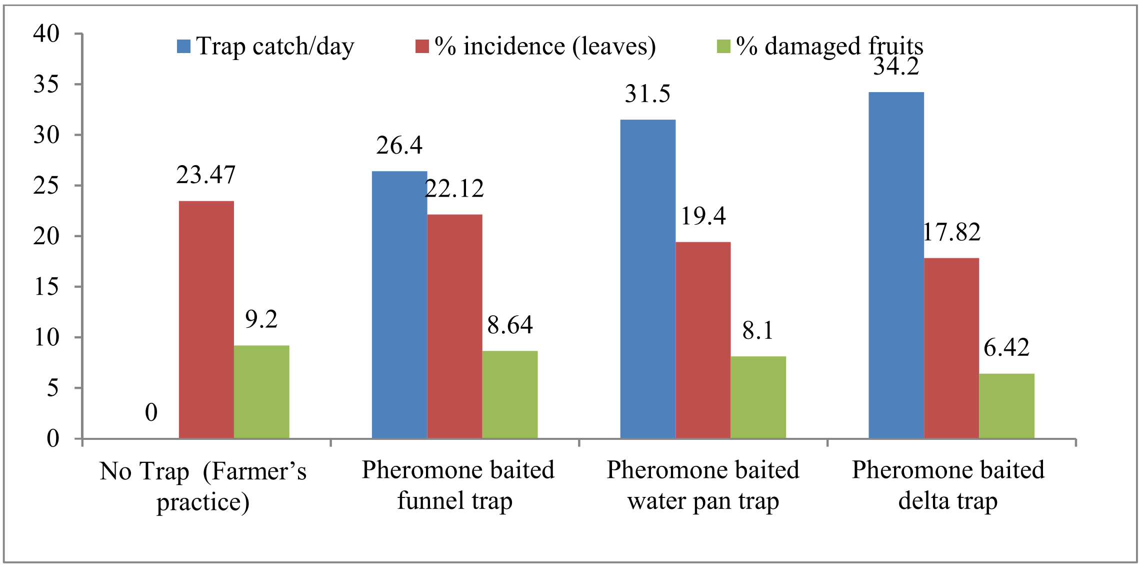
Agricultural biosecurity globally has been on a vulnerable juncture owing to increased international trade, large scale movement of agricultural produce between countries and within the country inviting not only the accidental introduction of invasive insect pests in the new horizons but threatening cultivation of crops globally. Climate change further has accelerated the risk of crops to new pest species. In last decade, at least 10 species of insect and mite pests have invaded India, of which tomato pinworm, *Tuta absoluta* and fall armyworm, *Spodoptera frugiperda* are the most recent ones. Among the two species, *T. absoluta* is a neotropical and one of the most devastating pests capable of causing up to 90-100% damage in tomato yield and fruit quality under greenhouses and field conditions. The pest has been classified as the most serious threat for solanaceous crop production worldwide including India (Sridhar *et al*. 2015, Shashank *et al*. 2015). The pest has also been reported from Himachal during 2015 in Solan area under open conditions (Sharma and Gavkare 2017) and in epidemic form in various vegetable growing areas of Himachal thereafter especially in solanaceous and legume crops (Sood and Yadav, 2017). Hence the present study was conducted with an aim to know the status of the pest in the state and evaluate certain traps for its effective monitoring and mass trapping.

Methodology

Random surveys were conducted in different part of the state under open and protected conditions to know the status and intensity of *T. absoluta*. The percent leaf blotch and fruit damage was recorded during the survey in the infested crops. Apart different traps comprising pheromone baited water pan traps, funnel traps and delta traps were evaluated for their effectiveness in monitoring/ mass trapping of the adult moths under protected conditions.

Results

The survey studies revealed the presence of the pest from the three agro ecological zones i.e. low, mid and high hills in districts Una, Sirmour, Hamirpur, Bilaspur, Solan, Shimla, Kangra, Mandi and Kullu of the state. The pest was observed causing serious damage to solanaceous crops especially tomato, brinjal, potato and legumes like french bean. The pest was prevalent in epidemic form in tomato and brinjal crops grown under protected conditions in Mandi, Kangra and Kullu districts of Himachal Pradesh.



The damage was very severe in these crops under protected conditions. The studies revealed that the tomato crop was the most susceptible followed by brinjal and potato. The infestation was maximum in tomato crop both under protected as well as open conditions at Sundernagar (45.70% blotches, 21.94% fruit damage and 9.97% blotches, 6.97% fruit damage, respectively). At Palampur, the leaf infestation per cent varied from 8.73 (open conditions) to 25.07 (protected conditions) in case of tomato, while fruit infestation was 4.40 and 13.87 per cent, respectively. In potato crop leaf mine damage was 3.45 per cent and 3.21 per cent at Sundernagar and Palampur, respectively. The results of monitoring of *T. absoluta* using different pheromone baited trapsrevealed that delta trap performed effectively better capturing

34.20 adults per day, under protected conditions, closely followed by pheromone baited water pan traps (31.5 adults/ day). Corresponding percent leaf infestation (blotches) in these two treatments was 19.4% and 17.82%, while fruit infestation observed was 6.42% and 8.10%, respectively. Pheromone baited funnel trap was the least effective amongst the evaluated traps.

Conclusion

Solanaceous crops especially tomato and potato are important crops of the region, the epidemic of this invasive pest is a serious concern especially due to its peculiar damage and failure of control measures for its management. The spread of pest under open conditions especially in summer tomato and potato with changing climate scenario may pose serious threat to small and marginal farmers who are earning their livelihood from cultivation of these commercial crops. There is an urgent need to keep close vigil for the pest in different regions of the state using comprising pheromone baited delta traps or water pan traps and to establish its status and look for suitable modules for its effective management.

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UID: 1613

Mustard Aphid *Lipaphis erysimi* (Kaltenbach) Incidence on Mustard and Predatory Dynamics of *Coccinella sptumpunctata* L. under Natural Farming Ecosystem

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Mustard (*Brassica campestris* L.) is the most important oilseed crops in India and holds the second position in India's agricultural economy after food grains. India is one of the major grower, producer, importer, and exporter of vegetable oils. Mustard contributes to about 25-30% of the total oilseed production in the country, making it an essential crop for food security and economic stability. Besides, mustard's adaptability to various agro-climatic conditions makes it a preferred crop for farmers across diverse regions. Despite its significance, the crop productivity is hindered by many challenges especially susceptibility to biotic stresses throughout the vegetative phase of the crop. A number of insect pests have been reported associated with mustard cultivation, however the mustard aphid, *Lipaphis erysimi*, has emerged as the most destructive pest causing substantial seed yield losses ranging from 9 to 96% under varied agro climatic conditions [Kumar and singh 2015; Dhilon et al 2018)]. The aphid is most active from February to April, displaying both winged and wingless forms. Nymphs and adult insects alike feed on the sap of leaves, flowers, buds, and pods, which results in the stunted plant growth. Infested leaves may curl, and in advanced stages may ultimately wither and die. The stunted plants attract sooty moulds (black coloured sticky mass) that thrive on the honeydew secreted by the aphids (Sahoo, 2012) which ultimately breaks the process of photosynthesis leading to death of the tissue. Additionally, the weak plants due to feeding by aphids makes them susceptible to plant viruses, as aphids serve as vectors to various plant viruses. Recent observations indicated significant alterations in the population dynamics of *L. erysimi* due to fluctuating weather parameters over the time, which in turn affects the tritrophic interactions with intensifying herbivory, thus it pertinent to generate data on the population dynamics of *L. erysimiin* and the predatory potential of *C. punctata* especially under natural farming ecosystem owing to rapid shift to natural farming in the state of Himachal Pradesh.

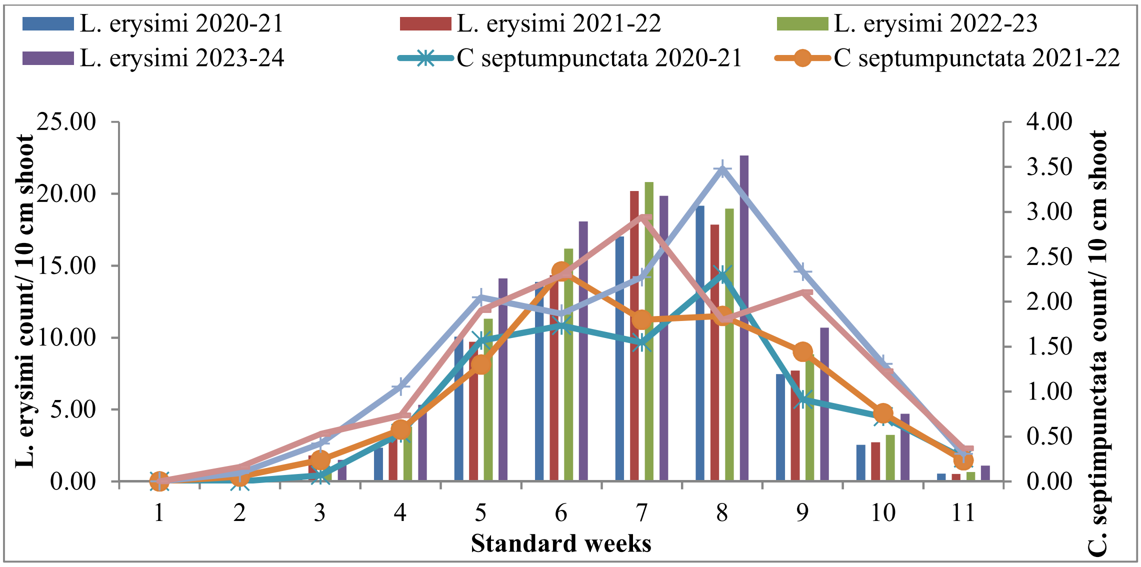
Methodology

The study was conducted at the experimental block of RSS Sundernagar on goghi sarson in Mandi district of Himachal Pradesh during the *Rabi* seasons 2020-21 to 2023-24. Mustard variety GSC 7 was sown at a spacing of 30cm x15 cm during last week of October or first week of November following standard natural farming package. All agronomic practices were applied throughout the experiment, except for the application of insecticidal NF formulations, in order to allow natural aphid infestation.

For data collection, five plants were randomly selected at two locations each and tagged for monitoring. The numbers of aphids (L. erysimi) and the predatory beetle (*C. septempunctata*) were counted from the top 10 cm main shoot starting from the 7th SMW till population was observed on the crop. The data were subjected to statistical analysis using analysis of variance and the association between aphid species and *C. septumpunctata* populations were adjudged by Pearson correlation.

Results

It was observed during the study that the aphid incidence on mustard was initiated during the 8th (2021-22 to 2023-24) or 9th (202020-21) Standard Meteorological Week (SMW) i.e. during second fortnight of February which peaked to its maximum during 12th (2021-22 & 2022-23) to 14th (2020-21 & 2023-24) SMW. It was observed that the aphid population increased over the years during the study period emphasizing the role of changing climatic parameters in exaggerating pest infestations (Fig 1). However, it was interesting to note that the population of predator, *C. septumpunctata* declined over the years even under natural farming ecosystem which suggested its overall decreasing populations. The predator appeared on mustard as soon as the pest was observed i.e. during the 8th or 9th SMW and peaked its population coinciding mostly with the peak aphid population i.e. on 14th (2020-21 & 2022-23), 12th (2021-22) and 13th (2023-24) SMW. A significant positive correlation ranging from 0.887 to 0.961 between *C. septempunctata* and *L. erysimi* during all the years though indicated its close association with mustard aphid and its predatory potential which signifies its evident role in biological management of the pest (Table 1).



Population buildup of mustard aphid *L. erysimi* and its predator *C. septumpunctata* in mustard (2020-21-2023-24)

Correlation between mustard aphid *L. erysimi* and its predator *C. septumpunctata* in mustard

Year	Correlation coefficients (r)
2020-21	0.961
2021-22	0.916
2022-23	0.887
2023-24	0.897

Conclusion

It is concluded from the present study that the mustard aphid population is increasing over the years and causing significant damage to the mustard crop probably due to increasing temperature and changing climatic conditions warranting suitable appropriate management measures. However, application of insecticides should be considered in view of safety to its natural predator, *C. septumpunctata* which otherwise is keeping a check on the population of this dreaded pest.

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UID: 1614

Effect of Different Post Emergence Herbicides on Growth and Yield of Clusterbean *Cyamopsis tetragonoloba* (L.) Under Dryland Ecosystem

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Clusterbean, scientifically known as (*Cyamopsis tetragonoloba* (L.) Taub.), commonly referred to as guar and belonging to the leguminaceae family and subfamily Papilionaceae, it enhances soil fertility through nitrogen fixation by root nodules. Its residues also contribute to soil fertility and productivity. it is a significant crop prominent for its ability to thrive in drought- prone regions, it is an important commercial crop in arid and semi-arid regions. Its pods are used as a vegetable in traditional culinary practices, while its seeds and straw provide nutritive fodder for livestock. The plant is also used as green manure and a cover crop, contributing to soil health and conservation. The seeds contain 30-33% galactomannan gum, which elevated clusterbean's status to an industrial crop (Whistler *et al*., 1948). This gum is used in various industries, including food, pharmaceuticals, cosmetics, mining, textiles, paper manufacturing and oil drilling. Weed infestation is a significant challenge in clusterbean cultivation, especially during the rainy season. Weeds compete with crops for water, nutrients, space and sunlight leading to severe yield reductions ranging from 29-48% and in some cases up to 70-98% (Patil *et al.,* 2021). The critical period of crop-weed competition in clusterbean is 20-30 days after sowing (DAS) with yield reductions of 47-92% if weeds persist beyond this period (Yadav et al., 2008). Traditional hand weeding is effective but labor-intensive, costly and often impractical due to labor shortages and rising costs. Herbicides offer a viable alternative for effective and economical weed control. Adoption of chemical weed control is increasing crop return by reducing the cost of production. However, there is still a lack of information on the appropriate type of herbicide, application timing, rate, and method. Additionally, the residual effects on subsequent crops remain a concern in our country. In view of the above facts, the present study entitled, "Effect of post emergence herbicides and herbicide mixtures on growth and yield of clusterbean was undertaken.

Methodology

A field experiment was conducted during *kharif* 2022 and 2023 at the Instructional farm, Dryland farming Research Station, Arjia, Bhilwara. The soil of the experimental site was sandy loam having 7.22 pH, 0.48% organic carbon and 251.46 kg N ha^{-1}, 15.83 kg P_2O_5 ha^{-1} and 363.21 kg K_2O ha^{-1} The experiment was laid out under randomize block design and with three replications and eight treatments i.e. T_1-unweeded check, T_2-weed free, T_3-imazethapyr 10% SL (100 g ha^{-1}) at 20 DAS,T_4-imazethapyr 35%+imazamox 35% (70 + 70 g ha^{-1}) (RM) at 20 DAS, T_5-propaquizafop 2.5% + imazethapyr 3.75% ME (33.3 + 50 g ha^{-1}) (RM) at 20 DAS, T_6-acifluorfen-sodium 16.5% + clodinafop propargyl 8% EC (123.75 +60 g ha^{-1}) (RM) at 20 DAS, T_7-acifluorfen sodium 16.5% + clodinafop - propargyl 8% (165 +80 g ha-1) (RM) at 20 DAS and T_8-fomesafen 11.1% + fluazifop-p-butyl 11.1% (220 +220 g ha-1) (RM) at 20 DAS. Clusterbean variety RGC 1033 was sown on 10th of July 2023. The recomanded dose of N, P_2O_5 and K_2O (20:40:00 kg ha^{-1}) was applied as a basal dose. The seeds were sown at the rate of 20 kg ha^{-1} at 30 x 10 cm spacing and at a depth of 3-4 cm. After 20 days of sowing the herbicides were applied by using knap-sack sprayer equipped with a flat-fan nozzle. Weed population was recorded by using 0.5 m^{-2} quadrat in all the treatments and then converted into number of weeds per m^{-2}.

Results

Experimental finding indicate that among the herbicidal treatment recorded significantly lowest weed density and weed dry matter was under application of fomesafen 11.1% +

fluazifop-p-butyl 11.1% (220 +220 g ha^{-1}) (RM) at 20 DAS (6.5 m^{-2}) being at par with acifluorfen sodium 16.5% + clodinafop - propargyl 8% (165 +80 g ha^{-1}) (RM) at 20 DAS and propagandize 2.5% + Imazethapyr 3.75% ME (33.3 + 50 g ha^{-1}) (RM) at 20 DAS over other herbicides treatments Among herbicides maximum height of plant (115.25 cm), higher number of branches per plant (6.52), pods per plant (31.42) and seeds per pod (7.36) was recorded under fomesafen 11.1% + fluazifop-p-butyl 11.1% (220 +220 g ha^{-1}) RM at 20 DAS which was at par with acifluorescence sodium 16.5% + clodinafop - propargyl 8% (165 +80 g ha^{-1}) (RM) at 20 DAS closely followed propagandize 2.5% + Imazethapyr 3.75% ME (33.3 + 50 g ha^{-1}) (RM) at 20 DAS and rest of treatment fomesafen 11.1% + fluazifop-p-butyl 11.1% (220 +220 g ha^{-1}) (RM) at 20 DAS recorded maximum grain yield (1271 kg ha^{-1}) and stover yield (1770 kg ha^{-1}) followed by acifluorfen sodium 16.5% + clodinafop - propargyl 8% (165 +80 g ha^{-1}) (RM) at 20 DAS. Further, higher net returns and benefit cost ratio was recorded with the application of fomesafen 11.1% + fluazifop-p-butyl 11.1% (220 +220 g ha^{-1}) (RM) at 20 DAS being at par with acifluorfen sodium 16.5% + clodinafop - propargyl 8% (165 +80 g ha^{-1}) (RM) at 20 DAS.

Table 1. Effect of post emergence herbicide on yield of clusterbean (2022 and 2023)

Treatments	Seed Yield (Kg/ha)			Seed Yield (Kg/ha)		
	2022	2023	Mean	2022	2023	Mean
T1-Unweeded check	577	507	542	741	673	707
T2- Weed free	1261	1090	1175	1608	1409	1508
T3-Imazethapyr 10% SL @ 100 g/ha at 15-20 DAS	1002	922	962	1242	1114	1178
T4- Imazethapyr + imazamox @75 g/ha at 15-20 DAS	1079	991	1035	1396	1195	1295
T5-Propaquizafop 2.5% @ 33.3 g/ha + imazethapyr 3.75 ME @ 50 g/ha (Ready mix) at 15-20 DAS	1112	1022	1067	1456	1198	1327
T6-Acifluorfen sodium 16.5% EC 140 g/ha + clodinafop - propargyl 8% (Ready mix) 750 ml/ha at 15 - 20 DAS	1100	989	1044	1398	1256	1327
T7-Acifluorfen sodium 16.5% EC 140 g/ha + clodinafop - propargyl 8% (Ready mix) 1000 ml/ha at 15 - 20 DAS	1156	1057	1106	1459	1395	1427
T8-8. Fomesafen 11.1% @ 220 g/ha + fluazifop - p-butyl 11.1% @ 220 g/ha (Ready mix) at 15 - 20 DAS	1327	1214	1271	1835	1705	1770
S.EM+	45	35		52	84	
C.D. at 5%	134	105		153	248	

Conclusion

Application of fomesafen 11.1% + fluazifop-p-butyl 11.1% (220 +220 g ha^{-1}) (RM) at 20 DAS (6.5 m^{-2}) provide a broad spectrum of weed control and recorded 134.5 % higher seed yield of clusterbean over unweeded check (542 kg ha^{-1}). However, this herbicide can ensure robust weed management, leading to healthier crops and improved agricultural productivity.

UID: 1615

Response of Short Duration Variety of Paddy for Adoption in Climate Change Scenario

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About 55% of Indians rely on agriculture as their main source of income, making it one of the world's largest agricultural economies. The contribution (production) of rainfed agriculture in India is about 42 per cent of the total food grain, 75 per cent of oilseeds, 90 per cent of pulses and about 70 per cent of cotton (Kolhapure, 2022). Climate change threatens agricultural production around the world in many ways, endangering the food supply and livelihoods of rural populations. One major element restricting the production of rice is drought stress, which causes significant economic losses. Both short dry spells and prolonged droughts create a serious threat to many people who depend on rainfed agriculture. The majority of India's impoverished reside in rainfed areas. Furthermore, it is anticipated that these areas will be most negatively impacted by climate variability (such as frequent floods, droughts, etc.) and, consequently, productivity. A strategy called Climate-Smart Agriculture (CSA) aims to assist those in charge of agricultural systems in efficiently adapting to climate change. Rice varieties with short maturity duration are needed to adapt to the changing climate and altered growing conditions. According the FAO, 2014, one of the technological options for adapting to climate change is to grow short duration varieties that can escape drought and submergence.

Importance Short Duration Varieties for climate change

1. Food security: short duration variety can help ensure food availability by allowing farmers to continuing cultivating rice in challenging conditions.
2. Time for straw management: Early maturation allows farmers to manage extra paddy straw and get fields ready for rabi sowing
3. Water and cost savings: Short-duration varieties reduce costs of inputs and irrigation water usage by 20% without reducing rice productivity.
4. Reduced stubble burning: Short-duration varieties help reduce stubble burning for safer environment.
5. Methane emission reduction: Short-duration varieties can help reduce methane emission by about 25%.
6. Multiple cropping systems: Short-duration varieties allow for multiple cropping systems.
7. Reduced risk of lodging and pest damage: Short-duration varieties have a lower risk of lodging and are less likely to be damaged by pests like rodents, birds and insects
8. Drought escape: In rainfed rice ecosystems, short-duration varieties can escape drought at the end of the wet season.

9. Water shortages: In irrigated rice ecosystems, short-duration varieties are preferred because they can help with water shortages late in the dry season.

Demonstration in NICRA Adopted Village

The demonstration of the short duration variety of paddy MTU 1153 was done in the NICRA adopted village Paraswani by KVK, Mahasamund (Chhattisgarh). The total cultivated area of Paraswani is 246.93 ha out of which 123.49 ha area is drought prone. The major constraints are the erratic rainfall, drought and delay in kharif sowing due to late maturity of paddy crop. In view of this demonstration oh f short duration variety of paddy variety MTU 1153 was done in the farmer's field with recommended package of practice. Seed treatment of paddy was done using bio fertiliser before sowing and DSR sowing technique was adopted. The average yield was obtained as 46.25 q/ha in the demonstrated field against the 40.97 q/ha yields in the farmers practice under rainfed condition. The average net return was Rs. 99388/- for the demonstrated field while Rs. 87864/- in the farmer's practice. The benefit cost ratio was estimated as 3.26 and 3.24 in the demonstrated and farmers field respectively.

We found that adoption of short duration varieties is beneficial for farmers, even in a non-drought year. It has been reported that one strategy to reduce greenhouse gas emissions of methane and nitrous oxide is the introduction of short-duration rice varieties. Due to a shorter cropping time, short duration varieties would also lessen the likelihood of agricultural loss by exposing crops to pests like wild animals and unlikely rainfall events during the harvesting of crop. This can further help farmers increase their incomes and climate resilience. Timely harvesting of short duration varieties provides sufficient time for timely field preparation and sowing of rabi crop otherwise performance of rabi crop is affected due to late sowing. This will help farmers to adopt such type of technological interventions their field, protecting their livelihoods and futures.

UID: 1623

Climate Resilient Technologies to Address the Impact of Drought in Small Onion

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The small onion is cultivated around 8000ha in Perambalur district. They are in bright colour and highly pungent due to its nature of soil. Drought is one of the major constraints limiting small onion cultivation in Perambalur District. In the conventional practice, the bulbs were planted on the sides of the ridges as well as top of the ridges, irrigation was done in furrows. In this method, the farmers encounter the problems like more incidence of disease and water scarcity during summer due to more no. of plants per meter square (30-40 Nos of plants on an average). To address the issue, a study was conducted at Echampatti village of Perambalur district under NICRA Project to investigate the effect of package of drought mitigation practices in order to improve the yield and increase water use efficiency of small onion in summer season.

Methodology

The present work was carried out by Hans Roever Krishi Vigyan Kendra, Perambalur in farmers field at Echampatti village. Soils type of the trial site are classified as clay loam and the pH of the Soil is 6.5-7.

Farmers included the following practices in to overcome drought viz., 1) cultivation of seed propagated small onions 2) Basal application CSR Bio @5Kg/ acre with 100 Kg of well composted FYM 3) Rian hose irrigation

Before transplanting of seedlings 25 kg N and 30 kg P_2O_5 and 25 K_2O was applied as the basal. The sources of N, P and K were Urea, Diammonium Phosphate (DAP) and Muriate of Potash (MOP) respectively. After 25 days 15 kg N and 10 kg P_2O_5 and 15 K_2O was applied as 1st top dressing. During 40th day, again 15 kg N and 10 kg P_2O_5 and 15 K_2O was applied as 2nd top dressing. Additionally, IIHR Vegetable special micro nutrient was applied @ 5g per liter at 25th and 35th day after sowing.

Cultivation of Seed Propagated Small Onions

Seeds are first sown at the middle of January in well prepared nursery beds of 120 cm width, 10.0 cm height and 30 feet length. Seed rate is 1 kg/ha. Seedlings of 15 cm height and 0.8 cm neck diameter are ideal for transplanting and this is achieved in 40 days. By cultivation of small onion through seeds the production cost is reduced up to 40%.

Rian Hose Irrigation

Rian hose irrigation once in 4 days @ 1 l/min/m flow rate while operating pressure 1 kg/cm^2.

Results

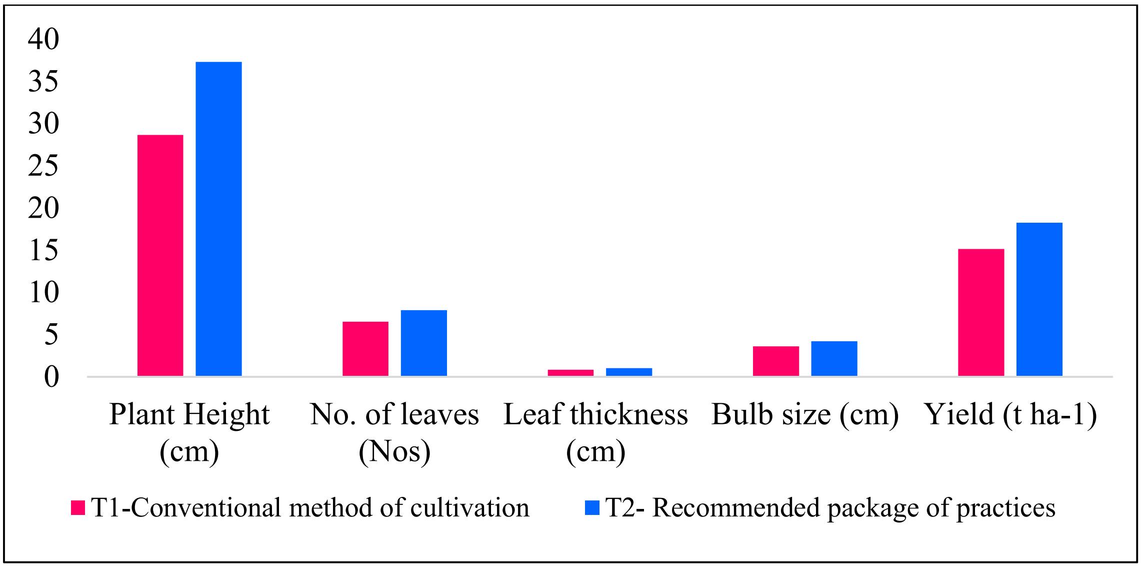
The results entered in Table and Fig clearly showed that, by addition of recommended package of practice in onion cultivation has significant influence on growth and yield parameter.

By interpreting the results we can clearly find that there is 30% increase in plant height, 20 % more number of leaves, 24% more of leaf thickness, 18% increase in bulb size and 21% increase in yield when compared to conventional method of cultivation of small onion. Similarly the percentage of disease incidence also significantly less in T2 (8.92) when compared to T1 (23.24).

The results indicated that, the incidence of disease also less because of spread of fungi through bulbs were overcome by cultivation of onions through seeds. And also, the healthy crops tolerant to disease leads to less percentage of disease incidence. Under drought stress condition the microbes present in the rhizosphere region increases the root volume, area, and length and thus leads to good crop stand and increased yield compared to conventional method of small onion cultivation. Similar findings were reported by Manjunatha *et al*., (2022) in Pearl millet and Silva *et al*., 2020 in rice. Onions require frequent, light irrigation because of shallow root systems, frequent irrigation is important for achieving high yields and uniform bulbs. The light irrigation also reduces the fungal infection leads to more of marketable bulbs. The laser pipe irrigation in ridges and furrow system, the plant can receive favorable conditions for formation of profuse root system thereby plant growth and vigour is high leads to better yield. The same findings were reported by Bangali *et al.,* (2012)

Effect of recommended package of practice on drought management

Treatments	Plant Height (cm)	No. of leaves (Nos)	Leaf thickness (cm)	Bulb size (cm)	Yield (t ha^{-1})	% Of Disease incidence
T1-Conventional method of cultivation	28.66	6. 51	0.82	3.58	15.12	23.24
T2-Recommended package of practices	37.31	7.87	1.02	4.21	18.24	8.92



Effect of recommended package of practice on drought management

Conclusion

From this study we concluded that, the combined effect of cultivation of seed propagated small onions, basal application CSR Bio and Rian hose irrigation may increase results good crop stand, more yield and less incidence of diseases. Hence, the farmers can get good market price for the produce.

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UID: 1624

Evaluation of black gram varieties under different moisture conservation practices for yield maximization under rainfed situation

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Pulses are staple protein food, and they contain about 22-24% protein for India's rural and vegetarian population. They are also a good source of fibre, low in fat, and play an important role in crop rotation, intercropping, and maintaining soil fertility through fixing atmospheric nitrogen. India is the world's largest producer, consumer, and importer of pulses and contributes 25–28% of the total global pulse production in the world. The major blackgram - growing states during the rabi season are Tamil Nadu with 2.55 lakh hectares (36.6 per cent), Andhra Pradesh with 2.13 lakh hectares (30.6 per cent) and Odisha with 1.88 lakh hectares (27 per cent) with a total production of 2.78 million tonnes, resulting in a productivity of 987 kg ha−1. The majority of the pulse cultivated area falls under rainfed, resource-poor, and harsh environments frequently prone to drought and other abiotic stress conditions, resulting in low productivity (Singh,2007). The per capita availability of pulses is diminishing during the recent fast due to increased population and faulty land management practices and improper varieties used. Adoption of proper moisture conservation practices and growing suitable varieties under resource constraints situations will enhance the productivity of pulses under dryland ecosystem (Subudhi, 2011). Keeping in view of these situations, field experiment was conducted to evaluate the effect of land configuration and improved varieties of black gram on yield and Rain water use efficiency in rainfed vertisols condition at AICRPDA main centre, Kovilpatti.

Methodology

During the *rabi* season of 2021–2022 to 2023–2024, field studies were conducted at the black soil farm of the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) main centre, Kovilpatti, of Tami Nadu Agricultural University. It was a clayey soil type with a pH of 8.02, low available nitrogen (135 kg N/ha), high available potassium (345 kg/ha), and low available phophorous (11.2 kg/ha). Compared to the 30-years of seasonal average rainfall of 147.9 mm, the cropping season received 532.3 mm of rain in 29 rainy days during 2023-2024. The trial was conducted in a split-plot design with three replications. The treatments comprised of three land configurations in the main plot (viz., compartmental bunding, ridges and furrows and farmer practices as control and three black gram varieties in the subplot (VBN 11, MDU 1, and VBN 8) for the current season crops were sown on 28.10.2023 at a spacing of 30 x 10 cm. The crops were harvested during the third week of January 2024 when they reached maturity. Various yield parameters, economics, and rainwater use efficiency were worked out as per the statistical analysis suggested by (Gomez & Gomez,1984)

Results

The suitability of the TNAU black gram short duration variety VBN8 (70-80 days) and medium duration cultivars *viz.,* MDU1, VBN11 in dryland situations has been evaluated using ridges and furrows, compartmental bunding, and farmer practices. Among the land configuration methods, of compartmental bunding registered a significantly higher grain yield of 983 kg/ha, which was 16.46 percent higher than the control.

Effect of black gram cultivars and moisture conservation practices on yield, economics and rain water use efficiency

Treatments	Yield (kg/ha)			Cost of cultivation Rs/ha	% increase in yield	Net returns (Rs./ha)	BC ratio	RWUE (kg/ha-mm)
	Grain / seed in 2023 - 24	Mean grain yield (3 years)	Stover yield (kg/ha)					
Main plot: Moisture conservation practices								
Compartmental bunding	983	670	3066	37000	16.46	28428	1.77	1.42
Ridges and furrows	967	648	3017	37000	14.57	27364	1.74	1.39
Control	844	541	2634	35500	-	20677	1.58	1.22
SEd	28	20.6	72					
CD (P=0.05)	62	44.8	140					
Sub plot: Blackgram varieties								
VBN 11	994	671	3102	36500	15.04	29661	1.81	1.43
MDU 1	936	643	2920	36500	8.33	25800	1.71	1.35
VBN 8	864	541	2695	36500		21008	1.58	1.24
SEd	29.5	21.2	65					
CD (P=0.05)	65	49.4	136					

However, it was on par with ridges and furrows method of land configuration during 2022-23 out of the three years. Among the varieties, VBN 11 recorded a significantly higher yield of 994 kg/ha than the other varieties, *viz.,* MDU 1 (936 kg/ha) and VBN 8 (864 kg/ha). There was a yield increase of 15.04 percent over VBN 8, with RWUE of 1.43 kg/ha-mm and a B:C ratio of 1.81 over other varieties.

Conclusion

Compartmental bunding can be recommended as the most suitable Land configuration techniques for cultivation of rainfed pulses under semi-arid zone of Tamil Nadu. Blackgram VBN11 performed better than other cultivars under rainfed *vertisols* and this can be recommended for domain districts of southern Tamil Nadu.

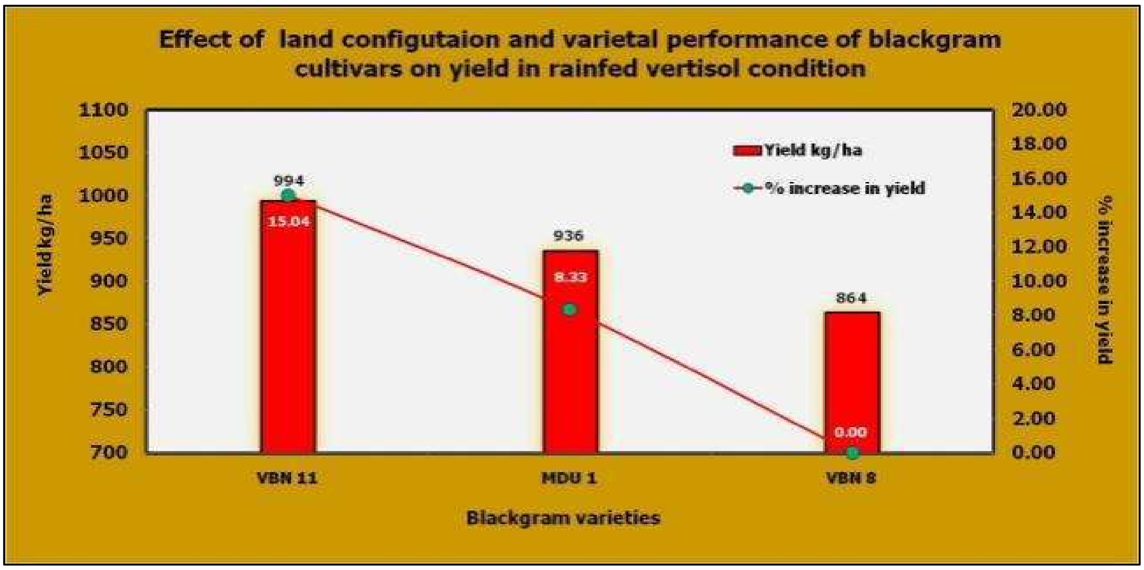

Fig 1. Effect of land configuration and varietal performance of blackgram cultivars on yield in rainfed *vertisol* condition

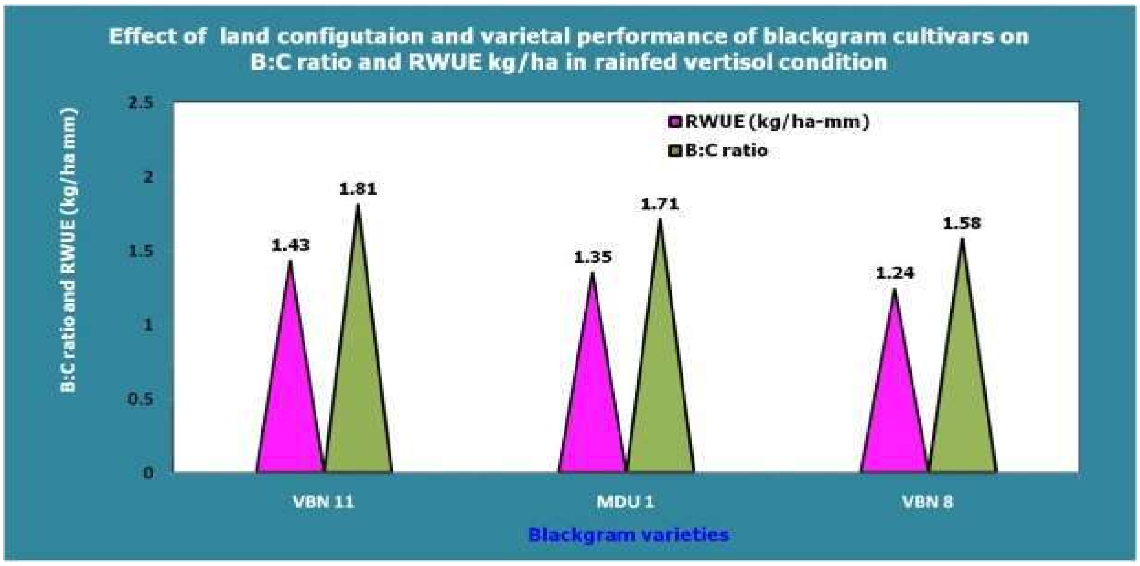

Fig 2. Economics of Blackgram Cultivars

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The Role of Silicon in Abiotic Stress Mitigation in Dryland Crops

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Silicon is the second most abundant element in the Earth's crust. Numerous studies demonstrate that silicon can enhance plants' ability to withstand harsh conditions by mitigating abiotic stresses, including drought, salinity, and metal toxicity. The sustainability of crop yields in dryland farming, a type of rainfed agriculture, is seriously threatened by abiotic stresses aggravated by climate change. This review aims to investigate how silicon nutrition can help reduce crop stress in dryland agricultural systems.

Methodology

A comprehensive literature review was conducted, covering studies published from 2015 to 2024. Databases such as Google Scholar, ScienceDirect, Frontiers, MDPI, and ResearchGate were searched using keywords like "silicon nutrition," "drylands," and "abiotic stress." This review also focuses on peer-reviewed articles and field studies published in various journals.

Key Findings

Silicon (Si) is absorbed by plant roots as silicic acid and transported through various influx and efflux transporters, with species-specific variations in Si accumulation. Si strengthens plant cell walls, enhancing mechanical stability and rigidity. It benefits plants by improving seed germination, cell membrane stability, carbon assimilation, water relations, osmotic adjustment, and drought stress tolerance. It regulates phytohormones (e.g., decreasing ABA and increasing gibberellins), forms phytoliths to stabilize membranes, and boosts antioxidant enzyme activity (e.g., CAT, SOD) and non-enzymatic antioxidants (e.g., AsA, GSH), reducing oxidative damage. Si application enhances photosynthetic efficiency and yield in crops like rice, wheat, and soybean under drought by increasing chlorophyll content, reducing transpiration, and improving hydraulic conductivity. It aids osmotic adjustment and cellular integrity in Si-accumulating plants and enhances root hydraulic conductivity in Si-excluding plants which helps to overcome salinity stress besides water deficit stress. By regulating gene expression (via JA, ABA, and phenylpropanoid pathways) and balancing phytohormones, Si strengthens resistance to environmental stress. It also reduces heavy metal toxicity in plants by lowering metal absorption and transport, creating metal-silicate complexes, and boosting antioxidant mechanisms. Under circumstances of severe metal stress, this leads to enhanced plant development and stress tolerance. Additionally, Si improves nutrient uptake (N, P, K, etc.) by enhancing water absorption, ion mobilization, and transporter activity, promoting overall plant health. Details of some of the studies on Si-mediated abiotic stress mitigation in plants are provided in Table1.

Beneficial Effects of Silicon under various stress conditions in different crops

Authors	Year	Crop	Conclusion
Alexander Calero Hurtado *et al.*	2024	Sunflower	Si alleviated salt stress effects in sunflower plants by significantly lowering hydrogen peroxide levels and increasing photosynthetic pigments and nutrient accumulation, leading to greater root and shoot dry biomass.
Pankaj *et al.*	2024	Sorghum	OSA application enhances growth and physiological attributes of plants, including weight, height, leaf area, photosynthesis, transpiration, stomatal conductance, and relative water content, under salt stress, with significant improvements compared to the control.
Faezeh Davoudi *et al.*	2024	Wheat	SiO_2 nanoparticles, combined with plant growth-promoting bacteria (PGPB), enhance wheat's water stress tolerance by significantly increasing shoot and root dry weights, boosting nutrient concentrations, and improving antioxidant enzyme activities while reducing Malondialdehyde content.
Sanaullah Jalil *et al.*	2023	Rice	SiO NPs supplementation significantly alleviated Cd-induced toxicity, mitigating the adverse effects on plant growth while maintaining chlorophyll content and photosynthetic attributes
Monika Patel *et al.*	2022	Groundnut	Si enhances Potassium use efficiency under K-limitation by up-regulating K uptake genes, boosting antioxidative enzyme activity, and promoting sugar, sugar alcohol, and phytohormone accumulation for signal transduction, osmotic regulation, and stress tolerance improvement.

Conclusion

Silicon (Si) nutrition enhances crop resilience in dryland agriculture by mitigating abiotic stresses like drought, salinity, and metal toxicity. It improves plant growth and stress tolerance through mechanisms such as better water relations, antioxidant activity, and regulation of stress-related phytohormones. Si boosts photosynthetic efficiency, osmotic adjustment, and nutrient uptake, benefiting both Si-accumulating and Si-excluding plants. Its role in stress resistance and productivity underscores its potential as a key nutrient for sustainable dryland farming, especially in the face of climate change. Further research is needed to optimize its application and interactions with other nutrients, especially under rainfed conditions.

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UID: 1644

Comparative Performance of Improved Variety of Finger Millet (Vl Mandua 352, 379, 380 And 382) Under Rainfed Cultivation in East Kameng District of Arunachal Pradesh

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Finger millet is a traditionally cultivated crop in the tribal belts of Arunachal Pradesh. Millet powder have been mixed up with different food staffs for a healthy diet. But the primary use of millets is for production of local wine as a traditional practice. However, the productivity of local finger millet is low and therefore three improved varieties from VPKAS have been studied in the district and subsequently demonstrated in the farmer’s field. The study focuses on assessing the adaptability, productivity, and overall performance of the improved finger millet varieties in the rainfed farming conditions of East Kameng District, Arunachal Pradesh. The district is characterized by hilly terrain, variable climatic conditions, and traditional agricultural practices, making it a prime candidate for evaluating rainfed crop. The improved finger millet variety VL Mandua 352 holds significant potential for rainfed cultivation in East Kameng District. Its adaptability, higher yields, and resilience to biotic and abiotic stresses make it a valuable crop for ensuring sustainable agriculture and rural livelihoods in the region.

Methodology

Site Selection: Trials were conducted in farmers' fields across representative locations in East Kameng District.

Varietal Characteristics: VL Mandua 352, 379, 380 and 382, developed for resilience in marginal conditions, was compared with local varieties.

Cultivation Practices: Standard agronomic practices, including spacing, sowing time, and organic input management, were followed.

Data Collection: Parameters such as germination rate, tiller count, grain yield, and biomass production were recorded.

Analysis: Data was statistically analysed with Randomised block design to determine the results

Yield Performance: VL Mandua 352 exhibited a significant yield advantage over other two and local varieties, with an average grain yield increase 60 to 95 % Over local one that have been presented in the Table 1.

Growth Characteristics: The improved varieties showed variety wise uniform plant height and other yield attributing characteristics, early maturity (100–110 days), and robust tillering ability.

Resilience: It demonstrated good resistance to common pests and diseases, particularly blast disease, which is prevalent in the region.

Adaptability: The variety adapted well to low-input farming systems and thrived under the region's erratic rainfall pattern.

Nutritional Benefits: The variety retained high levels of essential nutrients like calcium, iron, and dietary fiber, aligning with traditional dietary preferences.

Economic Feasibility: The variety showed higher profitability due to increased yield and lower susceptibility to diseases, reducing crop losses and input costs.

Socio-Economic Impact

Income Enhancement: Farmers adopting VL Mandua 352 and other VL Series crop reported an increase in household income due to higher marketable surplus.

Variety	Av. Plant ht(cm)	Av. effective tillers per plant	Av. No. of fingers per ear	Seed yield (q/ha)	Percent increase of yield (%)	Net return (Rs/Ha)	BCR
VL Mandua 379	85.5	5.9	8.8	19.3	60.83	27151.00	1.62
VL Mandua 382	82.8	5.6	8.2	18.8	56.67	24150.80	1.55
VL Mandua 352	85.2	6.5	10.1	23.4	95.0	31675.60	1.85
Check (undescriptive Local)	95.6	3.5	7.1	12.0		10436.00	1.32

Cost Efficiency: Lower input costs coupled with higher productivity made it a cost-effective choice for resource-limited farmers.

Food Security: The improved yield and resilience contributed to enhanced food security in the rainfed areas.

Recommendations

Scaling Up: Promote large-scale adoption of VL Mandua 352 through awareness campaigns and seed distribution initiatives.

Capacity Building: Conduct farmer training programs on best agronomic practices for finger millet cultivation.

Integrated Nutrient Management: Encourage the use of organic fertilizers and intercropping systems to further enhance productivity.

Policy Support: Advocate for government incentives to support rainfed millet farming and value-chain development.

Conclusion

The improved finger millet variety VL Mandua 352 has shown promising results in East Kameng District under rainfed conditions. Its adoption can potentially enhance productivity, improve farmers' incomes, and contribute to food and nutritional security in the region. However, concerted efforts are needed to address challenges in adoption and market integration to fully realize it's potential.

UID: 1647

Assessing the Performance of Finger Millet Varieties and Crop Establishment Methods in Rice-Fallow Situations

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Rice-fallow areas refer to the areas where paddy is cultivated during the *kharif* but remain fallow during the subsequent *rabi* due to various limitations. Lack of irrigation facilities, the cultivation of long-duration paddy cultivars, early cessation of monsoon rains, etc. leading to soil moisture stress to subsequent *rabi* crop. These factors collectively hinder the cultivation of crops during the *rabi* season, resulting in unutilized agricultural potential and unexploited opportunities for improving food security and farm income. By addressing these challenges through different strategies, rice fallows offer huge niche areas for growing dry land crops like pulses, oil seeds, small millet crops, spices, etc., which in turn address the three-fold securities like economic security, food security and nutritional security. Millets, which are traditional cereal grains, rich in nutritional values are mostly confined to the marginal and poor soils in hilly and undulated topographies under low input management. This is the major reason for low productivity of millet crops in India. Rice fallows are highly fertile lands, which have a large potential for expanding millet acreage and productivity. Among the millets, finger millet is a staple food for many people in semi-arid regions and can be grown in rice fallows to increase food security and also to improve the livelihoods of farmers. Terminal moisture stress and less plant stand establishment are the main constraints observed in finger millet cultivation in rice fallows. Selection of short duration varieties is a viable approach to escape the terminal moisture stress. In order to maintain 100% plant population and also to protect the crop from terminal moisture stress, best crop establishment method should be followed. In view of this, an experiment was conducted with various crop establishment methods and short duration varieties in rice fallow situations.

Methodology

An experiment was conducted during *rabi*, 2023-24 under rice fallow condition at Agricultural Research Station, Vizianagaram. Experimental site was situated 180^o 07' N latitude and 83^o 25' E longitude, with an altitude of 63.0 m above mean sea level in North Coastal Agro-Climatic Zone of Andhra Pradesh. The soil of the experimental site was clay loam with low in organic carbon, neutral in soil reaction, low in available nitrogen, high in available phosphorus and medium in available potassium. Experiment was conducted in strip plot design with three main plots and four sub plots, which replicated thrice. Main plots consisted of three crop establishment methods of finger millet *viz*., S_1: Relay sowing of finger millet in standing paddy 5-7 days before harvesting; S_2: Line sowing (dibbiling) after harvest of paddy, S_3: Transplanting of seedlings grown in nursery and sub plots consisted of four short duration finger millet varieties *viz*., V_1: VL 376; V_2: VR 708; V_3: VL 352; V_4: VL 379. Finger millet seed, which was pre-germinated was broadcasted 7 days before harvest of paddy crop. For line sowing, paddy sieves were removed immediately after harvest and finger millet seeds were dibbled in lines @ 10 kg ha^{-1}. Finger millet nursery was grown separately and 25 days old seedlings were planted immediately after removal of paddy sieves. Initial plant stands and other biometric observations were collected in all the treatments and analysed by using standard statistical procedures.

Results

Crop establishment methods and short duration varieties were significantly influenced the initial plant stand, yield attributing characters, grain yield and economics of finger millet. Broadcasting of finger millet seed 5-7 days before harvest of paddy is a common practice among the farmers. The plant stand establishment was not satisfactory in this method. Experimental results during *rabi*, 2023-24 revealed that, among different crop establishment methods, the initial plant stand was higher with transplanting

Table 1: Effect of crop establishment methods on growth and yield attributing characters of finger millet varieties under rice fallow situations

Treatments	Initial plant stand/m^2	Plant ht (cm)	Days to maturity	No. of tillers/m^2	Earheads/ m^2	Test weight (g)
Main plots: Establishment methods (S):3						
S1:Relay sowing in standing paddy 5-7 days before harvest	37.6	62.6	86.3	64	48.9	2.813
S2:Line sowing after harvest of paddy	41.6	74.8	88.5	81	66.3	2.897
S3: Transplanting of seedlings grown in nursery	42.8	59.9	95.6	106	80.9	2.904
S.Em±	0.62	1.30	0.34	1.50	1.87	0.010
C.D(P=0.05)	2.43	5.10	1.34	5.91	7.34	0.040
Subplots: Short duration varieties (V):4						
V1: VL 376	40.9	62.3	88.3	96.4	75.4	2.884
V2: VR 708	40.3	66.8	95.2	72.1	55.2	2.834
V3: VL 352	41.2	70.6	86.6	77.8	59.0	2.862
V4: VL 379	40.1	63.4	90.4	88.7	71.9	2.904
S.Em±	0.79	1.39	0.39	2.49	2.18	0.013
C.D(P=0.05)	NS	4.80	1.35	8.63	7.53	0.045
Interaction						
Two S at same level of V						
S.Em±	1.47	1.87	0.54	2.85	4.06	0.046
C.D(P=0.05)	NS	6.65	NS	9.60	13.41	NS
Two V at same level of S						
S.Em±	1.55	1.93	0.58	3.48	4.21	0.047
C.D(P=0.05)	NS	6.41	NS	11.52	13.53	NS

of seedlings grown in nursery, however it was found on par with line sowing after harvest of paddy. Days to maturity was 6-7 days longer in Transplanting of seedlings grown in nursery compared to other methods. Transplanting of seedlings grown in nursery recorded superior yield attributing characters, grain yield, straw yield, harvest index, net income and benefit cost ratio. Similar results were reported by Chapke et al Among, various short duration varieties, VL 376 recorded with the highest growth and yield attributing characters, however, it was found on par with VL 379 variety. VR 708 has the longest duration among all the varieties with taller plant height.

Conclusion

Based on the study it was observed that, transplanting of seedlings grown in nursery was found as an effective method in terms of plant stand establishment, growth, yield and economics. Among the short duration varieties, VL 376 and VL 379 varieties were high yielders

Table 2: Effect of crop establishment methods on yield attributing characters and yield of finger millet varieties under rice fallow situations

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	HI (%)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Main plots: Establishment methods (S):3						
S1: Relay sowing in standing paddy 5-7 days before harvest	1749	3796	31.7	60949	35782	2.42
S2:Line sowing after harvest of paddy	2387	4835	33.0	82176	49167	2.49
S3: Transplanting of seedlings grown in nursery	3027	5180	36.9	104815	71656	3.16
S.Em±	98.9	70.10	1.23	3576.5	3576.5	0.12
C.D(P=0.05)	388.5	275.25	NS	14043.1	14043.1	0.45
Subplots: Short duration varieties (V):4						
V1: VL 376	2586	4419	36.7	89542	59098	2.91
V2: VR 708	2158	4613	31.7	75193	44749	2.44
V3: VL 352	2311	4931	31.4	79386	48941	2.59
V4: VL 379	2494	4452	35.6	86463	56019	2.82
S.Em±	57.7	82.03	0.78	2378.7	2378.7	0.08
C.D(P=0.05)	199.6	283.85	2.71	8231.5	8231.5	0.27
Interaction						
Two S at same level of V						
S.Em±	116.8	215.89	1.77	3918.5	3918.5	0.13
C.D(P=0.05)	436.2	NS	NS	14953.4	14953.4	0.48
Two V at same level of S						
S.Em±	84.8	220.05	1.49	2867.4	2867.4	0.09
C.D(P=0.05)	279.3	NS	NS	9670.3	9670.3	0.31

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Impact of Elevated CO_2 and Elevated Temperature on Groundnut Genotypes

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Climate change stands as a critical global challenge, exerting a substantial influence on agricultural systems and food security. Increasing greenhouse gas emissions, particularly carbon dioxide (CO_2), coupled with rising global temperatures, changing precipitation patterns, and more frequent extreme weather events, profoundly impacts crop productivity. The increased level of atmospheric CO_2 concentration from 280 ppm to over 410 ppm has caused an alarming situation worldwide, and this is likely to reach 550 ppm by 2050 (Panozzo *et al*., 2019).

Groundnut (*Arachis hypogaea* L.) is a major oil seed and food crop primarily grown in tropical and subtropical agro-ecologies. Increasing CO_2 levels, irregular rainfall, drought, elevated temperature, and salinity adversely affect the growth, yield, physiology, and nutritional quality of groundnut. Elevated CO_2 concentrations can influence photosynthesis and biomass accumulation, while higher temperature may disrupt key physiological processes, including flowering, pod formation, and seed development. The CO_2 and Temperature Gradient Chambers (CTGCs) provide a unique platform to study the interactive effects of elevated CO_2 (eCO_2) and elevated temperature (eTemp) on crop growth and yield under simulated climatic conditions.Thesechambers enable precise control of environmental variables, allowing to assess the physiological, morphological, and biochemical responses of groundnut to future climate scenarios.Understanding these impacts is essential for developing climate-resilient groundnut varieties and optimizing management practices to sustain productivity in changing agro-climatic conditions.

Methodology

The studies were conducted using CTGC, a realistically designed facility constructed at ICAR-Central Research Institute for Dryland Agriculture, Hyderabad for measuring the impact of eCO_2 and eTemp on morphological, physiological and yield traits of groundnut. Initially a total of 457 groundnut genotypes, a core collection from Indian Institute for Groundnut Research, Junagarh were evaluated in field under rainfed conditions and a short-listed 42 genotypes selected werefurther evaluated following alpha-lattice design having three blocks for each replication in CTGCs. Morpho-Physiological characterization were done in five different treatments -

1. Chambers with natural climate which serve as - '**Reference**'**(aT)**.

2. Two Chambers are with temperature gradient of 1.5 ± 0.5°C (eT1) and 3 ± 0.5°C (eT2) over reference and referred as elevated Temperature **'eTemp'.**
3. Two Chambers are with Temperature gradient of 1.5 ± 0.5°C (eT1+eCO2) and 3 ± 0.5°C (eT2+eCO2) over reference with elevated CO_2 concentration of 550 ± 50 ppm – **'eTemp + eCO_2'**

Morpho-physiological traits, seed yield, and related attributes were evaluated, and the data were analyzed statistically using analysis of variance (ANOVA) model.

Results

The ANOVA for 42 groundnut genotypes showed significant genotypic differences **(**$p \leq 0.05$**)** for all the nine morphological traits, including fresh total biomass, dry total biomass, fresh pod weight, dry pod weight**,** plant height, branch number, pod number**,** seed weight, and harvest index. Among all the eight physiological traits, TSS, FAA and DH exhibited significant variation whereas there is no significant differences for Proline, SPAD, NDVI, Ltemp and FV/FM. Treatment effects were significant across most of the traits, highlighting the impact of elevated CO_2 and temperature. The genotype × treatment interaction was substantial for TSS, FAA among physiological parameters where as significant for all the morphological parameters, indicating genotype-specific responses to climatic stress.

Morpho-Physiological and Biochemical Responses

There were significant differences among treatments. Traits such as TSS, FAA, and NDVI exhibit the highest values under eCO_2+eT1 conditions. The elevated temperatures in eT1 and eT2 alone impacted most traits, their combination with eCO_2 mitigated the stress, resulting in performance comparable to aT (table 1).

Table 1. performance of groundnut under different treatment conditions

Treatment	TSS	FAA	SPAD	NDVI	Fv/Fm	DH	DTB	DPW	PH	BR	PN	SY
aT	8.35	1.96	37.12	0.52	0.70	27.00	78.89	23.40	103.00	5.00	20.00	17.83
eCO2+eT1	13.64	2.87	36.21	0.69	0.69	24.00	68.22	21.08	114.00	5.00	18.00	15.93
eCO2+eT2	12.64	2.77	36.57	0.66	0.69	25.00	63.44	19.72	112.00	5.00	17.00	14.65
eT1	11.62	2.29	36.25	0.65	0.71	25.00	55.10	17.81	106.00	5.00	16.00	12.52
eT2	11.47	2.23	36.39	0.65	0.72	26.00	47.50	16.09	97.00	5.00	15.00	11.00
GM	11.31	2.40	36.58	0.64	0.70	25.16	62.63	19.62	106.57	4.98	16.88	14.39
CV(%)	8.58	8.39	6.27	12.03	4.44	10.12	12.70	11.16	6.11	11.79	10.26	13.92
$LSD_{0.05}$	0.29	0.06	0.70	0.02	0.01	0.79	2.41	0.66	1.98	0.17	0.52	0.60

Where TSS=Total soluble sugars (mg/g FW),FAA=free amino acids (mg/g FW), SPAD= chlorophyll meter reading, NDVI= normalized difference vegetation index, Fv/Fm = Quantum yield, DH=days to flowering, DTB=dry total biomass(g/plant), DPW=dry pod weight(g), PH=plant height(cm), BR= number of branch, PN=number of pods, SY=seed yield(g/plant), GM= Grand mean, CV (%) = Coefficient of variation and LSD = Least significant difference.

Yield traits

Elevated temperature and CO_2 conditions significantly influenced yield-related traits in groundnut, leading to variations in pod weight, pod number, and seed yield per plant. Among the genotypes, EC38604 exhibited superior performance, maintaining higher yields and demonstrating resilience in traits such as total biomass and seed yield (table 2). Followed by AH56 and K6 demonstrated notable adaptability and resilience. AH56 excelled in traits such as fresh and dry pod weight and harvest index, while K6 ranked highly for seed yield and harvest index. These genotypes collectively represent promising genotypes for further research and breeding programs.

Table 2. Best performing genotypes across different treatments

Genotypes	TSS	FAA	SPAD	NDVI	Fv/Fm	DH	DTB	DPW	PH	BR	PN	SY
EC38604	11.27	2.43	35.55	0.65	0.71	26.00	96.59	29.44	145.00	5.00	25.00	23.55[a]
AH56	12.45	2.02	36.21	0.68	0.71	24.00	82.87	29.77	104.00	5.00	21.00	19.35[b]
K6	9.87	2.34	36.42	0.66	0.70	25.00	77.88	25.53	108.00	5.00	19.00	18.96[b]
AH182	11.86	1.93	37.10	0.65	0.70	24.00	69.40	25.56	102.00	5.00	20.00	18.61[bc]
Dheeraj	11.50	2.66	35.98	0.61	0.70	28.00	73.98	23.36	106.00	5.00	20.00	18.21[bcd]
AH62	11.53	2.34	36.68	0.61	0.69	28.00	81.46	25.41	108.00	5.00	19.00	18.08[bcd]
ICG6320	11.16	2.65	35.98	0.64	0.71	24.00	65.58	24.76	103.00	5.00	15.00	18.03[bcd]
AH7820	11.83	2.76	37.06	0.66	0.69	24.00	78.37	23.44	114.00	5.00	18.00	17.79[bcde]
AH816	11.51	2.07	36.12	0.66	0.71	25.00	75.82	22.25	117.00	5.00	21.00	16.97[cdef]
AH7795	12.16	2.76	36.38	0.67	0.71	24.00	75.62	21.74	113.00	5.00	21.00	16.45[defg]
GM	11.31	2.40	36.57	0.63	0.69	25.16	62.62	19.62	106.57	4.97	16.88	14.38
CV(%)	8.57	8.38	6.27	12.02	4.43	10.12	12.07	11.16	6.10	11.79	10.26	13.92
$LSD_{0.05}$	0.84	0.17	2.05	0.06	0.02	2.29	7.01	1.93	5.73	0.51	1.52	1.76

Where TSS=Total soluble sugars (mg/g FW),FAA=free amino acids (mg/g FW), SPAD= chlorophyll meter reading, NDVI= normalized difference vegetation index, Fv/Fm = Quantum yield, DH=days to flowering, DTB=dry total biomass(g/plant), DPW=dry pod weight(g), PH=plant height(cm), BR= number of branch, PN=number of pods, SY=seed yield(g/plant), GM= Grand mean, CV (%) = Coefficient of variation and LSD = Least significant difference.

Conclusions

This study provides critical insights into the impacts of elevated CO_2 and temperature on the growth, physiology, and yield traits of groundnut. Under controlled conditions using CTGC significant variability among the 42 evaluated genotypes highlights the potential for selecting and developing climate-resilient varieties. Elevated CO_2 and temperature significantly influenced all the yield-related traits and physiological responses such as proline, TSS, FAA, NDVI, Ltemp, and FV/FM. Among the genotypes, EC38604 consistently outperformed others, demonstrating resilience in total biomass, seed weight, and overall yield under elevated temperature and CO_2 conditions. This research contributes to the development of targeted strategies for improving groundnut productivity and resilience in the face of rising global temperatures and atmospheric CO_2.

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Salt-Tolerant Rice Cultivar Productivity and Profitability in Goa's Khazan Land

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Rice is Goa's most important food crop, accounting for 39% (52,442 ha) of total cultivated land in the state, while *khazan* lands cover 17,200 ha. The *Khazan* lands in Goa are mainly utilized for paddy farming, with rice being the principal crop due to water availability for irrigation and the fertile sediment deposited by tidal floods (Bhonsle and Krishnan, 2011). In addition to rice, other crops such as vegetables, coconut, and fruits may be grown on these grounds. Climate change and increasing sea levels have rendered recent agricultural practices in *Khazan* land throughout the state unsustainable. The majority of plants cannot withstand salt stress. However, response to high salt concentrations lower the osmotic potential of soil solution, resulting in severe ion toxicity and water stress in plants, which can result in nutritional deficiencies and instability and genotype (Sangeet and Vrunda, 2014.). The poor yield of *Khazan* rice varieties, as well as the strong market for high-yielding varieties like Jaya and Jyoti, which are the prominent types in Goa, are important reasons for the decline in Khazan farming. These cultivars are both incapable of withstanding stress or salinity. Jyoti accounts for over half of all rice cultivates in Goa, Jaya accounts for 30%, and other types, particularly those grown in the *Khazan*, account for the additional 20%. According to the climatic conditions of North Goa, despite extended rain and submergence, Jyoti and Karjat were destroyed, causing a tremendous loss to the farming community. In light of this, ICAR-KVK, CCARI has introduced and evaluated the productivity and profitability salt tolerant cultivars of Goa dhan-1 in *Khazan* lands.

Methodology

During *Kharif* 2022 and *2023*, the demonstration was carried out at Mayem village of Bicholim, Goa. Thirty-seven farmer's fields were adopted to test the salt-tolerant rice variety Goa dhan 1. Korgut, on the other hand, was utilized as a control in the National Initiative on Climate Resilient Agriculture's Technology Demonstration Component (TDC- NICRA). Before sowing, the seeds were treated with Goa Bio 1 to promote paddy development in salt-affected soils. Rice variety Goa dhan-1 was utilized for 135 days and broadcasted and fertilized with the recommended dose of NPK ha in the form of urea, single super phosphate, and muriate of potash. At the panicle initiation and flowering stages, nitrogen was administered as a top dressing. The recommended dose of P and half of the K dose were used as basal, with the remaining K dose administered at the panicle initiation stage. The standard procedure was followed for recording observations on crop growth and yield characteristics. Rice yield traits and overall yield were analyzed and reported.

Results

The comparative analysis of agronomic and economic performance between the rice varieties Goa Dhan 1 and Korgut in *khazan* lands of Goa highlighted the relationship between superior agronomic traits and increased productivity, which translated into higher profitability for Goa Dhan 1. Despite a slightly shorter plant height (114.2 cm) and panicle length (23.6 cm), Goa Dhan 1 showed denser panicles with a higher panicle weight (19.9 g) compared to Korgut (15.2 g). This superior panicle density, along with better tillering (10.5 tillers per plant) and panicle production (12.4 panicles per plant), resulted in a higher grain count per panicle (142.5 grains) and higher number of filled grains (92.58 filled grains per panicle) was also recorded in Goa Dhan 1. These enhanced agronomic traits contributed to its higher grain yield (2.4 t/ha) and straw yield (1.9 t/ha), surpassing Korgut's grain yield of 1.9 t/ha and straw yield of 1.45 t/ha (Figure 1). Economically, although the cost of cultivation for Goa Dhan 1 was higher (Rs. 26,800), the improved yields resulted in superior net returns (Rs. 35,700) and a better Benefit-Cost ratio (1.75) compared to Korgut's net returns of Rs. 31,758 and BC ratio of 1.68, indicating higher profitability (Figure 2).

Conclusion

The study highlights Goa Dhan 1 as a high-performing rice variety in terms of both agronomic and economic traits. Goa Dhan 1, with its superior productivity, better grain quality, and enhanced profitability, demonstrates its resilience to climate change challenges, particularly salinity stress, making it a promising alternative to the traditional Korgut variety. Despite higher cultivation costs, the improved yields under such challenging conditions result in greater profitability, making Goa Dhan 1 a more financially viable option for farmers in the *khazan* lands. This reinforces the need for selecting salt-tolerant and climate-resilient varieties that can maintain both sustainability and profitability amid the uncertainties of future climatic changes.

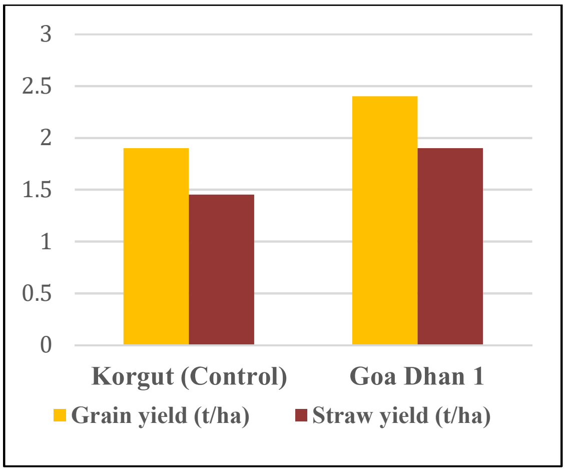

Figure 1: Yield of Goa Dhan 1 and Korgut (Control)

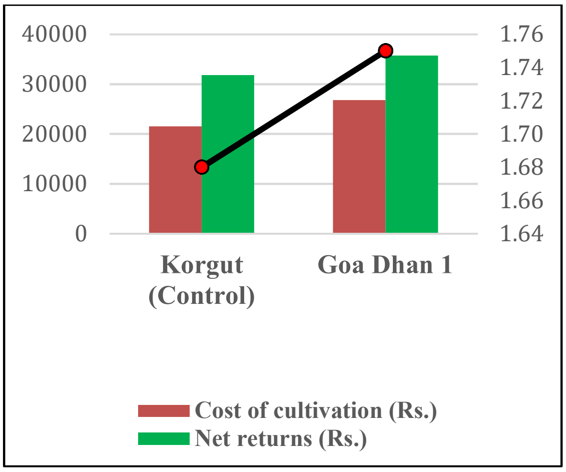

Figure 2: Economic Performance of Goa Dhan 1 and Korgut (Control)

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Introduction of Sunflower in Emerging Cropping Systems

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Sunflower (*Helianthus annum L.*) is an annual, erect and herbaceous plant belonging to family Compositae. Sunflower crop is cultivated in all three seasons of the year but, fails to produce productivity. Crop rotation is one of the important factors which influences the yield when sunflower crop is grown as sole crop. Hence, experiment entitled "Introduction of Sunflower in emerging cropping systems". was conducted at Oilseeds Research Station, Latur (Maharashtra) to study the effect of sunflower crop on succeeding crop in sequence cropping in respect to yield and soil health.

Methodology

A field experiment was conducted during *kharif-rabi* 2022-23 at Oilseeds Research Station, Latur (M.S.). Geographically Latur is situated between 18^0 05' to 18^0 75' North latitude and between 760 25' to 77^0 25' East longitude. The experiment was conducted in randomized block design with three replications on vertisols. The experimental soil was medium black with initial soil fertility of slightly alkaline in nature (*p*H 7.70) containing low in organic carbon (0.42%), low in available nitrogen (125.3kg ha^{-1}), medium in available phosphorous (18.20kg ha^{-1}) and very high in available potassium (498.58kg ha^{-1}). The gross and net plot size were 5.4 m x 4.8 m and 4.2 m x 4.2 m respectively. In *kharif* season maize, sunflower, groundnut and soybean crop were sown and in *rabi* season sunflower and groundnut crops were sown in split plot design with application of three fertilizer levels 100 % RDF, 100 % STCR and 50 % STCR. Standard package of practices were adopted for raising the crop. Data on various variables were analyzed by analysis of variance (Panse and Sukhatme, 1967).

Results

Sunflower Equivalent Seed Yield

The data pertaining to sunflower equivalent seed yield have been presented in Table 1. The sunflower equivalent seed yield varied significantly due to different cropping sequence and fertilizer levels. Among different cropping sequence, groundnut-sunflower cropping sequence recorded significantly higher sunflower equivalent seed yield which was at par with Soybean-sunflower cropping sequence and found significantly superior over rest of the treatments. Among various fertilizer levels application of 100% STCR produced highest sunflower equivalent seed yield which was significantly superior over 100% RDF and found at par with 50% STCR application. Highest harvest index was observed with 125% RDF application which was closely followed by 100% RDF application. The results are in accordance with the findings of Chauhan(1979), Khokhani et. al. (1993), Aglave et. al. (2009), Hedge and Babu (2009) and

System Economics

The gross monetary returns (GMR), net monetary returns (NMR) and benefit cost ratio of maize were computed and presented in Table 1. GMR and NMR were influenced significantly due to different cropping sequence and fertilizer levels. The significantly higher GMR and NMR were recorded with groundnut-sunflower cropping sequence which was at par with Soybean-sunflower cropping sequence and found significantly superior over rest of the treatments. Highest B:C ratio was also recorded with groundnut-sunflower cropping sequence. Among various fertilizer levels application of 100% STCR produced highest GMR and NMR over rest of the treatments. Highest B:C was also observed with 100% STCR application.

Conclusion

From the results it may be inferred that the groundnut-sunflower cropping sequence contributed sunflower equivalent seed yield, GMR, NMR and BC ratio, where as 100% STCR was found to be more remunerative for getting higher sunflower equivalent seed yield ,GMR, NMR and BC ratio.

Sunflower equivalent seed yield (kg ha^{-1}) and economics (Rs. ha^{-1}) of sunflower as influenced by different treatments

Sl. No.	Treattment	SEY (Kg/ha)	Economics (Rs/ha)		
			GMR	NMR	BC ratio
A	**Cropping System**				
1	Cs_1- Groundnut-sunflower	3393	173043	132600	4.28
2	Cs_2- Mize- sunflower	2323	118473	78030	2.93
3	Cs_3- -sunflower- Groundnut	2451	125001	84558	3.09
4	Cs_4- Soybean-sunflower	3005	153255	112812	3.79
	SE+	239	8781	8781	-
	CD at5%	716	26341	26341	-
B	**Fertilizer Levels**				
1	F_1- RDF	2453	125103	81353	2.86
2	F_2- 100% STCR	3325	169575	126738	3.96
3	F_3- 50% STCR	2602	132702	91745	3.24
	SE+	239	8781	8781	--
	CD at5%	716	26341	26341	--

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Sugarcane Clones Suitable for Late Planted Rainfed Conditions of Andhra Pradesh

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Late planting of sugarcane (May-June) purely under rainfed conditions with the onset of monsoon is a common cultivation practice in North Coastal Zone of Andhra Pradesh. Cane yields obtained under rainfed situations range from 50-60 t/ha as the crop suffer from moisture stress both at formative and maturity phases. Identification of clones with high cane yield, juice sucrose and tolerance to moisture stress is the priority area in sugarcane research. Earlier field experiments conducted at RARS, Anakaplle indicated that Co 6907, 84A 125, 81A99, 87A298, Co8201, Co7219 97A85 and 2009A 107 performed well under rainfed situations. Due to paucity of time and susceptibility to emerging pests & diseases, only 87A 298 was remained as a cosmopolitan variety. There is a dire need to identify new potential sugarcane clone for rainfed situation. Under this context this trial was conducted for evaluation of pre-release clones purely under rainfed conditions for three years (2021,2022 & 2023) resulted in identification of superior clones with high yield and high sucrose. Among the clones 2006A 223 (71.80 t/ha), 2015A 187 (69.65 t/ha), 2015A 194 (69.27 t/ha) and 2015A 183 (68.92 t/ha) recorded higher cane yield and juice sucrose percent onpar with noted checks for rainfed conditions. Among the clones numerically higher cane yield was recorded with sugarcane clone 2006A 223 (71.80 t/ha) and on par with other clones and checks. The high cane yield clones also registered higher NMC, Root spread area, total dry matter production, specific leaf area, SPAD/SCMR values and leaf proline content during stress period at 120-150 DAP denoting stress tolerance.

Methodology

Pre-release clones in early group developed through fluff supply programme were evaluated purely under late planted (May-June) rainfed conditions over three years viz., two years (2020-2021, 2021-22 and 2022-23) at Anakapalle. Soils are light textured with neutral pH. Planting material selected from mature crop was planted after soaking in 10% lime solution for one hour. Each clone was raised in six rows of eight meters row length adopting 60 cm spacing between rows. A recommended seed rate of 50,000 three budded setts per hectare (Four three budded setts/metre) was followed. Organic manure (25 tonnes of FYM/ha) and inorganic fertilizers (75kg N + 50kg P_2O_5 + 50 kg K_2O/ha) were applied. Trash mulching @ 3t/ha was applied on third day after planting. Early shoot borer was kept under check by spraying monocrotophos @ 1.6ml/litre. Deep ploughing & planting in deep furrows was adopted. Application of second dose of potassium was carried out as per recommendation. Metrological data recorded during crop was presented inTable1and 2. Data were recorded on Tiller population, root spread area, specific leaf area, SPAD/SCMR values, Total dry matter/stool, leaf proline content, Number of millable canes (NMC), and juice sucrose was determined by following standard procedures. Juice analysis was carried out in sucrolyzer (Meade & Chen, 1971). Data was analyzed statistically by Panse and Sukhatme, (1978).

Results

The mean ancillary data was found to be high in newly testing sugarcane clones for shoot populations, total dry matter for stools (NMC) root spread area, sheath moisture percent and cane yield due to timely and even distribution of rainfall during formative stage as well as maturity phase. The weather parameters during crop growth period of 2021-22, 2022-23 and 2023-24 were given in Table 1, 2 and 3, similar effects of temperature and rainfall on juice quality in sugarcane was also observed by Prasada Rao, (1988).

Tiller Production: Tiller population at 120 DAP varied from 66.70 ('000/ha) (Co 6907) to 103.81('000/ha) (2015A183). The standards 87A298 and Co6907 recorded a tiller production of 95.78('000/ha) and 66.70('000/ha) respectively.

SPAD/SCMR values: The SPAD chlorophyll meters readings at 120 DAP ranges from 33.20 (87A298)to 46.83(2006A223).

Specific Leaf Area SLA (cm^2/g): The SLA (cm^2/g) of sugarcane clones at 120DAP ranged from 101.62cm^2/g (87A298) to 114.63 cm^2/g (2015A187). The lower SLA (cm^2/g) 98.27 was recorded with 87A298 followed by Co 6907 (102.18 cm^2/g).

Conclusion

Based on observations made in present study it is concluded that among sugarcane clones studied, 2006A 223 (71.80 t/ha), 2015A 187 (69.65 t/ha), 2015A 199 (69.27 t/ha) and 2015A 183 (68.92 t/ha) recorded higher cane yield & juice sucrose percent on par to popular standards 87A298 (66.75 t/ha) and Co6907 (61.78 t/ha) in terms of cane yield and quality 18.49% and 18.15% respectively. These clones are to be tested in farmers' fields for observing the ground level performance with the feedback of the sugarcane growers prior to release for general cultivation.

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Crop Improvement and Stress Management in Wheat Variety DBW-187

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Climate change adaptation and mitigation strategies are crucial for food security in future. Achieving sustainable food security by integrating it with developing resilient agriculture practices to mitigate the impact of future climate change is a need in current situation. Wheat is one of the cereal crops which provide the primary energy requirement of the human diet globally and is cultivated over 215 million hectares worldwide. Wheat is a cool season annual, therefore it is sensitive to heat stress during all stages of its growth and development, particularly during reproductive stage. By the end of 21st century, the global mean temperatures are projected to be 1.8 to 4^0C warmer. With no mitigation strategies in place, yield losses are predicted for wheat in all major wheat producing countries due to impact of heat stress. High temperature affects the morphological, physiological and molecular responses in wheat's vegetative and reproductive phases beside shortening the crop cycle. A better understanding of plant responses to heat stress has practical implications for developing novel methods for sustainable and climate resilient agriculture wheat cultivation practice. DBW-187, which also known as Karan Vandana is a high-yielding wheat variety that is rich in protein and iron. It has a yield of around 7.5 tonnes per hectare. It has a protein content of more than 12% and an iron content of more than 42 parts per million (PPM). It is resistant to yellow rust and wheat blast disease. It also has better resistance to leaf rust and leaf blight. It has high heat tolerance across the country. The wheat variety DBW187 have been found superior over HD-3086 as far as heat tolerance is concerned. During the crop season 2021-22, the variety have shown heat tolerance with yield gain of 3.6% and 5.4%, respectively as compared to HD-3086 (Source: AICRP on Wheat and Barley progress report, 2020-21 & 2021-22). The variety flowers in 77 days and matures in 120 days after sowing. The average height of DBW 187 is 100 cm. It has better Chapati quality with a score of 7.7/10. It is suitable for the irrigated timely sown conditions of the North Eastern Plains Zones, which include Eastern Uttar Pradesh, Bihar, Jharkhand, Assam, and West Bengal.

Methodology

The field experiment was conducted in Rabi season 2023-24 in an area of about 6 hectare at 15 farmers fields. The crop was sown by zero tillage technique. Zero tillage is a farming technique that involves sowing seeds directly into the soil without disturbing it, and is also known as no-tillage or nil tillage. It can reduce the cost of cultivation by eliminating the need for ploughing, and can also save on seeds and fertilizers. It helps to increase soil health and fertility by promoting the accumulation of organic matter in the soil. It can help to reduce the risk of soil erosion. It can help to improve soil moisture retention and water infiltration. It can increase yields and profits for wheat farmers. It can help to control weeds primarily through herbicides. It is suitable for small, medium, and large farmers, and can be used with hand planting methods, animal traction, or mechanized planting.

FST type	Crop/Season (Name)	Technology demonstrated	No. of farmers	Area (ha)	Yield (q/ha)	Economics of demonstration (Rs/ha)		
						Gross Cost	Net Return	BCR
Irrigated without animal (FST-3)	Wheat (Rabi)	Demonstration of wheat (DBW-187) by ZTD	15	6	37.06	32600	51712	2.58

Results

The yield obtained was 37.06 q/ha with Gross Cost of 32600 Rs/ha and Net Return 51712 Rs/ha. The Benefit Cost Ratio was 2.58 which is far more superior than the yield of other varieties which is approximately 32-35 q/ha. The grain quality is inferior and even the cost of cultivation of other varieties is 20-25% more than DBW-187.

Conclusion

DBW-187 (Karan Vandana) gave the best performance in terms of productivity, quality of seed, cost of cultivation etc. So BCR of DBW-187 is 2.58. Therefore, this variety may be recommended to farmers for better yield and income.

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UID: 1675

Performance of Submerge Variety of Paddy (Swarna Sub-1)

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Climate change adaptation and mitigation strategies are crucial for food security in future. Achieving sustainable food security by integrating it with developing resilient agriculture practices to mitigate the impact of future climate change is a need in the current situation. Swarna-Sub1 is a semi-dwarf variety with a plant height of 100–110 cm. It is straw colour with medium slender grains. Swarna Sub-1 is genetically identical to the popular Swarna variety, but has a gene that increases its flood tolerance. Swarna Sub-1 has an average yield of 5,000–5,500 kg/ha under normal conditions. In stress conditions, the yield can reduce to 3,000–4,000 kg/ha. Swarna Sub-1 matures in 140–145 days depending on whether it is direct seeded or transplanted. Swarna-Sub1 variety is suitable for areas where the crop is usually affected by flash floods and submerged for 12–14 days. However, it is not recommended for those areas where flood water stays for more than 15–20 days. The husk colour of Swarna is golden and that of Swarna Sub-1 is white (straw colour), a character preferred by many farmers. Swarna Sub-1 can tolerate complete submergence for 14 to 17 days while Swarna can't tolerate submergence beyond 4-5 days. Climate change and the consequent increase in the incidence of drought and flood will remain a major threat to the small holders.

India is home for 86% of small and marginal farmers owning 47% of the total cultivable land. Approximately 67% of the rural population in India lives in severe poverty and mainly depends on agriculture (Bisht *et al.*, 2020). The adverse impact is more on these farmers because of extreme climate events. Henceforth, innovative research has a high priority given the adverse consequences and susceptibility in agriculture brought about by climate stresses. A Hattori *et al.* (2009) study strongly suggests that the development of stress tolerant rice varieties can enhance paddy production in flood prone areas. To increase the paddy yield under submergence conditions in India, a variety 'Swarna Sub-1' is developed by breeders at the International Rice Research Institute (IRRI) in 2009 (Veettil *et al.*, 2021; Gregorio *et al.*, 2013). This variety can withstand a submergence for 14 days and under normal conditions in comparison with other varieties, there are no significant differences in agronomic performance and grain yield (Neeraja *et al.*, 2007; Sarkar *et al.*, 2006). Under the National Food Security Mission (NFSM) of the Government of India, Swarna Sub-1 seed was distributed in its Eastern India programs during the year 2010 (Yamano *et al.*, 2015). The present study analyzes farmers choice of Swarna Sub-1 as a coping strategy against flood risks.

Methodology

The field experiment was conducted in Kharif season 2023-24 in an area of about 4 hectare at 10 farmers fields. The crop was sown by zero tillage technique. Zero tillage is a farming technique that involves sowing seeds directly into the soil without disturbing it, and is also known as no-tillage or nil tillage. It can reduce the cost of cultivation by eliminating the need for ploughing, and can also save on seeds and fertilizers. It helps to increase soil health and fertility by promoting the accumulation of organic matter in the soil. It can help to reduce the risk of soil erosion. It can help to improve soil moisture retention and water infiltration. It can help to control weeds primarily through herbicides. It is suitable for small, medium and large farmers. It can be used with hand planting methods, animal traction or mechanized planting.

Results

The yield obtained was 42.4 q/ha with Gross Cost of Ra. 39,650/ha and Net Return Rs. 43,878/ha. The Benefit Cost Ratio was 2.10 which is far more superior than the yield of other varieties. The average treatment effect confirms that the benefit of cultivating Swarna Sub-1 is much higher in submergence conditions than in normal conditions. An additional 19.0% and 48.2% of paddy yield and income is obtained respectively by cultivating Swarna-Sub1 in flooded conditions.

FST type	Crop/Season (Name)	Technology demonstrated	No. of farmers	Area (ha)	Yield (q/ha)	Economics of demonstration (Rs/ha)		
						Gross Cost	Net Return	BCR
Irrigated without animals (FST-3)	Paddy (*Kharif*)	Demonstration of flood tolerant variety of paddy (Swarna Sub-1)	10	4.0	42.4	39650	43878	2.10

Conclusion

The present study captured the adoption status and performance of Swarna Sub-1 in the flood-prone areas of Eastern India. The estimate revealed that paddy yield was significantly higher for Swarna Sub-1 adopters in the actual scenario and for non-adopters in the counterfactual scenario of adoption.

The performance of Swarna-Sub1 and other major paddy varieties was compared between normal and submergence plot conditions using average treatment effects. Compared to plots cultivated under normal conditions, paddy yield and net income obtained in submergence conditions were significantly higher for Swarna Sub-1 adopters. This shows that Swarna Sub-1 has potential for impact at scale to mitigate possible crop loss in flood-prone environments. Swarna Sub-1 gave the best performance in terms of productivity, quality of seed, cost of cultivation etc. So BCR of Swarna Sub-1 is 2.10. Therefore, this variety can be recommended to farmers for better yield and income in flood-prone regions.

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UID: 1679

Building Climate Resilience in Dryland Rice Farming with Drought-Tolerant "Swarna Shreya" Variety

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The impacts of climate change are significantly altering agricultural practices, particularly in Odisha, where variability in rainfall and temperature creates substantial challenges for farmers. Popular High Yielding rice varieties grown in Dhenkanal are not resilient to drought or heat stress, making them vulnerable to climate variability. To address this challenge, drought-tolerant variety "Swarna Shreya" has been introduced through the NICRA-TDC Project operating under the Krishi Vigyan Kendra (KVK), Dhenkanal, OUAT. This study aims to evaluate the effectiveness of drought tolerant variety "Swarna Shreya" in mitigating the impacts of water stress during dry spells in the Arachua village of Gondia block of Dhenkanal district. The village is prone to delayed monsoons, unseasonal rainfall and mid-season drought which provides an ideal situation for testing the performance of this drought-tolerant rice variety.

Methodology

Arachua village, located between 85°58' E and 86°2' E longitude and 20°29' N to 21°11' N latitude is part of the Mid Central Table Land Zone Agro-climatic zone of Odisha. It falls under the Gondia block of Dhenkanal district which has been recognized for its vulnerability to climate change impacts particularly erratic rainfall and water stress. Rice is the dominant crop in *kharif* season. The village experiences an average annual rainfall ranging from 888 mm to 1282 mm with high temperatures that can reach up to 46°C in the summer. Farmers traditionally grow medium to long-duration rice varieties like Jamuna, Kalakadamba which take 130-140 days to mature. However, these varieties are prone to moisture stress and diseases, resulting in poor yields.

Demonstration of Swarna Shreya

Under the NICRA-TDC Project, the introduction of the drought-tolerant rice variety "Swarna Shreya" addressed water stress challenges. This variety, known for its short growth duration (120 days), is well-suited for dryland conditions, resisting pests and dry spells. The demonstration involved the use of "Swarna Shreya" in conjunction with a package of advanced agricultural practices, including water-saving techniques and improved soil management. Yield comparisons were made between "Swarna Shreya" and the dominant rice varietiesof duration 130-140 days, grown under farmers' conventional practices. Data were collected on yield, net returns, and benefit-cost ratio (B: C ratio) for both "Swarna Shreya" and traditional variety to assess the economic and agronomic benefits.

Results

"Swarna Shreya**"** variety has demonstrated significant improvements in rice yield and income for farmers in Arachua village. The average yield of "Swarna Shreya" was found higher i.e. 40.7q/ha in 2022 and 43.5q/ha in 2023 as compared to the traditional varieties i.e. 33.3q/ha and 34.7q/ha in 2022 and 2023 respectively, which were prone to water stress during both the vegetative and reproductive stages. The adoption of "Swarna Shreya" resulted in a yield advantage of around 20-25% over the farmers' variety. In terms of economic returns, "Swarna Shreya" consistently outperformed the dominant rice varieties. The net return per hectare for "Swarna Shreya" was Rs.37,520 in 2022 and Rs 49,460 in 2023 compared to Rs19,315 and Rs25,391 for farmers' varieties in the respective years. The benefit-cost ratio (B:C ratio) was also higher for "SwarnaShreya" ranging from 1.85 to 2.09 as compared to farmers' variety ranging from1.40 to 1.50. The success of "Swarna Shreya" can be attributed to its drought tolerance, disease resistance and shorter duration which allowed farmers to mitigate the impacts of erratic rainfall and mid-season droughts. Farmers reported reduced water usage and fewer pest-related issues leading to lower cost of cultivation and higher overall profitability.

Season/ Year	Yield (q/ha)		% Increase	Cost of cultivation (Rs./ha)		Net Return (Rs./ha)		BC Ratio	
	FP	Demo		FP	Demo	FP	Demo	FP	Demo
Kharif, 2022	33.3	40.7	22.22	47,285	43,880	19,315	37,520	1.40	1.85
Kharif, 2023	34.7	43.5	25.36	50,255	45,370	25,391	49,460	1.50	2.09

FP: Farmers' Practice Demo: Demonstration

Conclusions

The adoption of drought-tolerant rice varieties like "Swarna Shreya" represents a crucial climate change adaptation strategy for farmers in drought-prone regions like Dhenkanal. By introducing stress-tolerant varieties coupled with improved agricultural practices, farmers can increase their resilience to climate variability, reduce crop losses and enhance their economic returns. The success of the demonstration in Arachua village highlights the importance of integrating climate-resilient technologies into local farming systems to mitigate the adverse effects of climate change.

Scaling up of "Swarna Shreya" cultivation is recommended across other vulnerable regions of the district observing the positive outcomes of the demonstration. The findings highlight the need for adoption of drought-tolerant rice varieties to face water stress situation during the dry spells and to promote sustainable agriculture in the context of climate change.

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Role of Climate Resilient Pearl Millet Cultivar MPMH-17 in Mitigating effect of Heat and Moisture Stress

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Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the sixth most important cereal crop after rice, wheat, maize, barley and sorghum. It is widely grown on 30 million ha in the arid and semi-arid tropical regions of Asia and Africa, accounting for almost half of the global millet production. Climate change becomes major tailback for sustainable agriculture in recent years. Extreme climatic events such as heat stress, moisture stress, new disease and pests become major barriers in successful crops production. Barmer district is the largest pearl millet growing division in Rajasthan with a contribution of more than 21% in the total state's acreage.

It has been reported that timely sowing, and heat and moisture stress tolerant cultivars will produce better yield. MPMH-17 is a dual-purpose hybrid variety of pearl millet that is known for its high grain and stover yields. MPMH-17 matures in about 79 days and flowers in 48 days. It has been reported that this variety can produce yield up to 2.8 t/ha. At research stations, numerous studies have been conducted on the yield and economics of pearl millet cultivar MPMH-17 and these studies have revealed that there are increase in the crop yield and net return of the farmers. Previous researchers reported that the yield of this cultivar significantly influenced by soil type, cropping system, management practices etc. (Yadav et al., 2013). But limited information is available on the yield and economics of the pearl millet variety MPMH-17 in farmers' fields. Keeping view above MPMH-17 variety of pearl millet was sown at farmers field to assess the yield potential of this variety under rainfed condition of Barmer district.

Methodology

During Kharif season 2023 pearl millet MPMH-17 was demonstrated at 150 farmer's field in 60.0 ha area. The selected farmers belong to the TDC-NICRA adopted village. Before onset of the monsoon, distributed the seed in TDC-NICRA villages. The soil and crop management advisory also provided the farmers. The TDC-NICRA team associated with this project regularly monitored the crop growth activities. The yield of the seed distributed farmers note down.

Results

During Kharif season 2023 pearl millet MPMH-17 was demonstrated at 150 farmer's field. The area covered by this demonstration was 60 ha area. Results reveled that there was about 28.6% higher grain yield as compared to the local variety (traditional). The yield of pear millet ranges from 8.54q. to 11.21q. Results further show that on an average farmer earned a net return of Rs. 4356/ha with this improved variety as compared to the local variety (413/-). The B:C ratio recorded 1.28 in improved variety as compared to the local variety B:C ratio (1.03).

Table 1: Effect of pear millet variety MPMH-17 on grain yield, net return and B:C ratio.

Pear millet cultivar	Yield (kg/ha)	Net return (Rs.)	B:C ratio
MPMH-17	936	4356/-	1:1.28
Local variety (traditional)	728	413/-	1:1.03

Conclusion

In the climate change scenario, the performance of the pear millet cultivar MPMH-17 found quite satisfactorily and farmers are getting higher net return and B:C ration as compared to the local variety.

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Enhancing Pea Productivity and Profitability through High-Yielding Varieties and Improved Agronomic Practices under NICRA project in Phek District of Nagaland

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Front line demonstrations were conducted in Thipuzu village under NICRA, located in Phek district of Nagaland, during the years 2018, 2019, 2020, 2021, 2022 and 2023. These demonstrations aimed to enhance garden pea productivity and farmers' income by replacing the traditional local pea variety with a promising high yielding improved variety Arkel combined with improved crop management practices. The study revealed that, across all six years, the Arkel variety, when cultivated using advanced crop management techniques, outperformed the traditional local variety grown using conventional farmer practices. The demonstrated plots recorded superior agronomic parameters, including greater plant height, a higher number of branches per plant, an increased number of pods per plant, and more seeds per pod.The findings revealed notable improvements in pod yield, with the recommended plot producing an average yield of 8.97 t/ha and achieving a benefit-cost ratio of 2.52. The farmer's practice resulted in a yield of 6.7 t/ha with a benefit-cost (B:C) ratio of 1.85. Additionally, the economic analysis highlighted significant benefits from the demonstrated plots. The gross returns, net returns, and B:C ratio were consistently higher in the plots utilizing the Arkel variety with improved management practices compared to traditional methods. These findings highlight the potential of integrating high yielding varieties with advanced agronomic practices to enhance agricultural productivity and profitability in the region.

UID: 1683

Influenced on Growth and Fruit Yield of Okra by Different Sowing Dates and Variety in South Garo Hills, Meghalaya

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The present investigation was undertaken at Asugre (NICRA village) in South Garo Hills, Meghalaya during *zaid* season for two consecutive years from 2023- 2024on the response of sowing dates on the growth and yield of okra varieties. The experiment was laid in Factorial RBD with two factors i.e. sowing dates (S_1-10th March, S_2-20th March, S_3-30th March, S_4-10th April and S_5-20th April) and variety (V_1-Arka Anamika F_1 and V_2-Arka Nikita F_1) replicated thrice. The results revealed that the growth and yield parameters decreased significantly with delay in sowing. Sowing okra on 20th March proved best for plant growth and yield. Days to 50% germination, days to first flower initiation was reduced gradually with delay in sowing from 10th March (S_1) to 20th April (S_4). The crop sown on 20th March (S_2) was found superior in growth and fruit yield over the later sown crops. Sowing on 20th March recorded significantly taller plants (103.49 cm), harvest duration (52.02 days), number of nodes per plant (17.79) which thereby attributing in production of highest fruits per plant (8.32), fruit weight (9.19 g) and finally on the yield (113.22 q/ha). The fruit yield was significantly higher under early sown crops over the later sown crops. The varietal effect was much profound under Arka Nikita F_1 over Arka Anamika F_1 on growth and yield attributes. It may also be noted that Arka Nikita F_1 sown on 20th March for two consecutive years gave the highest fruit yield. From the present findings, it is advised to sow Arka Nikita F_1 during 10th March to 20th March to harness maximum profit under South Garo Hills, Meghalaya as late sown crops suffer from flash flood and are often exposed to increased incidence of pests and diseases, producing low quality fruits.

UID: 1689

Performance of Pearlmillet Variety ABV-04 under Rainfed Conditions of Andhra Pradesh

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Pearlmillet is a versatile crop having the ability of drought tolerance, salinity and also have high water use efficiency, which make it as one of the most preferred crops in dry tract and rain shadow region of Ananthapuramu district. Moreover, it is best alternative crop for

groundnut. Pearlmillet is the sixth most important crop in the world after wheat (Triticum aestivum L.), rice (Oryza sativa L.), maize (Zea mays L.), barley (Hordeum vulgare L.) and sorghum (Sorghum bicolor L.). In the district due to erratic rainfall leads failure of groundnut crop. Hence introduced high yielding, biofortified, drought tolerant variety of pearl millet *i.e* ABV-04 in *kharif* season as front-line demonstration. The demonstration was carried from 2019-20 to 2021-2022 for about three years in 30 farmer's field. The variety demonstrated *i.e* ABV-04 is rich (biofortified) and Zn content is 70 ppm and Fe is 63 ppm. Hence it reduces anaemic condition in consumers too. The highest seed yield was observed with demonstration from 2019-20 to 2021-22 was 1297 kg ha^{-1}, 1357 kg ha^{-1}, 1825 kg ha^{-1} over control 985 kg ha^{-1}, 987 kg ha^{-1}, 1545 kg ha^{-1}, respectively. This could be attributed due to higher plant height (164.2 cm), panicle length (29.6 cm) and higher tillers per plant (4) in the demonstration compared to control. The data proved that pooled average yield recorded highest in demonstration compared to the local check over 27.3 %.

Table 1. Yield and economics of front line demonstration in pearl millet

Particulars	2019-20		2020-21		2021-22		Pooled	
	Demo	Farmers practice	Demo	Farmers practice	Demo	Farmers practice	Demo	Farmers practice
Seed yield (kg/ha)	1297	985	1357	987	1825	1545	1493	1172
Gross returns (Rs/ha)	23346	17730	25476	18687	25550	21630	24791	19349
Cost of cultivation (Rs/ha)	16500	16100	17547	17879	12975	13875	15674	15951
Net returns (Rs/ha)	6846	1630	7929	808	12575	7755	9117	3398
B:C ratio	1.4	1.1	1.4	1.04	1.97	1.56	1.6	1.2
% increase in yield	31		37		18		27.3	

Table 2. Growth and yield attributing characters of pearl millet

Particulars	Demo	Farmers practice	% increase in yield
Panicle length (cm)	29.6	25.6	15.6
Plant Height (cm)	164.2	155.4	5.7
Number of tillers per plant	4	3	33.3

Economic returns were observed as a function of yield and market price. Total average gross returns realized from adoption of high yielding variety is Rs. 23346/-, 25476/-, 25550/- during 2019-20, 2020-21, 2021-22 compared to farmers used variety Rs 17730/-, 18687/-, 21630/- respectively. It is due to higher seed yield compared to local variety. The highest benefit to cost ratio was observed with demonstration compared to local variety.

UID: 1694

Integrated Approaches to Reduce GHG Emissions and Boost Productivity in Rice -Wheat Systems

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Integrated approaches in rice-wheat cropping systems focus on combining sustainable practices such as optimized crop establishment methods and efficient nutrient management to mitigate greenhouse gas (GHG) emissions. These strategies aim to enhance soil health, improve productivity, and promote environmental sustainability, ensuring long-term resilience of the rice-wheat system. Thus, a field experiments was conducted at ICAR-IIFSR, Modipuram to evaluate the impact of crop establishment methods and nutrient management practices on greenhouse gas (GHG) emissions, soil carbon dynamics and crop yield in rice-wheat cropping system. Two crop establishment methods, transplanted puddled rice (TPR) and direct-seeded rice (DSR) for rice crop, and conventional and reduced tillage methods for wheat were assessed alongside five nutrient management practices *viz.* control, recommended dose of fertilizers (RDF), RDF + nitrogen inhibitor (DCD), organic farming and natural farming (NF). The results revealed that DSR method significantly reduced GWP compared to TPR, with nutrient treatments further enhancing the reduction. In high-carbon strata, RDF+DCD, organic and NF treatments reduced GWP by 54.0%, 32.5%, and 67.1%, respectively, compared to RDF. Similarly, in medium-carbon strata, these treatments achieved reductions of 52.6%, 31.7%, and 70.8%, respectively. Further, organic and NF treatments achieved 69.6% and 48.1%, and 71.9% and 43.2% higher total organic carbon (TOC) compared to control plots in the DSR and TPR methods, respectively. Nutrient treatments significantly increased labile carbon pools (CVL and CL) in DSR by 77.2%, 80.3%, 106.4%, and 88.2% in RDF, RDF+DCD, organic, and NF treatments, respectively. In TPR, recalcitrant carbon pools (CLL and CNL) were higher, with increases of 21.8%, 25.4%, 74.9%, and 32.3% over the control, respectively. Soil enzyme activities were significantly influenced, with organic and NF treatments demonstrating 200% and 161% higher dehydrogenase activity in DSR and TPR, respectively, over controls. However, rice and wheat yields were highest under RDF, while organic and NF treatments recorded yield reductions of up to 51.5%. Overall, the study highlights the potential of organic and natural farming practices in enhancing soil health and carbon sequestration, with yield trade-offs, and underscores the environmental benefits of DSR in mitigating GHG emissions.

UID: 1697

Performance of Climate Resilient Paddy Varieties for Sustainable Food Production under Aberrant Weather Conditions in NICRA Adopted Villages of West Garo Hills, Meghalaya

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In Meghalaya, rice is the predominant food grain, accounting for approximately 82.40% of the cultivated area and 86.42% of total food grain production. Despite its significance, rice productivity in Meghalaya (1.67 t/ha) remains below the national average (1.95 t/ha). In the West Garo Hills, rice (Oryza sativa), a staple food, is grown on 22,431.9 hectares. However, due to unscientific farming practices, erratic weather conditions, and inadequate pest and disease management, rice production and productivity are suboptimal. To address these challenges, the KVK in West Garo Hills conducted several trials on climate resilient paddy varieties, such as, CR-Dhan, Gitesh, Swarna-Sub1, Ranjit Sub-1 and Bahadur Sub-1 in three adopted villages of NICRA from 2019 to 2024. Altogether 79 demonstrations were carried out during the trial period. Results revealed that among the several climate resilient varieties the productivity was highest in Gitesh with 5.4 t/ha grain yield followed by Ranjit sub 1 with 5.1 t/ha and CR Dhan 805 with 4.8t/ha as compared to local varieties (Kochu Gism, Minil, Champali) with 1.8 to 2.2 t/ha. Notably, it was also observed that under the stress condition CR Dhan 805 matures early without compromising the yield. Profitability also followed similar trend where, net returns and B:C ratio was substantially higher in Gitesh and Ranjit Sub 1 compared to local varieties. These results indicate that these climate-resilient varieties are suitable options for the Garo Hills region, particularly under adverse weather conditions.

UID: 1709

Comparative Study of Potato and Mustard Intercropping Systems in Sugarcane Cultivation in Kushinagar District, Uttar Pradesh

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Intercropping, the practice of growing two or more crops simultaneously in the same place and time, has the potential to enhance yield on a given area of land. To assess the performance of potato and mustard intercropping systems in sugarcane cultivation, a series of additive experiments were conducted from 2021 to 2023 at Amawakhas village (*Lat 26.84^0 & Long 84.19^0*) in Kushinagar district, Uttar Pradesh, under the National Innovation in Climate

Resilient Agriculture (NICRA) Project. A total of 112 demonstrations were carried out, consisting of 56 trials in the sugarcane + potato intercropping system and 56 trials in the sugarcane + mustard intercropping system. The same set of farmers was selected each year for all trials. In each trial, sugarcane was planted in the 46th standard Meteorological Week (SMW) using a trench digger, while both potato and mustard were sown using line sowing. The results indicated that the sugarcane + potato intercropping system provided higher gross monetary returns compared to the sugarcane + mustard system. The study observed that erratic rainfall during the 2022-23 cropping season resulted in increased cultivation costs, reflected in BCR of 3.4 for the sugarcane-potato system. Conversely, above-normal rainfall in the 2021-22 seasons led to reduced cultivation costs, with a higher BCR of 3.6. These findings highlight the significant impact of rainfall variability on the economic performance of the sugarcane-potato cropping system. The average yield of sugarcane with potato was 879.5 q/ha (772.3 q/ha for sugarcane and 107.2 q/ha for potato), whereas the sugarcane with mustard system yielded 749.3 q/ha (741 q/ha for sugarcane and 8.3 q/ha for mustard). Analysis of pooled data revealed that the sugarcane + potato system resulted in a higher net return of INR 2,94,266 with a BCR of 3.5, compared to the sugarcane + mustard system, which generated a net return of INR 2,06,888 with a BCR of 3.2. The study concluded that intercropping sugarcane with potato yields higher financial returns for farmers than the sugarcane + mustard system.

UID: 1730

Critical Period of Weed Competition in Rainfed Major Millets: Review

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Millets, being climate-resilient crops, play a vital role in bolstering India's nutritional security while offering a cost-effective alternative to traditional staple foods like Rice and Wheat. Majority of millet crops are cultivated in poor and marginal lands, making them an ideal crop for resource-poor farmers and challenging environments. India being self-sustained food producing country, is now shifting its focus towards ensuring nutritional security. In this context, millets offer vast opportunities for improvement, playing a pivotal role in addressing the country's nutritional challenges. To achieve higher productivity, managing the weeds below economic damage level is crucial. In order to achieve this, determination of critical period of crop weed competition plays a pivotal role in successful weed management practices. Critical period of weed competition (CPWC) is commonly defined as a “window” in the crop growth duration in which weeds should be controlled to prevent unacceptable yield losses (Knezevic et al., 2002). The current review aims to synthesize existing knowledge on the critical period

of crop weed competition in major millets (Pearlmillet, Sorghum and fingermillet) and to identify the major weed flora in these crops.

Methodology

Comprehensive literature has been ransacked with respect to CPWC from different sources like Research gate, Google scholar, J-gate, CeRA, India journals.com and the most common methodology followed are presented here. The experimental designs typically consisted of treatments with weedy and weed free plots with different interval along with weedy check and weed free check throughout the crop growth period. Weed assessments were conducted using a 0.5-1 m^2 quadrant where weeds were counted, uprooted and sun dried to record dry weights. These data along with treatment grain yields were used to identify the CPWC, weed count, weed index and weed control efficiency.

Results and Discussion

Weed Flora in Major Millets:

Millets are highly vulnerable to weed infestation, with a diverse range of weeds, including grasses, sedges, and broad-leaved weeds (Table 1). The type, density, and competitive impact of weeds on millets are influenced by several factors, including geographical location, soil characteristics, climate, and management practices (Dubey et al., 2023.).

Table 1. Weeds associated with major millets in India

Crop	Major weeds
Pearl millet	*Cynodon dactylon, Echinochloa crusgalli, Brachiaria ramosa, Amaranthus viridis, Digera arvensis, Euphorbia hirta, Boerhaavia diffusa, Acanthospermum hispidum, Commelina benghalensis, Portulaca oleracea* and *Cyperus rotundus*
Sorghum	*Echinochloa crus-galli, Cyanodon dactylon, Sorghum halepense, Digitaria sanguinalis, Amaranthus viridis, Alternanthera pungens, Digera arvensis, Convolvulus arvensis, Eclipta alba, Trianthema portulacastrum, Euphorbia hirta, Physalis minima* and *Cyperus rotundus*
Fingermillet	*Cyperus rotundus, Cyanodon dactylon, Commelina benghalensis, Ageratum conyzoides, Dactyloctenium aegyptium, Echinochloa colona, Acanthospermum hispidum, Spilanthes acmella, Eragrostis Pilosa, Parthenium hysterophorus, Amaranthus viridis, Alternanthera sessilis, Celosia argentea, Euphorbia hirta,* and *Leucas aspera.*

Critical period of Weed Competition.

The CPWC in millets usually ranges from 15-42 days after sowing (Table 2). *Samba Laha et al.,2020* reported in Sorghum that the highest plant height and grain yield were recorded in weed free treatment between 15 to 60 DAS. Kamlesh, 2013 reported higher and more profitable grain and fodder yields with a weed free environment for the initial 30 to 45 DAS. In pearl millet, maintaining a weed-free environment up to 40 DAS resulted in higher plant height and grain yield compared to other treatments (*Thesiya et al., 2024).* The CPCWC for the finger millet varied from 25-60 days after sowing (DAS) (Yatish et al. 2020). CPWC for irrigated transplanted finger millet has been identified to be first 4-6 weeks from planting (Mishra 2015).

Under rainfed conditions, finger millet should be kept weed free during the first 5 weeks to prevent losses in yield (Sundaresh et al. 1975, Hedge et al. 1983). In finger millet intercropping system, 4-5 weeks after sowing was the most critical period of competition (Mohapatra and Haldar 1998).

Table 2. Critical period of weed competition in major millets.

Crop	Critical crop weed competition	Reference
Pearl millet	15-30	Labrada et al., 1994
Sorghum	28-42	Kumar and Sundar, 2002
Finger millet	25-42	Sundaresh et al., 1975

Conclusion

Determination of critical period of weed competition play a formidable role in managing the weed pressure to assure higher yield potential of rainfed major millets. The CPWC varies among millet species, growth stages, and environmental conditions, emphasizing the need for location-specific and crop-specific weed management recommendations. Managing the weed in this window is crucial key for effective usage of herbicide, labour and to achieve higher economic returns.

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Combating Drought and Improving the Pepper Production through Arka Microbial Consortium and Percolation Pit

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Wayanad district, due to its unique agro-climatic conditions, fertile soil, and adequate rainfall, is one of the prominent regions for pepper cultivation. However, in recent years, it has been reeling under severe drought due to adverse climatic condition which has led to crop failure, reduced flowering and fruit development, increased pest and disease incidence, and fertile soil depletion. In addition to that, the overuse of mineral fertilizers, pesticides and inadequate soil management practices, significantly affects the soil quality by altering its physical, chemical, and biological properties, and hence pose a threat to sustainable crop production (Aswati *et al*., 2016). In this context, the adoption of water conservation techniques like percolation pits and as alternative for chemical fertilizer, the use of bio-inputs like Arka Microbial Consortium has gained relevance among farmers.

Methodology

Demonstrations on enhancement of storage capacity using surface runoff rainwater through roads and construction of percolation ponds was administered in Padichira village, the area which receives the least amount of rainfall in Wayanad district. Percolation ponds was constructed with a dimension of 4 m x 2 m x 1.5 m (l x b x h) that can store 12, 000 L of water. Coconut husk lining is also provided at the bottom end to conserve water.

Arka Microbial Consortium is a carrier-based product which contains N fixing, P & Zn solubilizing and Plant Growth Promoting Microbes in a single formulation. It improves soil health, enhance water retention, and promote plant resilience under drought condition. It can be conveniently, applied either through seed, soil, water and nursery media like Coco-peat. In padichira, the roots of pepper plants are drenched with AMC @5 kg / acre by suspending in 300 litres of water.

Result

The application of arka microbial consortium and the percolation pit synergistically showed remarkable and requisite effect on yield of black pepper. AMC improved root health and enhances nutrient uptake, enabling plants to tolerate water stress more effectively. Meanwhile, Adoption of percolation ponds and constructing channels to drain surface runoff rainwater to their fields resulted in less water requirement of 2-3 irrigations compared to 4-5 in conventional. Increase in the level of water table in open wells were also witnessed. This method ensures consistent soil moisture even during dry periods.

Impact of arka microbial consortium and percolation pit on pepper in Padichira village of Wayanad district

Intervention	NICRA village		Non- NICRA Village	
	Yield (q/ha)	Net Return (Rs/ha)	Yield (q/ha)	Net Return (Rs/ha)
Combined effect of Arka microbial consortium and Percolation pit in pepper field	12.5	3,43,800	10.9	2,84,100

Conclusion

The synergestic effect of Arka Microbial Consortium (AMC) and percolation pit along with recommended dose of fertilizer has proven to be an effective strategy in combating drought stress in pepper cultivation. It is also noted that the combined effect reduced the quick wilt disease of pepper. The consortium enhances root protection and promotes beneficial microbial activity, creating an unfavourable environment for the pathogen and percolation pits combat quick wilt in pepper by addressing the root cause—water stagnation.

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Efficacy of Various Cane Node Priming Techniques for Enhancing Germination and Production Potential of Sugarcane (Saccharum sp. Hybrid)

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Sugarcane (*Saccharum officinarum* L.), a tropical, giant perennial grass, is one of the most important cash crops belonging to the family *Graminae*. It plays a crucial role in the Indian economy, contributing approximately 2.0% to the national Gross Domestic Product (GDP). India accounts for nearly 13.2% of global sugar production and about 41% of Asia's sugar output. However, sugarcane productivity in India remains relatively low due to poor germination and several biotic and abiotic stress factors such as drought, floods, temperature fluctuations, salinity, and alkalinity. Seed priming has been identified as an effective technique for improving germination, seed vigor, and crop performance. It enhances antioxidant capacity, regulates water content in seeds, and supports synchronized and accelerated germination. These benefits lead to improved seedling establishment, stimulated vegetative growth, and ultimately increased crop yield. Primed seeds exhibit faster emergence, more vigorous growth, and enhanced performance in adverse conditions. Despite significant evidence of its benefits on physiological parameters and yield, there is limited information on the effects of priming on vegetatively propagated crops like sugarcane, especially during crop development stages. This study was therefore undertaken in the low-cane germination regions of subtropical India to develop a cost-effective package aimed at achieving optimal sugarcane germination.

Materials and Methods

Field experiments were carried out during spring season to study the effect of priming cane node techniques on enhancing germination for two consecutive years (2021-22,2022-23) at the experimental farm Krishi Vigyan Kendra, Shamli, U.P. India with an objective to assess the effect of seed priming techniques on cane code for enhancing germination. The experimental soil was sandy loam in texture with 7.6 pH value, medium in nitrogen (254kg/ha), with available phosphorus (15.50 kg/ha) and medium in potassium (127 kg/ha), low in organic carbon (0.39%). Experiment was laid out in a randomized block design with six treatments and three replications with different varieties of early maturing. Data on germination, shoots, millable cane, cane yield and biological yield in cane were observed. Cane yield was recorded after crop harvest. There were six treatments and details are as under.

T1 - Un- primed cane node
T2 - Treating cane node in lime solution for 20 hrs.
T3 - Treating cane node in Ethophone (3%) for 2 hrs.
T4 - Treating cane node in Gibbrelic Acid (1%) for 2 hrs.
T5 - Treating cane node in urea solution (3%) for 2 hrs.
T6 - Treating cane node in Micronutrient (2%) for 2 hrs.

Result and Discussion

In case of variety, Different sugarcane varieties exerted significant difference on different characters of sugarcane. The maximum germination percentage (30DAP) (81.19 %), The maximum germination percentage (45DAP) (84.21 %), The maximum germination percentage (60DAP) (87.12 %), maximum shoot length (45 DAP) (27.91 cm), maximum root length (45 DAP) (8.08 cm), maximum Internodes length at the time of harvesting (18.13 cm), maximum internodes garth at the time of harvesting (8.99 cm), maximum green leaf length (240 DAP) (179.17 cm), maximum green leaf width (240DAP) (5.24 cm), maximum plant height at the time of harvesting (359.10 cm), maximum single cane weight at the time of harvesting (1.58 kg), minimum yield (597.83), maximum biological yield (1.97 kg) were recorded form V_2 (Co.0238) sugarcane variety. On the contrary, minimum germination percentage (60 DAP) (87.12 %), minimum shoot length (45 DAP) (21.36 cm), the minimum root length (45DAP) (6.19 cm), minimum Internodes length at the time of harvesting (15.40 cm), minimum internodes garth at the time of harvesting (7.40 cm), minimum green leaf length (240 DAP)

(154.15 cm), minimum green leaf width (240DAP) (4.29 cm), minimum plant height at the time of harvesting (301.02 cm, minimum single cane weight at the time of harvesting (0.79 kg), minimum yield (597.83), minimum biological yield (1.18 kg) were found from V_3 (Co.8272) variety.

In case of seed priming treatment, Different seed priming exerted significant difference on different characters of sugarcane. The maximum germination percentage (30DAP) (80.29 %), maximum germination percentage (45DAP) (83.05 %), longest shoot (45DAP) (25.18 cm), longest root (45DAP) (7.41 cm), maximum number of fertile tiller at the time harvesting (6.49), maximum number of internodes at the time harvesting (18.27), Longest Internodes at the time of harvesting (18.89 cm), maximum internodes garth at the time of harvesting (8.63 cm), maximum green leaf width (4.87 cm), maximum single plant weight (1.32 kg), maximum yield (837.13), maximum biological yield (1.70 kg) were recorded from T_1 (priming with lime solution) treatment. On the contrary, The minimum germination percentage(30DAP) (61.27 %), minimum germination percentage (45DAP) (67.53%), minimum germination percentage(60DAP) (71.57 %), shortest shoot (45DAP) (23.98 cm), shortest root (45DAP) (6.06 cm), minimum number of tillers (100DAP) (7.94), minimum number of fertile tiller (at the time of Harvesting) (4.71), minimum number of internodes (at the time of Harvesting) (16.24), shortest internode (at the time of Harvesting) (15.85 cm), minimum internodes garth (at the time of Harvesting) (7.77 cm), shortest green leaf (240DAP) (166.17 cm), minimum green leaf width (240DAP) (4.65 cm), minimum plant height (at the time of Harvesting) (319.69 cm), minimum single plant weight (at the time of Harvesting) (1.15 kg), minimum yield (519.82), minimum biological yield (1.43 %) were found from T_0 (control) treatment.

In case of interaction effective of variety and seed priming treatment, at The maximum germination percentage (30DAP) (86.99 %), maximum germination percentage (45DAP) (88.71 %), maximum shoot length (6.60 cm), maximum root length (7.27 cm), maximum Internodes length (19.67 cm), maximum internodes garth (9.37 cm), maximum single plant weight (1.68 kg), maximum yield (1103.56) were recorded from the interaction of V_2T_1 (Co.0238 variety with priming with lime solution) treatment combination. On the contrary, minimum germination percentage (30DAP) (53.45 %) was found from the interaction of V_1T_0 (Co.0118 variety with no priming), minimum germination percentage (45DAP) (63.80 %), minimum germination percentage (60DAP) (71.44), minimum number of tillers (6.63), minimum number of fertile tiller (3.33), minimum number of internodes (14.46), minimum yield (409.78) were found from the interaction of V_1T_0 (Co.0118 variety with no priming) treatment combination.

Conclusion

Considering the findings of the experiment, it can be concluded that – Co.0238 variety was superior for germination percentage, shoot length, root length, Internodes length, internodes garth, green leaf length, green leaf width, plant height, single cane weight, yield, biological yield of sugarcane. Priming with lime solution was superior for germination percentage, longest shoot, longest root, number of fertile tiller, number of internodes, Internodes length, internodes garth, green leaf width, single plant weight, yield, biological yield of sugarcane.The combination of Co.0238 variety with priming with 3% lime solution treatment may be the best to get highest germination percentage, shoot length, root length, Internodes length, internodes garth, single plant weight and also for good yield of sugarcane.

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UID: 1762

Introgression of Major Qtls and Genes for Abiotic and Biotic Stress Tolerance in CO 51 Rice through Marker-Assisted Gene Pyramiding

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Rice cultivation is particularly vulnerable to these environmental changes, facing several biotic and abiotic stresses that can reduce yields. Among the most damaging biotic stresses are drought tolerance, salinity, blast, and BB resistance, both of which cause substantial losses in rice crops. To address these challenges, advancements in genetics and biotechnology offer promising solutions to improve rice production and productivity. Modern breeding techniques, including marker-assisted selection and gene pyramiding, are being employed to develop new, high-yielding rice cultivars. By releasing such improved varieties, it is possible to help meet the food demand of a growing global population.

A key strategy to protect rice crops from abiotic and biotic stress is enhancing host plant resistance. The most effective approach for mitigating losses is through the pyramiding or stacking of multiple resistance genes or alleles into elite rice varieties. This method provides robust, broad-spectrum resistance/tolerance to various stresses, ensuring better protection for rice crops. By integrating these advanced genetic tools, rice breeders can develop cultivars that increase yields and withstand the challenges posed by biotic stresses, helping to secure food production in the face of climate change.

Methodology

CO 51, a widely cultivated rice variety in 14 Indian states and all three seasons in Tamil Nadu, has moderate blast resistance but is highly susceptible to drought, salinity and BB. This study aims to pyramid *qDTY1.1*, *qDTY2.1, qDTY12.1* from Apo and Way Rarem, *saltol* from FL478, *Pi9, Pi54 and xa13 from 562-4 3* genes into CO 51 to enhance resistance against stresses. Foreground selection was performed using linked markers as foreground markers and Background markers used for background selection.

Phenotypic Screening

Drought screening at the reproductive stage (RSDS) was conducted under a Rain-Out Shelter (ROS) following standard agronomic practices for both stress (S) and non-stress (NS) conditions. Irrigation was halted 10 days before booting in stress plots, while NS plots were irrigated until maturity. Gas exchange parameters, RWC, chlorophyll content, and drought tolerance indices were recorded. BILs, along with recurrent and donor parents, were sown in a Uniform Bed Nursery (UBN) at the Hybrid Evaluation Centre, Cudalur. Blast scoring followed the IRRI SES system (2002), and BLB screening involved inoculating 21-day-old seedlings with Xanthomonas oryzae pv. oryzae at tillering.

Results

Screening for Drought and Salinity

A study on 16 advanced breeding lines (BILs) of IMF5, derived from CO 51 MSP and incorporating six QTLs/genes (qDTY1.1, qDTY2.1, qDTY12.1, Saltol, xa13, and Pi54), evaluated drought tolerance. Recurrent parent CO 51 scored 8.60 for leaf drying and 6.10 for leaf rolling, while donor parents Apo and Way Rarem performed better with scores of 1.40–1.60 and 0.40–0.60, respectively. The BILs exhibited improved scores of 3.4–6.2 (average 4.6) for leaf drying and 1.8–4.4 (average 3.1) for leaf rolling. Spikelet fertility of CO 51 dropped to

72.40% under stress, but BILs maintained 85.32–92.13% (average 86.99%), showing enhanced resilience.

The recurrent parent, CO 51, showed a relative drought yield (RDY) of 36.12% and drought tolerance efficiency (DTE) of 63.88%, while pyramided lines demonstrated RDY values of 1.62–46.04% (average 14.76%) and DTE ranging from 53.96–98.38% (average 85.24%). The drought susceptibility index (DSI) of pyramided lines (0.02–0.46, average 0.15) was lower than CO 51 (0.36). BILs exhibited superior drought tolerance with lower TOL, SSI, YSI, and RT and higher STI and DYI values. Yields ranged from 31.19–46.53 g (normal) and 20.17–37.58 g (stress), with stable grain traits and enhanced physiological parameters like chlorophyll content, photosynthetic rate, and RWC.

For salinity screening at germination at petridish, CO 51 exhibited germination rates of 95.00%, 89.00%, and 87.00% at 80 mM, 100 mM, and 125 mM NaCl concentrations, respectively, while the donor parent FL478 achieved 100% germination across all concentrations. In pyramided lines of CO 51, germination ranged from 96.00–100% at 80 mM, 94.00–100% at 100 mM, and 89.00–100% at 125 mM. CO 51 recorded shoot lengths of 7.80 cm (0 mM), 3.70 cm (80 mM), 3.70 cm (100 mM), and 2.60 cm (125 mM), and root lengths of 3.50 cm, 2.00 cm, 1.40 cm, and 0.70 cm, respectively. Pyramided lines showed improved shoot and root lengths under stress conditions.

BLB and Blast Resistance Screening

The xa13 gene for bacterial leaf blight (BLB) resistance was validated in the 16 pyramided lines. CO 51 recorded a BLB lesion score of 9.05 cm, while donor parent 562-4 showed strong resistance (0.34 cm). The BILs exhibited resistance with lesion scores ranging from 0.66 to 1.39 cm (average 0.89 cm), underscoring the success of pyramiding xa13 for enhanced disease resistance.

The Pi9 and Pi54 gene for blast resistance was validated in the 16 pyramided lines. CO 51 recorded a score of 6, while donor parent 562-4 showed strong resistance (0.3). The BILs exhibited resistance with lesion scores ranging from 0 to 5, underscoring the success of pyramiding Pi9 and Pi54 for enhanced disease resistance.

Conclusion

The present study focused on pyramiding or stacking genes that confer resistance to drought, salinity, blast, and bacterial blight stress in the CO 51 rice variety, aiming to enhance the existing cultivar. This improvement was effectively achieved using MABB with markers closely linked to the target genes. The study enabled the early identification of progenies carrying the desired QTLs/genes during the breeding process. Phenotypic screening against the drought, salinity, blast, and bacterial blight validated the successful introgression of the targeted QTLs/genes into the genetic background of CO 51.

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UID: 1769

Maize-Groundnut Intercropping System under Rainfed Conditions: Evaluating Performance in Upland Hills with Mild Slopes

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A field experiment was designed to assess the feasibility of intercropping maize and groundnut in comparison with solo maize and groundnut, and conducted in farmer fields during the kharif seasons of 2022-23 & 2023-24 in Lungshang (NICRA Adopted) village, Ukhrul district of Manipur. In the experiment, an intercropping system i.e. One row of maize with two consecutive rows of groundnut was considered a better alternative against farmer practice (Mono-cropping of Maize/Groundnut). For the comparison, 20 farmer fields were selected as intervention plots (Intercropping system of maize and groundnut) and 20 farmer fields as control (Monocropping of Maize/groundnut). The planned intercropping system (Maize and Groundnut) was found promising in yield comparison as compared to the common farmer practice. Maize Equivalent Yield (9.49±0.34 t/ha) and Groundnut Equivalent Yield (3.03±0.11 t/ha) were found higher as compared to sole maize (5.58±0.20 t/ha) and sole groundnut (1.84±0.09 t/ha), form the pool data of 2022-23 and 2023-24 respectively, which was furthered re-validated by paired t-test with 1% LoS. In consideration of Land Equivalent Ratio (LER), the overall performance of the intercropping system for Maize ranged from 1.55 (55%) to 1.82 (82%) and LER for Groundnut ranged from 1.51 (51%) to 1.84 (84%) over the sole crops, which indicates the better performance of the intercropping system.

UID: 1771

Evaluation of Sowing Techniques for Soybean Cultivation in Dryland Condition of Madhya Pradesh, India

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Soybean is known as “Golden bean”, “Miracle crop” etc., because of its several uses. Madhya Pradesh is known as ‘Soy state’. Currently Madhya Pradesh accounts for nearly 87% of the area under the crop in the country and contributes about 83% of the total national production. In dryland region, many times, soybean crop suffer due to poor drainage and moisture stress as well. *In-situ* soil moisture is limiting factor for crop production in dry land areas. The *in-situ* moisture conservation practice (Land configuration) make sure the crop production through safe disposal of excess water or its retention as and when required. This study was conducted during 2023-24 at research field of AICRPDA, Indore. Three sowing techniques were adopted for soybean (RVS-24) sowing *i.e.* Farmer’s practice (T1), Broad Bed Furrow (T2) and Raised Bed System (T3). Randomized block design applied for statistical analysis with eight replications. Results reported that raised bed system resulted highest seed yield (1908 kg ha^{-1}), net return (₹59228/-) and B:C (3.04) which was followed by BBF. Under BBF seed yield (1745 kg ha^{-1}), net return (₹51270/-) and B:C (2.77) was recorded. Lowest seed yield (1532 kg ha^{-1}), net return (₹42472/-) and B:C (2.52) recorded in farmer’s practice. Despite erratic climate, yield under advance systems were better than farmer’ practice. The lowest Rain Water Use Efficiency (RWUE) was recorded under farmer’s practice (1.35 kg /ha-mm) and highest was in raised bed system (1.1.69 kg /ha-mm). Higher productivity of soybean can be achieved by adopting advance sowing techniques as compared to other flat methods.

Methodology

The field experiment was conducted during *kharif* season at research field of dryland project, Indore. Three treatments were adopted for the trial *i.e.* T1- Flat sowing, T2- Broad Bed Furrow (BBF) and T3- Raised Bed System. Randomized Block Design (RBD) statistical design with eight replications were applied for analysis. RVS 24 verity of soybean were sown for the experiment during 2023-24

Results

Data presented in given Table 1 showed that maximum soybean seed yield (1918 kgha^{-1}) was obtained under raised bed system (T3). Under farmer’s practice (T1) seed production of soybean was 1532 kgha^{-1}, which was lowest among all treatments. Under BBF (T2), seed yield (1745 kgha^{-1}) was recorded. Sowing of soybean on raised bed (T3) resulted more seed yield by 25.19% over flat sowing (T1). Soybean seed yield under Broad Bed Furrow (T2) was also higher (13.90 %) than flat sowing (T1). Soybean crop production was low due to excess and continuous rainfall during crop growth period. Data presented in Table also showed that soybean (RVS 24) recorded highest net return of ₹59228 and B:C ratio (3.04) with treatment T3. The lowest monetary return was recorded with T1. The lowest Rain Water Use Efficiency (RWUE) was recorded under farmer's practice (1.35 kg/ha-mm) and highest was in raised bed system (1.69 kg/ha-mm).

Table 1: Yield and economics of soybean cultivation influenced under different sowing techniques

Treatments	Seed Yield (kg ha^{-1})	Net Return (₹ ha^{-1})	B: C Ratio	RWUE (kg /ha-mm)
T_1- Sweep Blade type Seed Drill	1532	42472	2.52	1.35
T_2- Sowing by Broad bed planter (BBF)	1745	51270	2.77	1.54
T_3- Raised bed Furrow System (FIRBS)	1918	59228	3.04	1.69
S Em (±)	52	1474	0.04	
CD at 5%	159	4323	0.12	

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UID: 21401

Performance of Thermo-Insensitive Wheat Variety under Heat Stress Condition in NICRA Villages in Jhansi District of Bundelkhand Region

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Wheat (*Triticum aestivum* L.) is the second most important cereal crop of India after rice and plays a vital role in food and nutritional security of the country. India is the second largest wheat producer in the world, after China. Nearly 55 per cent of the world population depends on wheat for about 20 per cent of calories intake (DWR, Karnal, 2014). It is grown in an area of 34.15 million hectares area with production 112.92 million tonnes and productivity of 49.6 q/ha in India (DES, 2023-24). Wheat production is presently facing challenges such as climate change, soil degradation, water scarcity, pests and diseases etc. Heat stress during february-march month in bundelkhand region resulted in drastic yield reduction, shriveled and low grain weight in wheat. Adoption of heat tolerant varieties along with appropriate crop management practices such as recommended fertilizer application, irrigation at critical crop growth stages, weed, insect-pest and diseases management practices in adopted NICRA villages significantly contributed in harnessing the yield potential of heat tolerant varieties and minimize the yield loss among wheat growing farmers of Jhansi district.

The present study was carried out by Krishi Vigyan Kendra, Jhansi to evaluate the performance of suitable thermo-insensitive variety of wheat under frontline demonstrations (FLD) in NICRA villages under heat stress condition.

Methodology

Frontline demonstrations (FLD) were conducted during *Rabi* 2022-23 and 2023-24 for consecutive 2 years on thermo-insensitive variety "Raj-4079" in 45.0 ha area for 112 beneficiaries/ farmers comprising 1-acre area for each beneficiary/farmer of Jhansi district by KVK, Jhansi (Banda University of Agriculture and Technology, Banda). The demonstrations were conducted in 3 NICRA (National Innovation on Climate Resilient Agriculture Project) villages viz. Gandhinagar, Birgua and Bawaltada in Badagaon block of Jhansi district. Among inputs, 40.0 kg seed of thermo-insensitive Wheat variety Raj-4079, 160 gm Vesta (clodonafop + metsulfuron) herbicide, 60 gm tebuconazole fungicide for seed treatment per acre per farmer were distributed in 10 clusters for 112 beneficiaries. Line sowing of Raj 4079 variety with duration 110-120 days having a yield potential of 55-60 q/ha was done through seed drill during second fortnight of November and harvesting was completed in second fortnight of March in 2022-23 and 2023-24.

Total rainfall received during the entire crop growth period was 7.0 mm & 9.0 mm during 2022-23 and 2023-24, respectively. Recommended package and practices were adopted by each beneficiary as and when needed. Based on the soil health card report, pH was neutral to slightly saline, nitrogen content was low, phosphorus was medium, potassium was high and sulphur was observed in low to medium range in different clusters. The grain yield was recorded by randomly harvesting plants from 1 m × 1 m quadrant, followed by sun-drying and threshing. The grain yield was recorded in kg and converted into q/ha. The gross return was calculated by multiplying grain yield with selling price of wheat (Rs. 1900) while net return was estimated by subtracting gross cost from gross return. The B:C ratio was calculated by dividing gross return from gross cost

Results

The recorded data shows that the demonstrated thermo-insensitive variety "Raj-4079" provided yield advantage of 42.62 & 33.46 % respectively compared to check variety (Lok 1) during rabi 2022-23 and 2023-24. Demo plots recorded higher grain yield to the tune of 43.5 q/ha & 42.5 q/h, respectively rabi 2022-23 and 2023-24.

Conclusion

Higher grain yield, net return and B:C ratio in demonstrated variety were attributed to better growth parameters and yield attributes under heat stress condition, adoption of recommended package of practices and scientific cultivation techniques as suggested by KVK Jhansi

Demonstrated thermo-insensitive variety "Raj-4079" under FLD's resulted in positive impact in improving socio-economic status of farmers. Instead of selling produce to the mandi/market, beneficiaries/farmers were persuaded for its horizontal expansion among other/neighboring farmers of Jhansi district

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Response of Method of Planting and Integrated Nutrient Management on Rice

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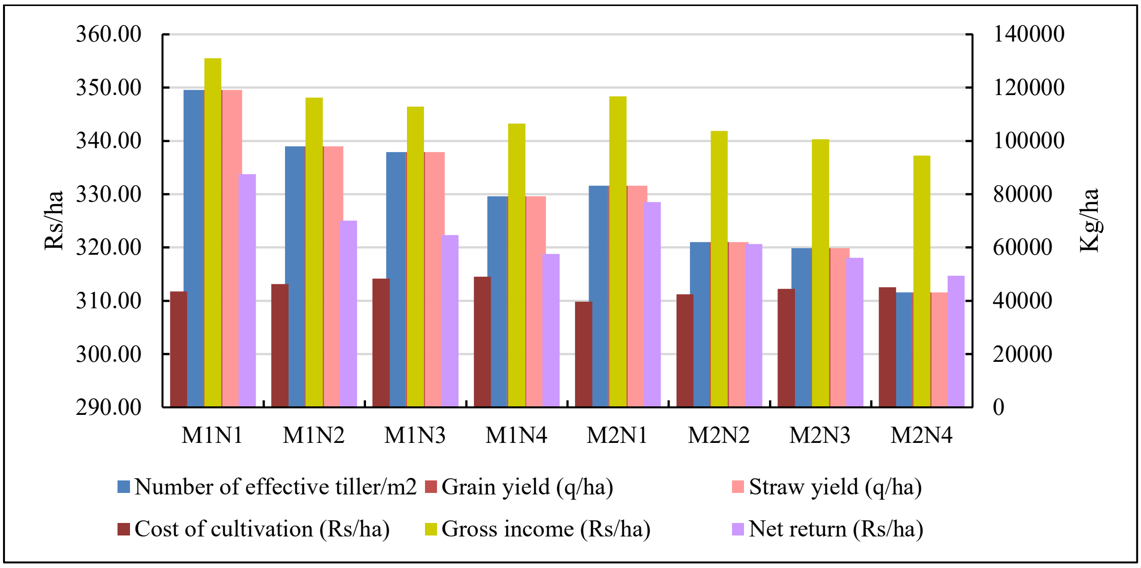
Rice (Oryza sativa L.) is one of the most significant cereal crops, with more than 70 % of world's population (Yadav and Singh, 2006). Direct seeding offers certain advantages like labour saving, timely sowing, less drudgery, early crop maturity by 7-10 days, low water requirements, high tolerance to water deficit, timely sowing, low production cost, less methane emission, etc. It also preserves natural resources especially underground water and maintains physical properties of soil. Dry seeding is practiced on rainfed lowland, upland and flood prone areas. Drum seeding is another option to transplantation, as it requires less labour and performs as well as transplanting in many situations (Yadav and Singh, 2006). Integrated nutrient management approach is flexible and minimizes use of chemicals but maximize use careful and efficient use of all key sources of plant nutrients and improve the soil health. To meet ever demand of increasing population INM is the best option. INM has been found to boost rice yields significantly by reducing fertilizer losses to environment and regulating nutrient delivery, resulting in high nutrient use efficiency (Parkinson et al., 2013). Integrated application of organic and inorganic exhibited higher grain and straw yields of rice with high nutrient uptake over application of inorganic only. Integrating nutrient management (INM) aims for careful and efficient use of all key sources of plant nutrient in a holistic way (Farouque and Takeya, 2007).

Methodology

The present investigation was carried out during kharif season of 2020 at Agronomy Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.). Geographically, experimental site (Kumarganj) is located at 26°47 North latitude and 82°12' East longitude and altitude of about 113 meters above from mean sea level in Indo Gangetic regions of Uttar Pradesh. In this study, there is 2 factors in which factor A include (Transplanting, Drum seeder), factor B (100% RDF (120N:60P_2O_5 :60K_2O Kg/ha.) through IF, 75 % RDF through IF + 25% RDN through FYM, 75% RDF through IF + 25% RDN through compost, 50% RDF through inorganic + 50% RDN through FYM).

Results

The yield and economics of transplanted rice with 100% RDF (120N:60P_2O_5:60K_2O Kg/ha) was found superior among all the treatments followed by transplanted rice along with 75 % RDF through IF + 25% RDN through FYM. The similar trends were found in case of gross return, net return and benefit-cost ratio.



Yield and economics of various treatments

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Sustainable Soil Management for Resilient Rainfed Agro-ecosystem

UID: 1011

Effects of Rainfed and Irrigated Conditions on the Organic Carbon Store in South Gujarat's Medium-Black Cotton Soils

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Gujarat state's most significant cash crop is cotton (*Gossypium* spp.), sometimes known as the "white gold" or "queen of fibers." A useful predictor of soil production potential is the amount of carbon in the soil, particularly soil organic carbon (SOC). The physical, chemical, and biological aspects of the soil are impacted, and it is essential for maintaining agricultural productivity, environmental quality, and soil quality (Zhang et al. 2003). The replenishment, enhancement, and improvement of the soil organic carbon (SOC) pool is vital, as it is an exceedingly valuable natural resource. With tropical soils, maintaining soil productivity and guaranteeing food security thus depend on effective SOM management. Therefore, one of the primary goals of the current study is to determine the SOC stock from profile soils in Gujarat from rainfed and irrigated cotton (hybrid/Bt/desi).

Methodology

The entire cotton-growing region in the South Gujarat zones experiences semi-arid, subtropical weather. According to taxonomy, the district's principal soils are classified as *Vertisols* and *Vertic integrades* of the *Inceptisols* order. Excavations were made in all profiles up to a soil depth of 120 cm. Each soil profile layer's total SOC stock (t/ha) was calculated by multiplying the layer's OC content (g kg^{-1}) by its bulk density (Mg m^{-3}), thickness (m), and ten (Batjes, 1996). Nonetheless, the following soil strata were found in the study profiles: 0–15, 15–30, 30–60, 60–90 and 90–120 cm soil depth.

Results

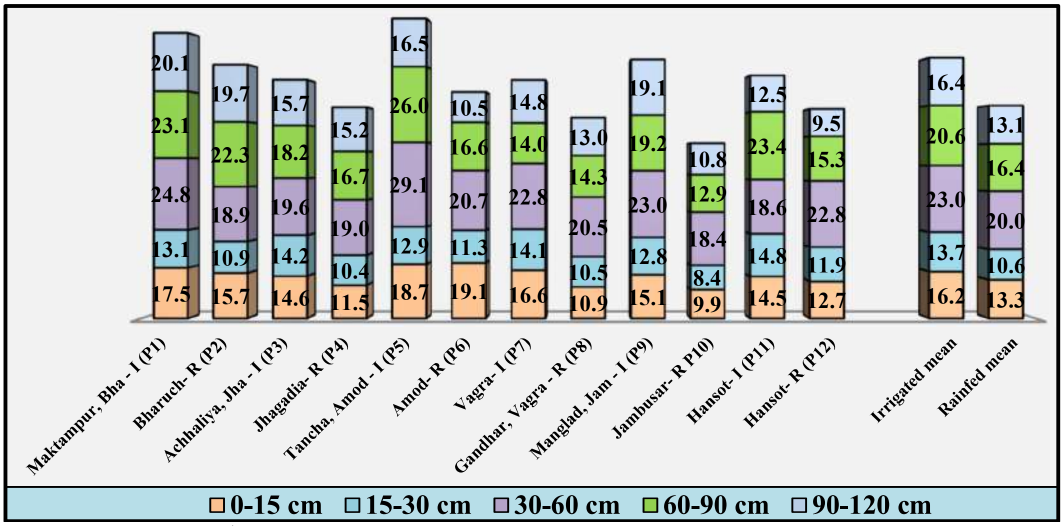
SOC stock gradually decreased down the profiles in both irrigated and rainfed situations. However, extent of decrease was not uniform and was found to vary from profile to profile for any particular depth in both the situations. SOC stock in irrigated profiles of cotton growing areas of South Gujarat *i.e.* Maktampur- Bharuch (P1), Bharuch (P2), Achhaliya-Jhagadia (P3), Jhagadia (P4), Tancha-Amod (P5), Amod (P6), Vagra (P7), Gandhar-Vagra (P8), Manglad-Jambusar (P9), Jambusar (P10), Hansot (P11) and Hansot (P12) at varying depths are graphically presented in Fig 1. Mean SOC stock (t ha^{-1})in any particular depth at 0-15, 15-30, 30-60, 60-90 and 90-120 were 16.2, 13.7, 23.0, 20.6 and 16.4 in irrigated crops and 13.3, 10.6, 20.0, 16.4 and 13.0 in rainfed crop. In that context, when SOC stock up to 30 cm (Table) in irrigated soil depth was considered the profiles along with SOC stock (t ha^{-1})

can be arranged as: P5 (31.6) > P7 (30.7) > P1 (30.6) > P11 (29.3) > P3 (28.8) > P9 (27.9). The fact otherwise indicated that the crop productivity index of the above profile soils (up to 30 cm) including surrounding areas would be of the same order as above.

The results revealed that SOC stock in P2 at 0-15, 15-30, 30-60, 60-90 and 90-120 cm soil depths varied from 13.1 to 24.8 t ha^{-1},while the same in P4, P6, P8, P10 and P12 ranged respectively from 10.9 to 22.3, 10.4 to 19.0, 11.3 to 20.7, 10.5 to 20.5 and 8.5 to 18.4 t ha^{-1}.Like irrigated profiles, rainfed profiles (Table), based on the SOC stock (t ha^{-1}) up to 30 cm depth, can be arranged as: P6 (30.4)> P2 (26.6) > P12 (24.7) > P4 (21.9) > P8 (21.4) > P10 (18.4) which indicated that the crop productivity index of the profiles and surrounding areas would be of the same order as above. Thus, it further signified that the highest emphasis must be given to improve the carbon stock of P10 (Jambusar) and its surrounding areas for possible improvement of soil health and cotton yield. Balanced fertilization in combination with FYM could be an option for improving SOC stock or sequestering SOC under rainfed situation as suggested by Patil *et al.* (2014). However, addition of manure on long term basis would be needed for enhancing SOC stocks and stabilization of organic C in the soil profile as opined by Zhao *et al.* (2008).

Depth wise distribution of SOC stock (t ha^{-1}) in irrigated (I) and rainfed (R) cotton growing soils of Bharuch district

Cotton growing talukas	Depth (cm) wise distribution of SOC (t ha^{-1}) stock		
	0-30	0-60	0-120
Maktampur- Bharuch - Irrigated (P1)	30.6	55.3	98.5
Bharuch- Rainfed (P2)	26.6	45.5	87.6
Achhaliya (Jhagadia) - Irrigated (P3)	28.8	48.4	82.3
Jhagadia- Rainfed (P4)	21.9	40.9	72.8
Tancha (Amod) - Irrigated (P5)	31.6	60.8	103.4
Amod- Rainfed (P6)	30.4	51.1	78.1
Vagra- I (P7)	30.7	53.5	82.2
Gandhar (Vagra) - R (P8)	21.4	41.9	69.2
Manglad (Jambusar) - I (P9)	27.9	51.0	89.3
Jambusar- R P10)	18.4	36.7	60.5
Hansot- I (P11)	29.3	47.9	83.8
Hansot- R (P12)	24.7	47.5	72.3
Irrigated	29.8	52.8	89.9
Rainfed	23.9	43.9	73.4



SOC stock (t ha^{-1}) in different depths of irrigated (I) and rainfed (R) soil profiles collected from Bharuch cotton growing belt

Conclusion

When mean SOC stock of all irrigated profiles was compared with that of respective rainfed profiles, it was noticed that rainfed soils were quite inferior to irrigated counter parts showing poor productivity potential as opined by Zhang *et al.* (2003). This was possibly due to higher addition of organic matter/ manures/ compost *etc.* in irrigated soils by the farmers, apart from higher biomass production, including roots of crop under irrigation and balanced fertilization resulting in higher litter- fall and subsequent deposition under irrigated condition (because of hybrid / *Bt* cotton variety) which ultimately improved the SOC stock of soils under arable irrigated systems.

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UID: 1015

Eco-physiological Control of Pearl Millet Crop Towards Soil Moisture Stress: An Eddy Covariance Based Analysis

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Pearl millet (*Pennisetum glaucum*), known as *Bajra/Cumbu* in India, is a crucial crop in drought-prone regions of the subcontinent. Being a C4 crop, its water requirement is low and it is adaptable to low-fertility / harsh weather. Thus, pearl millet is considered to be an ideal rainfed food grain crop during *Kharif* season in western India, particularly in the state of Rajasthan. This study investigates the eco-physiological capabilities of Pearl Millet to withstand soil dryness using an eddy covariance flux tower at ICAR-CAZRI, Jodhpur, during 2023 *Kharif* season.

Methodology

Eddy covariance flux tower, equipped with CO_2/H_2O analyzer, 3-D sonic anemometer and other bio-meteorological sensors, was established over the pearl millet field at ICAR-CAZRI research farm. Raw flux tower data were processed using EddyPro software, with necessary corrections and compensation adjusting the dynamic crop height during the growing season. Post-processing included quality checks of ecosystem fluxes and meteorological parameters, excluding poor-quality data and gap-filling thereafter as needed. A seamless time series was prepared and the Net Ecosystem CO_2 Exchange (NEE) was partitioned into Gross Primary Production (GPP) and Ecosystem Respiration (Reco) using Reddyproc. The Bigleaf, R package, was utilized to derive surface (Gs) and canopy conductance (Gc), as well as the decoupling coefficient (Ω).

Results

The energy balance closure for Pearl Millet was determined to be 84%, indicating high-quality flux data. In August, the crop exhibited a Leaf Area Index (LAI) of 2.0 to 2.2. Soil moisture content was favorable (Soil Moisture Index; SMI 0.8 to 1.0) during the first week of August but decreased significantly (SMI 0.2 to 0.3) in the last week due to poor rainfall distribution. Canopy conductance showed variations corresponding to SMI, with Gc values of approximately 0.003 to 0.004 ms^{-1} during favorable conditions and approximately 0.0015 ms^{-1} during stress. Surface conductance (Gs) followed a similar pattern to that of Gc, with values of approximately 0.005 ms^{-1} under favorable conditions and approximately 0.0025 ms^{-1} during stress. The decoupling coefficient ranged from 0.3 to 0.4, indicating strong canopy control of pearl millet over mass and momentum exchange. The daily crop coefficient (Kc) was derived using actual and potential evapotranspiration, revealing a peak Kc value of 0.6 during the reproductive stage, reflecting limited moisture availability. The seasonal Ecosystem Water Use Efficiency (EWUE), calculated as GPP/ET, was found to be 2.7 gC kg^{-1} H_2O, which is comparatively high for a rainfed crop.

Conclusion

Pearl millet demonstrates robust stomatal control, enabling it to adapt to arid and semi-arid environments with limited moisture without significantly compromising carbon influx. These eco-physiological traits position pearl millet as a viable candidate for sustainable cropping systems under climate change scenarios.

UID: 1033

Standardizing Drilling Patterns and Nutrient Levels for Higher Yield of Browntop Millet in Rainfed Areas of Northern Karnataka

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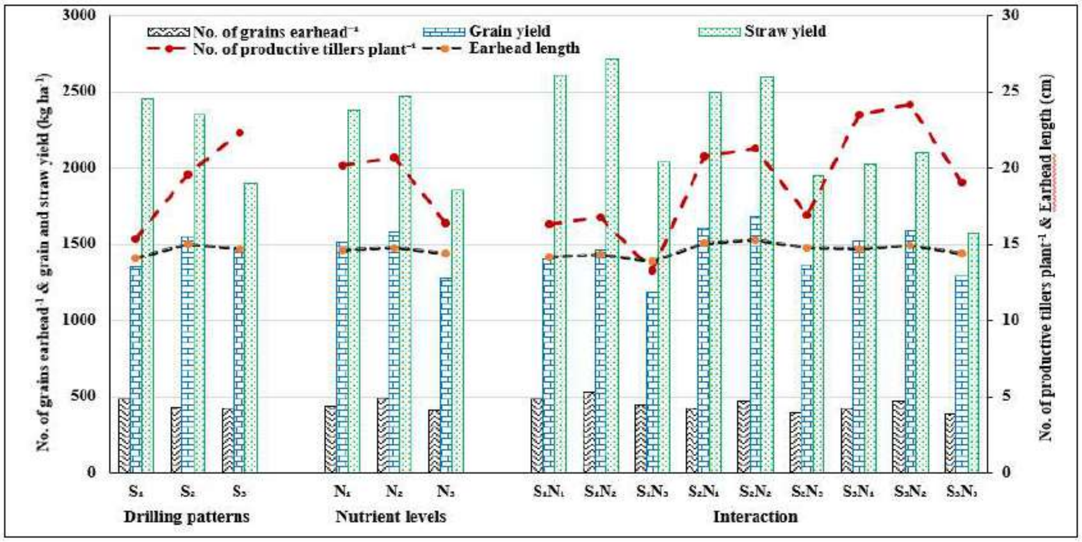
Browntop millet (*Brachiaria ramose* L.) is a rare, annual, warm-season grass from the Poaceae family, mainly used in forage systems. Native to Southeast Asia, it is grown in regions like Western Asia, Africa, and Australia. In India, it thrives in dryland areas, particularly along the Karnataka-Andhra Pradesh border. Browntop millet with its peculiar physio-biological characters serves as a climate-resilient crop and grows well in various soils (Sukanya *et al.*, 2022). Its rapid growth makes it ideal as a catch crop to control soil erosion. Nutritionally, it surpasses other millets, offering high fiber, protein, calcium, and iron, making it beneficial for diabetes and malnutrition (Vishwanatha *et al.*, 2024). Hence, the browntop millet's appeal extends to both farmers and consumers, making it a promising crop for addressing climate change, malnutrition, and lifestyle diseases, while also offering potential for agricultural entrepreneurship. Though, farmers are cultivating the crop since ages the yield levels are very low as against its production potentiality. Lack of standardized package of practice is the major constraint in widening the gap between production potential yield and actual yield at farmer's field (Pavan Kumar *et al.*, 2022). To address this gap, the present study was conducted to study the effect of varied drilling patterns and nutrient levels on yield levels of browntop millet to provide farmers with standard drilling patterns and nutrient levels for higher yield.

Methodology

The field experiment was conducted during *Kharif* season for three consecutive years from 2021 to 2023 at ICAR-Krishi Vignan Kendra Hanuamanamatti, Haveri, Karnataka. This zone falls under Northern Transitional Zone (Agroclimatic Zone VIII) of Karnataka. The soils are slightly acidic possessing red sandy loam texture. The experiment was laid out in Split Plot Design and replicated thrice. The main plot consisted of three varied drilling patterns (S_1: 30 cm X 10 cm, S_2: 45 cm X 10 cm and S_3: 60 cm x 10 cm) and the sub-plots consisted of three levels of nutrients (N_1: 30:15:15 kg NPK ha^{-1}, N_2: 45:22.5:22.5 kg NPK ha^{-1} and N_3: 22.5:10:10 kg NPK ha^{-1}). The seeds were sown in the beds of 3.6 m x 3.0 m dimension surrounded by rised bunds during first fortnight of July every year. The FYM @ 6 t ha^{-1} was commonly applied to all the treatments two weeks prior to sowing and 100% P&K and 50% N were applied as basal dose followed by two top dressing of N at 30 and 60 DAS. At harvest, the yield parameters and yield of browntop millet was recorded from the net plots of the three replications and expressed as means of each treatment. Further, the data of three consecutive seasons was pooled and presented (Fig).

Results

The results pertaining to effect of varied drilling patterns and nutrient levels on yield attributes and yield of browntop millet is depicted in Fig. Among the varied drilling patterns, drilling browntop millet seeds at a spacing of 45 cm x 15 cm resulted in significantly higher earhead length (15.0 cm) and grain yield (1555 kg ha^{-1}), while, number of grains per panicle (487) and straw yield were significantly higher under 30 cm x 15 cm spaced treatment. However, number of productive tillers per plant were significantly profuse under wider spaced treatment i.e., 60 cm x 15 cm (22.3). The varied levels of nutrients supply had significant influence on yield attributes and yield of browntop millet. The application of 45:22.5:22.5 kg NPK ha^{-1} resulted in significantly higher number of productive tillers per plant (20.7), earhead length (14.8), number of grains per earhead (491), grain yield (1580 kg ha^{-1}) and straw yield (2470 kg ha^{-1}). The crop performance with respect to yield attributes and yield showed a gradual decrease with reduced levels of nutrient levels application. The lowest values of yield attributes and yield were recorded under least supply of nutrients i.e., (22.5:10:10 kg NPK ha^{-1}). The varied levels of nutrient and drilling patterns showed significant interaction effects on yield attributes and yield of browntop millet. The treatment combination of wider spacing and highest nutrient level supply (60 cm x 15 cm spacing supplied with 45:22.5:22.5 kg NPK ha^{-1}) resulted in significantly higher grain yield (1591 kg ha^{-1}) over rest of the treatment combinations.



(Legend: Drilling patterns; S_1: 30 cm X 10 cm, S_2: 45 cm X 10 cm and S_3: 60 cm x 10 cm
Nutrient levels; N_1: 30:15:15 kg NPK ha^{-1}, N_2: 45:22.5:22.5 kg NPK ha^{-1} and N_3: 22.5:10:10 kg NPK ha^{-1})

Effect of varied drilling patterns and nutrient levels on yield attributes and yield of browntop millet (pooled of 3 years)

Conclusion

The spacing of 45 cm x 15 cm and application of 45:22.5:22.5 kg npk ha^{-1} were found to be the optimum crop management practices in order to achieve higher grain yield levels. Hence, these can be recommended for rainfed areas of northern transitional zone of karnataka as standard agro-techniques for browntop millet cultivation.

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UID: 1045

Long Term Effect of Nutrient on Carbon Sequestration, Biodiversity and Sustainability in Vertisols of India

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Based on the model of 'Rothamsted Classical Experiments' started by JB Lawes and JH Gilbert, Indian Council of Agricultural Research (ICAR) launched AICRP on Long Term Fertilizer Experiments (LTFEs) in September, 1970 and have been continuing since more than five decades. In this study, treatments were evaluated with prime focus on soil health and soil quality under LTFEs across the country. Soil health is very vital because there is a fatigue in terms of crop productivity, soil quality and sustainability. It is well documented that organics improves physical, chemical and biological state of soil, but enhancement in crop yield due to organics is at slow pace. Therefore, in order to maintain soil quality and production level in agriculture, integrated nutrient management (100% NPK+FYM) could be one of the options to sustain productivity and soil health and also soil carbon build-up. Thus, application of 100% NPK+FYM significantly improved the crop productivity and soil quality as a result led to higher sustainability indices i.e. Sustainable yield index and soil quality index across all the LTFEs.

Methodology

The AICRP on LTFE started in 1970 at several locations covering predominant cropping systems and major soil groups in our country. The experiment comprised of ten to twelve treatments with four replications in randomized block design (RBD). The treatments selected for the present investigation includes control, 100% N, 100% NP, 100% NPK and 100% NPK+FYM. The basic experimental information of studied sites is as follows (Table 1).

Table 1. Basic information of experimental sites

Location	Soil Type	Taxonomic Class	Cropping system	Year of start	Latitude	Longitude	Altitude (m)
Akola	Vertisols	Typic Haplustert	Sorghum-Wheat	1996	20°42'N	77°02'E	307
Jabalpur		Typic Chromustert	Soybean-Wheat	1972	23 °10'N	79°59'E	411
Parbhani		Typic Haplusterts	Soybean - Safflower	2006	26°40’N	78°15’E	347
Raipur		Typic Haplustert	Rice-Wheat	1996	21°17'N	81°45'E	695

Results

Crop Productivity

The grain yield was significantly higher with optimal fertilizer dose (100% NPK) than with the application of 100% N alone and 100% NP indicating imbalanced nutrient application resulted in lower productivity (Fig 1). Similarly, it was also noted that when P fertilizer was included (100% NP) then higher yield was obtained; while there was a further improvement noted when K was included (100% NPK) in fertilizer schedule compared to 100% N alone. The grain yield increased significantly with application of 100% NPK + FYM. The magnitude of response was observed in the order: control < 100% N < 100% NP <100% NPK < 100% NPK+FYM. The application of 100% NPK+FYM recorded significantly maximum grain yield across locations in Vertisols.

These results established the importance of P application as a major fertility constraint in controlling productivity of crop grown especially in black soils. The data clearly indicated that addition of integrated application of fertilizer with FYM was found to be beneficial for maintaining the fertility and consequently improved the productivity potential of different cropping system. These findings indicated that balanced application of recommended 100% NPK+FYM through fertilizer led to higher yield over imbalanced applications. Integrated use of optimal fertilizer and organic manure was found to be superior over 100% NPK for sustaining the fertility of soil and subsequent crop productivity.

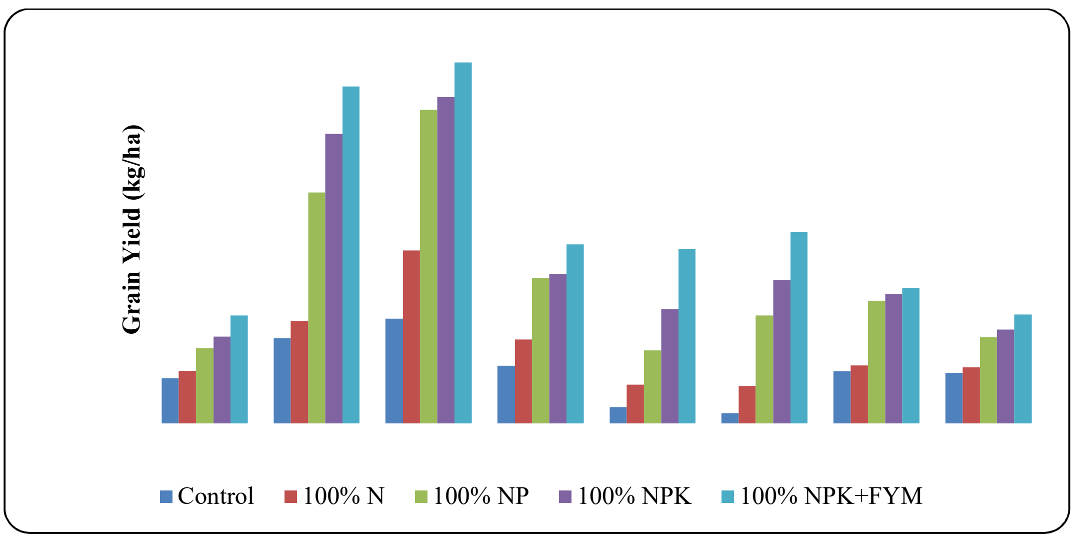

Fig 1. Crop yield (kg ha^{-1}) in LTFEs in Vertisols under AICRP LTFE

Sustainable Yield Index

The SYI of different centre presented in the Table 2. The higher SYI was recorded in 100% NPK+FYM and 100% NPK. The application of 100% NPK also recorded higher SYI as compared to imbalanced fertilization. The applications of 100% NPK along with FYM were found beneficial for maintaining higher SYI. The application of imbalance fertilization to the sequence resulted substantial decrease in the SYI.

Impact on microbial diversity and enzymatic activities

The sol microbial diversity and enzymatic activities enhanced by application 100% NPK along with FYM in different cropping sequence. The maximum population of bacteria, fungi and actinomycetes was observed in INM treatment. Similarly, enzyme activities were also influenced by application of organic and inorganic sources of nutrients in different cropping sequence in Vertisols. However, soil enzymatic activities were influenced significantly with application of 100% NPK+FYM. Therefore, use of inorganic fertilizers i.e. 100% NPK might be combined with organic manure that may sustainable practice for enhancing microbial count and enzymatic activities in Vertisols (Tables 3, 4 and 5). The application of 100% N and 100% NP decreases diversity of heterotrophic microbial community. The higher amount of carbon added to soil responsible for positive C sequestration under 100% NPK + FYM (INM treatment) followed by 100% NPK, 100% NP and 100% N in Vertisols of under different cropping system of Akola and Raipur (Table 4 and Fig 2). Therefore, it may be concluded that the long term INM and balanced fertilization will be helpful to mitigate the adverse impact of increasing GHG concentration.

Table 2. Magnitude of change in sustainable yield index (SYI) under AICRP LTFE

Centre	Crop	Control	100% N	100% NP	100% NPK	100% NPK+FYM
Raipur	Rice	0.60	0.43	0.61	0.61	0.66
	Wheat	0.26	0.38	0.68	0.67	0.75
Jabalpur	Soybean	0.13	0.14	0.26	0.32	0.35
	Wheat	0.14	0.15	0.49	0.54	0.59
Akola	Sorghum	-0.01	0.22	0.25	0.34	0.47
	Wheat	0.02	0.32	0.33	0.50	0.59
Parbhani	Soybean	0.16	0.21	0.63	0.70	0.80
	Safflower	0.25	0.39	0.51	0.57	0.83

Table 3. Impact on microbial diversity and enzymatic activities in Vertisols (LTFE, Jabalpur)

Treatment	DHA (µg TPF g^{-1} soil 24 hr^{-1})	Acid phosphatase (µg PNP g^{-1} soil hr^{-1})	Alkaline phosphatase (µg PNP g^{-1} soil hr^{-1})	β-glucosidase activity (µg PNP g^{-1} hr^{-1})	Bacterial (cfu x 10^7 g^{-1} soil)	Fungi (cfu x 10^7 g^{-1} soil)	Actinomycetes (cfu x 10^7 g^{-1} soil)
Control	7.62	9.50	14.9	27.0	10.9	18.9	12.6
100% N	8.73	10.9	16.3	30.6	13.6	19.4	15.6
100% NP	9.68	11.7	20.7	32.4	17.5	22.8	17.3
100% NPK	11.6	13.1	22.5	36.5	21.6	28.7	24.8
100% NPK+FYM	13.7	15.1	28.3	45.2	32.6	37.4	36.6
CD (p=0.05)	0.76	0.97	1.46	3.48	2.45	2.89	2.71

Table 4. Impact on carbon sequestration and enzymatic activities at LTFE Akola

Treatment	SOC stock (Mg ha^{-1})	C-Build up % over initial	C-Build up / depletion rate (Mg C ha^{-1} yr^{-1})	C-Sequestered (Mg C ha^{-1})	C-Stabilization rate (%)	C-Sequestered (Mg C ha^{-1})	CO_2 Evolution (mg 100^{-1} g)	DHA (µg/ g/24h)	Urease activity (µg/ g/24h)
Control	7.49	-34.5	-0.049	-1.62	-20.0	-1.62	21.1	32.9	35.9
100% N	9.71	-12.6	0.018	0.60	-7.30	0.60	26.7	38.0	42.0
100% NP	11.3	6.09	0.068	2.24	3.53	2.24	31.1	40.1	49.0
100% NPK	12.9	23.4	0.11	3.84	13.6	3.84	34.4	45.3	55.6
100% NPK+FYM	15.8	68.7	0.20	6.72	39.8	6.72	44.8	63.0	68.7
Initial SOC stock	9.11	-	-	-	-	-	-	-	-
CD (0.05)	-	-	-	-	-	-	2.15	2.08	1.54

Table 5. Impact on enzymatic activities in Vertisols (LTFE, Raipur)

Treatment	Urease (µg $NH4^{+}$ - N g^{-1} soil h^{-1})	Dehydrogenase (TPF µg 24 hr^{-1}g^{-1})	Acid-phosphatase (µg p-nitrophenol g^{-1} hr^{-1})	Alkaline-phosphatase (µg p-nitrophenol g^{-1} hr^{-1})
Control	20.04	35.06	55.11	119.81
100% N	30.13	42.22	58.17	134.17
100% NP	32.40	43.38	64.01	141.12
100% NPK	39.37	49.28	65.85	142.21
100% NPK + FYM	44.08	55.39	76.30	160.67
CD (0.05)	3.04	4.68	6.52	11.00

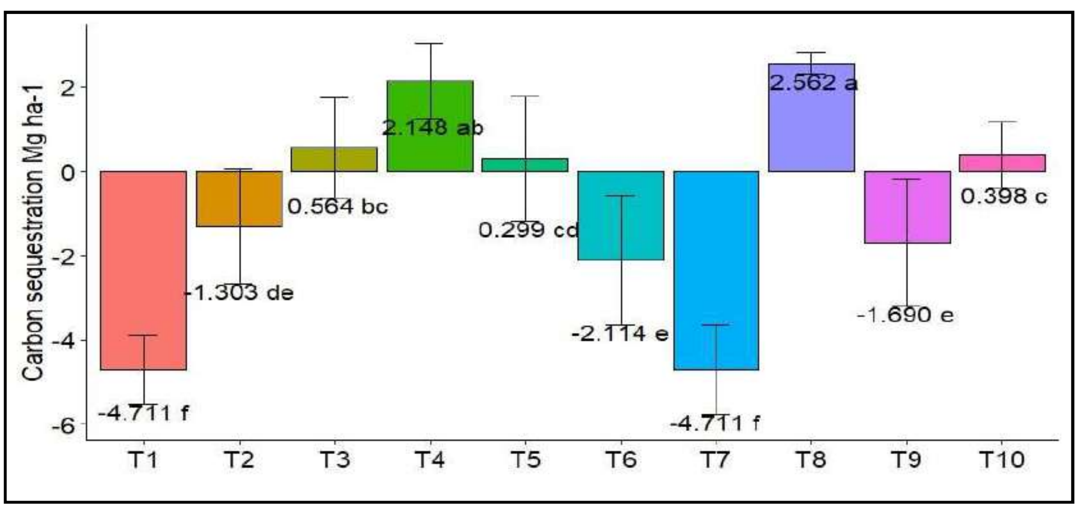

Fig 2. Impact of long-term fertilizer and manure application on carbon sequestration at Raipur

Conclusion

The maximum value of crop productivity, SYI, microbial diversity and enzymatic activities were observed with 100% NPK+FYM (INM) followed by 100% NPK as compared to imbalance treatments. Results indicated that nutrient management in balanced and INM have not only sustained productivity but also improved soil health. Continuous use of either N or NP is harmful. In Vertisols, application of FYM is essential to maintain productivity, which in turn maintains the supply of nutrients to crop. 100% NPK+FYM is effective in sustaining soil quality and overall soil health. Soil enzymes play a vital role in nutrient cycling and availability and it was recorded that inclusion of organic source (FYM) with 100% NPK enhanced the activities of urease, dehydrogenase, acid and alkaline phosphatase in soil. Inclusion of FYM also helps in improving carbon stock in soil that in turn favors microbial diversity. Thus, balance and integrated nutrient management is essential for maintaining soil health and overall sustainability of the system across LTFEs of Vertisols.

UID: 1060

Soil Beneficial Microflora and Cane Yields Under Organic Cultivation of Rainfed Sugarcane

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Soil biota is essential for sustainable agriculture as they provide five critical ecosystem services for agricultural productivity are Soil structural integrity and dynamics, Carbon cycling, Nutrient cycling, Biotic control, nd Mutualism. Organic farming is a holistic production system which promotes and enhances agro-ecosystems health including bio-diversity, biological cycles and soil biological activities. Sugarcane is one of the important commercial crop in North Coastal Zone of Andhra Pradesh and rainfed sugarcane occupies around 45 per cent of total cane area in North coastal districts of Andhra Pradesh. Sugarcane production has tended to remain either stagnant or is declining despite application of high cost inputs. Experts attribute this stagnation is due to destruction of soil health by application of imbalanced fertilizers without addition of organic matter. Hence, the present study was conducted from 2021-22 to 2023-24 with organic sources of inputs for standardization of organic farming protocol for sugarcane cultivation under rainfed condition.

Field experiment was conducted from 2021-22 to 2023-24 in *Inceptisols* with 2 treatments i.e T1 : Organic Farming (Nutrient Management : Cane trash *insitu* incorporation, Farm Yard Manure @ 10 t per ha, Biofertilizers i.e Azotobacter, PSB & KRB @ 5 kg ha^{-1} at the time of planting and application of enriched compost @ 2 tha^{-1} at 30DAP, Spraying of Panchagavya @ 3 % @ at 30 & 60 DAP and Biofertilizers i.e Azotobacter, PSB & KRB @ 5 kg ha^{-1} at 45 DAP. Drenching of Jeevamrutham @ 1000 L ha^{-1} at, 45, 60, 75, 90 and 105 DAP)., T2 :

Inorganic Farming : 100 % recommended dose of chemical fertilizers with a test variety of 93A 145. Exhaust crop was sown before main crop and two treatments were isolated with a distance of 1.5 m. Land preparation followed by furrow formation at 60 cm spacing. Planting was done with 3 budded setts. All the package of practices were followed as per the protocol given above. Soil samples collected after harvest of maize crop were taken as initial for main experiment, subsequently soil samples were collected in rhizosphere of plant at formative phase of sugarcane for assay of beneficial microbial population i.e Azospirillum, Azotobactor, Phosphorus Solubilizing Bacteria and Potassium Solubilizing Bacteria. Results revealed that, microbial population of 5.78 x 10^5 c.f.u./g soil of azospirillum, 3.45 x 10^5 c.f.u./g soil of azotobacter and 1.0 x 10^3 c.f.u./g soil of phosphorus solubilizing bacteria was recorded in initial soil sample. In all the three years significant buildup of microbial population in organic farming over inorganic farming was observed and it was increased to 6.80 x 10^5 c.f.u./g soil and 7.8 x 10^5 c.f.u./g soil of azospirillum and azotobactor population, however phosphorus solubilizers were not increased in first year and later years significant increase of solubilizers to 4 x 10^3 c.f.u./g soil. Whereas in inorganic farming it was 5.25 x 10^5 c.f.u./g soil and 4.56 x 10^5 c.f.u./g soil of azospirillum and azotobactor and phosphorus solubilizers were not detected in inorganic farming plots.

Regarding cane and sugar yields, during first two years significantly superior cane and sugar yields were recorded in inorganic farming over organic farming, however onpar cane yields (58.27 & 56.20 tha^{-1} in organic and inorganic farming, respectively) during third year of study. Three years mean cane yields of 55.51 & 59.65 tha^{-1} were recorded in organic and inorganic farming, respectively with yield reduction of 13.18 % in organic farming. Sugar yields also followed the same trend as higher sugar yields were recorded in inorganic farming during first two years, whereas in third year relatively higher sugar yields was recorded in organic farming with a mean sugar yield of 7.48 & 8.03 tha^{-1}, respectively in organic and inorganic farming, respectively.

UID: 1072

Long-Term Effects of Organic Manure and Inorganic Fertilization on Yield and Biological Soil Quality Indicators of Rainfed Cotton (KC 3) Under Southern Vertisols

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Cotton, an important fiber crop, is cultivated widely in tropical and sub-tropical regions, which play an important role in the national economy. It occupies about 50,000 hectares of the cultivated land of the country. The farmers are generally subsistence small holders with poor knowledge of fertilizer management. Now a days, most of the farmers use high yielding varieties and consequently it requires more fertilizer application. Although farmers are willing to use more N fertilizer for a better crop yield. The lower yield of cotton with association of inorganic fertilizers is one of the challenges for farmers. A very few farmers are using different processed organic fertilizers as the substitute of cow dung or farmyard manure along with inorganic fertilizers in cotton cultivation. Organic fertilizers or manures release nitrogen, potassium, phosphorus and other nutrient elements to the soil. In cotton nitrogen encourages vegetative growth and boll setting by increasing sympodial branches and boll weight. But nitrogen can be reduced yield and quality of cotton to have excess nitrogen in late reproductive stage. Application of organic and inorganic fertilizers increase the accumulation of C, N, and P in the soil and improve the soil's ability to supply nutrients to crops. Fertilizers are used to increase soil fertility and it contribute a lot in food production and food security. Organic fertilizer is the source of soil organic carbon and soil organic carbon is an important indicator of soil health, particularly impacts on soil fertility for crops, because it has several benefits. Many studies have shown that applying organic fertilizers to the soil surface can provide a rich food source for microorganisms and significantly increase microbial community composition and diversity. Therefore, rationally balancing organic and chemical fertilizer input and enhancing crop yields and soil sustainability are the targets that need to be focused urgently in current cotton cultivation practices. The aim of this experiment was to investigate the effects of combined application of inorganic and organic fertilizers on cotton yield and soil biological properties in vertisols condition.

Methodology

This research work was conducted during the year 2011-12 to 2022-23. Every year rabi season, cotton (KC 3) sowing has been taken in black soil farm (Vertisols) during the last week of September (odd years) to find out the long-term effect of organic and inorganic nutrients on crop yield and soil fertility. The depth of the black soil varies from 110 to 150 cm with the infiltration rate of 0.9cm hr^{-1}. Considering the mechanical fraction, the soil is clayey with clay content of 46.4 to 61.2 per cent, 10.0 to 17.5 per cent silt and 12.6 to 24.5 per cent coarse sand. The soil bulk density varies from 1.21 to 1.36 kg m^{-3} with the field capacity of 35 per cent and permanent wilting point of 14 per cent (Sunflower as an indicator plant). The soil has sub angular blocky structure with pH generally neutral to a tendency towards alkalinity at lower depths (7.8 to 8.2). The soil available nutrients *viz.,* low in soil available nitrogen, medium in soil available phosphorus and high in soil available potassium. The experiment was conducted in randomized block design (RBD) replicated thrice under rainfed condition. The treatments comprised of T_1 - Control, T_2 - 100 % RDF (40:20:40 NPK kg ha^{-1}), T_3- 50 % RDF (20:10:20 NPK kg ha^{-1}), T_4- 50 % N (crop residues), T_5 -50 % N (FYM), T_6 - 50% RDN through fertilizers+ 50% RDN through crop residues + 50% P & K, T_7 -50% RDN through fertilizers+ 50% RDN through FYM + 50% P & K, T_8 -100 % RDF + 25 kg $ZnSO_4$ ha^{-1} and T_9 - FYM @ 12.5 ha^{-1}. As per the treatment schedule, the full dose of inorganic fertilizers and organic manures were applied as basal application.

Results

In rainfed vertisols condition, long term application of 100 % RDF (40:20:40 NPK ha^{-1}) + 25 kg $ZnSO_4$ ha^{-1} recorded higher seed cotton yield (1214 kg ha^{-1}). The combined application of 50% RDN through fertilizers+ 50% RDN through FYM + 50% P & K has found superior in seed cotton yield (1112 $kgha^{-1}$) when compared to crop residues application under rainfed vertisols. While applied with organic manures alone *viz.,* 50 % N (FYM) registered higher seed cotton yield (850 $kgha^{-1}$) (Fig.1). It may be due to increased plant height and leaf area index which resulted in increased photosynthetic activity thereby, resulting in increased translocation of photosynthates from the source to sink.

The application of zinc to cotton along with other NPK fertilizers registered significant increase in yield and quality of cotton. These results are conformity with that of Zafar Abbas *et. al.* (2020) and Naveen *et. al.*,2024.

Regarding soil enzymes, the plots applied with FYM @ 12.5t ha^{-1} in semi arid regions of Kovilpatti deep black soils, registered higher soil dehydrogenase activity (65.0µg TPF/g /day) and microbial population *viz.,* bacteria (47.0×10^6 cfu g^{-1}), fungi (33.7×10^4 cfu g^{-1}) & actinomycetes (29×10^3 cfu g^{-1}) in rainfed cotton and it was followed by the treatment that received 50 % N (FYM) alone. The lowest value was recorded in the untreated control plot (Fig.2&3). It may be due to addition of farm yard manure that might have increased the soil organic matter content, resulting in more microbial proliferation and thereby sustaining the soil health. Similar finding was reported by Machala santhosh kumar (2020).

Fig. 1 Effect of organic and inorganic plant nutrients on seed cotton yield (kg/ha) under rainfed vertisols in cotton (KC 3)

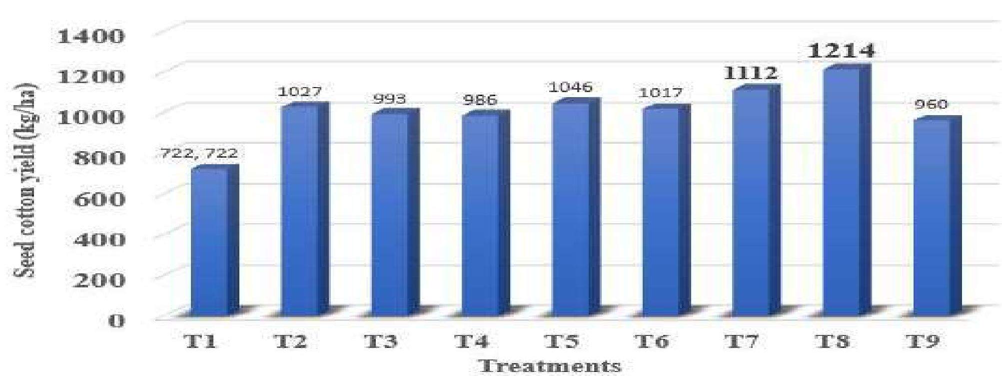


Fig 2.Effect of organic and inorganic plant nutrients on soil enzymes under rainfed vertisols in cotton (KC 3)

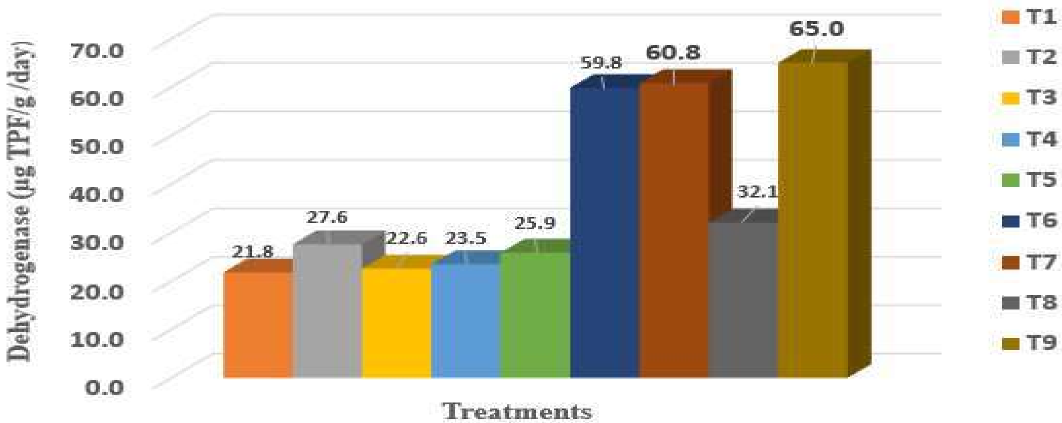
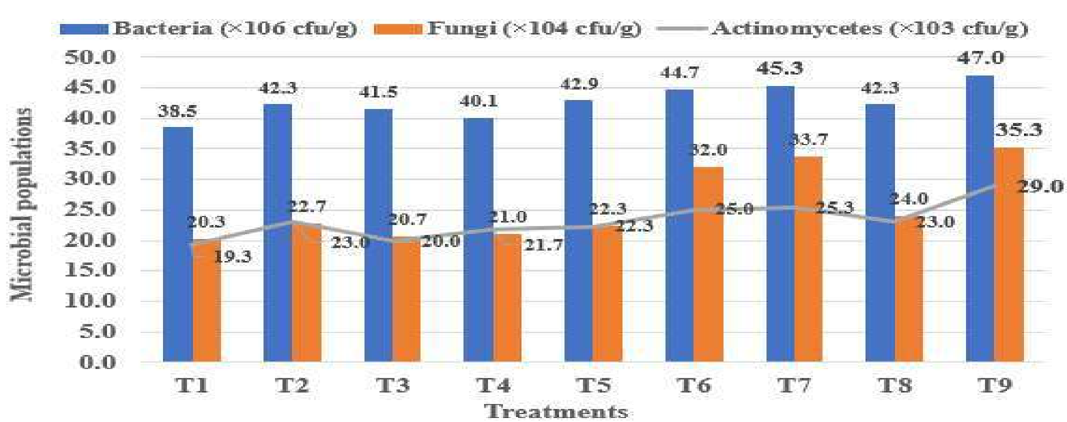


Fig 3.Effect of organic and inorganic plant nutrients on soil microbial populations under rainfed vertisols in cotton (KC 3)



Conclusion

In long term nutrient management practices, involving 100 % Recommended dose of fertilizer along with 25 kg $ZnSO_4$ ha^{-1} registered higher seed cotton yields besides enhancing microbial population under semiarid rainfed condition of cotton crop in southern Tamil Nadu.

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UID: 1076

Nutrient Management through Residue Retention for Increasing the Productivity of *Kharif* Cowpea – *Rabi* Sorghum Sequence Cropping System

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The experiment was conducted on Kharif Cowpea – *Rabi* Sorghum crop sequence at Agricultural Research Station, Mohol under the ACZ theme since 2019 with objectives 1)To study the effect of residue retention on productivity of crop sequence and 2)To study the effect of residue retention on soil health under *Kharif* Cowpea – *Rabi* sorghum sequence cropping system. The experiment was conducted in split pot design with three replications. The treatments for *Kharif* Cowpea (Residue retention) are 1.Control (*Kharif* fallow) 2.Cowpea as a green manuring crop (Cowpea to be harvested above ground level at flowering stage for surface application as a green lopping with fertiliser dose of 0:50 kg N: P_2O_5/ha + PSB + *Rhizobium* seed treatment 3.Cowpea as a green manuring crop(Cowpea to be harvested above ground level at flowering stage for surface application as a green lopping with 12.5:50 kg N: P_2O_5/ha + PSB + *Rhizobium* seed treatment.4.Cowpea as a grain (Cowpea to be harvested above ground level for grain purpose only and root biomass is retained in soil) with fertiliser dose 25:50 N:P_2O_5 Kg/ha + PSB + *Rhizobium* seed treatment. The treatments for *Rabi* Sorghum (Nutrient management) are N_1 : Recommended dose of *rabi* sorghum

(50:25:25 N:P_2O_5:K_2O Kg/ha) , N_2 : 75 % Recommended dose of nitrogen along with full recommended dose of P_2O_5 and K_2O (37.5:25:25 N:P_2O_5:K_2O Kg/ha and N_3 : 50 % of recommended dose of nitrogen with complete recommended dose of P2O5 and K_2O (25:25:25 N:P_2O_5:K_2O Kg/ha)

Results

At the end of 4th year of experimentation, it was observed that the maximum green biomass yield of cowpea 20.19 q ha^{-1} was recorded in the treatment green manuring along with nitrogenous and phosphatic fertilizer and without potassic fertilizer i.e 12.5:50:0 kg N:P_2O_5:$K_2$0/ha (C_3) as compared to treatment with green manuring without nitrogenous and potassic fertilizer i.e 0:50:0 kg N:P_2O_5:$K_2$0/ha (C_2). However, the maximum grain yield 5.59 q ha^{-1} was recorded in the treatment N_2- (37.5:25:25 N:P_2O_5:K_2O Kg/ha) as compared to treatment N_1 and N_3. In case of *rabi* sorghum the treatment with 25:50 N: P_2O_5 Kg/ha (C_4) recorded significantly higher grain (14.49 q ha^{-1}), stover yield (30.57 q ha^{-1}) and net returns (Rs.53020 ha^{-1}) and B:C ratio (2.23) as compared with other treatments. The RWUE (Kg ha^{-1} mm^{-1}) was found in increasing trend from C_1 to C_4 treatment i.e C_4> C_3> C_2>C_1 for *rabi* sorghum grain. The application of fertilizer dose of 50:25:25 N:P_2O_5:K_2O Kg/ha to rabi sorghum recorded significantly higher grain (13.41qha^{-1}) and stover (28.43 q ha^{-1}) yields as well as higher net returns was (Rs.31903 ha^{-1}) with maximum B:C ratio (1.77) as compared with other treatments. The RWUE (Kg ha^{-1} mm^{-1}) in case of *rabi* sorghum was in the order of N_1 > N_2 > N_3 for *rabi* sorghum. The interaction effects were non- significant for grain and stover yields

Yield and economics of *kharif* cowpea- *rabi* sorghum sequence as influenced by Residue Retention and Nutrient Management

(a) Kharif Cowpea

Sub- treatment Residue management	*Main-Tillage systems, Yield (q ha^{-1})*							
	N₁: (50:25:25 N:P_2O_5:K_2O kg/ha)		N_2- (37.5:25:25 N:P_2O_5:K_2O kg/ha)		N_3- (25:25:25 N:P_2O_5:K_2O kg/ha)		Mean	
C_1: *Kharif* Fallow	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow	Fallow
C_2: Green manuring with 0:50 kg N: P_2O_5/ha	Green	Dry	Green	Dry	Green	Dry	Green	Dry
	18.74	3.00	18.32	2.93	17.95	2.87	18.34	2.93
C_3: Green manuring with 12.5:50 kg N: P_2O_5/ha	Green	Dry	Green	Dry	Green	Dry	Green	Dry
	20.65	3.30	20.17	3.23	19.75	3.16	**20.19**	**3.23**
C_4: Grain purpose with 25:50 N:P_2O_5 Kg/ha	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
	5.17	16.54	**5.59**	17.89	4.90	15.68	5.22	16.70

Nutrient composition of cowpea as a green manure: N- 2.35 %, P-0.30 %, K- 2.25 %, OC- 41.1% C: N- 17.49

(b) Rabi Sorghum

Treatment	Yield (q ha^{-1}) Grain 2022-23	Stover 2022-23	Cost of Cult^n Rs.ha^{-1}	NMR Rs.ha^{-1}	B:C Ratio	RWUE (Kg ha^{-1} mm^{-1})
Main- *Kharif* Cowpea Residue Retention (R)						
C_1:*Kharif* Fallow	10.41	21.98	29945	18281	1.61	6.77
C_2:Green manuring with 0:50 kg N: P_2O_5/ha	12.22	25.78	42508	20332	1.48	7.94
C_3:Green manuring with 12.5:50 kg N: P_2O_5/ha	13.18	27.81	42653	25276	1.59	8.57
C_4:Grain purpose with 25:50 N:P_2O_5 Kg/ha	**14.49**	**30.57**	43214	53020	**2.23**	9.42
SE+	0.141	0.297	-	629.724	0.015	--
CD at 5%	0.50	1.047	-	2221.5	0.053	--
N_1: (50:25:25 N:P_2O_5:K_2Okg/ha)	**13.41**	**28.43**	40912	**31903**	**1.77**	**8.72**
N_2- (37.5:25:25 N:P_2O_5:K_2O kg/ha)	12.50	26.37	38987	29958	1.76	8.13
N_3- (25:25:25 N:P_2O_5:K_2Okg/ha)	11.81	24.80	38842	25821	1.66	7.68
SE+	**0.118**	**0.249**	-	559.594	0.014	**--**
CD at 5%	**0.36**	**0.754**	-	1692.1	0.043	**--**
SE+	**0.239**	**0.504**	**--**	1109.78	0.028	**--**
CD at 5%	**N.S.**	**N.S.**	**--**	N.S.	N.S.	**--**

Khari fallow (C_1)	**Green manuring (C_2)**	**Green manuring (C_3)**	**Grain purpose(C_4)**
C_1N_1=Rs.31277	C_2N_1= Rs.43840	C_3N_1=Rs.43985	C_4N_1 = Rs.44546
C_1N_2 =Rs.29352	C_2N_2 = Rs.41915	C3N =Rs.42060	C_4N_2 = Rs.42621
C_1N_3 =Rs.29207	C_2N_3 = Rs.41770	C_3N_3 =Rs.41915	C_4N_3 = Rs.42476

Nutrient composition of cowpea as a green manure: N- 2.35 %, P-0.30 %, K- 2.25 %, OC- 41.1% C: N- 17.49

Rates: Sorghum Grain- Rs.3563-q^{-1}, Stover- Rs.550 q^{-1} Cowpea Grain – Rs.4500 q^{-1}, Stover – Rs.300 q^{-1}, N- Rs.12.85 kg^{-1}, P_2O_5 - Rs.50 kg^{-1}, K_2O -Rs. 36 kg^{-1}

Total rainfall received during crop growth period: 153.8 mm

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Foliar Spray as Resilient Rainfed Technology to Mitigate Mid-Season Dry Spell in Rainfed Groundnut Under Semiarid Alfisols

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The risk involved in the cultivation of rainfed crops depends on the nature of drought (chronic and contingent), duration and frequency of occurrence within the season. The climate change has intensified the number of dry spells during crop growth period which led to unavoidable yield loss. Groundnut (Arachis *hypogea*) shows different water needs at different growth stages. Water demand is highest at peg penetration to pod initiation and pod development to maturity stage of the crop (Puppala *et al.,* 2023). Foliar spray with different chemical nutrients not only facilitates better plant growth and development but also helps to alleviate different kinds of abiotic stresses like drought. The leaf feeding is the use of fertilizers to enhance overall nutrient level, sugar production, maintains of plant turgor in the plant and also sustain the abiotic stress. overall, the foliar spray as climate resilient technology helps to pass on the stress particularly at critical growth stages and maintains the normal plant growth and yield occurred due to mid-season dry spell in rainfed groundnut (Srinivasa Rao and Gopinath, 2016). Understanding the effect of mid-season dry spell on groundnut crop growth and yield, foliar sprays with different nutrients are explored in rainfed groundnut grown in semi-arid *Alfisols* at Agricultural Research station Ananthapuramu, Andhra Pradesh, India.

Methodology

Field experiment was conducted in split plot design with three replications during *kharif*, 2017 to 2023 at Agricultural Research Station, Ananthapuramu under Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India. The experiment site is in semi-arid region with an average annual rainfall of 535 mm. The treatments consist of main plots:M1- Foliar spray during dry spell; M2 - Foliar spray after relieving of stress/dry spell (with favorable soil moisture). Sub plots: S1-Urea @ 1%; S2-Urea @ 2%; S3-Water soluble complex fertilizer (19:19:19) @ 0.5%; S4-Water soluble complex fertilizer (19:19:19) @ 0.5% recommended dose of micronutrient for foliar spray (to be decided based on soil test: Zinc, Boron, Iron, Manganese etc.); S5-Recommended dose of micronutrient for foliar spray (to be decided based on soil test: Zinc, Boron, Iron, Manganese etc.); S6-Water spray and S7- Control (no spray of any material/water). However, Recommended fertilizer dose of 20 N: 40 P_2O_5: 40 K_2O is common for all the treatments. Two foliar sprays were given each at peg penetration to pod initiation and pod development to maturity when there was continuous dry spell of 10 days in between the rainfall events.

Results

The effect of foliar spray with different nutrients to mitigate the mid-season drought in rainfed groundnutis presented in table. The pooled statistically analyzed data reveals that, non-significant differences were found in groundnut pod yield and shelling (%). whereas, haulm yield reveals significant differences both in main and sub plots. However, rain water use efficiency and relative leaf water content showed significant differences in sub plots only. Higher groundnut pod yield (1380 kg/ha) was recorded with the (S4) foliar spray of 19:19:19 @ 0.5% + recommended dose of micronutrient ($ZnSO_4$ @ 0.2 %) during dry spell and stress relived after rainfall. This might be attributed to the positive effect of N, P, K, and $ZnSO_4$ which enhances the plant growth and canopy due to cell division & expansion besides influencing the metabolic process and mitigating the dryspell effect over 10 days and above during critical crop growth period. The same treatment was found effective in mitigating the mid-season drought and recorded higher B:C ratio in rainfed groundnut grown in semi-arid alfisols. The Results are in line with the findings of Chatterjee and Bandyopadhyay (2017).

Effect of foliar spray with different chemical nutrients on yield, shelling (%), rain water use efficiency, relative leaf water content and economics for rainfed groundnut in semi-arid Alfisols.

Treatments	Pod Yield (kg/ha)	Haulm yield (kg/ha)	Shelling (%)	RWUE (Kg/ha-mm)	RWC (%) (During Dry Spell)	RWC (%) After receipt of rain)	B:C Ratio
Main plots: Time of spray (M1: During dry spell & M2: after relieving from stress / dry spell)							
M1	1114	3802	62.0	3.58	51.7	53.3	--
M2	1172	3353	61.0	3.77	49.8	56.2	--
SEm±	79.02	16.73	0.57	0.25	1.13	1.31	--
LSD (P=0.05)	NS	109.65	NS	NS	NS	NS	--
Sub plots: Foliar Spray with different nutrients							
S1	1027	3691	59.1	3.31	49.8	53.4	1.06
S2	1065	3738	61.9	3.43	51.5	53.4	1.05
S3	1168	3738	63.2	3.76	52.7	55.7	1.07
S4	1380	3310	61.6	4.45	51.2	59.3	1.33
S5	1305	3191	59.4	4.20	52.1	57.6	0.98
S6	1170	3786	65.5	3.77	50.7	53.6	1.05
S7	887	3595	60.3	2.86	47.5	50.5	0.99
SEm±	90.7	114.67	2.46	0.29	2.17	1.70	--
LSD (P=0.05)	266.5	336.69	NS	0.85	NS	5.05	--

Conclusion

Foliar spray with different chemical nutrients can save the standing crop due to mid-season drought conditions. Spraying with micronutrients based on soil test also corrects the deficiencies and enhances yield. Crop was protected particularly at the time of peg penetration to pod initiation and pod development to maturity when there was continuous dry spell under unexpected midseason dryspell as a contingency measure.

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Effect of Integrated Nutrients Management on Chemical Properties of Soil in *Vertisols*

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The Integrated nutrient management (INM) primarily refers to the judicious, efficient, and integrated use of all available sources of organic, inorganic and biological components to combine traditional and modern techniques of nutrient management into an environmentally sound and economically optimal agricultural system (Janssen, 1993). The INM techniques reduce losses due to leaching, runoff, volatilization, emissions, and immobilization while maximizing nutrient use efficiency (Zhang *et al.,* 2012). Additionally, INM aims to improve the physical, chemical, biological, and hydrological aspects of the soil to increase agricultural production and reduce land degradation (Esilaba *et al.,* 2005). Crops grow better under friable and well-aggregated soils with optimum soil bulk density as it greatly influencing crop root growth and nutrient uptake. Practicing long-term INM brings a favourable difference in soil bulk density (Saha *et al.,* 2010). The main reason for decreasing bulk density under INM was aggregation of soil particles due to increasing organic matter as well as stability of aggregates which leads to an increase in the total pore space in the soil. (Islam *et al.,* 2012) also concluded that the addition of organic matter through organic manure decreases the bulk density of soil. The available N, P_2O_5 and K_2O status improved after harvest of the crops due to integrated nutrient management (Dhonde and Bhakare 2008).

The nutrients availability in soil, nutrient uptake, yield attributes and yield of soybean were significantly influenced by FYM along with 100% NPK application (Meshram *et al*., 2019). Depletion of soil fertility status due to indiscriminate use of fertilizers to crop, and poor crop stand led to low productivity of entire cropping system. Application of organic material along with inorganic fertilizers into the soils leads to increase in productivity of the cropping system enhance the use efficiency of fertilizer input and sustain the soil health for longer period (Acharya and Sharma, 2008 and Jat *et al.,* 2015). Soil health indicates the capability of a soil to provide ecosystem services. The health of a soil reflects how well the soil can carry out its environmental functions. A soil is evaluated as healthy if it provides comparable or better ecosystem services relative to undisturbed reference soils of similar type in the same region. Otherwise, the soil is unhealthy, unable to perform the normal environmental functions of similar soils in the inherent ecosystem.

Methodology

The present study was conducted at the research farm of AICRP on Dryland Agriculture, College of Agriculture, Indore, (M.P) India. The experimental area is situated at 22.43° N latitude and 75.66° E longitude and at elevation 555.5 meter above mean sea level in the Western part of the Madhya Pradesh.

Details of the treatment

Treatments

T_1	Control
T_2	N_{20} P_{13} (Fertilizer N and P @ 20 and 13 kg ha^{-1})
T_3	N_{30} P_{20} (Fertilizer N and P @ 30 and 20 kg ha^{-1})
T_4	N_{40} P_{26} (Fertilizer N and P @ 40 and 26 kg ha^{-1})
T_5	N_{60} P_{35} (Fertilizer N and P @ 60 and 35 kg ha^{-1})
T_6	FYM 6 t ha^{-1} + N_{20} P_{13} (FYM @ 6 t ha^{-1} in rainy season on Only plus fertilizer N and P @ 20 and 13 kg ha^{-1})
T_7	Residues 5 t ha^{-1} + N_{20} P_{13} (Crop residues of soybean @ 5 t ha^{-1} plus fertilizer N and P @ 20 and 13Kg ha^{-1})
T_8	FYM 6 t ha^{-1} (Farmyard manure @ 6 t ha^{-1})
T_9	Residues 5 t ha^{-1} (Crop residues of soybean @ 5t ha^{-1})

Representative soil samples (0-10, 10-20, 20-30, and 30-45 cm depth) were collected with the help of stainless steel auger from the experimental plot before sowing and after harvesting of crop. The samples were analysed for pH, EC, Av N, Av P, Av K, Av S and micronutrients by standard methodology.

Results

The soil chemical properties are affected due to grow soybean under different nutrient management carry out. In contemporary study, the pH of soil on application of solo fertilizers and integrated fertilizers ranged 7.53-7.69, 7.56-7.78, 7.79-7.92 and 7.98-8.35 at 0-10, 10-20, 20-30 and 30-45 cm depth of soil. The pH of soil at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil showed non significance under solo fertilizers and integrated fertilizers treatments. Halemani *et al*. (2004) noted that the application of various organic manures did not influence pH and EC significantly. The EC of the soil ranged 0.21-0.34, 0.19-0.28, 0.17-0.27 and 0.16-0.26 dS m^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of soil. The pH of soil at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil showed significant under solo fertilizers and integrated fertilizers treatments. It has been observed that the treatment receiving integrated fertilizers (T6) showed significantly lowest EC of the soil as compared to sole organic or inorganic fertilizer application and the control. Lal Bahadur *et al.* (2012) found that application of organic manures along with inorganic fertilizers was more effective to decrease the EC of soil as compare to without organic manures application. Dwivedi *et al.* (2007) has also found no marked influence of continuous use of inorganic fertilizers on electrical conductivity of soil, while combination of FYM and fertilizer changed the EC of soil.

The available Nitrogen of soil under different quantity of solo fertilizer application and integrated fertilizer application including control ranged 172.3-315.0, 156.7-296.7, 148.3-232.7 and 138.3-206.4 kg ha^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of inorganic and organic fertilizers. It has been observed that the treatment receiving integrated fertilizers (T6) and organic treatment showed significant increases in available Nitrogen as compared to sole inorganic fertilizer application and the control. Dwivedi and Dwivedi *et al*. (2015) observed that the content of available N in soil increased significantly with the use of recommended fertilizer dose in combination with manure. Similarly, available P of soil mean value ranged 9.2-16.0, 9.1-15.6, 8.6-14.2 and 8.5-13.6 kg ha^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of inorganic and organic fertilizers. The significantly higher available P of soil was recorded under the treatments receiving integrated fertilizers treatments (T6) or organic treatment and under the higher application of inorganic fertilizers (T5) (Table 4.3). Patidar *et al.* (2021) found that the application of integrated fertilizers (100% NPK + FYM) treatment resulted in highest value (38 kg ha^{-1}) of available P and the lowest values of available P in control. Thakur *et al.* (2011) also reported that in *Vertisol*, the integrated fertilizers application (FYM with 100% NPK) improved available P over its initial value. Further, available K of soil ranged 455.7-723.9, 455.1-703.2, 453.4-655.2 and 451.7-620.2 kg ha^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of solo fertilizers and integrated fertilizers treatments. It has been observed that the treatment receiving integrated fertilizers (T6) and organic inputs showed significant in available K of soil as compared to sole inorganic fertilizer application and the control. Release of potassium due to interaction of INM fertilizer with clay, besides the direct potassium addition to the pool of soil that increase available potassium content with the use of INM fertilizer has also been reported by Ali *et al.* (2021). Tolanur and Badanur (2003) further reported that the organic carbon content, available N, P and K were significantly influenced by the use of 50 percent N through organic manure in conjunction with 50 percent RDF through chemical fertilizer under pearl millet- pigeon pea cropping systems in *Inceptisol*. The available S of soil mean value ranged 9.2-19.1, 9.0-18.4, 8.5-17.1 and 7.7-16.8 Mg kg^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of inorganic and organic fertilizers. It has been observed that the treatment receiving integrated fertilizers (T6) and sole organic inputs showed significant increases in available S of soil as compared to sole inorganic fertilizer application and the control. Inwati *et al.* (2022) found that the application of integrated fertilizers (NPK with FYM) resulted in significantly higher available S content (39.8 kg ha^{-1}) than initial value (15.6 kg ha^{-1}).

The mean value of DTPA-Extractable micronutrients ranged 1.88-2.73 mg kg^{-1}, 0.39-0.81 mg kg^{-1}, 1.42-1.7 mg kg^{-1} and 2.33-2.83 mg kg^{-1} of Fe, Zn, Cu and Mn respectively under the treatments receiving various doses of solo fertilizers and integrated fertilizers treatments. It has been observed that the treatment receiving integrated fertilizers (T6) showed significant in DTPA-Extractable micronutrients of soil as compared to sole inorganic fertilizer application and the control. Thakur *et al.* (2011) in long-term fertilizer experiment on *Vertisol* showing that the addition of Zn along with T5-100% NPK significantly raised the level of available Zn content (1.33 mg kg^{-1}) in soil. Selvi *et al.* (2003) the application of integrated fertilizers (10 t ha^{-1} FYM along with 100% NPK) recorded significantly higher availability of Fe (5.84 mg kg^{-1}) over control (T10) under millet-maize-cowpea system. Zn, Cu, Fe and Mn micronutrient increased with an increase in organic carbon Prasad et al. (2020). Bonde and Gawande (2017) who had indicated that the integration of organic and inorganic sources of nutrition significantly improved the soil available content of N, P, K and micronutrient.

Conclusion

These findings highlight the effectiveness of integrated nutrient management in enhancing soil nutrient availability, particularly at varying soil depths, compared to solo fertilizer treatments and by INM increases soil nutrient availability and it is having positive impact on soil health.

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Impact of Different Nutrient Management Practices for Sustainable Groundnut (*Arachis Hypogea*) Productivity in Semi-Arid *Alfisols* under Rainfed Conditions

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Rainfed soils are poor in fertility, complex, highly diverse and risk prone. However, supports major production systems in arid and semi-arid regions with annual rainfall ranging from 500-900 mm (Singh *et al.,* 2004). Semi-arid *Alfisols* are predominant in southern Andhra Pradesh, supports mono-cropping system of groundnut adopted largely by small and marginal farmers. Low rainfall, uneven distribution coupled with frequent droughts are the conspicuous characters of climate in this region (Viramani *et al.,* 1991). Soils are low in organic carbon, low in available N, P, K, S contents and also deficient in available Mg, Zn and B (Srinivasarao *et al.,* 2013). However, resource poor, small and marginal farmers supply meager quantity of nutrients to soil and thus crop suffers from multi nutrient deficiencies consequently low yields. Therefore, to sustain crop yields and soil fertility requires adoption of different nutrient management practices such as integrated nutrient management (INM), soil test-based fertilizer application (STBF) and application of recommended dose of fertilizers (RDF). Present study is an attempt in this direction and evaluating the impact of above nutrient management strategies in achieving the higher productivity and sustainability in semi-arid *Alfisols* under rainfed ecology.

Methodology

Field experiment was conducted during kharif, 2017 to 2023 as non-replicated trial with large sized plots of 150 m^2 each at Agricultural Research Station, Ananthapuramu under Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India. The experiment site is in semi-arid region with an average annual rainfall of 535 mm. The treatments consist of T1: Control; T2: INM 50% RDF + FYM @ 4 t/ha; T3: STBF for NPK application based on soil test values; T4: RFD (20 N – 40 P_2O_5 – 40 K_2O kg /ha).

Results

The impact of different nutrient management practices for sustainable groundnut productivity is presented in table 1. The pooled mean data analyzed reveals that, mean pod yield of groundnut over seven years was higher with respect to soil test-based fertilizer application followed by recommended dose of fertilizer application and integrated nutrient management practices for rainfed *Alfisols* as compared to control. However, haulm yield of groundnut was highest in INM followed by STBF and RDF as compared to control. This might be attributed to required quantity of nutrients supplied through STBF and RDF and it has been has reflected in pod yield.

Table 1. Impact of different nutrient management practices for sustainable groundnut productivity in semi-arid *Alfisols* under rainfed conditions

Treatment	Groundnut Pod yield (kg/ha)							Pooled yield (kg/ha)		B:C Ratio	BD (Mg m^{-3})	WHC (%)	OC (%)	Uptake (kg/ha)		
	2017	2018	2019	2020	2021	2022	2023	Pod	Haulm					N	P	K
T1: Control	1433	83	627	455	625	857	983	723	1733	1.19	1.40	21.2	0.24	18	14.5	35
T2: INM	1752	185	1007	590	745	1169	1237	955	1908	1.21	1.36	35.6	0.49	30	18.4	38
T3: STBF	1764	172	857	786	960	1292	1107	991	1889	1.56	1.38	23.5	0.42	28	18.0	39
T4:RDF	1828	152	968	686	840	1028	1291	970	1762	1.17	1.38	21.3	0.39	30	17.8	42

However, the soil properties such as bulk density was optimized in INM treatment as compared to other nutrient management practice due to application of organic manures to soil. the water holding capacity was also improved in INM and organic carbon content was increased over time in INM treatment over time. Though, the mean pod yield was higher in STBF and RDF practices, improvement in the soil physical properties was considerable in INM practice. This favorable soil atmosphere was also reflected in the nutrient uptake. The results are in line with the findings of Srinivasarao *et al.,* 2013. However, cost benefit ratio indicates that, among different nutrient management practices, STBF followed by INM and RDF is suitable to achieve the sustainable yield of groundnut grown in semi-arid *Alfisols* under rainfed conditions.

Conclusion

Sustaining crop yields in rainfed soils is very difficult as the soils under semi-arid conditions with low rainfall are poor in soil fertility, highly diverse and complex. Such conditions require an adoption of appropriate nutrient management practices such as INM as this practice improves soil properties besides optimum nutrient supply. Further, STBF application can supply required nutrients and reduce cost of production in groundnut to resource poor small and marginal farmers under rainfed conditions.

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UID: 1102

Effect of Integrated Nitrogen Management on Fodder Yield, Energy Efficiency and Carbon Footprint in Sorghum

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The study investigates the effects of different nitrogen management treatments, including inorganic, organic, and integrated sources, on fodder sorghum yield, energy use, and carbon emissions. The experiments were carried out at the ICAR-CIRG, Makhdoom during the kharif seasons of 2021 and 2022. The experiments were designed with nine treatments in the randomized block design, which included 100% nitrogen from urea, vermicompost, and

poultry manure, as well as mixtures in different ratios to get the recommended dose of nitrogen (100 kg N ha^{-1}). Results indicated that application of 75% RDN through urea and 25% RDN through vermicompost yielded the highest green and dry fodder yield. Energy demand peaked in the 100% RDN from urea treatment (14,774 MJ ha^{-1}), while the poultry manure treatment had the lowest energy requirement (9,704 MJ ha^{-1}). Energy use efficiency was maximized by the treatment combining 75% RDN through urea with 25% RDN through vermicompost, suggesting that organic inputs improve efficiency. Carbon emission assessment identified nutrient application as the primary source of emissions, with the highest from urea (912 kg CO_2-e ha^{-1}) and the lowest from poultry manure (396 kg CO_2-e ha^{-1}). The integrated treatment of 75% RDN through urea + 25% RDN through vermicompost also demonstrated the greatest net carbon gain and output, highlighting the benefits of integrated organic and inorganic fertilizers to optimize yields, energy efficiency, and carbon management in fodder sorghum production.

UID: 1117

Studies on Effect of Rainwater Conservation Techniques and Application of Potassium to Pigeonpea under Dryland Conditions

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The field experiment was conducted at the Zonal Agricultural Research Station, Solapur on medium black soil for the seven consecutive years (*kharif*) from 2016-17 to 2023-24 with objectives to study the effect of rainwater conservation techniques on soil moisture and to study the response of graded levels of potassium on yield of pigeonpea. The experiment was laid out in Factorial Randomized Block Design, having three treatments for A factor and five for Factor B which were replicated thrice. The treatments are A) Rainwater Conservation Techniques: M_1 -Flatbed (transplanting of seedlings on 90 cm x 60 cm), M_2 - Opening of ridges & furrow one month before sowing and transplanting of seedlings on 90 cm x 60 cm, M_3 -Opening of ridges & furrow one month before sowing and transplanting of seedlings on 180 cm x 30 cm (transplanting of seedlings on alternate row + dibbling of black gram on the middle row). B) Potassium levels: K_0 -0 kg K_2Oha^{-1}, K_1 12.5 kg K_2Oha^{-1} K_2 -25 kg K_2Oha^{-1} K_3 -37.5 kg K_2Oha^{-1} K_4 -50 kg K_2O ha^{-1}. The application of N and P_2O_5@ 25:50 kg ha^{-1} along with FYM @ 2 t ha^{-1} and seed treatment with biofertilizer (*Rhizobium* and PSB) common to all treatment. The seeds of pigeonpea variety *Rajeswari* was sown in the polythene bags one month prior to sowing. The one-month seedlings were transplanted on onset of monsoon. The initial soil properties of the experimental plot were pH: 7.56, EC (dS m^{-1}): 0.28, organic carbon: 0.51 %, Av. N-154, Av. P- 1915, Av. K- 687 kg ha^{-1}, bulk density (Mg m^{-3}) 1.17, PWP: 80 mm, FC: 304 mm, $CaCO_3$: 8.8 %. All the standard analytical procedures given by Jackson (1973) were used for analytical purpose. The data obtained in respect of the observations was statistically analysed by using the procedures.

Results

Yield-Grain and Straw:

The rainwater conservation techniques, M_3 *i.e.* opening of ridges & furrows one month before sowing and transplanting of seedlings on 180 cm x 30 cm (transplanting of seedlings on alternate row + dibbling of black gram on the middle row) recorded significantly higher mean pigeonpea equivalent grain yield and straw yield (13.44 and 25.93 q ha^{-1}). The treatment M_3 was at par with M_2 (12.08and 24.33 q ha^{-1}).

Table 1: Pigeonpea equivalent grain yield, straw yield, MUE and Total nutrient uptake of pigeonpea influenced by rainwater Conservation techniques and potassium levels under dryland conditions (2015-16 to 2023-24)

Treatment Details	Yield (q ha^{-1})		MUE (kg $ha^{-1}mm^{-1}$)	Total Nutrients Uptake (kg ha^{-1})		
	Pigeon pea equivalent grain yield	Straw		N	P	K
Moisture Conservation Techniques (MCT)						
M_1	10.84	21.12	2.58	35.43	14.72	31.46
M_2	12.08	24.33	2.89	36.58	17.01	35.27
M_3	13.44	25.93	3.07	40.22	19.01	39.70
SE±	0.23	0.83	0.08	1.85	0.29	0.63
CD (5%)	0.64	2.34	0.21	NS	0.82	1.76
Potash levels (K)						
K_0	9.45	17.25	2.31	29.50	13.25	29.14
K_1	11.27	21.54	2.61	38.86	15.26	33.21
K_2	12.62	24.98	3.01	38.39	17.81	36.74
K_3	13.87	27.27	3.22	41.12	19.35	39.85
K_4	13.38	27.93	3.07	39.20	18.91	38.45
SE±	0.29	1.08	0.10	2.39	0.38	0.81
CD (5%)	0.82	3.02	0.27	6.71	1.05	2.27
MCT x K						
SE ±	0.51	1.86	0.17	4.14	0.65	1.40
CD (5%)	NS	NS	NS	NS	NS	NS

Note: During 2015-16 and 2017-18 due to deficient rainfall sowing was not carried out.

The application of potassium @ 37.50 kg K_2O ha^{-1}(K_3) recorded significantly higher mean pigeonpea equivalent grain yield (13.87 q ha^{-1}) However, it was on par with K_4. The application of 50.00 kg K_2O ha^{-1} recorded significantly highest mean straw yield (27.93 q ha^{-1}) and it was on par with K_3 and K_2. Mallesha et al. (2014) reported higher grain yield of pigeonpea where fertilizer dose of 25:50;25 N:P_2O_5:K_2O kg ha^{-1} applied. Interaction effects were found to be non-significant for grain and straw yields.

Moisture use efficiency:

The mean moisture use efficiency (MUE kg ha^{-1} mm^{-1}) was recorded significantly higher in the treatment M_3 (3.07 kg ha^{-1} mm^{-1}). But it was found on par with M_2. The crop nutrient uptake depends on the amount of nutrients and amount of moisture in the soil. Moisture conservation practices helps to higher uptake of nutrient from the soil resulted in better crop growth and yield. (Mallareddy et al., 2016). The application of potassium at the rate of 37.5 kg ha^{-1} recorded significantly higher MUE (3.22 kg ha^{-1} mm^{-1}) and it was on par with K_2 and K_4.

Soil analysis at harvest:

The soil available nutrients status at harvest of pigeonpea is reported in Table 2. Among the different moisture conservation techniques, the treatment M_3 recorded significantly higher mean available nitrogen (173 kg ha^{-1}) and mean available potassium (774 kg ha^{-1}) and it was on par with M_2 treatment. Among the potassium levels, application of potassium @ 37.5 kg K_2Oha^{-1} recorded significantly higher mean available nitrogen content (174 kg ha^{-1}) and mean available potassium content (782 kg ha^{-1}) over rest of the treatments except K_0 and K_1. The mean available phosphorus content was found to be significantly highest in K_2 treatment (20.65 kg ha^{-1}) over rest of the treatments except K_0 and K_1. The interaction effects were also found to be significant for available phosphorus content. The treatment M_1K_2 recorded significantly highest available P content (21.81kg ha^{-1}) over rest of the treatments.

Nutrient uptake:

The rain water conservation techniques, M_3 recorded significantly highest mean uptake of P and K (19.01 and 39.70 kg ha^{-1}) respectively over rest of the treatments. Among the potassium levels, application of potassium @ 37.5 kg ha^{-1} (K_2) recorded significantly higher mean uptake of N, P and K (41.17, 19.35 and 39.85 kg ha^{-1}) respectively. Balpande etal*.,* (2016) reported the significantly increased potassium assimilation in pigeonpea with increased levels of K (Table 1).

Conclusion

The rain water conservation techniques *i.e.* Opening of ridges & furrow one month before sowing and transplanting of pigeonpea seedlings on 180 cm x 30 cm (transplanting of seedlings on alternate row + dibbling of black gram on the middle row) along with the application of 37.5 kg K_2O ha $^{-1}$ along with general recommended dose of fertilizers (25 : 50 N: P_2O_5 kg ha^{-1} + 2 t ha $^{-1}$ FYM) at the time of sowing grown on medium deep black soil considering the uncertainty of onset of rainfall in scarcity zone of Maharashtra is better for obtaining higher yield and to maintain nutrient status and retain moisture in soil.

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Sub-Soiling: A Resilient Technique for Effective Rainwater Conservation and Enhancing Production Potential of Soybean in Rainfed Agro-ecosystem

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Soybean has become an important oilseed crop in India in a very short period with approximately 10-million ha area under its cultivation. The major soybean growing states are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh, and Chattisgarh. Most of the area under soybean cultivation is a rainfed. Erratic behaviour of monsoon affecting the production potential. Soybean is grown on 13 lakh ha area in Marathwada region of Maharashtra state. Majority of the small and marginal farmers are preferring to grow soybean during *kharif* season. The average productivity of soybean varies depending of monsoon behavior. Occurrence of frequent dryspells affects the productivity of soybean in the region. Majority area falls under assured rainfall zone and is characterized by 2-3 prolonged dry spells during crop growth is the major constraint in achieving the targeted production potential. Productivity of soybean can be increased by sub-soiling techniques. Sub-soiling can be found effective in rainwater conservation and yield enhancement. Subsoiling facilitates downward water movement and enhances drainage so as to induce deeper penetration and consequently better root growth (Gajri et al., 1991). Annual sub-soiling reduced bulk density by 4.9% compared with no-till control plots on silty loam soils. Sub-soiling can increase soil porosity and decrease the soil bulk density up to 3-4% (Solhjou and Niazi, 2001). Consequently, infiltration rate in sub-soiled soils has been significantly improved than control (Soltanabadi et al., 2008). Sub-soiling breaks the hard pan layer of the soil and thus favours the percolation and enhances drainage and consequently induced deeper root penetration (Ishaq et al., 2001).

Methodology

The experiment was conducted during 2018-19 to 2023-24 for period of 6 years on research farm of All India Coordinated Research Project for Dryland Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani (Maharashtra). The average rainfall of the region is 892 mm. The soils of the area are medium black. The experiment was laid out in split plot with 4 replications, the experimental plot size was 4.5 m x 5.0 m and soybean was sown at 45 x 10 cm spacing. The recommended dose of fertilizer i.e. FYM 5 t ha^{-1} & (30:60:30 NPK Kg/ha) was applied. The experiment was executed with three main treatments viz., S_1 - Sub soiling in every year, S_2 - Sub soiling in alternate year and S_3 - Sub soiling once in three years with five sub treatments viz., D_1 - Sub-soiling at every 1.0 m horizontal distance, D_2 - Sub-soiling at every 1.5 m horizontal distance, D_3 - Sub-soiling at every 2.0 m horizontal distance, D_4 - Sub-soiling at every 2.5 m horizontal distance and D_5 - Sub-soiling at every 3.0 m horizontal distance. Soybean was sown using tractor drawn seed drill and subsoiling was executed using tractor drawn sub-siler. The infiltration rate under different treatments was determined by conducting infiltration test using double ring infiltrometer. Automatic stage level recorders with H-flume and stilling basin were installed for measurement of runoff and soil loss under different treatments.

Results

The interaction effect of sub soiling in years Vs. Sub soiling horizontal spacing is found to significant. The treatment of sub soiling in alternate year with a horizontal spacing of 1.5 m recorded highest soybean yield of 1501 kg/ha and is found significantly superior and at par with sub soiling in once in three year with with horizontal spacing of 2.0 m. Similar trend of NMR is also found in the interaction effect on an average mean minimum runoff of 280 mm was observed under sub soiling at every year followed in sub soiling in alternate year whereas maximum mean runoff of 336 mm was observed in sub soiling in once in three year. Among sub soiling spacing treatments, mean minimum runoff of 256 mm was observed in sub soiling at 1.5 m spacing followed by in the treatment of sub soiling at 1.0 m and 2.0 m spacings. On an average mean minimum soil loss of 3.01 tons/ha was observed under sub soiling at once in three years followed in sub soiling alternate year whereas mean maximum soil loss of 3.35 tons/ha was observed in sub soiling in every year. Among sub soiling spacing treatments, mean minimum soil loss of 2.56 tons/ha was observed in sub soiling at 1.5 m spacing followed by sub soiling at 2.0 m spacing. Therefore, it is observed that sub soiling in alternate years with a spacing of 1.5 m proved to be the best combination in reducing runoff and soil loss and thus effective rainwater conservation. Mean Infiltration rate was found higher under the treatment of sub soiling in every year with a spacing of 1.5 m and 2.0 m. Thus, it is observed that subsoiling increases infiltration rate.

Interaction effect of Sub soiling years and sub-soiling horizontal spacing on soybean grain yield

Soybean grain yield kg/ha					
Sub soiling rotation/years / Sub soiling horizontal spacing	**D_1**	**D_2**	**D_3**	**D_4**	**D_5**
S_1 - Sub soiling in every year	1390	1466	1449	1380	1346
S_2 - Sub soiling in alternate year	1424	1501	1484	1415	1380
S_3 - Sub soiling once in three years	1374	1451	1434	1365	1330
Interaction S x D					
SE +	17				
CD at 5%	52				
NMR, Rs./ha					
Sub soiling rotation/years / Sub soiling horizontal spacing	**D_1**	**D_2**	**D_3**	**D_4**	**D_5**
S_1 - Sub soiling in every year	33807	36799	36366	33838	32621
S_2 - Sub soiling in alternate year	35552	38544	38111	35583	34366
S_3 - Sub soiling once in three years	33893	36885	36452	33924	32707
Interaction S x D					
SE +	816				
CD at 5%	2448				

Conclusion

Sub soling in once in three with horizontal spacing of 1.5 m is found suitable for higher grain yield, moisture conservation and obtaining higher energy use efficiency.

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UID: 1126

Economic Evaluation of Minimum Tillage in Field Pea (*Var*. Aman) Cultivation in Rice Fallow: A Comparative Study from Mayangkhang and Hengbung Villages of Senapati District of Manipur

Jyotsna, Dipin, Ratan, David and Rocky Thokchom

Field pea (*Pisum sativum*) is an important leguminous crop grown in the rice-fallow ecosystems of North Eastern India, where its cultivation follows rice harvest. Rice-fallow land typically faces issues such as soil degradation and poor moisture retention, which can affect subsequent crop yields. Minimum tillage, which involves less soil disturbance compared to conventional tillage, has been suggested as a sustainable agricultural practice that may improve crop productivity and economic returns by conserving soil moisture, reducing labor costs, and increasing yield potential. This study aims to assess the economic impact of minimum tillage for field pea (*Var*. Aman) cultivation in rice fallows in two different villages: Mayangkhang and Hengbung of Manipur. By comparing demonstration plots using minimum tillage with local practices, this research provides valuable insights into the financial viability of adopting such sustainable agricultural practices in the region.

Methodology

Study area and crop

The study was conducted in two villages, Mayangkhang and Hengbung, over four cropping seasons (2016-17, 2018-19, 2020-21, and 2022-23). Both villages are located in the rice-fallow regions of Manipur, India. The crop under investigation was field pea (*Var*. Aman), a legume widely grown in rice fallows for its nitrogen-fixing properties and ability to improve soil health. In Mayangkhang village 5 hectares rice fallow land was dedicated to the study, involving 20 beneficiaries, whereas, in Hengbung village 5 hectares rice fallow land was dedicated to the study, involving 21 beneficiaries.

Experimental design

The experiment compared two types of agricultural practices for field pea cultivation.

a. Demo plots: Plots where minimum tillage was applied.

b. Local plots: Plots where traditional tillage methods were used.

Each village had both Demo and Local plots, and the data for yield, gross cost, net income, and Benefit Cost Ratio (BCR) were collected and analyzed annually.

Parameters recorded

The yield of field pea in quintals per hectare for both Demo and Local plots were measured at the time of harvesting. The total expenses incurred in the cultivation process were calculated as gross cost (Rs.). It includes all direct and indirect costs such as labor, seeds, fertilizers, irrigation, and equipment usage.

Gross Cost = Total expenditure on cultivation (seeds, labor, fertilizers, etc.)

Net income was calculated subtracting the gross cost from the gross revenue. The net income from field pea cultivation, calculated by following formula:

Net Income = Gross Revenue - Gross Cost

where, Gross Revenue=Yield (q/ha) × Market Price per quintal (Rs/q)

Benefit Cost Ratio (BCR) is calculated as the ratio of net income to gross cost. It indicates the economic profitability of the cultivation system. It calculated by the following formula:

BCR = Net Income/Gross Cost

A BCR greater than 1 indicates a profitable venture, while a BCR less than 1 suggests the system is not profitable.

Data analysis: For each year, yield data for both Demo and Local plots were compared to assess the effect of minimum tillage on field pea productivity. For gross cost (Rs), the cost of cultivating field pea in both types of plots was recorded to assess the financial investment. Net Income (Rs) was calculated from the difference between gross revenue and gross cost for both Demo and Local plots. The BCR was calculated to compare the profitability of both farming methods. The BCR was used to assess the economic feasibility of adopting minimum tillage for field pea cultivation in rice-fallow systems. The results were summarized for each year and compared to determine trends and differences in economic performance between the Demo and Local plots over the four years.

Statistical analysis: The data was analyzed using descriptive statistics to assess trends in yield, gross cost, net income, and BCR over the study period. The economic performance of both practices was compared using the calculated BCR to determine which method provided better economic returns.

Results

***Mayangkhang Village*:** As per the data in Table 1, the average yield in the Demo plots increased from 13.62 q/ha in 2016-17 to 14.00 q/ha in 2022-23, showing a consistent increase over the years. In contrast, the Local plots had a lower yield, ranging from 11.02 q/ha in 2016-17 to 11.93 q/ha in 2022-23. The gross cost in the Demo plots ranged from Rs 47,500 in 2016-17 to Rs 48,819.43 in 2022-23, with a slight increase in each season. The Local plots had a lower cost, with values ranging from Rs 43,256 in 2016-17 to Rs 46,823.95 in 2022-23. The net income for the Demo plots increased from Rs 32,060 in 2016-17 to Rs 32,953.24 in 2022-23. The Local plots had a net income of Rs 15,321 in 2016-17, increasing to Rs 16,600.57 in 2022-23. The BCR for the Demo plots remained constant at 1:68:1 throughout the study period, indicating consistent profitability. The Local plots had a BCR of 1:35:1, showing lower returns compared to the Demo plots.

Table 1. Economics of demonstration from minimum tillage of field pea *var.* Aman in rice fallow of Mayangkhang village

Economics of demonstration	2016-17		2018-19		2020-21		2022-23	
	Demo	Local	Demo	Local	Demo	Local	Demo	Local
Yield (q/ha)	13.62	11.02	13.74	11.29	13.86	11.40	14.00	11.93
Gross Cost (Rs)	47500	43256	47913.91	44301.26	48302.62	44741.86	48819.43	46823.95
Net income(Rs)	32060	15321	32347.23	15692.44	32627.73	15851.02	32953.24	16600.57
BCR	1:68:1	1.35:1	1:68:1	1.35:1	1:68:1	1.35:1	1:68:1	1.35:1

*Area = 5 ha; Beneficiaries = 20

***Hengbung Village*:** A careful scrutiny of the data in Table 2 that in *Hengbung* village, the Demo plots showed an increase in yield from 13.26 q/ha in 2016-17 to 13.82 q/ha in 2022-23. The Local plots showed a steady yield increase, from 10.90 q/ha to 11.60 q/ha over the same period. The gross cost in the Demo plots ranged from Rs 46,000 in 2016-17 to Rs 47,995.85 in 2022-23. The Local plots had a lower cost, with values ranging from Rs 42,652 in 2016-17 to Rs 45,488.77 in 2022-23. The net income for the Demo plots increased from Rs 22,100 in 2016-17 to Rs 22,937.66 in 2022-23. The Local plots showed a smaller increase in net income, from Rs 12,448 to Rs 13,223.47. The BCR for the Demo plots was consistent at 1:48:1, indicating higher profitability compared to the Local plots, which had a BCR of 1:29:1.

Table 2. Economics of demonstration from minimum tillage of field pea *var.* Aman in rice fallow of Hengbung village

Economics of demonstration	2016-17		2018-19		2020-21		2022-23	
	Demo	Local	Demo	Local	Demo	Local	Demo	Local
Yield (q/ha)	13.26	10.90	13.44	11.12	13.65	11.36	13.82	11.60
Gross Cost (Rs)	46000	42652	46484.38	43539.17	47243.87	44519.31	47995.85	45488.77
Net income (Rs)	22100	12448	22324.56	12772.47	22669.99	13015.56	22937.66	13223.47
BCR	1.48:1	1.29:1	1.48:1	1.29:1	1.48:1	1.29:1	1.48:1	1.29:1

**Area = 5 ha; Beneficiaries = 21*

The results clearly indicate that minimum tillage practices for field pea cultivation in both Mayangkhang and Hengbung villages consistently outperformed local traditional tillage practices in terms of yield, net income, and Benefit-Cost Ratio (BCR). The increase in yield in Demo plots can be attributed to better moisture conservation and improved soil structure due to reduced tillage. This enhanced yield directly contributed to higher net income despite the slight increase in gross cost over the years. The higher BCR in the Demo plots indicates that minimum tillage is more economically viable compared to the Local plots. While both villages showed similar trends, Mayangkhang demonstrated slightly higher yields and net incomes compared to Hengbung, possibly due to variations in soil quality, climate, and local farming practices. However, the overall findings suggest that minimum tillage is a beneficial practice for enhancing the profitability of field pea cultivation in rice-fallow systems.

Conclusion

This study highlights the significant economic benefits of adopting minimum tillage practices for field pea cultivation in rice fallows in the Mayangkhang and Hengbung villages. The demonstration plots consistently showed higher yields, net incomes, and BCR compared to local practices, making minimum tillage a promising sustainable agricultural practice. Encouraging farmers in rice-fallow regions to adopt minimum tillage could lead to enhanced productivity and economic stability, contributing to the overall sustainability of agricultural systems in the region.

UID: 1132

Impact of Organic and Integrated Nutrient Sources on Soil Quality and Yield of Rabi Sorghum+Chickpea (2:4) Intercropping System

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Poor soil properties and low soil moisture content are major limitations for cultivating a second crop after the rainy season in the drylands of Northern dry zone of Karnataka. Mulching by green leaf manure crop (Sunhemp and Glyricidia), crop residues (Sorghum stubbles), FYM and Vermicompost improvement in soil moisture content and recycles plant nutrients upon decomposition. Conservation of soil moisture offers an opportunity for stabilising and increasing yields of winter season crops in rainfed areas. Thus, conservation effective soil and nutrient management practices are needed to improve input use efficiency (Das *et al.,* 2020). Common inter cropping systems in the region are sorghum +chickpea (2:4), safflower + chickpea (1:3 or 2:4). The *rabi* cropping situation covers to an extent of 30-35 percent of the total net cropped area. With the above background, the present investigation was carried out to study the to study impact of soil properties and productivity of *rabi* sorghum and chickpea through integrated nutrient management.

Methodology

A field experiment was carried out during the *Rabi* season of 2017-18 to 2022-23 under the Northern dry zone of Karnataka at All India Coordinated Research Project for Dryland Agriculture, Vijayapura centre. The experiment was laid out in a randomized complete block design (RCBD) with three replications and seven treatments (T1 – Control, T2 – Recommended package practices (RPP), T3 - 50% N through FYM + 50% inorganic sources, T4 - 50% N through vermicompost + 50% inorganic sources, T5 - 50% N through sunhemp + 50% inorganic sources, T6 - 50% N through Glyricidia loppings + 50% inorganic source, T7 - 50% N through crop residues + 50% inorganic sources). The *Rabi* Sorghum + Chickpea (2:4) intercropping system was rotated with safflower + chickpea (2:4) next year and birotational system continuous.

Results

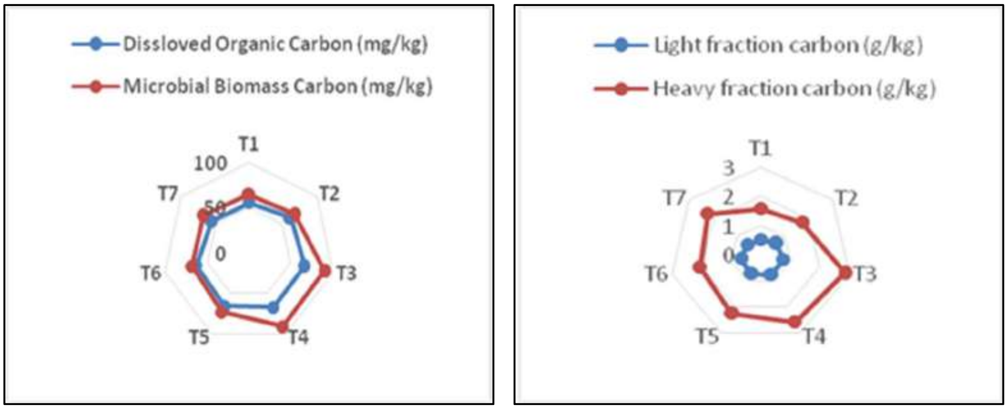
Results of pooled data indicated that application of 50% N through FYM + 50% N through inorganic sources was recorded the significantly higher sorghum equivalent yield (1972.0 kg/ha), B:C ratio (3.2) and rain water use efficiency (24.9 kg/ha-mm) in *rabi* sorghum + chickpea intercropping system and statistically on par with 50% N through vermicompost + 50% inorganic sources and 50% N through sunhemp + 50% inorganic sources with respect to sorghum equivalent yield (1835.0 kg/ha) and B:C ratio (3.1) as compared to control.

The improved soil chemical properties like decrement of pH from 8.01 to 7.82, organic carbon (0.51 %), available N (211.7 kg/ha), available P_2O_5 (18.0 kg/ha), available K_2O (422.7 kg/ha); and DTPA extractable Zn, Fe, Cu and Mn values of 0.48, 2.53, 0.80 and 3.69 mg/kg, respectively. Soil organic carbon pools of dissolved organic carbon (66.9 mg/kg), microbial biomass organic (90.4 mg/kg), light fraction carbon (0.77 mg/kg) and heavy fraction carbon (2.58 mg/kg); were recorded with the application of 50% N through FYM + 50% N through inorganic sources as compared to control.

Soil chemical properties as influenced by organic and inorganic sources of nutrients on *Rabi* Sorghum + chickpea (2:4) intercropping system (Pooled: 2017-18 to 2022-23)

Treatment	pH	Organic C (%)	Av. nutrient (kg/ha)			Micronutrient (ppm)			
			N	P_2O_5	K_2O	Zn	Fe	Cu	Mn
T1	8.10	0.42	177.7	13.1	385.4	0.35	1.72	0.61	2.85
T2	8.08	0.44	194.4	14.5	392.5	0.42	2.19	0.64	3.31
T3	7.82	0.51	211.7	18.0	422.2	0.48	2.53	0.80	3.69
T4	7.78	0.50	209.4	17.7	419.2	0.48	2.57	0.79	3.62
T5	7.84	0.48	205.0	16.9	413.1	0.48	2.21	0.73	3.53
T6	7.88	0.45	201.6	16.3	391.5	0.46	2.19	0.69	3.34
T7	7.98	0.43	191.7	16.1	388.9	0.44	2.11	0.66	3.24
Mean	7.93	0.46	198.8	16.1	401.8	0.44	2.21	0.70	3.37
Sem±	0.04	0.01	2.6	0.3	2.0	0.005	0.06	0.01	0.04
CD (p=0.05)	0.12	0.03	7.5	1.0	6.0	0.01	0.2	0.04	0.12
CV (%)	8.8	9.1	7.8	10.3	9.8	8.9	7.8	9.1	10.2
Initial value of soil properties	7.92	0.43	191.0	13.3	424.0	-	-	-	-

RPP: 3 t/ha FYM + 50: 25:0: N: P_2O_5: K_2O kg/ha



Influence of organic and inorganic sources of nutrients on soil organic carbon pools

Conclusion

Permanent manorial trials assess the long-term effects of organic and inorganic sources of nutrients on yield, chemical properties of soil. The present study conducted for six years with 3 sets of birotational systems indicated that 50% N through FYM or vermicompost or sunhemp along with 50% N through inorganic sources improved yield and soil chemical properties in *rabi* sorghum + chickpea (2:4) intercropping systems of Northern dry zone of Karnataka.

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Effect of Foliar Spray on Cowpea [*Vigna unguiculata (L.) Walp*.] Under Rainfed Condition

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An investigation was carried out College of Agriculture, Navsari Agricultural University, Campus Bharuch during *kharif* 2023. The experiment was arranged in a randomized block design (RBD) with nine treatments, which included: T1 (Control), T2 (RDF 20-40-00 NPK kg/ha), T3 (RDF + 2% Panchagavya), T4 (RDF + 2% Cow urine), T5 (RDF + 2% Vermi bed wash), T6 (RDF + 1% Novel), T7 (RDF + 2% Urea), T8 (RDF + 1% 19-19-19) and T9 (RDF + Nano urea 2 ml/lit), each with three replications. The soil of experimental plot was clayey with low in available nitrogen (240.42 kg/ha), available phosphorus (39.58 kg/ha) and high in available potassium (338.28 kg/ha). The soil reaction (pH) was slightly alkaline (7.68). The finding revealed that, significantly higher growth parameters *viz*. plant height at 60 DAS (71.33 cm) and at harvest (75.38 cm), number of branches per plant at 45 (8.65) and 60 DAS (9.64), dry matter accumulation per plant at 45 DAS (20.80 g) and at harvest (32.24 g) recorded with treatment T6 (RDF + 1% Novel) however, it was found statistically at par with T3 (RDF + 2% Panchagavya) and T8 (RDF + 1% 19-19-19). While, number of root nodules per plant at 45 DAS did not show significant differences due to various foliar nutritions, but the highest number of root nodules (28.21) was observed under treatment T6 (RDF + 1% Novel). Yield attributes *viz*. number of pods per plant (25.55), number of seeds per pod (17.41) and length of pod (18.24 cm) as well as seed yield (1625 kg/ha) and stover (3004 kg/ha) yield were also recorded significantly higher with T6 (RDF + 1% Novel) and found statistically at par with T3 (RDF + 2% Panchagavya) and T8 (RDF + 1% 19-19-19). While, 100 seed weight was not significantly influenced by different treatments. Protein yield (354.61 kg/ha) was recorded significantly higher with T6 (RDF + 1% Novel), which was statistically at par with T3 (RDF + 2% Panchagavya) and T8 (RDF + 1% 19-19-19). Significantly, P (0.640%) and K (1.247%) content in the seeds and N, P and K (0.867%, 0.320% and 1.095%, respectively) in stover were significantly influenced by treatment T6 (RDF + 1% Novel. These values were statistically comparable to those in T3 (RDF + 2% Panchagavya). Significantly, the highest total N, P and K uptake by cowpea (82.75, 19.93 and 53.18 kg/ha, respectively), were reported under T6 (RDF + 1% Novel), over rest of the treatments, but it was statistically at par with T3 (RDF + 2% Panchagavya). Available nitrogen recorded significantly higher (277.20 kg/ha) in treatment T6 (RDF + 1% Novel), which was statistically comparable with T3 (RDF + 2% Panchagavya) and T8 (RDF + 1% 19-19-19). Application of T6 (RDF + 1% Novel) noted that higher agronomic efficiency of nitrogen (21.43 kg/kg) and phosphorus (10.72 kg/kg) as compared to rest of the treatments. While, higher apparent recovery efficiency of nitrogen and phosphorus resulted in treatment T6 (RDF + 1% Novel) by registering the value of 144.27% and 15.87% respectively. Among the different foliar nutrition maximum net return (1,01,851 ₹/ha) was achieved with foliar nutrition of T6 (RDF + 1% Novel) along with BCR of (3.31). While, lowest net return (71,324 ₹/ha) was achieved with T1 (Control). Based on one year field experiment, it can be concluded that cowpea *cv*. GC 3 fetched appreciably higher yield and economic returns when fertilized with RDF (20-40-00 NPK kg/ha) along with foliar nutrition 1% Novel or 2% Panchagavya or 1% NPK (19-19-19) at branching and flowering stages.

UID: 1139

Moisture Conservation through Crop Residues in Pearl Millet [*Pennisetum glaucum* (L.)] under Rainfed Condition of Northern Dry Zone of Karnataka

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Pearl millet [*Pennisetum glaucum* (L.)] is an important cereal crop of arid and semi-arid regions of India. It is popularly known as Bajra and being drought tolerant generally grown as rainfed crop on marginal lands under low input management conditions. Pearl millet grains are not only nutritionally comparable but are also superior to major cereals with respect to protein, energy, vitamins and minerals (Rao *et al.*, 2006). Besides they are rich source of dietary fibre, phytochemicals, micronutrients, nutraceuticals and hence, now a days they are rightly termed as “nutricereal”.

Use of crop residues as a mulch is a viable approach to retain soil moisture and nutrients under rainfed situation because mulch is poor conductor of heat that effectively moderates soil temperature, maintains soil moisture and helps to increase the soil fertility. If the variety or hybrid is stay green type then fodder is used for livestock. Otherwise the fodder is burnt. Burning of crop residue has significant implications for climate change (Kumar *et al.*, 2015). This leads to the emission of harmful gases and air pollutants into the atmosphere. With this background the experiment was planned with the objectives: to study the growth and productivity of pearl millet as influenced by crop residue cover and to study the soil fertility status after incorporation of residues.

Methodology

The field experiment was conducted during three consecutive *kharif* seasons of 2020, 2021 and 2022 under AICRP on Pearl millet at RARS, Vijayapur having annual rainfall from 550 to 680 mm. Soil of the experimental plot was clay loam in texture, alkaline in reaction (pH 8.35) with low organic carbon (0.60%). The available soil N, P and K were 212.00, 22.3 and 401.9 kg ha^{-1}, respectively. The experiment was laid out in randomized block design with ten treatments replicated thrice. The treatments were T_1: Control, T_2: Crop residue (CR) mulch at 5.0 t/ha, T_3: Pusa Hydrogel dry at 5.0 kg/ha, T_4: SPG 1118 dry at 5.0 kg/ha, T_5: Pusa Hydrogel slurry at 5.0 kg/ha, T_6: SPG 1118 slurry at 5.0 kg/ha, T_7: T_3+ CR mulch at 5.0 t/ha, T_8: T_4+ CR mulch at 5.0 t/ha, T_9: T_5+ CR mulch at 5.0 t/ha and T_{10}: T_6+ CR at 5.0 t/ha. Urea and diammonium phosphate (DAP) were used as source of nitrogen and phosphorus. The seed rate used was 4 kg ha^{-1} with plant geometry at 45 x 15 cm in each experimental plot. Dry powder and slurry (dry powder mixed in water) of Pusa Hydrogel and SPG 1118 were applied during sowing to the seed rows. Previous year stored pearl millet residue was applied/placed in between the rows at 15 DAS (after thinning). Standard procedures were used to measure the growth and yield parameters. Significance and non-significance difference between treatments were derived through the procedure provided for a single LSD value (Gomez and Gomez, 1984).

Results

Mean data of three years indicate that, in pearl millet compared to T_1 i.e. control plot (1614 and 5314 kg/ha) (Table 1) treatment combination of crop residue mulch at 5.0 t/ha + SPG 1118 (polymer gel) slurry application at 5.0 kg/ha i.e. T_{10} recorded significantly higher grain and dry fodder yield, respectively (2242 and 7131 kg/ha) and it was on par with T_2: crop residue mulch at 5.0 t/ha at 10-15 DAS (2139 and 6989 kg/ha), T_9: crop residue mulch at 5.0 t/ha + Pusa hydrogel slurry application at 5.0 kg/ha (2125 and 7096), T_8: crop residue mulch at 5.0 t/ha + SPG 1118 dry application at 5.0 kg/ha (2057 and 6961 kg/ha) and T_7: crop residue mulch at 5.0 t/ha + Pusa hydrogel dry application at 5.0 kg/ha (2055 and 6861 kg/ha). Growth parameters like plant height and no of productive tillers also showed the same trend. Whereas, net returns was significantly higher in T_2 (Rs. 25,968 per ha) compared all other treatments.

Table 1. Effect of moisture conservation technologies on growth, yield and net returns of pearl millet

Treatments	Plant height (cm)	No of productive tillers/plant	Grain yield (kg/ha)	Dry fodder yield (kg/ha)	Net returns (Rs./ha)
T_1	160.6	2.53	1614	5314	17,559
T_2	174.3	2.84	2139	6989	25,968
T_3	167.6	2.58	1861	6121	16,835
T_4	169.1	2.58	1768	6046	15,265
T_5	169.2	2.62	1844	6492	16,535
T_6	169.9	2.64	1957	6496	18,518
T_7	171.6	2.73	2055	6861	19,476
T_8	172.4	2.82	2057	6961	19,459
T_9	175.2	2.96	2125	7096	20,722
T_{10}	176.3	3.00	2242	7131	22,834
S.Em ±	1.9	0.05	65.6	171.5	1183.1
C.D.(0.05)	5.6	0.16	194.8	509.5	3515.3

The data on available soil nutrients status showed that T_2 i.e. Crop residue mulch at 5.0 t/ha (232.23, 25.14, 428.50 kg/ha), T_{10}: T_6+ CR at 5.0 t/ha (229.43, 24.58 and 428.97 kg/ha), T_9: T_5+ CR mulch at 5.0 t/ha (230.37, 24.71 and 434.77 kg/ha), T_7: T_3+ CR mulch at 5.0 t/ha (222.63, 24.85 and 419.83 kg/ha) and T_8: T_4+ CR mulch at 5.0 t/ha (228.67, 26.36 425.10 kg/ha) were recorded significantly higher available soil NPK, respectively than the control plot (203.03, 21.12 and 393.47 kg/ha). Grain uptake of NPK was significantly higher in T_{10}

(43.52, 11.70 and 21.79 kg/ha) and it was found to be on par with T_2 (42.28, 10.32 and 20.92 kg/ha), whereas T_1 (30.09, 7.96 and 14.75 kg/ha) recorded significantly lower value.

Table 2. Effect of moisture conservation technologies on nutrient status of soil after harvest of pearl millet and uptake of nutrients by grain (kg/ha) (After *Kharif* 2022 harvest)

Treatments	Available N	Available P	Available K	N uptake	P uptake	K uptake
T_1	203.03	21.12	393.47	30.09	7.96	14.75
T_2	232.23	25.14	428.50	42.28	10.32	20.92
T_3	206.23	22.60	404.70	35.83	10.07	18.56
T_4	210.30	21.59	396.70	34.62	8.74	16.41
T_5	198.17	22.15	401.23	35.24	9.20	19.32
T_6	208.83	20.70	407.07	39.47	9.77	20.48
T_7	222.63	24.85	419.83	40.97	10.72	19.92
T_8	228.67	26.36	425.10	42.39	11.16	20.99
T_9	230.37	24.71	434.77	41.77	10.66	24.40
T_{10}	229.43	24.58	428.97	43.52	11.70	21.79
S.Em ±	7.52	0.97	9.16	1.66	0.64	2.62
C.D.(0.05)	22.35	2.88	27.21	7.44	1.89	7.77

Conclusion

The experimental Results indicated that treatment T_2 i.e. crop residue (CR) mulch at 5.0 t/ha was given significantly higher grain and dry fodder yield in pearl millet. Polymer application with crop residues i.e. treatment T_{10} was also given higher grain and dry fodder yield but the cost of polymer increases the cost of cultivation and hence recorded lower net returns. Application of crop residue mulch at 5 t/ha at 10-15 DAS in pearl millet was found to be economically better.

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Productivity and Profitability of Integrated Sources of Nutrients on Maize (*Zea mays*) under Rainfed Midhills of Jammu

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Globally maize is grown on an area of about 197.19 million hectares with production of 1125.03 million tones and the average productivity is 5.71 t ha^{-1}. In India, it is cultivated on an area of 9.21 million hectare with production of 25.13 million tones and productivity of 2.63 t ha^{-1} (Anonymous, 2020). In J&K Union Territory, maize is grown on an area of about262.35thousand hectares with a production of 5744thousand tones and productivity of 2.12 t ha^{-1} (Anonymous, 2019). Maize is the most important cereal crop grown extensively during *kharif* season in Jammu region. The profitable production of maize crop may be affected by many factors, among these soil fertilities to produce maize grain and straw is of immense significance. The Jammu region soil have been exhausted in macro and micro nutrients, therefore hampering the yield of crops. The fertilizer use status indicates that a notable bulk of chemical fertilizers is being used in the Jammu and Kashmir including huge amount of nitrogenous fertilizers. Nitrogen supply through chemical fertilizer to the plant not be taken by the crop plants efficiently due to the volatilization and leaching losses. The adverse effects of chemical fertilizers on soil health and high cost of nitrogenous fertilizers restricts the use of this input. The organic manures are natural sources of nutrients and inclusion of the organic manures like FYM and Mule compost in management has become a necessity to improve the soil fertility and to sustain the productivity of maize crop. Therefore, the present investigation was taken up to study the effect of inorganic and organic fertilizer application on productivity, nutrient uptake and improve soil properties

Methodology

A field experiment was carried out at research farm of Maize Breeding Research Station, Udhampur, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during 2023. An experiment comprises of ten combinations of organic and inorganic fertilizers viz: T_1-Control, T_2-100 % recommended NPK , T_3-100 % recommended NPK +1 % $ZnSO_4$, T_4-100 % recommended NPK + 0.1 % Borax, T_5-75 % recommended N + 25% FYM, T_6-75 % recommended N + 25% N Mule, T_7-75 % recommended N + 25 % N FYM + 1 % $ZnSO_4$, T_8-75 % recommended N + 25 % N FYM + 0.1 % Borax, T_9-75 % recommended

N + 25 N Mule + 1% $ZnSO_4$ and T_{10}-75 % recommended N + 25% N Mule + 0.1 % Borax were tested in randomized block design under sandy loam soil having slightly acidic in nature, well drained low in carbon, (0.35), low in available nitrogen (220 kg ha^{-1}) and potassium (185 kg ha^{-1}) and medimum in available phosphorous (16.21 kg ha^{-1}).

Results

The results revealed that the maximum grain yield of maize (3688 kg/ha) was obtained with the application of 100 % recommended NPK +1 % $ZnSO_4$ (T_3) which was statistically at par with 75 % recommended N + 25 N Mule + 1% $ZnSO_4$ (T_9) and 100 % recommended NPK + 0.1 % Borax, (T_4) and 75 % recommended N + 25% N Mule + 0.1 % Borax (T_{10}) grain yield 3625, 3500 and 3431.The minimum grain yield of 2000 kg/ha was obtained in the control. The highest net returns to the tune of Rs 70226/ ha were realized with the application of 100 % recommended NPK +1 % $ZnSO_4$(T_3) with corresponding benefit: cost ratio of 3.78 and also recorded maximum RWUE of 4.51. The minimum net return, benefit: cost ratio and RWUE was observed in control plots (Bhandari *et. al.* 2021).

Conclusion

It may be concluded that application of 100 % recommended NPK +1 % $ZnSO_4$ (T_3) which was statistically at par with 75 % recommended N + 25 N Mule + 1% $ZnSO_4$ was found to be best in terms of yield and economics of maize under Rainfed mid hills of North West Himalayas.

Effect of integrated application of organic and inorganic sources of nutrients on yield, economics and rain water use efficiency of maize

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivatio n (Rs/ha)	Net income (Rs/ha)	B:C ratio	RWUE (kh/ha-mm)
T_1	2000	3586	21700	30265	2.39	2.45
T_2	3306	5898	24929	60886	3.44	4.05
T_3	3688	6477	25249	70226	3.78	4.51
T_4	3500	6180	25329	65371	3.58	4.28
T_5	3014	5248	27088	50831	2.88	3.69
T_6	3125	5562	26338	54754	3.08	3.82
T_7	3292	5680	27408	57563	3.10	4.03
T_8	3111	5416	27488	52940	2.93	3.81
T_9	3625	6427	26658	67346	3.53	4.44
T_{10}	3431	5968	26738	61938	3.32	4.20
Mean	3209	5644	25893	57212	3.2	3.9
CD (05%)	344	549	-	-	-	-

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Moisture Conservation Practices Improve Productivity and Profitability of Rainfed Cropping Systems in Bundelkhand Region

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Bundelkhand region is ecologically sensitive due to various climatic and soil constraints resulting low crop productivity and higher natural resource degradation. The growing of *rabi* crops is difficult due to low soil moisture availability in post-monsoon season (Palsaniya et al., 2023). The dry spells, due to erratic rainfall distribution, especially at critical stages, affect the yield of kharif crops adversely. In rainfed areas, all the rainfall received is not available for the crops and a significant part is lost as runoff. In fact, successful dry farming depends chiefly upon the success with which the rains that fall during any season of the year may be stored and kept in the soil until needed by plant for their growth. The fundamental operation of dryland farming includes a soil treatment which enables the largest possible proportion of the annual precipitation to be stored in the soil. India's success in achieving the required agricultural production targets depends on its ability to conserve, manage, and recycle water resources (Lal, 2008). Keeping these facts in view, the present study was undertaken to assess the effect of different soil moisture conservation practices on productivity and profitability of rainfed cropping systems.

Methodology

A field experiment was conducted at ICAR-Indian Grassland and Fodder Research Institute, Jhansi during the 2018–2022. The Bundelkhand region is known for its frequent droughts, uneven terrain, infertile soil, and extreme temperatures. It experiences a semi-arid and receives an average annual rainfall of 908 mm, with 80 % of the precipitation occurring during the southwest monsoon from June to September. The remaining rainfall arrives through 'western disturbances' in the winter months, spanning from December to February. The soil of the experimental field was loamy in texture, low in organic carbon and available nitrogen and medium in available phosphorus and potassium.

The treatments consisted of four moisture-conservation practices and four cropping systems. The experiment was laid-out in a strip plot design with 3 replications. Runoff water was collected in the pond during *kharif* season and used for supplemental irrigation to *rabi* crops. In Sesbania-mustard system, Sesbania was grown and turn down in the soil at 45-50 DAS for green manuring. However, sorghum + cowpea was sown in paired row and harvested at 50% flowering stage for green fodder.

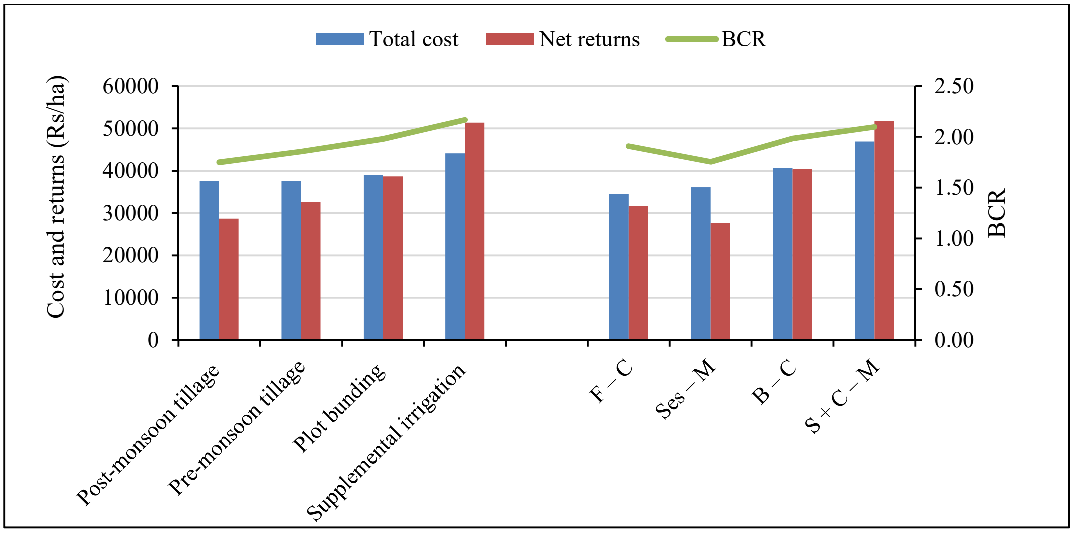
Chickpea equivalent yield (CEY) was calculated to compare cropping system performance by converting the yield of non-chickpea crops into equivalent chickpea yield on price basis.

Results

Sorghum + cowpea (fodder) – mustard cropping system had the highest system productivity (2.22 t/ha) with one supplemental irrigation, followed by blackgram – chickpea. The maximum rain water use efficiency (3.16 kg/ha-mm) was also recorded in sorghum + cowpea – mustard system followed by blackgram–chickpea system in the table give below. The effect of supplemental irrigation on system productivity was more pronounced in the blackgram – chickpea cropping system than the others. Plot bunding also helped to maintain higher soil moisture, particularly during stress periods, resulting in 15–18% higher system productivity in different cropping systems. Pre-monsoon tillage had a slight advantage over post-monsoon tillage for increasing system productivity. The cost of cultivation varied from minimum with fallow-chickpea (34.5×10^3 ₹/ha) to maximum under sorghum + cowpea – mustard system (46.9×10^3 ₹/ha). Similarly, the highest net return was also computed in sorghum + cowpea – mustard system (51.8×10^3 ₹/ha) which was 28.2, 63.4 and 87.7 percent higher than blackgram–chickpea, fallow–chickpea and *Sesbania* – mustard system, respectively. Similar trend was observed for benefit to cost ratio (BCR). Among moisture conservation practices, one supplemental irrigation gave the higher net return (51.4×10^3 ₹/ha) and BCR (2.17) followed by plot bunding (51.4×10^3 ₹/ha ; 1.98). One supplemental irrigation increased net return by 13-18% over rest of the treatments.

Effect of moisture conservation practices on system productivity in terms of chickpea equivalent yield (kg/ha) of different cropping systems (pool data of four years)

Moisture conservation practices	Fallow-chickpea	Sesbania-mustard	Blackgram-chickpea	Sorghum+cowpea-mustard	Mean
Post-monsoon tillage	1136	1085	1335	1744	1325
Pre-monsoon tillage	1184	1124	1446	1868	1406
Plot bunding	1352	1270	1543	2055	1555
Supplemental irrigation	1663	1594	2195	2221	1918
Mean	1334	1268	1630	1972	



Effect of moisture conservation practices and cropping systems on cost of production, net returns and BCR

Conclusion

On the basis of four years experimentation, it can be concluded that sorghum + cowpea (fodder) – mustard cropping system with one supplemental irrigation could be recommended for realizing higher productivity and profitability under rainfed conditions.

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Evaluating *in-situ* Moisture Conservation Techniques and Crop Suitability for Enhanced Productivity under Rainfed Conditions in the Pre-monsoon Season

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Rainfed agriculture, which relies heavily on seasonal rainfall, often faces challenges of inconsistent water availability, especially during the pre-monsoon season. Effective moisture conservation practices are crucial in these systems to optimize water use and reduce crop stress, ensuring higher productivity and stability. In-situ moisture conservation techniques, like compartmental bunding and tillage modifications, have shown promise in enhancing soil water retention and yield, especially in semi-arid regions. Crop selection also plays a vital role, as different species exhibit varying drought resilience and water-use efficiency. Legumes, for example, have been noted for their adaptability and soil-moisture conservation benefits. This study evaluates the combined effect of moisture conservation practices and crop choice to identify optimal strategies for rainfed pre-monsoon farming.

Methodology

A field experiment was conducted at AICRP on Dryland Agriculture, UAS, GKVK, Bangalore (12° 35' N latitude and 77° 35' E longitude at 930 m MSL) during the pre-monsoon season 2022 on a rainfed experimental farm to evaluate the effect of moisture conservation practices and crop choice on soil moisture retention, yield and economic returns. The experiment was laid out in a split-plot design with three replications. The main plot treatment comprises three moisture conservation practices: conventional tillage (M_1), duck foot cultivator tillage (M_2), and compartmental bunding (3×2.8 m) (M3). Sub-plots were assigned to three different crops: Green gram (C_1), Field bean (C_2), and Sesamum (C_3). Soil moisture was monitored at two depths (0-15 cm and 15-30 cm) at 30, 60, and 90 days after sowing (DAS) using a gravimetric method. Crop yields were recorded at harvest and rainwater use efficiency (RWUE) was calculated based on total seasonal rainfall and seed yield. Economic returns were estimated through net returns and the benefit-cost (BC) ratio. Statistical analysis was performed using ANOVA and significant differences were tested at $p=0.05$. This approach allowed assessment of the influence of both moisture conservation practices and crop type on yield, RWUE and economic viability under pre-monsoon rainfed conditions.

Results

Yield and economics: The experiment results in Table below demonstrate the significant effects of different moisture conservation practices and crop types on seed yield, rainwater use efficiency (RWUE), net returns and the benefit-cost (B:C) ratio during the pre-monsoon season. Among the moisture conservation practices, compartmental bunding (M_3) achieved the significantly higher seed yield (970 kg ha^{-1}), RWUE (1.47 kg ha-mm^{-1}), net returns (₹. 31,971 ha^{-1}), and BC ratio (1.94), as compared to both conventional tillage (M_1) and duck foot cultivator (M_2). Compartmental bunding likely contributed to improved soil moisture retention and reduced runoff, aligning with recent studies that report enhanced water conservation and yield benefits from bunding in rainfed agriculture (Prasad *et al.*, 2023). Duck foot cultivation (M_2) also provided significant improvements over conventional tillage, likely due to enhanced soil loosening and moisture retention that improved RWUE and yield, although not as effectively as compartmental bunding. Among the crop types, field bean (C_2)

and green gram (C_1) demonstrated the highest seed yields, with field bean yielding 1,176 kg ha⁻¹ and green gram yielding 1,113 kg ha⁻¹. In terms of RWUE, field bean and green gram also exhibited superior performance (1.79 and 1.69 kg ha-mm⁻¹, respectively) compared to sesamum, which yielded only 441 kg ha⁻¹ with an RWUE of 0.67 kg ha-mm⁻¹. This trend aligns with recent findings that highlight the adaptability of legumes like field bean and green gram to moisture-limited conditions, often due to their deep root systems and efficient nutrient uptake (Sharma & Kumar, 2024; Singh et al., 2022). Additionally, the high economic returns and BC ratio for green gram (₹. 50,183 ha⁻¹, 2.39) reinforce its suitability as a profitable pre-monsoon crop choice under rainfed conditions, consistent with prior research on legume profitability (Kumar *et al*., 2021). Compartmental bunding as a moisture conservation practice shows substantial potential to improve seed yield, water use efficiency, and economic returns under pre-monsoon rainfed conditions. Among crops, green gram and field bean emerged as the most productive and economically viable, particularly when paired with effective moisture conservation techniques. Implementing these strategies could significantly benefit farmers operating under similar agro-climatic conditions.

Soil moisture content (%): The soil moisture content observed from the study highlight the impact of different moisture conservation practices and crop types on moisture retention across soil depths (0-15 cm and 15-30 cm) at 30, 60, and 90 days after sowing (DAS) during the pre-monsoon season. Among the moisture conservation practices, compartmental bunding (M3) consistently retained the highest soil moisture at all stages (33.06%, 30.81%, and 34.27% at 30, 60, and 90 DAS, respectively, in both soil depths). This practice significantly outperformed both conventional tillage (M_1) and the duck foot cultivator (M_2). The improved moisture retention with compartmental bunding can be attributed to its ability to limit surface runoff and increase infiltration, which is consistent with findings by Rathod et al. (2023) and Patel *et al*. (2022), who reported that bunding practices enhance soil moisture conservation and reduce water stress in rainfed cropping systems. The duck foot cultivator (M_2) also showed better moisture retention than conventional tillage (M_1) at each depth and time point, although the differences were less pronounced compared to compartmental bunding. This improvement in soil moisture could be due to the deeper soil loosening achieved by the duck foot cultivator, which enhances water infiltration and reduces evaporation rates. Across all crops, field bean (C_2) had the highest soil moisture content at each DAS (29.47%, 25.95%, and 29.79% at 30, 60, and 90 DAS, respectively), followed closely by green gram (C_1). Sesamum (C_3), however, consistently showed the lowest soil moisture content, indicating its relatively higher water demand and/or limited root system, which may have resulted in reduced soil moisture retention. This trend aligns with previous studies by Sharma and Kumar (2024) and Singh *et al.* (2022), which observed that legumes like field bean are more effective in conserving soil moisture due to their deep-rooting systems, which reduce the rate of moisture depletion in the topsoil. Compartmental bunding significantly improves soil moisture retention in both the 0-15 cm and 15-30 cm soil layers throughout the crop growth stages. Among the crops, field bean and green gram exhibited the highest soil moisture retention, making them suitable choices under moisture-conservation-focused practices. Implementing these conservation practices could help sustain soil moisture and reduce the adverse effects of dry spells in rainfed farming.

Effect of moisture conservation practice and different crops on yield and economics in pre monsoon season

Treatment	Seed yield (kg ha^{-1})	RWUE (kg ha-mm^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Main Plot: Moisture conservation practices				
M_1: Conventional tillage	828	1.26	23892	1.72
M_2: Duck foot cultivator	932	1.42	27506	1.78
M_3: Compartmental bund (3 x 2.8 m)	970	1.47	31971	1.94
S.Em.±	25.28	0.04	2072	-
CD (p=0.05)	99.28	0.15	8136	-
Sub plot: Crops				
C_1: Green gram	1113	1.69	50183	2.39
C_2: Field bean	1176	1.79	23108	1.65

Conclusion

The study concludes that compartmental bunding is the most effective in-situ moisture conservation practice for enhancing soil moisture retention, yield and economic returns under rainfed pre-monsoon conditions. Among the crops evaluated, field bean and green gram showed superior performance in terms of yield, rainwater use efficiency and economic viability. Combining effective moisture conservation practices with suitable crops like field bean or green gram could optimize productivity and resilience in rainfed systems, benefiting farmers facing water-limited conditions.

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Influence of Tillage and Cover Crops on Productivity and Water Use Efficiency in Conservation Agriculture Based Pigeon Pea – Finger Millet Sequence Cropping System

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One of the biggest challenges in agriculture during the 21st century is to meet the food and fodder demands of the growing population and livestock from decreasing per capita land availability without environmental degradation. Advanced agronomic practices such as conservation, minimum tillage, cover cropping etc., absolutely necessary to enhance productivity and maintain environmental sustainability. Conservation agriculture is a sustainable system of farming that safeguard and conserves natural resources besides enhancing crop production. The three main principles of conservation agriculture (CA) (minimum soil disturbance, crop diversification and permanent soil cover) contribute to protecting the soil from erosion and degradation, improving soil quality and biodiversity, preserving the natural resources and increasing their use efficiency, optimizing crop yields, while imparting environmental sustainability (Sharma et al., 2022). Cover crops are defined as the close-growing crops that provide soil protection and soil improvement between periods of normal crop production. Cover crops can be leguminous or non-leguminous, known to improve sustainability of soil and environmental quality. Hence, the present study was undertaken to assess the influence of tillage and cover crops on productivity, water use efficiency and soil physio-chemical properties in conservation agriculture-based pigeon pea – finger millet sequence cropping system at the AICRP on Dry Land Agriculture, UAS, GKVK.

Methodology

A field experiment was conducted at AICRP on Dryland Agriculture, UAS, GKVK, Bangalore (12^o 35' N latitude and 77^o 35' E longitude at 930 m MSL) during 2021-23, India. The soil at the experimental site is red sandy loam with low in organic carbon content (0.32%) and available nitrogen (214.88 kg ha^{-1}), medium available phosphorus (42.50 kg ha^{-1}) and potassium (72.55 kg ha^{-1}) with a slightly acidic pH (5.17). Experiment layout using split-plot design with three replications consists of three treatments in the main plot - Conventional tillage (M_1), Reduced tillage (M_2) and Zero tillage (M_3) and three treatments in sub-plot – Control (C_1), Sunhemp (C_2) and Horsegram (C_3). Pigeon pea (Var: BRG-5) and finger millet (Var: MR-6) were sown in *Kharif* season using seed drill and zero till seed drill as per treatment. The water use efficiency was worked out in terms of grain yield/mm water. The observations recorded in these studies were analyzed statistically for test of significance following the Fisher's method of analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984).

Results

Yield: Tillage practices significantly influenced the seed yield of both pigeon pea and finger millet. Conventional tillage (M1) recorded the highest mean seed yield for pigeon pea (1023 kg ha^{-1}) and finger millet (2486 kg ha^{-1}), followed by reduced tillage (M2) with yields of 988 kg ha^{-1} for pigeon pea and 2367 kg ha^{-1} for finger millet. Zero tillage (M3) resulted in the lowest yields for both crops, with 854 kg ha^{-1} for pigeon pea and 2085 kg ha^{-1} for finger millet. The reduced seed yield under zero tillage could be attributed to poor seedbed preparation, leading to suboptimal plant growth and development. The results align with other studies indicating that conventional tillage often leads to higher initial yields due to better soil structure and root penetration, though long-term effects may favour reduced or zero tillage for sustainability. Among cover crops, horsegram (C3) significantly outperformed the control (C1) and sunhemp (C2) in terms of yield, with a mean pigeon pea seed yield of 1107 kg ha^{-1} and finger millet yield of 2414 kg ha^{-1}. The higher biomass production from horsegram likely contributed to improved soil fertility, benefiting the succeeding crops through enhanced nutrient cycling.

Economics: The benefit-cost (B:C) ratio followed a similar trend to yield. Conventional tillage (M1) resulted in a B:C of 1.75 for pigeon pea and 2.85 for finger millet. Reduced tillage (M2) slightly improved the pigeon pea BC ratio to 1.87 while maintaining similar values for finger millet. Zero tillage (M3) had the lowest BC ratio for pigeon pea (1.71) but the highest for finger millet (3.06), indicating its potential economic advantage in finger millet production despite lower yields. For cover crops, horsegram (C3) had the highest BC ratios of 2.01 for pigeon pea and 2.94 for finger millet, reflecting its superior productivity and cost-effectiveness. Sunhemp (C2) also performed well, but the control (C1) had the lowest

BC ratios, emphasizing the importance of integrating cover crops for improved profitability in conservation agriculture systems.

Yield, economics and water use efficiency as influenced by conservation agriculture practices and cover crops in pigeon pea - finger millet sequence cropping system

Treatments	Pigeon pea Seed Yield (kg/ha)			Finger millet Seed Yield (kg/ ha)	B: C ratio (Pigeon pea)			B: C ratio (Finger millet)	Pigeon pea RWUE (kg ha^{-1} mm^{-1})			Finger millet RWUE (kg ha^{-1} mm^{-1})
	2021	2023	Mean	2022	2021	2023	Mean	2022	2021	2023	Mean	2022
Tillage practice												
M_1	974	1071	1023	2486	1.92	1.58	1.75	2.85	0.82	1.80	1.31	2.98
M_2	941	1034	988	2367	2.05	1.69	1.87	2.96	0.79	1.74	1.27	2.92
M_3	813	894	854	2085	1.87	1.54	1.71	3.06	0.68	1.50	1.09	2.73
S. Em. ±	31.2	34.35	-	17.60	-	-	-	-	-	-	-	-
CD (p=0.05)	122.6	134.8	-	69.10	-	-	-	-	-	-	-	-
Cover crop												
C_1	752	827	790	2192	1.66	1.37	1.52	2.98	0.63	1.39	1.01	2.70
C_2	921	1012	967	2331	1.97	1.62	1.80	2.94	0.77	1.70	1.24	2.89
C_3	1054	1159	1107	2414	2.20	1.82	2.01	2.94	0.88	1.95	1.42	3.04
S. Em. ±	24.8	27.23	-	28.50	-	-	-	-	-	-	-	-
CD (p=0.05)	76.3	83.91	-	87.90	-	-	-	-	-	-	-	-

Water Use Efficiency (RWUE): Reduced tillage (M2) and zero tillage (M3) significantly enhanced the rainwater use efficiency (RWUE) of both crops compared to conventional tillage (M1). For pigeon pea, M2 and M3 recorded RWUE values of 1.27 kg ha mm^{-1} and 1.09 kg ha mm^{-1}, respectively, compared to 1.31 kg ha mm^{-1} under M1. In finger millet, zero tillage (M3) demonstrated the highest RWUE (2.73 kg ha mm^{-1}), reflecting its potential to utilize available water resources more efficiently. This improved RWUE under reduced and zero tillage could be linked to better soil moisture retention and reduced evaporation losses. Cover crops also had a significant impact on RWUE. Horsegram (C3) recorded the highest RWUE values for both pigeon pea (1.42 kg ha mm^{-1}) and finger millet (3.04 kg ha mm^{-1}), followed by sunhemp (C2). This suggests that cover crops, particularly horsegram, play a crucial role in enhancing water use efficiency by improving soil structure and moisture conservation. The study highlights the superiority of conventional tillage in achieving higher initial yields in pigeon pea and finger millet, but reduced and zero tillage practices offer better water use efficiency, making them suitable for long-term sustainability. The integration of horsegram as a cover crop significantly boosts crop productivity, economic returns and resource use efficiency. Therefore, reduced tillage with horsegram cover cropping emerges as a promising conservation agriculture strategy for improving yield, profitability and water use efficiency in the pigeon pea–finger millet cropping system (Srinivasarao et al., 2022).

Conclusion

This study highlights the benefits of conservation agriculture in the pigeon pea–finger millet cropping system, focusing on tillage practices and cover crops' influence on productivity, water use efficiency and soil health. While conventional tillage resulted in higher initial yields, reduced and zero tillage practices significantly improved rainwater use efficiency (RWUE), showing their potential for sustainable resource management in dryland agriculture. Horsegram, used as a cover crop, enhanced soil fertility and moisture retention, thereby boosting both yield and economic returns. The cover crop's impact on RWUE and crop productivity underlines its importance in conservation agriculture for optimizing resource efficiency and reducing input costs. The integration of reduced tillage with horsegram cover cropping proved particularly advantageous, combining improved yield, profitability and water conservation. These findings emphasize that adopting reduced tillage with suitable cover crops can be a robust approach to promoting resilient and sustainable farming in resource-limited dryland systems.

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Integrated Nutrient Management with Nano-N in Rainfed Production System

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The challenges faced in rainfed areas are multifaceted and complex. The primary issue, to which other problems are related, is the uncertainty of rainfall and its inadequate control and management in the field, resulting in low and unstable agricultural production. The brief duration of the rainy season and poor moisture retention capacity of soils due to topographical and textural factors further exacerbate the situation. Mitigating risk factors, implementing in-situ moisture conservation practices, appropriate fertilization, and adopting suitable crops, varieties, and agronomic practices are therefore crucial for the success of dryland agriculture. The combination of low rainfall and poor nutrient status has significantly impacted crop production in most arid regions. Integrated nutrient management and in-situ rainwater harvesting techniques contribute to improved soil fertility and crop productivity by enhancing nutrient availability in the root zone and increasing nutrient absorption. Maize, being a nutrient-demanding crop, responds favorably to nitrogen fertilization. The integrated use of chemical and organic fertilizers on yield and yield components of maize is critical for ensuring food security through the improvement of plant nutrient stocks in soils and the rapid uptake of plant nutrients, thereby limiting losses to the environment and reducing inorganic fertilizer input costs. Nitrogen is an essential nutrient for maize and a key determinant of grain yield, as it is a crucial element in the structural components of amino acids, nucleic acids, chlorophyll, ATP, and phytohormones. Soil water status has been demonstrated to have a significant indirect influence on the amount of available soil nitrogen, as well as the form in which it is absorbed by seedlings. Variations in soil water status may substantially affect the concentrations of mineral nutrients in soil solutions and their uptake by plants. Globally, more than 50% to 75% of applied conventional nitrogen fertilizer is not utilized by crops, and the recovery of applied nitrogen by maize rarely exceeds 50%. The low nitrogen use efficiency, adverse environmental effects, and the demand for nitrogen fertilizers necessitate the use of nano fertilizers as an alternative to conventional nitrogen fertilizers.

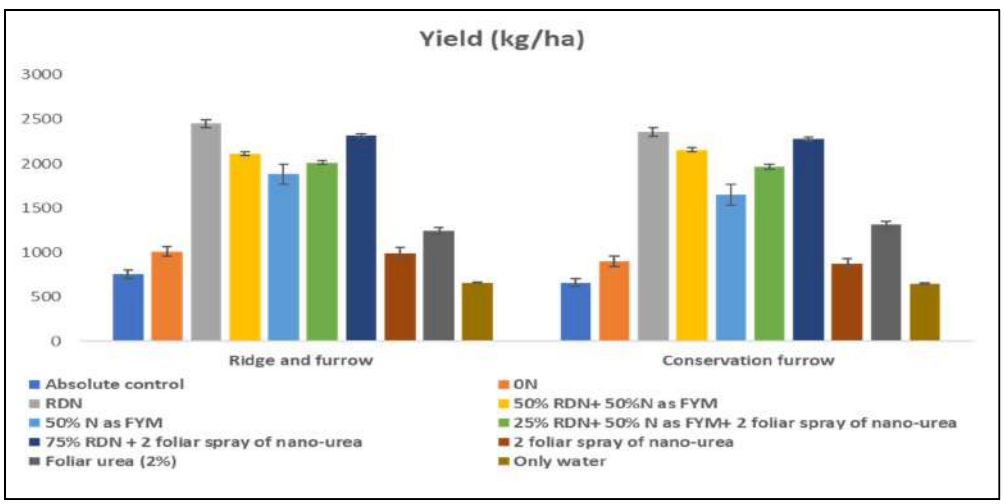
There has been significant interest and potential for utilizing nanotechnology and its products in agriculture to enhance resource use efficiency, reduce the excessive application of inorganic fertilizers and pesticides, and protect soil and environmental health through the judicious use of essential agro-inputs, particularly water and nutrients, in various crops on a sustainable basis. Nano-fertilizers are engineered to increase nutrient availability, thereby improving nutrient use efficiency. There is a dearth of information concerning the effect of integrated nutrient management practices with nano-fertilizers under in-situ soil moisture conservation practices in dryland cultivation. This study aims to elucidate impact of integrated nutrient management practices with nano-fertilizers on yield and soil Nitrogen content in dryland maize production system.

Methodology

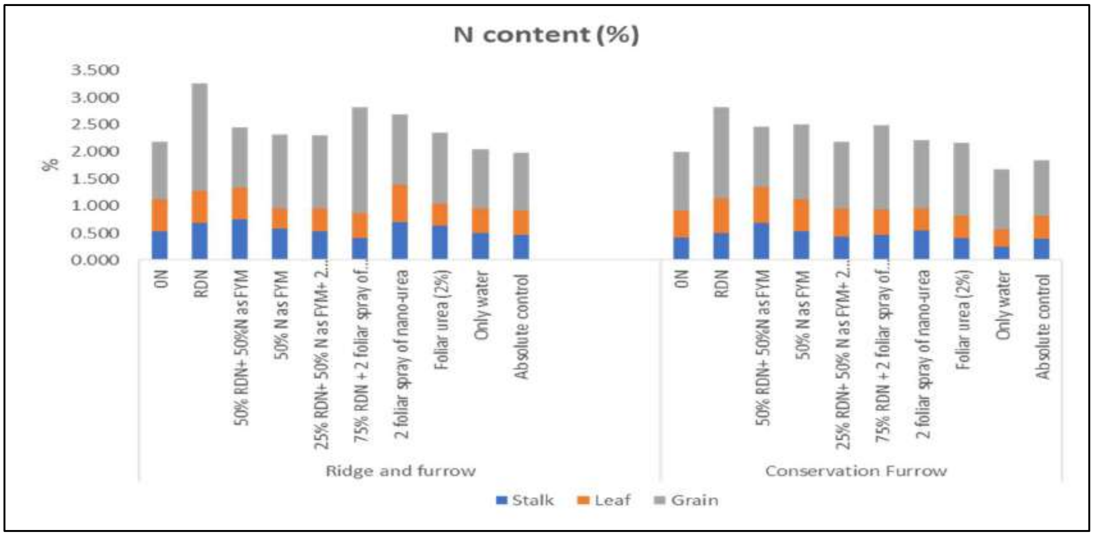
A field experiment was conducted at Gungal Research farm, CRIDA, Hyderabad in maize (var. DHM-117) with the following treatments: 0N (T1), Recommended dose of N (RDN) (T2), 50% RDN + 50% N as FYM (T3), 50% N as FYM (T4), 25% RDN + 50% as FYM + 2 foliar spray nano-N (T5), 75% RDN + 2 foliar spray nano-N (T6), 2 foliar spray nano-N (T7), foliar urea (2%) (T8), only water (T9), Absolute control (T10). The study was conducted under two in-situ soil moisture conservation practices: ridge and furrow and conservation furrow. The foliar sprays were administered at v7 and v11 stages of the crop. Various agronomic parameters, including plant height, leaf area, and yield, were measured. The plant leaf, stem, and grain samples were analyzed for N content using a CHNS analyzer. The soil available N was determined using the Subbiah and Asijah method (1959), and total N was determined using a CHNS analyzer. The NRAse activity of the leaves was analyzed colorimetrically at 540 nm following the foliar application of fertilizers.

Results

The study demonstrated that the administration of 75% RDN + 2 foliar spray nano-N and RDN resulted in higher crop production compared to the other treatments (as illustrated in the figure below). The yield under the application of only two foliar sprays of nano N and urea was significantly lower. However, the yield under conservation furrow was comparatively lower than that observed under ridge and furrow practice. The cob length ranged from 8 cm to 12 cm, with the maximum observed in RDN, followed by T6, T3, T5, and T4, and the minimum in absolute control. The plant height varied from 90 to 140 cm, with the maximum observed in T6, followed by other treatments. The leaf area in T6 and T2 were approximately equivalent, while the lowest values were observed in T7, T8, T9, and T10. The nitrate reductase activity (NRase), which indicates the activity of nitrate reductase enzyme in reducing nitrate to nitrite, was determined after foliar spraying of the fertilizers. It was observed that NRase activity in T6 and T2 was higher after both foliar spray schedules, followed by T3 and T5. The total nitrogen content in the harvested stalk, leaf, and grain samples is depicted in the figure below. The nitrogen content in grains was higher than that in stalks and leaves. The total N uptake was highest under T2, followed by T6, T3, T5, and T4, with no significant difference among the remaining treatments. The available N content in the post-harvest soils ranged from 150 to 220 kg/ha across the different treatments. The total N content was found to be significantly higher in the subsurface soils under both in-situ soil moisture conservation measures compared to the surface soils.



Yield under different N management treatments



Nitrogen content in harvested stalk, leaf and grain

Conclusion

The study demonstrated that replacing 25% of RDN with two foliar applications of nano-N under rainfed conditions can be considered viable, as it yielded results comparable to RDN. This approach potentially reduces the environmental impact associated with excess N fertilizer application while enhancing NUE.

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Improving Productivity of Rainfed Mungbean through Foliar Spray of Agrochemicals in Shivalik Foothills of Punjab

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In Punjab, *rainfed* area lies in North-Eastern part in the form of 10 to 20 km wide strip known as the '*Kandi*' area. The crop production in *rainfed* areas is mostly dependent on rainfall received during the monsoon season. The productivity of *rainfed* crops remains low, which is attributed to erratic distribution of rainfall, intermittent dry spells during the crop season, delayed onset and early withdrawal of the monsoon. Mungbean (*Vigna radiata* (L.) Wilczek) is a major food and cash crop in South and Southeast Asian farming systems (Rachaputi *et al* 2019). It is India's third most important pulse crop, accounting for nearly 16% of the country's total pulse area. Approximately 56% of India's cultivated land comes under *rainfed* agriculture, generating 40% of the nation's food supply (Venkateswarlu and Prasad 2012).

Implementing foliar application of agrochemicals emerges as a promising strategy to supplement mungbean plants' nutrient needs during crucial growth stages. This method offers potential benefits by optimizing the use of agrochemicals, curbing losses in various processes, and swiftly delivering nutrients to the crop. Therefore, ensuring an optimal supply of both macro and micronutrients under balanced conditions becomes imperative to achieve heightened productivity.

By identifying the most suitable sowing dates and optimizing agrochemical applications, this study aims to improve the resilience of rainfed mungbean systems and ensure a stable supply of this important legume crop, ultimately contributing to food security and economic development.

Methodology

A field experiment was conducted at Punjab Agricultural University (PAU)-Regional Research Station (RRS), Ballowal Saunkhri (SBS Nagar) during *kharif* seasons of 2022 and 2023. The experimental site is 346 metres above mean sea level and situated in the *Shivalik foothills.* The soil at experimental site was loamy sand in texture, normal in reaction (pH 7.0) and had electrical conductivity of 0.26 ds m^{-1}. It was low in available nitrogen (136.9 kg ha^{-1}), high in available phosphorus (24.2 kg ha^{-1}) and medium in available potassium (136.3 kg ha^{-1}). The experimental setup consisted of 14 treatments arranged in a split-plot design with three replications having two mungbean sowing dates (timely sowing and late sowing) that were taken in the main-plot. Seven treatments of foliar spray of agrochemicals [control, KNO_3 @ 1%, KNO_3 @ 1.5%, thiourea @ 500 ppm, thiourea @ 750 ppm, N:P:K (20:20:20) @ 1% and N:P:K (20:20:20) @ 1.5%] were taken as sub-plot treatment. Foliar spray of agrochemicals were done at flowering and pod formation stages in mungbean. Mungbean variety ML 1808 with a seed rate of 20 kg ha^{-1}, was planted at a depth of 4 cm using a seed drill, with row spacing set at 30 cm. The crop experienced a total of 381.3 and 236.1 mm of rainfall throughout the growing season during 2022 and 2023, respectively.

Results

Timely sown crop noted the highest seed yield, rainfall water use efficiency (RWUE), net return and BC ratio, which were significantly more than late sowing (Table). This was due to the fact that all the growth parameters were high in the timely sowing. Foliar spray of KNO_3 @ 1.5% produced the highest seed yield, RWUE, net return and BC ratio which were significantly higher than other treatments of agrochemicals, but it was statistically at par with foliar spray of N:P:K (20:20:20) @ 1.5% (Table). There was an increase of 33.2% in seed yield with foliar spray of KNO_3 @ 1.5% and increase of 29.1% in the second year with foliar spraying of N:P:K (20:20:20) @ 1.5% from control. The increased yield might be a result of nutrient supply through foliage precisely when the crop requires it, allowing for efficient translocation of photosynthates from source to sink. Shivshankar and Singh (2022) suggested that this increase in yield could stem from an augmented sink size, enhanced fruit setting, redirected energy toward the sink, efficient metabolite transfer, and subsequent accumulation of these metabolites in grains, ultimately leading to improvements in yield attributes and higher seed yield. When applied foliar as a solution in water for faster uptake, potassium stimulates cell turgor, which is required for growth and stomata opening. The application of KNO_3 through foliar spray has promoted the synthesis of free proline in plants and increased biosynthesis of phenols in plants and improved the plant water relations, which helps under stress conditions.

Productivity, rainfall water use efficiency, net returns and BC ratio of mungbean as influenced by sowing time and spray of agrochemicals (Pooled data of 2 years)

Treatments	Seed yield (kg/ha)	Rainfall Water use efficiency (kg/ha/mm)	Net returns (Rs/ha)	BC ratio
Sowing date				
Timely sowing	885	3.00	43,922	2.54
Late sowing	785	2.69	35,804	2.26
LSD (P=0.05)	29	0.08	2,814	0.12
Foliar spray of agrochemicals				
Control	700	2.36	29,876	2.08
KNO_3 @ 1%	888	3.04	43,947	2.54
KNO_3 @ 1.5%	933	3.18	47,402	2.65
Thiourea @ 500 ppm	776	2.63	35,229	2.25
Thiourea @ 750 ppm	786	2.66	35,924	2.27
N:P:K (20:20:20) @ 1%	862	2.95	41,865	2.46
N:P:K (20:20:20) @ 1.5%	904	3.09	44,923	2.55
LSD (P=0.05)	38	0.12	2,502	0.10

Conclusion

This study indicated that the optimum KNO_3 concentration for mungbean, foliar spray was 1.5%. Foliar spray of KNO_3 and N:P:K (20:20:20) can alleviate moisture stress during flowering and pod formation stages of mungbean which led to obtaining higher productivity under these foliar application of agrochemicals from the control crop.

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Yield and Soil Fertility of Bt cotton (Gossypium hirsutum L.) as Influenced by Soil and Foliar Application of Nutrients

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Cotton (Gossypium hirsutum L.) is considered an important fiber crop of India. Gujarat is the leading cotton growing state, which is grown in 2.76 mha with a productivity of 606 kg/ha (Anonymous,2017). External supplementation of plant nutrients needs to be emphasized keeping in view their role in improving yield and quality. Since little information is available on soil application of Mg and foliar spray of Mg, K, Fe and Zn on yield and soil fertility of Bt cotton, the present investigation was carried out for tlitywo years to draw conclusive inferences.

Methodology

The experiment was conducted during Kharif season of the years 2015 and 2016 at Agriculture Research Station, Sardarkrushinagar Dantiwada Agriculture University, Talod (North Gujarat on loamy sand soils. The soil was normal in EC (0.12 mmhos/cm), low in O.C (0.23%), medium in available P2O5 (48.6 kg/ha), available K2O (226 kg/ha) and deficient in Fe(3.79 ppm) and Zn(0.48 ppm). The experiment was comprised of 12 treatments of soil application of MgSO4 at square formation, flowering, and boll development stages arranged in a randomized block design with three replications

Results

Soil application of MgSO4 @ 15 kg/ha + three foliar sprays of KNO3 @ 3.0 % recorded significantly the highest seed cotton yield of 1569 kg/ha in pooled data. (Table 1). Similar findings that significantly increased seed cotton yield (SCY) per plant as compared with the untreated control were also reported by Basavaraj et al. (2017). Soil available magnesium was significantly increased due to soil application of MgSO4 @ 30 kg/ha + three foliar sprays of KNO3 @ 3.0 %, but it was found at par with the treatment combined with the soil application of MgSO4 @ 15 and 30 kg/ha during individual years and in pooled Results. Application of different treatments failed to exert their significant effect on available Fe and

Zn contents in soil (Table 2). Similar findings were also recorded by Uday Badugu (2012). The Results showed that the maximum gross income (Rs. 67467/ha) and net income (Rs. 31767/ha) were recorded due to soil application of MgSO4 @ 15 kg/ha + three foliar sprays of KNO3 @ 3.0 % (Table 1). This is on the expected line as the higher the nutrition to the crops higher the cotton yield will be and it will ultimately lead to higher gross and net returns.

Effect of different treatments on yield, economics and fertility (Pooled of 2 years data)

Treatment details	Seed cotton yield(kg/ha)	Net Income (Rs/ha)	Pooled data of soil fertility(ppm)		
	Pooled		Mg	Fe	Zn
Control(Three water sprays)	1136	21248	28.38	3.97	0.36
Three foliar sprays of KNO3 @ 1.5 %	1070	14810	27.38	4.34	0.36
Three foliar sprays of KNO3 @ 3.0 %	1298	21014	27.60	4.27	0.37
Soil application of MgSO4 @ 15 kg/ha	1055	17465	32.73	4.54	0.39
Soil application of MgSO4 @ 30 kg/ha	1171	21703	36.88	4.70	0.39
Soil application of MgSO4 @ 15 kg/ha +Three foliar sprays of KNO3 @ 1.5 %	1142	17006	33.93	4.61	0.40
Soil application of MgSO4 @ 15kg/ha +Three foliar sprays of KNO3 @ 3.0 %	1569	31767	33.48	4.73	0.41
Soil application of MgSO4 @ 30 kg/ha +Three foliar sprays of KNO3 @ 1.5 %	1287	22491	36.88	4.73	0.41
Soil application of MgSO4 @30 kg/ha +Three foliar sprays of KNO3 @ 3.0 %	1497	27921	36.88	4.76	0.41
Foliar application of ZnSO4 @ 0.5 % +FeSO4 @ 1.0 %	1285	27095	27.28	5.10	0.44
Soil application of MgSO4 @ 15kg/ha +Three foliar sprays of KNO3 @ 3.0 % + Foliar application of ZnSO4 @ 0.5 % +FeSO4 @ 1.0 %	1227	15901	34.73	4.91	0.43
Soil application of MgSO4 @30 kg/ha +Three foliar sprays of KNO3 @ 3.0 %+ Foliar application of ZnSO4 @ 0.5 % +FeSO4 @ 1.0 %	1436	24138	36.45	5.18	0.46
C.D. at 5 %	161.8		4.45	NS	NS

Conclusion

In short, it can be concluded that the maximum seed cotton yield and monetary returns, as well as soil fertility status were recorded with the application of 15 kg MgSO4 /ha as basal and three foliar sprays of KNO3 @ 3.0 % at square formation, flowering and boll development stages with the recommended dose of fertilizers (120+00+00 kg N, P2O5, K2O /ha).

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Effect of Plant Growth Regulators and Nutrient Management on Seed Protein, Seed Test Weight and Available Post-Harvest Soil Nutrient Status in Pearl Millet (*Pennisetum glaucum*)

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Pearl millet is a very important and potential cereal of dry and rainfed regions. In Indian condition we are the leading Pearl millet growing country, attributing forty two percent of global production. Indian context, it is principally grown as a rainfed crop in varied climatic condition. Cumbu is grown in 7.13 m.ha with 8.07 m.tons total production and crop productivity of 1132 kg/ha. (Season and Crop Report) [1]. In Indian continent Rajasthan, Maharashtra, Gujarat, UP and Haryana are predominant growing states. Generally arid regions receive 10 percent of the total nutrients used in India, which consist about 1.4 million tons. Pearl millet yield is considered as low in our country generally owing to higher mortality and make use of lesser fertilizers. It uptakes 72.5 kg N, P2 O5 and K2 O per hectare per annum, meanwhile just 10 to 20 kg of these through source of fertilizers. It is an efficient and important source of seed protein comprises high digestibility (12.61%) by faintly superior aminoacid, fat (5.1%), mainly iron (2.80%), carbohydrates (69.41%), mineral (2.31%), riboflavine (Vitamin B2) and niacin (Vitamin B4) [2]. Thus, there is a necessitate to advance fertility supervision with the optimal number of plant population for current hybrids to sustain in crop yield and per unit area productive capacity. The PGRs contain possible for improving crop productivities in environmental stress. Growth regulators are chemical substances which will be modified the expansion of growth parameters and crop growing processes most important to increased yield, enhanced grain quality or make easy to harvest [3]. Application of PGRs have been descript to provoke physiologically efficient, including photosynthetic ability of crops and it was resulted in better growth and yield of a number of crops not including significant enhancement of cost of cultivation [4,5] ascribed that the growth regulators contain promising to increase crop production in environmental stress. In view of the aforesaid facts, present study examined different levels of nutrient and plant growth regulators on quality as well as status of soil fertility after crop harvest

Methodology

An experiment was conducted from 2019-2021 at Millets Farm, TNAU, Coimbatore in Rabi season for learning the significance of N level and crop growth regulators to asses grain proteins and soil nutrient position after harvest of Pearl millet crop. The farm location is positioned in 110 N latitude and 770 E longitudes and at altitude of 426.9 MSL. The field trials were laid out in RBD (Randomized Block Design) with 3 replications and 10 treatments viz. T1-125% RDF*, T2-100% RDF*, T3-75% RDF*, T4-125% RDF*+Foliar application of chlormequat chloride (250 ppm) at 20 and 40 DAS, T5-100% RDF*+Foliar application of chlormequat chloride (250 ppm) at 20 and 40 DAS, T6- 75% RDF*+Foliar application of chlormequat chloride (250 ppm) at 20 and 40 DAS, T7-125% RDF*+Foliar application of NAA (40 ppm) at 20 and 40 DAS, T8-100% RDF*+Foliar application of NAA (40 ppm) at 20 and 40 DAS, T9-75% RDF*+Foliar application of NAA (40 ppm) at 20 and 40 DAS and T10–Control. Crop had been grown with 45 × 15 cm spacing. Cumbu hybrid CO 9 selected to this trial and 5 kg per hectare seed rate was utilized. The main field soil was slight alkalinity (8.08), narrow EC (0.861 dsm-1), sand clay loamy, less OC (0.591%), low, medium and high in available N, P2 O5 and K2 O (260.1: 20.5: 694.3 kg ha-1) respectively. Soil samples were collected and Nitrogen (N) estimated by method developed the scientists Subbiah and Asija [6]. By using spectrophotometer, soil available phosphorus was estimated and Potassium content in soil was analysed with neutral normal ammonium acetate extraction method by Flame Photometer (Stanford and English) which is indicated in kg ha-1 [7,8].

Results

An assessment of data shown that influence of effect of PGRs and Nitrogen nutrient did have been significant effect on protein content, test weight and available nutrient status after harvest of Pearl millet. The higher rate of N uptake by plant is more significantly on development parameters, yield and yield factors where produced higher grain and Stover yields. More accessible available Nitrogen, phosphorus and Pottasium (214 ha-1 N, 20.10 kg ha-1 P2 O5 and 557.01 kg ha-1 K2 O) were received under 125% RDF+foliar application of chloromequat chloride (250 ppm) at 20 and 40 DAS which was on par with treatment T7 at 195 ha-1 N, 18.9 kg ha-1 P2 O5 and 522.1 kg K2 O (Table 1). Improved Dry Matter Production (DMP) with higher nutrients applied were found owing towards impact of NPK in influencing the use of sunshine by the augmented dry production biomass and any insufficiency of nitrogen reduces the sunshine use efficiency or facilitate to photosynthetic activities [9,10]. In view of protein content and grain test weight, 125% RDF+chloromequat chloride (250 ppm) at 20 and 40 DAS (T4) resulted maximum grain protein content and test weight during the crop growing period. It might be due to combined application of nitrogenous and phosphates fertilizers with potassium rendered high value of grain and stover yield in Cumbu [11]. This may be for the reason that the fertilizers of nitrogen and phosphorus improved the N and P2 O5 contents into seed besides creating a favourable situation in crop and more photosynthetically competence; it ideal for simultaneously more crop growth and yield. The development in growth characteristics through these PGRs appears has to be due to this role in changing a variety of physiological and metabolite processes in plant system [12]. The foliar applied chlormequat chloride and NAA promoted a positive influence on the development of the plant, when dry and environmental wet period temperature was happened in the growing time of pearl millet. Maximum grain protein content (12.65%) and test weight (12.70 g) were recorded in application of 125% RDF+chloromequat chloride (250 ppm) at 20 and 40 DAS (T4) and it was at par with treatment T7 (Figures 1 and 2). It might be due to the discharge of nutrients in essential quantity on critical plant growth period at higher dose and moreover increased rate of photosynthesis activities and fasten the transport by the function of PGRs [13]. Whereas, Menon et al., [14] stated that improvement in dry biomass by PGRs owing to reduction during photorespiration, moreover, it is well structured reason that the dry matter accumulation was the difference between photosynthesis and respiration progression in the plant system [11]. Kumar et al., [15] detailed that foliar applied chlormequat chloride and NAA was show considerably influenced lying on growth characters like plant height, total number of tillers, DMP and chlorophyll content were recorded [13]. Additionally, a number of scientists, Sivakumar et al., [16] and Yadav et al., [17] in pearl millet, Perveen et al., in wheat [18], Chandrashekhara et al., [19] and Shewry et al., [20] in maize also can be stated considerable improvement in growth parameters in variety of crops suitable to appliance of PGRs. Knowles et al., [21] attributed positive persuade of PGRs on carbon cycle in crops through good quality of increasing in chlorophyll content leading to higher CO2 fixation as well as in rate of photosynthesis.

Conclusion

125% RDF with foliar application of chlormequat chloride (250 ppm) on 20th and 40th days after sowing should be practiced for increasing grain quality, test weight and maximizing the yield. Application of PGRs have been descript to provoke physiologically efficient, including photosynthetic ability of crops and it was resulted in better growth and yield of a number of crops not including significant enhancement of cost of cultivation and this study ascribed that the growth regulators contain promising to increase crop production in environmental stress. The treatment 125% Recommended dose of fertilizer with chlormequat chloride (250 ppm) on 20 and 40 Days after sowing recorded maximum grain protein content, test weight and nutrients uptake during the crop growing period.

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Impact of Long-Term Organic and Inorganic Fertilization on Soil Organic Carbon Fractions in Finger Millet Monocropping and Finger Millet–Groundnut Rotation Systems

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Soil organic carbon (SOC) is a critical indicator of soil health, influencing nutrient availability, microbial activity, and overall soil fertility. Long-term fertilizer experiments are essential for understanding how prolonged use of organic and inorganic amendments affects SOC dynamics and crop productivity, especially in tropical regions (Sathish *et al*., 2016). Such long term trials help elucidate the role of integrated nutrient management on SOC fractions, nutrient cycling, and microbial activity over extended periods (Lal, 2015). Finger millet (*Eleusine coracana* L.), a staple crop with high nutritional value and resilience to environmental stress, and groundnut (*Arachis hypogaea* L.), a legume with nitrogen-fixing abilities, offer a unique crop rotation system that can enhance soil fertility through organic matter addition and nitrogen enrichment (Bationo *et al*., 2006). This study examines SOC and related fractions under finger millet monocropping and finger millet–groundnut rotation systems with varying applications of farmyard manure (FYM), maize residue (MR), and NPK fertilizers. Such integrated approaches have been shown to boost soil quality, SOC sequestration, and crop productivity, thereby supporting sustainable intensification and climate-resilient agriculture.

Methodology

A field experiment was conducted during kharif 2023 at AICRP for Dryland Agriculture, UAS, GKVK, Bangalore, to assess integrated nutrient management effects on soil organic carbon fractions in finger millet monocropping (Var: GPU-28) and finger millet–groundnut rotation (Var: GKVK-5). The randomized complete block design (RCBD) had five treatments (FYM & maize residue) with two replications. The red sandy loam soil was low in organic carbon (0.48%) and nitrogen (252.86 kg ha^{-1}), medium in phosphorus (49.31 kg ha^{-1}) and potassium (166.04 kg ha^{-1}), with acidic pH (5.26). Baseline soil samples were analyzed before treatments. The experiment was laid out in a RCBD with five treatments in each series (i.e. FYM & Maize Residue) and two replications in two cropping systems: finger millet (*Eleusine coracana*) monocropping and finger millet–groundnut (*Arachis hypogaea*) rotation with five treatments indicated below.

FYM-series	MR-Series
T1:Control (no fertilizers)	**T1:**Control (no fertilizers)
T2:Farmyard manure (FYM) at 10 t/ha	**T2:**MR (Maize Residue) (5 t/ha)
T3:FYM+50% recommended NPK dose	**T3:**MR+50% recommended NPK dose
T4:FYM+100% recommended NPK dose	**T4:**MR+100% recommended NPK dose
T5:Only NPK (recommended dose)	**T5:**Only NPK (recommended dose)

Finger millet and groundnut were grown using standard practices. Organic amendments (FYM, maize residue) and chemical fertilizers (NPK) were applied per treatment, with RDF based on soil test values (Finger millet: 50:50:25, Groundnut: 25:50:25 kg/ha). Soil samples (0–15 cm depth) were collected annually post-harvest, air-dried, sieved, and analyzed for SOC fractions, including $KMnO_4$-C, WSC, VLC, LC, LLC, and SIC. Data were statistically analyzed using ANOVA to evaluate treatment effects on SOC fractions and related parameters. (Gomez and Gomez, 1984).

Results

Influence on Soil Organic Carbon (SOC) and Soil Inorganic Carbon (SIC): In the finger millet monocropping system (Table 1), SOC levels were highest under FYM + 100% NPK (0.66%) and lowest in the control (0.13%). Similarly, SOC under FYM + 100% NPK in the rotation system (Table 2) was 0.67%, which was also significantly higher than the control (0.21%) and NPK-alone treatment (0.32%). This trend aligns with studies that have shown increased SOC levels with the use of organic amendments, which can improve soil aggregation and reduce carbon losses through stabilization mechanisms (Bhattacharyya et al., 2007). The higher SIC values with FYM treatments further underscore the enhanced soil organic matter stabilization and improved carbonate formation.

Permanganate Oxidizable Carbon ($KMnO_4$-C) and Water-Soluble Carbon (WSC): $KMnO_4$-C and WSC are indicative of the labile carbon pool that is readily available to soil microbes. Treatments with FYM + 100% NPK exhibited the highest $KMnO_4$-C values (664.20 mg kg^{-1} and 673.56 mg kg^{-1}) in both cropping systems. Similar trends were observed with WSC, where the FYM + 100% NPK treatment showed the highest WSC values (41.20 mg kg^{-1} and 41.78 mg kg^{-1}, respectively as shown in tables below). These findings align with Wang et al. (2016), who reported that integrating organic amendments with chemical fertilizers enhances labile carbon fractions, promoting microbial activity and nutrient cycling. In contrast, sole NPK treatments recorded lower $KMnO_4$-C and WSC values, indicating lack of labile organic carbon that limits microbial nutrient mineralization (Lal, 2015).

Soil organic carbon fractions as influenced by long term application of FYM, MR and NPK fertilizers under finger millet monocropping during 2023

Treatments	SOC (%)	Soil Inorganic carbon (g/kg)	Permanganate oxidizable Carbon ($KMnO_4$-C) (mg kg^{-1})	Water-soluble carbon (WSC) (mg kg^{-1})	Very labile carbon – VLC (%)	Labile carbon – LC (%)	Less labile carbon – LLC (%)
FYM							
T_1:Control	0.13	6.96	488.39	22.03	0.05	0.03	0.02
T_2:FYM (10 t/ha)	0.42	10.64	573.89	34.67	0.21	0.10	0.11
T_3: FYM + 50% NPK	0.51	14.43	591.96	39.06	0.32	0.27	0.18
T_4: FYM+ 100% NPK	0.66	15.08	664.20	41.20	0.45	0.31	0.20
T_5: Only NPK	0.25	8.14	522.99	28.77	0.25	0.08	0.07
S.Em.±	0.01	0.27	15.50	0.32	0.01	0.004	0.003
CD (p-0.05)	0.03	0.84	47.77	2.83	0.02	0.012	0.009
Maize residue							
T_1:Control	0.13	6.33	476.87	21.06	0.07	0.05	0.03
T_2: MR (5 t/ha)	0.40	10.46	565.85	29.03	0.15	0.11	0.10
T_3: MR + 50% NPK	0.47	12.93	579.87	36.49	0.27	0.19	0.14
T_4: MR+ 100% NPK	0.50	13.95	586.93	38.44	0.30	0.20	0.16
T_5:Only NPK	0.25	8.18	520.06	27.18	0.21	0.05	0.07
S.Em.±	0.01	0.25	14.91	0.75	0.004	0.003	0.002
CD (p-0.05)	0.03	0.78	45.94	2.32	0.012	0.009	0.007

Comparative Analysis of Cropping Systems: Comparing the finger millet monocropping with the millet–groundnut rotation system revealed that the latter generally showed slightly higher SOC and $KMnO_4$-C values under similar treatments (e.g., 0.67% vs. 0.66% SOC in FYM + 100% NPK). This could be attributed to the rotation system's potential for improved nutrient cycling and organic matter dynamics due to legume integration, which has been documented to enhance SOC accumulation through biological nitrogen fixation and organic residue addition (Drinkwater et al., 1998). The rotation system also showed more pronounced increases in SIC and WSC, suggesting better soil quality and fertility restoration capabilities.

Labile and Stable Carbon Pools: The distribution of very labile carbon (VLC), labile carbon (LC), and less labile carbon (LLC) fractions further elucidates the stability of SOC under different treatments. FYM + 100% NPK recorded the highest VLC, LC, and LLC values, particularly in the rotation system (Table 2), with VLC of 0.47%, LC of 0.32%, and LLC of 0.21%. Higher proportions of VLC and LC suggest that organic amendments, particularly FYM, increase the availability of easily decomposable organic matter, fostering microbial activity and nutrient availability in the short term (Six et al., 2002). Conversely, control and NPK-alone treatments had significantly lower VLC and LC, pointing to a limited organic carbon pool.

Soil organic carbon fractions as influenced by long term application of FYM, MR and NPK fertilizers under finger millet –groundnut rotation system

Treatments	SOC (%)	Soil Inorganic carbon (g/kg)	Permanganate oxidizable Carbon ($KMnO_4$-C) (mg kg^{-1})	Water-soluble carbon(WSC) (mg kg^{-1})	Very labile carbon – VLC (%)	Labile carbon – LC (%)	Less labile carbon – LLC (%)
				FYM			
T_1: Control	0.21	6.16	496.25	24.36	0.12	0.08	0.06
T_2:FYM (Farm yard manure) (10 t/ha)	0.44	11.31	582.47	35.70	0.30	0.13	0.12
T_3: FYM + 50% NPK	0.54	15.09	600.41	40.04	0.36	0.30	0.20
T_4: FYM+ 100% NPK	0.67	15.69	673.56	41.78	0.47	0.32	0.21
T_5: Only NPK	0.32	8.84	532.01	29.83	0.30	0.09	0.08
S.Em.±	0.01	0.28	15.74	0.95	0.007	0.004	0.003
CD (p-0.05)	0.03	0.88	48.51	2.93	0.022	0.014	0.010
				Maize residue			
T_1:Control	0.22	6.31	476.88	23.01	0.10	0.07	0.05
T_2: MR (5 t/ha)	0.45	10.83	577.50	31.96	0.28	0.12	0.12
T_3: MR + 50% NPK	0.50	13.90	592.47	37.50	0.32	0.21	0.18
T_4: MR+ 100% NPK	0.51	14.82	595.79	39.24	0.36	0.22	0.19
T_5: Only NPK	0.31	8.28	530.12	26.22	0.27	0.08	0.08
S.Em.±	0.01	0.26	15.21	0.79	0.006	0.003	0.003
CD (p-0.05)	0.03	0.81	46.89	2.45	0.019	0.010	0.008

Conclusion

The results indicated that combining FYM with NPK fertilizers significantly improved both labile and stable SOC pools, enhancing soil fertility and carbon sequestration potential in both cropping systems. The finger millet–groundnut rotation system demonstrated superior SOC enhancement compared to monocropping, suggesting its suitability for sustainable, climate-resilient farming in long-term scenarios. These findings align with broader literature suggesting that organic amendments coupled with chemical fertilizers are beneficial for long-term soil health and carbon management.

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Optimizing Maize Seed Yield and Quality through Biostimulant-Based Nutrient Management

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The study was conducted to assess the influence bio-stimulant based nutrient management on maize seed yield and yield parameters. Yield attributes such as cob length, cob weight, number of seed rows per cob, number of seeds per row, and test weight were significantly improved with seed treatment using biofertilizers (Azotobacter, PSB, PGPR) and foliar applications of humic acid (HA) and seaweed extract (SWE) at the knee-high and pre-tasseling stages. The interaction between nutrient levels and biostimulants was notable, with a combination of 75% recommended dose of fertilizers (RDF) and biostimulants achieving yield parameters comparable to 100% RDF. This demonstrates the potential of biostimulant-based management to replace 25% of RDF without compromising yield. Moreover, soil biological properties, including microbial counts and enzyme activities, were significantly enhanced with 75% RDF + biostimulants, reflecting improved soil health. These findings underscore the effectiveness of biostimulant-based nutrient management in optimizing maize productivity and sustainability.

Methodology

A field experiment was conducted during 2023–2024 at ICAR-Indian Institute of Seed Science, Regional Station, Bengaluru, Karnataka, India. The field experiment was laid out in Randomized Complete Block Design with factorial concept and replicated thrice. There were 16 treatment combinations involving 3 nutrient management practices (N_1: 100 % RDF, N_2: 75% RDF, N_3: 100% RDF), 5 bio-stimulants (B_1: Control, B_2: Azatobactor+PSB, B_3: Azatobactor + PSB + PGPR, B_4: Azatobactor + PSB + PGPR + Humic Acid, B_5: Azatobactor + PSB + PGPR + Sea weed Extract, were evaluated in this study.

Results

Nutrient levels significantly affected maize yield and yield components. The highest values were recorded with 100% RDF (N1), which achieved a seed yield of 9088 kg/ha. Compared to 75% RDF (N2), this represented an 18.6% increase, while the seed yield at 50% RDF (N3) was 6603 kg/ha, a 27.3% decrease compared to 100% RDF. Biostimulant treatments significantly enhanced yield parameters compared to the control (B1). The highest seed yield (8960 kg/ha) was achieved with the combined application of Azotobacter, PSB, PGPR, humic acid, and seaweed extract (B5), which was 32.7% higher than the control (6753 kg/ha). Similarly, the number of seeds per cob (563.79 in B5) increased by 79.5% compared to the control (314.16). Test weight (29.69 g) in B5 was 14.9% higher than in B1 (25.85 g).

The second-highest performance was observed with B4 (Azotobacter, PSB, PGPR, and humic acid), which recorded a seed yield of 8483 kg/ha *i.e.* 25.6% higher than the control. These results highlight the role of biostimulants in improving nutrient uptake, stress tolerance, and overall plant growth. The interaction between nutrient levels and biostimulants showed significant improvements. Notably, the combination of 75% RDF with B5 resulted in a seed yield of 8483 kg/ha, just 6.7% lower than 100% RDF with B1 (9088 kg/ha). This demonstrates that biostimulant-based management can replace 25% of RDF without a substantial yield penalty. Additionally, parameters such as the number of seeds per cob (498.22) and test weight (28.67 g) in this combination showed comparable values to 100%

RDF treatments. The percentage increases in yield and yield parameters with biostimulant treatments emphasize their efficacy in enhancing nutrient use efficiency and crop productivity. The improvements can be attributed to the synergistic effects of biofertilizers (Azotobacter, PSB, PGPR) and biostimulants (humic acid, seaweed extract) in promoting nutrient availability, improving root development, and enhancing microbial activity in the soil. Compared to the control, the application of B5 increased cob length by 32.6%, cob girth by 32.7%, and seed weight per cob by 32.7%. These results are consistent with previous studies, which reported the beneficial effects of humic acid and seaweed extract in improving nutrient uptake and photosynthetic activity. The significant interaction effects suggest that integrating biostimulants with reduced RDF levels is an effective strategy for sustainable maize production. By reducing RDF by 25% while maintaining yield, this approach supports cost-effective and environmentally friendly farming practices.

Influence of Biostimulant based nutrient management on seed yield and yield parameters of maize.

Treatments	No. of seed rows per cob	No. of seeds per row	No. of seeds per cob	Test weight (g)	Cob length (cm)	Cob girth (cm)	Seed weight per cob (g)	Seed yield (kg/ha)
Nutrient Levels								
N1	19.43	28.83	572.58	28.53	17.98	8.92	127.75	9088
N2	16.38	24.31	402.03	27.51	15.16	7.53	107.72	7664
N3	14.12	20.94	299.00	27.01	13.06	6.48	92.81	6603
S Em±	0.28	0.41	15.56	0.40	0.25	0.13	1.81	129
CD (p=0.05)	0.64	1.17	32.55	1.16	0.71	0.37	4.87	373
Biostimulants								
B1	14.44	21.42	314.16	25.85	13.36	6.63	94.92	6753
B2	15.29	22.69	352.57	26.56	14.15	7.02	100.54	7153
B3	16.20	24.03	393.94	27.65	14.98	7.44	106.48	7575
B4	18.14	26.91	498.22	28.67	16.78	8.33	119.24	8483
B5	19.16	28.42	563.79	29.69	17.72	8.80	125.94	8960
S Em±	0.36	0.53	20.09	0.52	0.33	0.16	2.34	166
CD (p=0.05)	1.03	1.53	58.19	1.50	0.95	0.47	6.77	482
Interaction								
S Em±	0.62	0.91	34.79	0.90	0.57	0.28	4.05	288
CD (p=0.05)	1.78	2.65	100.79	2.60	1.65	0.82	11.73	834

Nutrient levels (N): N_1: 100 % RDF; N_2: 75 % RDF; N_3: 50 % RDF
Biostimulants (B): B_1: Control; B_2:(*Azatobactor sp +PSB);* B_3: B2+ PGPR; B_4: B3 + Humic Acid; B_5: B4+ Sea weed extract

Conclusion

Findings of the present study concluded that biostimulant-based nutrient management can effectively replace 25% of the recommended dose of fertilizers (RDF) without compromising maize yield and seed quality. The combination of 75% RDF with biofertilizers and foliar applications of humic acid and seaweed extract resulted in yield parameters statistically comparable to 100% RDF. This approach not only maintained high seed yield but also improved soil biological properties, including microbial activity and enzyme functions. The findings highlight the potential of biostimulants to enhance nutrient use efficiency, reduce dependency on chemical fertilizers, and promote sustainable maize production.

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Effect of Restricted Irrigation on Wheat Grain Yield in South West Haryana

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Wheat is the most of cereal crop in the world. It contributes as a major source of calories and protein in the daily human diet. Drought has become a major abiotic stress that severely affects wheat production globally. Mahendergarh district occupies the southern extremity of the Haryana state, ground water scarcity is the major problem of the district. The normal monsoon rainfall of the district is 420 mm, which is unevenly distributed over the area with 26 rainy days, mean maximum temperature 41^oC (May-June) and a mean minimum temperature 5.6^oC (January). Wheat is the main rabi season crop grown in Mahendergarh district of Haryana state. Wheat variety WH 1142 is drought tolerant, resistant to yellow rust, early sowing (25 October- 05 November) restricted irrigation (two irrigations) and medium input conditions, average yield of 48.1 q/ha and a potential yield of 62.5 q/ha, is selected for the limited irrigation condition. Gap between farmers' practices and improved practices is another important reason for low productivity under limited irrigation conditions. Therefore, a need to minimize this gap to increase the productivity of wheat crops at farmer's fields. Demonstrations of improved technologies with an integrated crop management approach at farmers' fields through frontline demonstrations are one of the ways to increase the productivity of the crop.

Methodology

Frontline demonstrations on wheat crops were conducted during 2022-23 and 2023-24 at selected twenty farmers' fields in Mahendergarh district of Haryana state under the National

Innovations on Climate Resilient Agriculture (NICRA) programme. Important and necessary process – selection of Gadania and Bairawas NICRA villages and farmers, identification of farming situations, typology of irrigated with animals, analysis of soil samples, assessment of gaps between farmers' practices and improved practices, identification of technologies to be demonstrated, rationalization of critical inputs, training programmes, regular monitoring visits, organizing field days, reporting of successful cases etc. was carried out in an effective manner. Emphasis was laid to demonstrate those technologies for which a maximum gap was observed. The technologies that were demonstrated included improved variety for restricted irrigation (WH 1142), optimum seed rate, seed treatment with chlorpyriphos and inoculation with azotobacter and PSB, use of fertilizers in balanced doses, proper weed management practices, management of disease and insect pest, etc. The critical inputs used by the centre were – quality seed of improved variety suitable for specific farming situation, chlorpyriphos and biofertilizers (azotobacter and PSB. NPK fertilizers and other inputs were used by the partner farmers. Financial support for the purchase of critical inputs was provided by Indian Council of Agricultural Research (ICAR) -Agricultural Technology Application Research Institute (ATARI). Observations on yield and other parameters were recorded and compared with farmers' practice. Economics of demonstration plots and local check plots (farmers' practice) was calculated to compare the relative performance.

Results

Adoption of improved practices in demonstration plots provided higher yield and returns than those obtained under farmer's practices. Average yield of two years in demonstration plots was 40.5 q/ha which was 16.7 percent higher than the average yield of local check plots (34.7 q/ha). More water saving and higher yield thus obtained in demonstration plots resulted into higher net returns. Average additional net returns of ₹11399/ha, were obtained in demonstration plots with an average additional cost of cultivation of ₹975/ha resulting in a higher benefit cost ratio.

Yield and economics of improved wheat variety WH 1142 during 2022-23 and 2023-24

Crop yields (q/ha)		Economics of demonstration (Rs./ha)				Economics of local practice (Rs./ha)			
Demo	Local	Gross Cost	Gross Return	Net Return	BCR	Gross Cost	Gross Return	Net Return	BCR
40.5	34.7	42622	103658	61035	2.43	41647	91284	49636	2.19

Conclusion

Irrigation water saving with higher yield and returns in demonstration plots indicates that there is a possibility of minimizing the extension gap by conducting frontline demonstrations at farmers' fields with the restricted two irrigations wheat variety WH 1142 with medium input conditions.

UID: 1220

Effect of Foliar Application of NPK and Micronutrient on Yield of Cotton

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In India, Cotton (*Gossypium hirsutum* L.) is grown in an area of 13.5 million hectares with a production of 36.5 million bales and productivity of 460 kg ha $^{-1}$ (COCPC, 2020) and popularly known as 'White Gold' grown mainly for fibre all over the world.

Erratic rainfall and prolonged dryspells are frequent in rainfed regions of Vidarbha region of Maharashtra State. Under drought stress, there is a reduction in nutrient uptake by the roots, suffering crop growth, resulting in an inability to meet the nutrient requirement of the crop at a critical stage. Potassium fed plants, grown under water stress conditions, maintained higher leaf water potential, turgor potential and relative water content. The application of Zn increases auxin levels within the plants which in turn enhances the root growth and consequent improvement of drought tolerance in plants (Waraich et al, 2011). Hence, under such situation foliar nutrition can be found beneficial. Hence the present investigation is conducted to study the effect of foliar nutrition on the growth and yield of cotton to mitigate the ill effects of drought situations with different set of treatments in situations of stress and after relieving of stress.

Methodology

The field experiment was conducted at the research field of AICRP for Dryland Agriculture, Dr. PDKV, Akola (MS) during 2022-23. The effect of time of application and different foliar sprays on yield and economics of cotton is studied and analysed. The experiment was laid out in a factorial randomized block design with eight treatments and three replications. For this study two factors are considered, in factor A: Time of application with treatments T_1:Foliar spray after and during dry spell T_2 : Foliar spray after relieving of stress/dry spell and for factor B different foliar sprays is uses, S_1 : Application of urea, @1% S_2:Application of urea @2%, S_3:Application of water soluble complex fertilizer 19:19:19@0.5%, S_4:Application of water soluble complex fertilizer 19:19:19@ 0.5% + Zinc sulphate @0.5% , S_5:Application of Zinc sulphate @0.5%, S_6:Water spray, S_7:Application of KNO_3@1.5% , S_8:Control (No spray of any material/water).

Results

The Results showed that treatment of foliar spray during dry spell recorded significantly higher seed cotton yield, cotton stalk yield, B:C ratio and high rainwater use efficiency than treatment of foliar spray after relieving of stress. Drought disturbs the mineral-nutrient relations in plants through its effects on nutrient availability, and partitioning of transport processes in plants. Frequent soil drying is likely to induce a decrease in nutrients particularly P due to reduced diffusion and poor uptake, in addition to restrictions in available water, with strong interactive effects on plant growth and functioning (Singh et al, 2006). Treatment of foliar spray of 19:19:19 mix water soluble fertilizer + ZnSo4 @0.5% recorded significantly higher seed cotton yield, cotton stalk yield, NMR, B:C ratio and high rainwater use efficiency than rest of the treatments. Cotton productivity was increased due to application of different foliar spray (Singh *etal* 2015 and Kochar *etal* 2024). This might be due to foliar applied nutrients sustaining proper leaf nutrition as well as carbon balance and improving photosynthetic capacity.

Cotton, productivity, economics and RWUE as influence by various treatments

Treatments	Seed Cotton Yield (Kg ha^{-1})	Cotton Stalk Yield (Kg ha^{-1})	COC (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C Ratio	RWUE (Kg ha^{-1} mm^{-1})
A. Time of Application						
T_1-Foliar spray during dry spell	1155	2044	40643	56872	2.39	0.99
T_2 - Foliar spray after relieving of stress	1043	1846	39971	48095	2.20	0.90
S.Em.+-	6.14	10.87		519		0.01
C.D. at 5 %	17.74	31.40		1498		0.02
B. Sprays						
S_1-urea@ 1.0 %	1081	1914	40028	51264	2.28	0.93
S_2-urea@ 2.0%	1085	1920	40060	51539	2.28	0.93
S_3- 19:19:19 water soluble complex fertilizer @ 0.5%	1236	2188	41458	62921	2.52	1.06
S_4-19:19:19@ 0.5% + $ZnSo_4$@0.5 %	1276	2258	42445	65263	2.54	1.10
S_5- Zn So_4@0.5 %	1015	1796	40127	45525	2.13	0.87
S_6- Water Spray	1000	1770	39290	45134	2.15	0.86
S_7 - KNO_3 @1.0 %	1191	2107	40784	59737	2.46	1.03
S_8–Control	909	1609	38264	38482	2.00	0.78
S.Em.+-	9.21	16.31		778		0.01
C.D. at 5 %	26.61	47.10		2246		0.02
C. Interaction Effect (T x S)						
S.Em.+-	49.14	86.98		4149		0.04
C.D. at 5 %	NS	NS		NS		NS
C.V. %	13.41	13.41		23.71		13.41
Mean	1099	1945		53483	2.30	0.95

Conclusion

It was concluded from the study that foliar spray of 19:19:19@ 0.5% + $ZnSo_4$@0.5 % (75% during dry spell gave highest seed cotton yield, Net monetary returns, benefit cost ratio, rainwater use efficiency and yield attributing characters.

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Effect of Soil Moisture Dynamics on Soybean Yield Under Different Sowing Times

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Soybean (Glycine max L.) is one of the most important leguminous crops globally, providing essential protein and oil for human consumption, livestock feed, and industrial purposes. Its growth and productivity are influenced by various factors, with soil moisture being a critical determinant of yield potential. Water availability during key phenophases significantly affects soybean development, including emergence, seedling, flowering, and pod development. The timing of sowing, in particular, plays a pivotal role in determining soil moisture levels, as well as the overall growth and yield performance of soybean. Different sowing dates may subject the crop to varying climatic conditions, which can impact both moisture retention and the physiological processes of the plant. Additionally, variety selection is crucial, as some varieties exhibit better adaptability to moisture stress, influencing both yield and biomass production. This study aims to evaluate the effect of sowing time and soybean variety on soil moisture content and its subsequent impact on seed yield, straw yield, and biological yield. Understanding the interaction between sowing time, variety, and soil moisture can provide valuable insights for optimizing soybean cultivation practices, enhancing productivity, and ensuring sustainable crop production under varying environmental conditions.

Methodology

A field experiment was conducted at All India Coordinated Research project on Agrometeorology (AICRPAM), under AICRP for Dryland Agriculture Research, Dr. PDKV, Akola during kharif season of 2022-23. Four sowing dates (26th MW-25 June, 27th MW -06 July, 28th MW-11 July, 29th MW-20 July) were undertaken to create a different set of environmental conditions and three varieties (V1-JS-335, V2-JS-9305, V3-AMS-100-39) were laid out in a Factorial Randomized Block Design with four replications.

Results

The soil moisture content at the 15-30 cm depth during various soybean phenophases was influenced by both sowing time and variety. Sowing in late June (D1-26 MW) generally resulted in higher moisture content, especially during Seedling (34.60%) and Branching (33.60%) stages, though moisture declined by the Maturity stage (28.60%). Sowing in early July (D2-27 MW) had higher moisture content at Emergence (35.70%) and Flowering (34.10%) but saw a decrease in moisture during Pod formation (29.13%) and Grain Filling (29.25%). Mid-July sowing (D3-28 MW) had moderate moisture retention during Seedling (31.60%) and Branching (32.40%), but moisture content dropped significantly as the crop reached Flowering (30.20%) and Maturity (29.60%). Late July sowing (D4-29 MW) showed the lowest moisture content overall, particularly in early growth stages, with Seedling moisture at 30.20% and Pod Development at 29.98%, although there was a slight increase at Maturity (30.40%). In terms of variety, JS-9305 consistently had higher moisture retention, particularly during the Seedling (33.91%) and Branching (32.53%) stages, compared to JS-335 and AMS-100-39, which also maintained good moisture levels but showed slightly lower retention during later stages.

The seed yield, straw yield, and biological yield of soybean were influenced by both sowing time and variety. Early sowing (D1-26 MW on 25 June) produced the highest yields, with seed yield at 1875 kg/ha, straw yield at 2332 kg/ha, and a biological yield of 4208 kg/ha. Sowing in early July (D2-27 MW) resulted in slightly lower yields: 1706 kg/ha seed yield, 2161 kg/ha straw yield, and 3867 kg/ha biological yield. Mid-July sowing (D3-28 MW) and late July sowing (D4-29 MW) showed a significant decline in all yield parameters, with D4-29 MW yielding the lowest values (956 kg/ha seed yield, 1332 kg/ha straw yield, and 2288 kg/ha biological yield). Among varieties, JS-335 (V1) had the highest seed yield (1551 kg/ha) and biological yield (3519 kg/ha), while JS-9305 (V2) had the lowest yields across all parameters. AMS-100-39 (V3) performed similarly to JS-335, with a seed yield of 1504 kg/ha and biological yield of 3442 kg/ha. Overall, early sowing and the JS-335 variety resulted in the best yields, while late sowing and JS-9305 yielded the least.

Soil moisture content during different phenophases of soybean at (15-30 cm) depth and Yield

Treatment	Soil moisture content (%) at (15-30 cm) depth.								Yield in Kg	
	EM	SL	BR	FL	PF	GF	PD	M	Seed	Bio.
Sowing time (D)										
D_1-26 MW (25 June)	31.60	34.60	33.60	33.70	33.47	30.79	31.89	28.60	1875	4208
D_2-27 MW (06 July)	35.70	32.90	29.98	34.10	29.13	29.25	32.64	29.90	1706	3867
D_3-28 MW (11 July)	32.80	31.60	32.40	30.20	31.94	31.80	30.91	29.60	1410	3275
D_4-29 MW (20 July)	30.80	30.20	31.90	31.60	29.13	32.65	29.98	30.40	956	2288
Variety (V)										
V_1-JS-335	32.69	33.45	32.46	32.45	31.50	31.56	30.20	29.85	1551	3519
V_2-JS-9305	32.23	33.91	32.53	32.60	31.42	31.40	30.27	29.52	1406	3266
V_3-AMS-100-39	32.35	33.20	32.45	32.89	31.20	31.66	30.40	29.43	1504	3442

Conclusion

This study evaluated the effects of sowing time and soybean variety on soil moisture content and yield performance. the interaction between sowing time and moisture availability was found to substantially influence key soybean growth stages, with early sowing in late June offering favorable moisture retention during critical phenophases, resulting in enhanced seed yield and biological yield. Among the varieties tested, JS-335 consistently outperformed others, showing superior moisture retention and higher overall yield, making it particularly suitable for regions prone to moisture stress. These results suggest that adopting early sowing practices, combined with the selection of varieties like JS-335, can significantly improve soybean productivity, especially in dryland agriculture.

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Potential of Nano Nitrogen Spraying on Productivity and Nutrient Use Efficiency in Finger Millet under Dryland Conditions

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Dryland agriculture is characterized by its dependency on resource-poor soils and adverse climatic conditions. Finger millet (*Eleusine coracana*) is a key crop in dryland regions, valued for its adaptability, nutritional profile and resilience to climate change. However, its productivity is often limited by nutrient deficiencies, particularly nitrogen, which is essential for plant growth and yield. Conventional fertilizers exhibit low nutrient use efficiency in drylands due to rapid losses caused by leaching and volatilization. Nano-fertilizers offer a promising solution to these challenges with their unique properties like high surface area, controlled release and enhanced nutrient absorption. Recent research has focused on optimizing combinations of conventional nitrogen fertilizers with nano-fertilizer formulations to improve nutrient use efficiency and crop yields in dryland systems.

Methodology

A field experiment was carried out during the *Kharif* seasons of 2021 and 2022 at AICRP for Dryland Agriculture Project, University of Agricultural Sciences, GKVK, Bengaluru situated in the Eastern Dry Zone of Karnataka at 12˚ 58' N latitude and 75˚ 35' E longitude at an altitude of 930 meter above mean sea level. The experiment was laid out in a Randomized Complete Block Design with three replications and 10 treatments viz., T_1: Recommended PK + soil application of Zinc; T_2: Recommended PK + spraying of Nano-N (twice); T_3: N_{50}PK + soil application of Zinc; T_4: N_{50}PK + spraying of Nano-N (twice); T_5: N_{75}PK + soil application of Zinc; T_6: N_{75}PK + spraying of Nano-N (twice); T_7: N_{100}PK + soil application of Zinc; T_8: N_{100}PK + spraying of Nano-N (twice); T_9: Recommended PK; T_{10}: Recommended NPK.

Bold and healthy seeds of finger millet were selected for sowing at a spacing of 30 cm × 10 cm. Treatment wise fertilizers were applied and recommended dose fertilizer (RDF) for finger millet was @ 50:40:37.5 kg NPK ha^{-1}, respectively. Nano-Nitrogen foliar spray was given at the concentration of 2ml per litre as per the treatment after 35 and 55 DAS and the source of these nano fertilizers are commercial IFFCO product. Grains were harvested at maturity, cleaned for impurities, dried in natural condition. Grain yield per hectare was worked out using grain yield per net plot and expressed in kg ha^{-1}. Nitrogen use efficiency was worked out using the formula given by Paul *et al*., 2015.

Results

The results of pooled data revealed that treatment T_8 (100 per cent RDF + foliar spray of nano-N twice) recorded significantly higher grain yield (3166 kg ha^{-1}) and straw yield (4482 kg ha^{-1}) and was on par with the treatment T_6 (75 per cent N and recommended PK + foliar spray of nano-N twice) (3164 and 4480 kg ha^{-1}, respectively) and other treatments in comparison.

However, treatment T_9 (Recommended PK) recorded significantly lesser grain (1427 kg ha^{-1}) and straw yield (2169 kg ha^{-1}). The grain and straw yield of finger millet in T_{10} increased 16.61 and 19.04 per cent, respectively and in T_{11} 16.53 and 18.99 per cent, respectively as compared to recommended NPK (T_{10}). Similar findings were reported by Manikandan and Subramanian (2014), Garcıa-Lopez *et al*. (2019) and Kumar *et al*. (2020) Furthermore, combined application of 75 per cent N and recommended PK along with foliar spray of nano-N twice (T_6) recorded higher partial factor productivity (84.20 kg kg^{-1}) and agronomic efficiency (46.22 kg kg^{-1}).

Table 1: Yield of finger millet as influenced by combined application of conventional and foliarspray of nano-N fertilizers

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index	PFPn (kg kg-1)	AEn (kg kg-1)
T_1: Recommended PK + soil application of Zinc	1507	2325	0.39	-	-
T_2: Recommended PK + spraying of Nano-N (twice)	1720	2478	0.41	-	-
T_3: N_{50}PK + soil application of Zinc	1979	2743	0.42	79.16	22.07
T_4: N_{50}PK + spraying of Nano-N (twice)	2240	3414	0.40	80.65	32.41
T_5: N_{75}PK + soil application of Zinc	2645	3851	0.41	70.54	32.48
T_6: N_{75}PK + spraying of Nano-N (twice	3164	4480	0.41	84.20	46.22
T_7: N_{100}PK + soil application of Zinc	2775	4139	0.40	55.49	26.95
T_8: N_{100}PK + spraying of Nano-N (twice)	3166	4482	0.41	63.22	34.72
T_9: Recommended PK	1427	2169	0.40	-	-
T_{10}: Recommended NPK	2715	4101	0.40	54.30	25.76
Sem±	54.09	105.49	-	-	-
CD @ 5%	160.72	313.41	-	-	-

Note: PFPn- Partial factor productivity of nitrogen; AEn- Agronomic efficiency of nitrogen

Conclusion

Applying 75 per cent of the recommended dose of nitrogen (RDN) combined with the recommended doses of phosphorus and potassium (PK), along with foliar application of nano-N twice demonstrates significant potential for efficient nutrient management. This approach minimizes nitrogen losses, making it a promising strategy for promoting sustainable agriculture.

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Effect of Conservation Tillage, In-situ Incorporation of Cotton Residue and Integrated Nutrient Management on Yield Attributes and Yield of Bt Cotton (Gossypium Hirsutum L.)

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India covers an area of 12.60 million hectare with the production of 6.12 million tons. In fact, the average yield of cotton is very low and it is around 486 kg/ha as against the average yield of 797 kg/ha in the world (Anonymous, 2019). Conservation agriculture has emerged as a new paradigm to achieve the goals of sustainable agricultural production. It involves the new and innovative ways of generating and promoting technologies that focus on resource conservation as a way to enhance productivity in a sustainable manner. Conservation agriculture aims at reversing the process of degradation inherent to the conventional agricultural practices like intensive cultivation and burning or removal of crop residues. Through conservation agriculture, nutrient demands are also met for the cotton crop.

Therefore, resource conservation becomes a top priority and restoration of precious soil resource by way of innovative means of management is the need of the day.

Crop residues are good sources of plant nutrients and are important components for the stability of agricultural ecosystems. About 400 million tons of crop residues are produced in India alone. In areas where mechanical harvesting is practiced, a large quantity of crop residues is left in the field, which can be recycled for nutrient supply. Integrated methods involving combination of organic and inorganic manures can sustain nutrient extraction and maintain the higher level of productivity and soil fertility on a long-term basis. Among the total residues available in India, cereals including maize and cotton contribute 70 per cent (352 Mt) and 11 per cent (53 Mt), respectively. In addition, the surplus quantity of residues from cereals and fibre crop contribute 58 and 23 per cent, respectively, to the total, and approximately 80 per cent of surplus cotton residues are subjected to on-farm burning (Veeraputhiran, 2020). The crop residues, which are having enormous value if utilized properly, will have great potential for improving soil fertility, creation of pollution-free environment besides improving the yield of crops. There is little information available on cotton residue incorporation with tillage and integrated nutrient management. Keeping the of the above view, the present experiment was carried out.

Methodology

A field experiment was conducted during *kharif* 2020-21, 2021-22, 2022-23 and 2023-24 AICRP on dryland Agriculture Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani to evaluate the effect of cotton residue incorporation with conservation tillage and integrated nutrient management in *Bt* cotton (*Gossypium hirsutum* L.). The treatments of the study consisting of three tillage treatments *viz.,* conventional tillage (ploughing once + cultivator once + rotavator once), reduced tillage (cultivator once + rotavator once) and zero tillage in main plot. Five integrated nutrient management practices (100% RDF (120:60:60 kg NPK ha^{-1}), 100% RDF + cotton residue @ 3 t ha^{-1} + Decomposing microorganisms (DM) @ 12 kg ha^{-1}, 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + Decomposing microorganisms (DM) @ 12 kg ha^{-1}, 50% RDF + FYM 12 t ha^{-1} + cotton residue @ 3 t ha^{-1} + Decomposing microorganisms (DM) @ 12 kg ha^{-1} and control) .The experiment is carried out in split plot design with main plot as tillage practices and in sub plot in situ cotton residue incorporation and INM practices with three replications. The cotton residue was shredded by tractor operated shredder and incorporated into soil. The size of the shredded cotton stalks was of 1 to 2 cm. Yield of net plot was converted in to hectare basis and recorded. The soil microbial population were determined by serial dilution method using different media *i.e.* nutrient agar media for bacteria, potato dextrose agar media for fungi and ken knight media for actinomycetes. Soil bulk density was determined by core sampler and infiltration rate was determined by double ring infiltrometer.

Results

Yield attributes and yield : Effect of conservation tillage

The yield attributes and yield of *Bt* cotton were significantly affected by conservation tillage during pooled. The conventional tillage (ploughing once + cultivator once + rotavator once) recorded significantly higher number of bolls per plant (45.05), boll weight (3.60 g), seed cotton yield per plant (139.86 g) and seed cotton yield (1865.67 kg/ha respectively) as compared to zero tillage. It remained at par with reduced tillage (cultivator once + rotavator once). The higher mean seed cotton yield of 1865.67 kg/ha was obtained in conventional tillage (ploughing once + cultivator once + rotavator once). Whereas, mean higher number of bolls per plant (45.04), boll weight (3.60 g), seed cotton yield per plant (139.86 g) were observed in conventional tillage (ploughing once + cultivator once + rotavator once) as compared to zero tillage.

Pooled result of number of picked bolls plant^{-1}, boll weight (g) and seed cotton yield (g) plant^{-1}, seed cotton yield (kg ha^{-1}) of *Bt* cotton hybrid as influenced by different treatments during 2020-21 to 2023-24

Treatments	Number of picked bolls plant^{-1}	Boll weight (g)	Seed cotton yield plant^{-1}(g)	Seed cotton yield (Kg/ha)	NMR (₹ ha^{-1})	BC ratio
A) Main plot treatments (conservation tillage)						
T_1 - Conventional tillage	45.05	3.60	139.86	1865.67	57075	1.86
T_2 - Reduced tillage	42.27	3.40	133.14	1738.67	52826	1.86
T_3 - Zero tillage	26.39	2.46	77.48	1034.55	20645	1.56
SEm±	1.30	0.09	2.40	29.59	1645.16	0.06
CD at 5%	4.26	0.29	8.34	102.90	6247	0.22
B) Sub plot treatments (Integrated nutrient management)						
N_1 - 100% RDF (120:60:60 kg NPK ha^{-1})	43.01	3.52	128.39	1807.32	64494	2.23
N_2- 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	45.29	3.82	134.35	1921.56	67486	2.14
N_3 - 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	42.93	3.57	127.36	1823.06	50889	1.71
N_4 - 50% RDF + FYM 12 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	38.05	3.09	114.37	1495.42	20978	1.23
N_5 - Control	20.21	1.76	79.67	886.59	20107	1.51
SEm±	0.97	0.07	1.65	32.21	1906	0.07
CD at 5%	2.86	0.21	4.89	95.25	5649	0.22
Interaction (A x B)						
SEm±	1.86	0.13	2.96	54.40	3177	0.09
CD at 5%	5.48	0.38	8.76	160.89	7354	0.27

Effect of integrated nutrient management

The yield attributes and yield of Bt cotton were significantly affected by integrated nutrient management. The application of 100% RDF + cotton residue @ 3 t/ha + DM @ 12 kg/ha recorded significantly higher number of bolls per plant 45.29, boll weight 3.52 g, seed cotton yield per plant 134.35 g and seed cotton yield 1921.56 kg/ha respectively. It remained at par with 100% RDF (120:60:60 kg NPK/ha) and 75% RDF + FYM 6 t/ha + cotton residue @ 3 t/ha + DM @ 12 kg/ha during *kharif* 2020-21 and remained at par with 75% RDF + FYM 6 t/ha + cotton residue @ 3 t/ha + DM @ 12 kg/ha during four year of study.

Economics: **Effect of conservation tillage**

The conventional tillage (ploughing once + cultivator once + rotavator once) recorded significantly higher NMR 57075 ₹/ha) as compared to zero tillage and remained at par with reduced tillage (cultivator once + rotavator once) during pooled analysis. The B:C ratio was recorded under reduced tillage (cultivator once + rotavator once) was 1.86 Rs/ha.

Conclusion

Conventional tillage with 100% RDF (120:60:60 kg NPK ha^{-1}) + in situ incorporation of cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} resulted in higher yield attributes. Microbial population were enhanced under zero tillage and 50% RDF + FYM 12 t ha^{-1} + in situ incorporation of cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}. Bulk density and infiltration rate were also improved under conventional tillage and 50% RDF + FYM 12 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}. Soil fertility was higher in conventional tillage and 75% RDF + 6 t ha^{-1} FYM + 3 t ha^{-1} cotton residues + 12 kg DM) .

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Effect of Tillage and Residue Management Practices on Properties of a Rainfed Alfisol under Sorghum - Blackgram Rotation

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Tillage increases the soil erosion by loosening the soil. Further, tillage accelerates decomposition of soil organic matter. The loss of soil and soil organic carbon together lead to deterioration of soil properties and ultimately, soil degradation (Indoria *et al*., 2017). Appropriate soil management practices such as reduced or zero tillage, and retention of residues on the soil surface can improve soil physical, chemical and biological properties. Conservation agriculture can play a major role in stabilizing production in rainfed regions by mitigating water and nutrient stress through adoption of reduced tillage, crop rotations and residue retention. While several successful case studies on conservation agriculture have been reported from irrigated production systems (Aulakh *et al.,* 2012), very limited efforts were made in rainfed production systems. A long-term study was conducted to assess the effect of tillage and residue retention treatments on soil properties of a semi-arid tropical Alfisol.

Methodology

The long-term experiment was initiated in 2013 with sorghum and black gram as test crops in yearly rotation at Hayathnagar Research Farm of Central Research Institute for Dryland Agriculture, Hyderabad. The experiment was laid out in a split-plot design with two tillage systems: conventional (CT) and minimum (MT) in main plots and three residue retention treatments: no residue application (S0), retaining the residue by cutting the crop at 35 cm height (S1), retaining the residue by cutting the crop at 60 cm height (S2) in case of sorghum. For black gram crop, the residue retention treatments were no residue (S0), 50% residue retention by clearing of residue from alternate rows (S1), 100% residue retention (S2). The soil of the experimental site is an Alfisol, sandy loam in texture, slightly acidic in soil reaction and low in organic carbon and available nitrogen. In the seventh year of the experiment, in 2019, soil samples from three depths (0 - 7.5 cm, 7.5 – 15 cm and 15 – 30 cm were collected from the experimental and analyzed for different soil properties using standard methods.

Results

Soil organic carbon did not differ significantly with tillage at any of the depths, but increased with residue retention at all depths (Table 1). Soil available N was significantly higher under minimum tillage at 0-7.5 cm depth, but was not affected by tillage at 7.5-15 cm and 15-30 cm depths. Available N increased with residue retention at all three depths. Available P increased with residue retention at all depths, but was not influenced by tillage. Available K was not affected by tillage at any of the depths, but increased with residue retention at all the three depths. Interaction effects between tillage and residue retention were not significant.

Conclusion

Retaining residues on the soil surface can lead to significant improvements in soil properties. Combining residue retention with minimum tillage further enhances these benefits.

Effect of tillage and residue management practices on soil organic carbon, available nitrogen, available phosphorus and available potassium at three depths

Tillage	Residue	Organic carbon (g/kg)			Available N (kg/ha)			Available P (kg/ha)			Available K (kg/ha)		
		0-7.5 cm	7.5-15 cm	15-30 cm	0-7.5 cm	7.5-15 cm	15-30 cm	0-7.5 cm	7.5-15 cm	15-30 cm	0-7.5 cm	7.5-15 cm	15-30 cm
MT	S0	4.64	4.22	3.63	180.9	140.1	106	32.3	20	12.2	110.6	98.1	84.8
	S1	4.95	4.41	3.84	216.7	167.7	119.5	37.2	24.4	14.4	121.8	106.1	93.2
	S2	5.47	4.59	4.14	252.3	182.7	144.3	41.3	29.5	17.5	137.2	117.4	102
	Mean	**5.02**	**4.41**	**3.87**	**216.6**	**163.5**	**123.3**	**36.9**	**24.6**	**14.7**	**123.2**	**107.2**	**93.3**
CT	S0	4.49	4.12	3.44	147.3	123.6	96.1	28.5	17.9	10.3	106.1	94.5	76.4
	S1	4.72	4.24	3.66	175.3	146.1	109.2	31.6	20.3	12.6	117.9	102.5	87.3
	S2	5.2	4.45	3.94	208.3	161.9	125.5	35.2	25.2	15.5	129.5	110.8	95.7
	Mean	**4.81**	**4.28**	**3.69**	**177.0**	**143.9**	**110.3**	**31.8**	**21.1**	**12.79**	**117.9**	**102.6**	**86.5**
Residue means	S0	4.57	4.17	3.54	164.1	131.9	101.1	30.4	19.0	11.3	108.4	96.3	80.6
	S1	4.84	4.33	3.75	196.0	156.9	114.4	34.4	22.4	13.5	119.9	104.3	90.3
	S2	5.34	4.52	4.04	230.3	172.3	134.9	38.3	27.4	16.5	133.4	114.1	98.9
LSD#	Tillage (T)	NS	NS	NS	4.97	NS	NS	NS	NS	NS	NS	NS	NS
	Residue (R)	0.37	0.13	0.14	11.6	12.6	16.2	4.5	4.4	4.0	6.2	9.7	12.6
	R x T*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	T x R**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

# $P < 0.05$, * Residue treatments at same tillage treatment, ** Tillage treatments at same or different residue treatments

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Outcome of Foliar Application of Nano-Urea on Economics of Bunded Upland Rice in Bastar Plateau Zone of Chhattisgarh

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India ranks second in the world for rice production involving high yielding rice varieties within intensive agriculture involving huge amounts of nutrient removal, particularly the nitrogen replenished by N-fertilizers which have Nitrogen Use Efficiency of 45- 50% (Iqbal *et al.*, 2020) meaning that on a global scale, more than 50% of the N applied to agricultural soils is potentially lost into the environment. It can be seen that there is an increase in the application of inorganic nutrient sources day by day, enabling soil to deteriorate in terms of soil fertility. Use efficiency of N needs to be improved substantially by increasing the efficiency of agricultural systems and adopting environmentally sound agronomic practices (Zhang *et al.,* 2023), and exploring modern technologies. Nano-fertilizers possess unique features that enhance plants' performance in terms of ultra-high absorption, increase in production, rise in photosynthesis and significant expansion in the leaves surface area (Nongbet *et al.*, 2022; Rautela *et al.,* 2021). Besides, the controlled release of nutrients contributes in preventing eutrophication and pollution of water resources (Guo *et al.,* 2018).It was reported that, uptake efficiency of Nano-urea is more than 80% compared to prilled urea application (Kumar *et al.*, 2021). When sprayed on the leaves, Nano-nutrient formulation enters through the stomata through the gas exchange and is assimilated by the plant cells (Abdel-Aziz *et al.,* 2018; Tarafdar *et al.*, 2014).

Methodology

A two year field experiment has been conducted during *kharif* 2022 and 2023 at dryland farm of Shaheed Gundadhoor College of Agriculture and Research Station Jagdalpur, District Bastar, State Chhattisgarh. The experiment was conducted in random bock design replicated thrice with ten treatments which were T_1: N_0PK, T_2:N_{50}PK, T_3: N_{75}PK,,T_4:N_{100}PK T_5: N_0PK+Nano-urea, T_6: N_{50}PK+Nano-urea, T_7: N_{75}PK + Nano-urea, T_8: N_{100}PK + Nano-urea, T_9:N_{75}PK+ Nano-urea (thrice) and T_{10}: N_{50}PK + Nano-urea (thrice). The soil was sandy loam in texture, slightly acidic in nature and soil fertility status in terms of available nitrogen and phosphorus was low, medium in potassium and normal in DTPA extractable Zn. The test crop was rice variety Danteshwari and RDF was 80:40:40 kg N, P_2O_5 and K_2O/ ha. Entire P and K applied as basal. Nitrogen is applied in 3 splits – 1/3rd each at sowing, tillering (35-40 DAS) and panicle initiation (55-60 DAS). Nano urea (4%) sprayed twice and thrice (30-35 DAS, 55-60 DAS and 70-75 DAS) as per treatment and volume applied @ 2 ml/ litre of water (1250 ml Nano urea in 625 litres of water per ha).

Results

Different treatments had a significant effect on grain and straw yield of upland rice, as delineated in Table. Foliar spray of nano-urea with soil application of either 75% or 100% recommended N recorded similar but significantly higher grain yield (2989-3178 kg/ha) compared to other treatments. Although the increase was 3.58 and 2.55 percent more in N_{100}PK + nano-urea (twice) and N_{75}PK + nano-urea (thrice), respectively as compared to N_{100}PK. Similar Results were recorded for straw yield. N_{100}PK + nano-urea (twice) and N_{75}PK + Nano-urea (thrice) yielded 3944 and 3920 kg straw/ ha, respectively as compared to 3735 kg/ ha in N_{100}PK and the corresponding increase was 5.6 and 5 percent in the respective treatments. The harvest index was at par among the treatments. These findings were in agreement with reports of Kumar *et al.* (2020) and Abdel-Aziz *et al.* (2018). The highest additional return and overall economic benefit was recorded under treatment N_{100}PK + Nano-urea (twice) (T8) *i.e.* Rs.2401 and Rs. 1571, respectively but treatment N_{75}PK + Nano-urea (thrice) (T9) gave Rs. 1744 additional return and Rs. 884 overall economic benefit and also 25 % saving in N fertilizers over recommended (T4) as shown in Table 2.These findings are in agreement with the reports of Kumar *et al.* (2020)

Conclusion

Treatment 7 in upland rice can be recommended for nutrient management in terms of yield advantage and saving of urea.

Effect of nano-urea on yield of bunded upland rice

Treatment		Grain yield (kg/ha)			Straw yield (kg/ha)			HI (%)
		2022	2023	Mean	2022	2023	Mean	
T1	N_0PK	1460	1315	1388	2126	1925	2026	40.65
T2	N_{50}PK	2405	2378	2392	2760	2744	2752	46.50
T3	N_{75}PK	2694	2705	2700	3080	3109	3095	46.59
T4	N_{100}PK	3055	3080	3068	3710	3761	3735	45.09
T5	N_0PK + Nano-urea (twice)	1995	1824	1910	2415	2220	2317	45.17
T6	N_{50}PK + Nano-urea (twice)	2700	2645	2673	3430	3378	3404	43.98
T7	N_{75}PK + Nano-urea (twice)	3040	2937	2989	3788	3679	3734	44.46
T8	N_{100}PK + Nano-urea (twice)	3210	3145	3178	3974	3915	3944	44.62
T9	N_{75}PK + Nano-urea (thrice)	3180	3112	3146	3952	3888	3920	44.52
T10	N_{50}PK + Nano-urea (thrice)	2876	2724	2800	3504	3337	3420	45.01
LSD (p=0.05)		291	274	278	305	297	301	0.22
CV (%)		13.68	11.38	11.96	12.44	10.38	11.48	10.33

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Integrated Farming System for Sustainable Productivity, Profitability and Employment Generation in North Eastern Ghat Zone of Odisha

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In India, rainfed agriculture occupies 58% net sown area, contributing 44% of food grain production and supporting 40% of the population. Due to increase in human population and declining per capita land availability in India, there is no scope for horizontal increase in land area for food production. There is also decreasing yield, resource use efficiency and profitability in rainfed agriculture. The only possibility to increase the food production is by increasing the production per unit area and time. Only vertical increase in land area is possible by integrating different farm enterprises which requires less space and time and ensures regular income round the year to the farmer. Crop cultivation under drylands is always risky and uncertain due to erratic and uneven distribution of rainfall and crop failure has become common phenomenon in drylands. The farmers often experience crop failure because of non- or poor availability of water at the critical stages of crop growth. Dryland farming is more prone to uncertainty of rainfall. In this context farming system approach can play important role in increasing the production per unit area and time. Integrated farming system (IFS) is a viable approach for obtaining sustainable income in drylands through integration of different enterprises. In view of the above conditions, an attempt was made for a holistic and innovative approach of IFS with the objective to increase and sustain the productivity and profitability of small and marginal farmers.

Methodology

The on farm research on rainfed based integrated farming system (IFS) was conducted at the villages such as Jamujhory and Sitalapani of the Kandhamal District of Odisha under AICRP for Dryland Agriculture, Phulbani, Odisha during 2021-2023. These two villages often experiences scarce and erratic monsoon rainfall during *Kharif* season. The villages received rainfall of 1283.6 mm, 1981.6 mm and 1766.8 mm during 2021, 2022 and 2023 in 64, 78 and 75 rainy days, respectively as against normal rainfall of 1407 mm with 65 rainy days. The total number of dry spells occurred during *kharif* 2021, 2022 and 2023 were 4, 1 and 2 respectively. Practice of sole cropping is predominant in this area and results in low yields or sometimes even crop failure due to ill distribution of monsoon rainfall. In such areas, climate resilient interventions such as improved varieties and intercropping systems are the feasible options to minimize the risk in crop production and ensure reasonable returns.

Different agricultural interventions were taken to combat the climate aberration such as delayed on monsoon, early season drought, mid season drought and terminal drought and for the successful crop production. The IFS model were conducted by taking 12 Nos of farmers i.e. small farmers with crops + livestock in rainfed situations (3 Nos); marginal farmers with crops + livestock in rainfed situations (3 Nos); small farmers with crops + livestock in partially irrigated situations (3 Nos); marginal farmers with crops + livestock in partially irrigated situations (3 Nos). The IFS models were compared with the control treatment of 12 Nos of farmers with same farming situations. Details of constraints in existing system and interventions implemented in RIFS are given in Table 1.

Table 1. Details of constraints in existing system and interventions implemented in RIFS

Module	Existing system	Constraints in Existing system	Interventions implemented in RIFS
NRM module	Not adopted the in-situ moisture conservation practices in rice, maize and vegetable crops	Not aware about different in-situ moisture conservation practices such as deep summer ploughing, mulching, raising bund height and application of OM and farm pond	• Summer ploughing for all the crop • Raising bund height in rice • Organic mulching in vegetable crops • RF system in all the vegetable crops • Application of OM in all the crops
Crop Module	Sole cropping of rice, maize and few vegetables	Low yield from local varieties and yield reduction due dry spells and draught situations	• Intercropping systems • Improved draught tolerant varieties • Application of balanced nutrition • Organic nutrient management
Livestock module	Rearing of Desi cow only	Low income from livestock such as cow, buffalo, goat due to Desi breed and diseases	• Rearing of good breeds of cow, goat, buffalo • De-worming of cattle • Mineral nutrition of cow, goat and buffalo • Sanitation of shed
Perennial tree module	No perennial tree	No cultivation as perennial tree	• Supplied the drumstick, papaya and banana seedling for Badi system.
Optional module	Desi poultry bird rearing	Less income from the Desi poultry bird rearing	• Rearing of improved poultry bird rearing
Capacity building	Traditional cultivation	Lack of knowledge on improved crop management practices	• Need based training to farmers on improved technology in crop production • Field days

The demonstrations were conducted on improved crop varieties such as Rice (var. Sahabhagi, Lalat), Maize (var. P-3501, NMH-51, OMH 14-27), Pigeon pea (var. NTL 724), Cowpea (var. Gomti), Radish (var. Pusa Chetki), Tomato (var. Priya), Brinjal (var. Blue star), Bean (var. Raikia Local) and Okra (var. JKOH 7315). The demonstrations were also conducted on different intercropping systems such as maize + cowpea, maize + pigeonpea and pigeonpea + radish. The different management practices such as *in-situ* moisture conservation, nutrient management, pest and disease management and weed management were also taken care of for these crops and cropping systems. In the rainfed situations, crops were grown with the rainfall only whereas in the partial irrigated conditions, irrigation was done from the farm pond. In livestock, cattle, goat and poultry were reared. In perennial tree, drumstick, papaya and banana were cultivated. The goat manure, cow dung and farm waste were recycled to crops after composting. IFS enterprises were compared by quantifying physical indicators of sustainability based system productivity, gross income, net income and employment generation. The economics of each enterprise was calculated based on the economic produce of that enterprise.

Results

IFS model surpassed the conventional cropping system (CCS) with respect to its productivity, gross income and net income during all the study years (Table 2).

Table 2. Productivity and profitability of integrated farming system (IFS) in omparison to conventional cropping system (CCS)

Systems / particulars	2021-22			2022-23			2023-24		
	SP (Kg)	NR (Rs.)	EG (Man-days)	SP (Kg)	NR (Rs.)	EG (Man-days)	SP (Kg)	NR (Rs.)	EG (Man-days)
Marginal farmers - Crops + Livestock – Rainfed situations									
IFS	7471	52500	143	7550	54500	152	7580	55200	155
CCS	2880	22400	76	2920	23200	80	2950	23400	82
Small farmers - Crops + Livestock – Rainfed situations									
IFS	9036	92533	267	9120	93800	268	9140	93900	269
CCS	3200	28600	122	3250	29200	125	3260	29400	126
Marginal farmers - Crops + Livestock – Partially irrigated situations									
IFS	8731	70500	260	8780	72000	262	8820	72500	264
CCS	3750	28600	125	3780	28800	126	3785	28900	127
Small farmers - Crops + Livestock – Partially irrigated situations									
IFS	12296	125500	315	12350	128500	318	12360	128600	319
CCS	6500	46500	180	6550	47200	182	6580	47350	184

SP: System productivity; NR: Net return; EG: Employment generation; IFS: Integrated farming systems; CCS: Conventional cropping system

The system productivity, net return and employment generation from 0.8 ha of land (marginal) of IFS in rainfed situations were found to be 7471 kg, Rs. 52500/- and 143 respectively during 2021-22; 7550 kg, Rs. 54500 /- and 152 during 2022-23; 75890 kg, Rs. 55200/- and 155 respectively during 2023-24. The increase in system productivity, net return and employment generation from 0.8 ha of land (marginal) of IFS in rainfed situations in comparison to conventional cropping system (CCS) were found to be 157-159%, 134-136% and 88-90% respectively. Similar results were also found in case of small farmers of average land holding of 1.5 ha in rainfed situations. The system productivity, net return and employment generation from 0.8 ha of land (marginal) of IFS in partially irrigated situations were found to be 8731 kg, Rs. 70500/- and 260 respectively during 2021-22; 8780 kg, Rs. 72000/- and 262 during 2022-23; 8820 kg, Rs. 72500/- and 264 respectively during 2023-24. The increase in system productivity, net return and employment generation from 0.8 ha of land (marginal) of IFS in partially irrigated situations in comparison to conventional cropping system (CCS) were found to be 132-133%, 147-151% and 108% respectively. Similar results were also found in case of small farmers of average land holding of 1.5 ha in partially irrigated situations. Inclusion of improved varieties of crops and intercropping systems act as insurance against main crop failure and allied enterprises such as goatery and dairy has helped to increase the IFS productivity and profitability as compared to popular crops or cropping system (CCS) in the area. In CCS, employment generation was limited during the crop growing season only for sowing, interculture and harvesting operations. On the contrary, under IFS employment generated uniformly round the year without giving much relaxation during lean period.

Conclusion

The results obtained from IFS experiment during 2021-23 showed that farm productivity and profitability could be sustained by integrating different livestock enterprises, i.e. dairy and goatery along with modified cropping systems with farm pond for supporting the farmers in North Eastern Ghats Zone of Odisha. The IFS model in this zone provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.

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Changes in Soil Physico-Chemical Properties after Long Term Application of Integrated Nutrient Management in Direct Seeded Rice-Field Pea Cropping System

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India ranks second in the world for rice production involving high yielding rice varieties within intensive agriculture involving huge amount of nutrient removal. It can be seen increase in application of inorganic nutrient sources day by day enabling soil to deteriorate it's physico-chemical properties. Application of organic sources of nutrients along with fertilizers has improved soil properties as well as maintained good soil health besides improving the availability of nutrients to plants and hence productivity also (Katar et al., 2012).

Methodology

A long-term field experiment has been conducted since *kharif* 2014 at long term field trial of dryland farm of Shaheed Gundadhur College of Agriculture and Research Station Jagdalpur, District Bastar, State Chhattisgarh. The experiment was conducted in random bock design with twelve treatments; which were T_1 control, T_2 100% recommended dose of fertilizer (100:60:40 kg ha^{-1}), T_3 (100% PK), T_4 (100% NK), T_5 (100% NP), T_6 (100% NPK+5 t FYM), T_7 (100% NPK+5 t FYM+ $ZnSO_4$@25kg ha^{-1}), T_8 (100% NPK+5 t FYM+ $ZnSO_4$@25kg ha^{-1} + Lime 3 q ha^{-1}), T_9 (50% NPK), T_{10} (50% NPK + 5 t FYM), T_{11} (50% NPK + 5 t FYM+ $ZnSO_4$@25kg ha^{-1}) and T_{12} (50% NPK + 5 t FYM+ $ZnSO_4$@25kg ha^{-1}+ Lime 3 q ha^{-1}) replicated four times. Soil organic carbon and pH determined in the laboratory while bulk density (BD) and hydraulic conductivity (HC) measured directly in the field by standard procedures after *rabi* harvest of 2023-24.

Results

Changes in bulk density

After a span of nine years of continuous cropping of rice- field pea with the application of organic manure along with inorganic fertilizer lead to improve significantly the soil bulk density. Soil bulk density of treatments at 15 cm soil depth ranges from 1.34 to 1.44 g/cc. The highest value (1.45 g/cc) of bulk density was observed in 100% NP (T5) and followed by 100% PK(T3) and 100% NK (T_4) while the lowest value (1.34 g/cc) of bulk density was recorded in T8 and 100% NPK+5 t FYM (T_6). Bulk density of soil helps in aeration as well as proper movement of water in soil. It provides structural support to plant. More compact soil shows high value of bulk density than others. In treatment 100% NPK+5 t FYM + 25 kg $ZnSO_4$ and lime @ 3 q/ha (T_8) the incorporation of organic manure lead to decrease the bulk density of soil and is at par with T6, T7, T10, T11 and T12 which have shown significant decrease in soil bulk density as compared to plots treated alone with the inorganic fertilizers. There were 1.4-2.9 % decrease in BD in treatments where FYM were given @ 5 t/ha as compared to initial (within the span of 9 years) as shown in Fig 1.

Changes in hydraulic conductivity

Data reveals that the addition of FYM with chemical fertilizer enhances the hydraulic conductivity of soil by better particle aggregation. The range of hydraulic conductivity among different treatments was recorded from 3.44×10^{-3} cm/sec in T5 to 3.94×10^{-3} cm/sec in T8. In T8, the addition of organic manure shows significant increase on hydraulic conductivity. There were 6.8-7.9 % increase in HC in treatments where FYM were given @ 5 t/ha as compared to initial (within the span of 9 years) as shown in Fig 2.

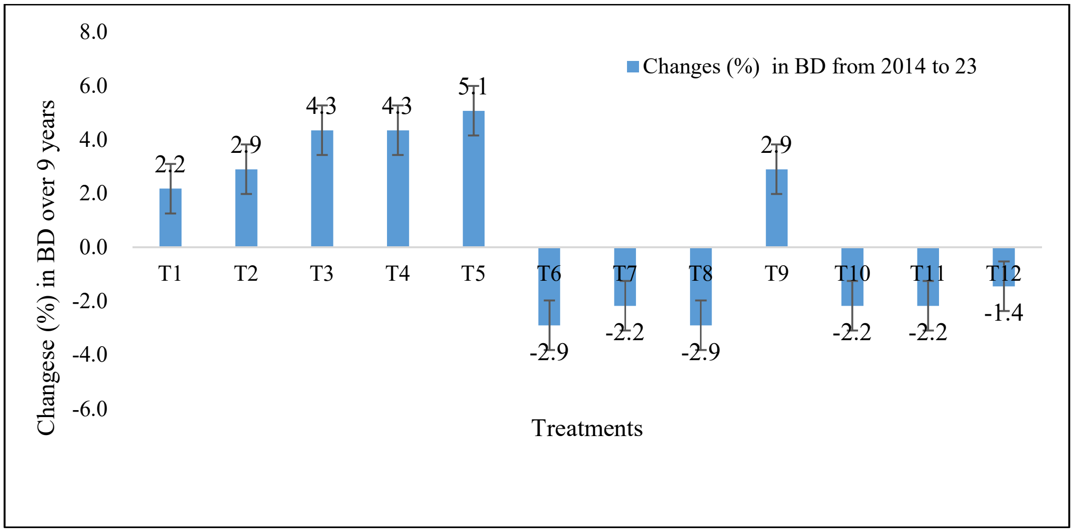

Fig 1. Long-term effect of INM on changes in bulk density over nine yeas

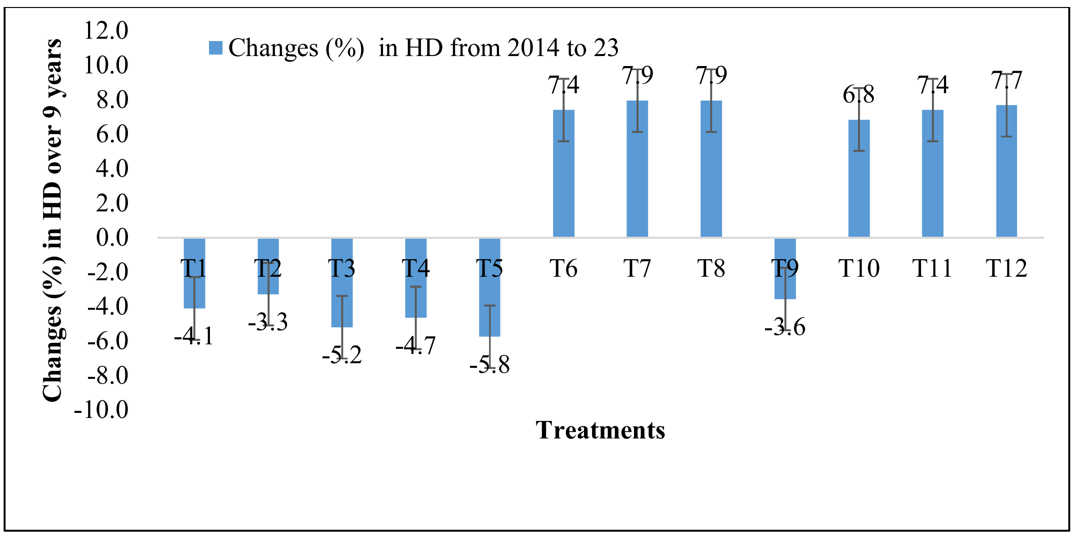

Fig 2. Long-term effect of INM on changes in hydraulic conductivity over nine years

Changes in pH

The soil reaction in terms of pH among treatments ranges from 6.32 in T_4 to 6.64 T_8 and T_{12} as shown in Fig 3. There was significant increase in pH in all the treatments where FYM was applied and the increase was 3.5 to 4.7 per cent over the span of nine years. The results were supported by findings of Sahu *et al.* (2021).

Changes in organic carbon

Continuous application of FYM along with fertilizers showed significant effect on soil OC as shown in Fig 4. The range of OC content in soil among different treatments was 0.62 to 0.73

per cent. There was significant increase in OC in all the treatments where FYM was applied and the increase was 6 to 9 per cent over the span of nine years.

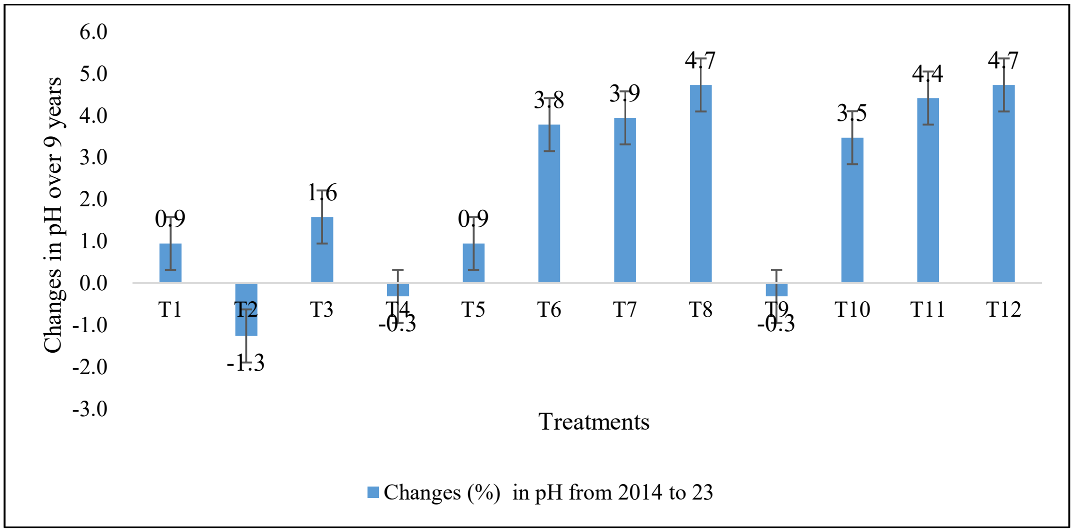

Fig 3. Long-term effect of INM on changes in pH over 9 years

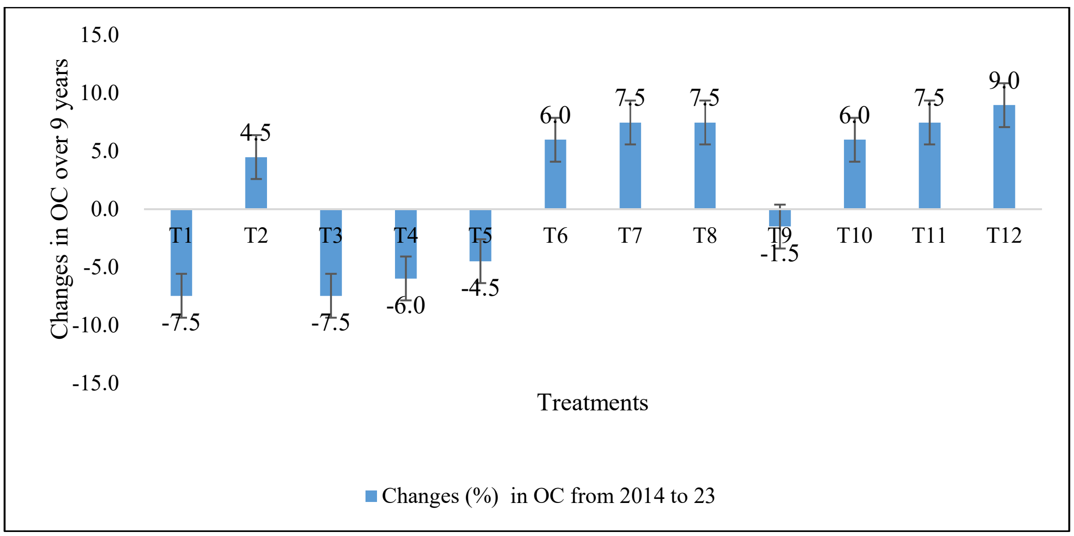

Fig 4. Long-term effect of INM on changes in organic carbon over 9 yeas

Conclusion

The combined application of FYM along with fertilizers could enhances the soil physico-chemical status in terms of increase in organic carbon, HC and decrease in BD.

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Assessing the Release of Soil Available P Using Zeolite, FYM and Elemental Sulphur through Incubation Study

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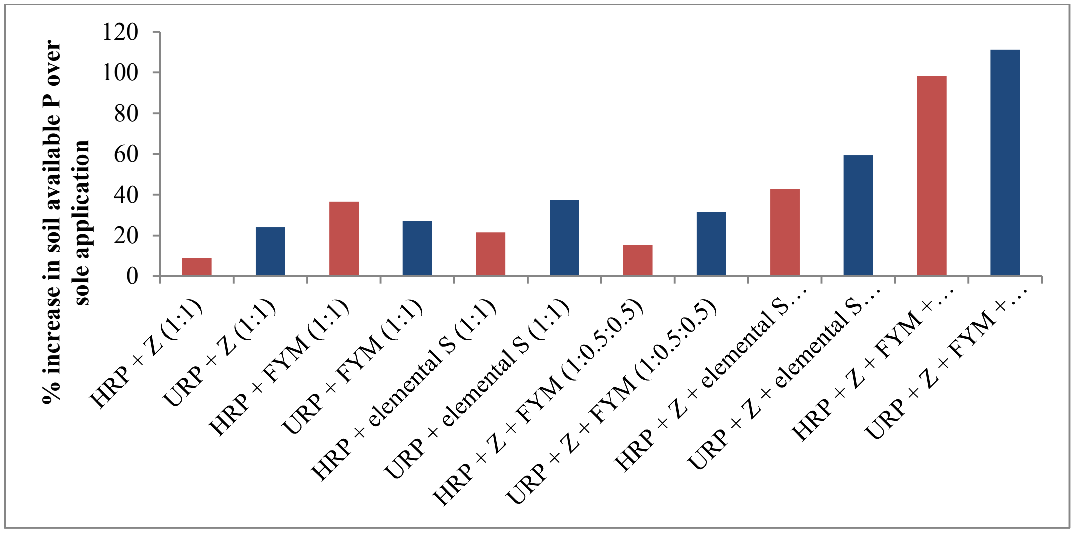
Phosphorus is primary nutrient required for plant growth and development. It plays an important role in glucose metabolism, nitrogen metabolism, energy metabolism, and plant function. Phosphate ore is the raw material for P fertilizers which is a non-renewable resource. However, only high grade rock phosphate is used in the preparation of water soluble chemical fertilizers. The unutilised low grade rock phosphate can be a great source to meet P demand. Yet, its use is limited due to poor dissolution, release and P availability. Natural zeolite, silicate mineral with high surface area and cation exchange capacity can enhance P release from rock phosphate. Its application improves the nutrient availability and moisture content in the soil by holding water and nutrients in its structural pores and makes it available back to plant. It was found that zeolite can improve the P availability and P uptake from rock phosphate (Zheng et al 2019, Chavez-Urbiola et al., 2024 and Viana et al., 2024). Moreover, sulphur and FYM are known to enhance P release from rock phosphate. Thus, incubation study was taken up to evaluate soil available P due to supplementation of zeolite (Z), FYM and elemental sulphur (S) to low and medium grade rock phosphate.

Methdology

Two types of rock phosphate- Hirapur rock phosphate (HRP) and Udaipur rock phosphate (URP) was collected from Madhya Pradesh and Rajasthan. Although both are low grade rock phosphate, the total P_2O_5 content in HRP is 11% and URP is 19%. Incubation study was carried at 30 ^{0}C for 4 weeks with surface soil (0-15 cm) collected from Hayathnagar Research Farm, CRIDA, Hyderabad. Further weekly measurement for 0.5M $NaHCO_3$ extractable P was carried by taking representative samples. The experiment was conducted with 14 treatments combinations in a completely randomized design (CRD) with four replications. Phosphorus content in the extract was estimated calorimetrically based on the reaction with ammonium molybdate and development of the 'Molybdenum Blue' colour. The absorbance is measured at 882 nm in a spectrophotometer and is directly proportional to the amount of phosphorus extracted from the soil.

Results

Data emanated from laboratory incubation experiment indicated that P release from sole RP was lower throughout the incubation period than the commercial SSP (Figure 1). However, variable amounts of P were released from both HRP and URP by incubating with FYM, zeolite (Z) and elemental S (S). The sole application of HRP and URP could maintain soil available P upto 2.80 and 3.33 ppm while the combined application HRP and URP with Z, FYM and S could maintain soil available P upto 5.55 and 7.02 ppm. The release of P from both RPs (HRP and URP) improved by combined application with zeolite which followed the order: RP + Z + FYM+ S > RP + Z + S > RP + Z + FYM > RP + S > RP + Z > RP + FYM.



Conclusion

The combined application of Z, FYM and S with HRP and URP could maintain two times higher soil available P compared to sole application of both HRP and URP. This suggests an alternative strategy to utilize the unutilised low and medium grade rock phosphate.

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Effect of Growing Pigeon Pea with Nutri Cereals as Intercrop on Yield and Rainwater Use Efficiency in Dryland Vertisol Condition

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Tamil Nadu state having bothtropical, subtropical, and temperate climate with a net cultivable area of 6 million hectares. The average annual rainfall variability was from 650 mm in Thoothukudi district to 1460 mm in Kanayakumari district. The majority of the southern regions of Tamil Nadu are classified as drylands, and the districts with the lowest annual rainfall are found in this zone where rabi is the primary growing season. Pulses, maize, sorghum, minor millets, sesame, and sunflower are planted during this 70–90 days growing period, which has 400 mm of seasonal rainfall. The pigeon pea, or *Cajanus cajan* L., is a predominant leguminous crop with global agricultural and economic significance [Sarkar *et al.,* 2020]. Also called "arhar" or "tur," it is grown in a variety of agroclimatic zones, particularly in tropical and subtropical countries [Jadav *et al.,* 2020]. A hardy and drought-tolerant crop, pigeon pea is a major source of protein, energy, and essential nutrients for millions of people, especially in developing nations. They also play a significant role in rainfed agriculture in Tamil Nadu and India, where 63% of all pigeon peas are produced. Unlike cereal and oilseed crops, pigeon pea is cultivated under a distinct kind of intercropping system that has a synergistic effect on the plant and increases soil productivity [Praharaj and Blaise, 2016]. Furthermore, minor millets have the benefit of being short-duration and can be readily included into cropping systems such as sequence cropping, relay cropping, intercropping, multiple cropping, and mixed farming. Crop production integration, a variety of agricultural techniques, and the best conservation practice result in sustainable production, which eventually raises income and improves livelihoods in dryland agriculture. For hot and rather dry conditions, millets are the most resilient, hardy, and climate-adaptable crops.(Dhaka *et al .,* 2023). Hence, the purpose of this experimental study was to determine the best nutri cereal to be taken as an intercrop for medium-duration pigeon pea grown in dryland Vertisols of southern agroclimatic zone of Tamil Nadu.

Methodology

A field study was carried out in the black soil farm of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) main centre, Kovilpatti of Tami Nadu Agricultural University during the *rabi* season of 2021-2022. The soil type was clayey vertisols with a pH of 8.81, low in available nitrogen (134 kg N/ha), low in available phophorous (10.7 kg/ha) and high in available potassium 380kg/ha. The rainfall received during the cropping season was 532.3 mm in 29 rainy days as against the 30 years seasonal average rainfall of 147.9 mm. The trial was conducted in Randomized Block Design with three replications. The treatments consisted of seven treatments with 6 pigon pea based intercropping systems and one sole crop pigeon pea alone. Six nutri cereals viz., barnyard millet (Co 2), foxtail millet (Co 7), kodo millet (Paiyur 1), proso millet (Co 5), little millet (Co 5) and pearl millet (CoCu10) were taken up as inter crops. The crops were sown with two rows of pigeon pea and six rows of inter crops. The main crop pigeon pea (CoRg-7) was sown at a spacing of 45 x 30 cm and the nutri cereals were sown with a row spacing of 22.5 cm except pearl millet at a spacing of 45x10cm. The soil moisture conservation practice of compartmental bunding was imposed before the start of sowing. The crops were sown on 25.10.2021 and the main crop pigeon pea was harvested on 10.02.2022. The intercrops were harvested during the second week of January 2021 at maturity. The total rainfall received during the period was 532.3 mm in 29 rainy days. Various yield parameters, economics and rainwater use efficiency were worked.

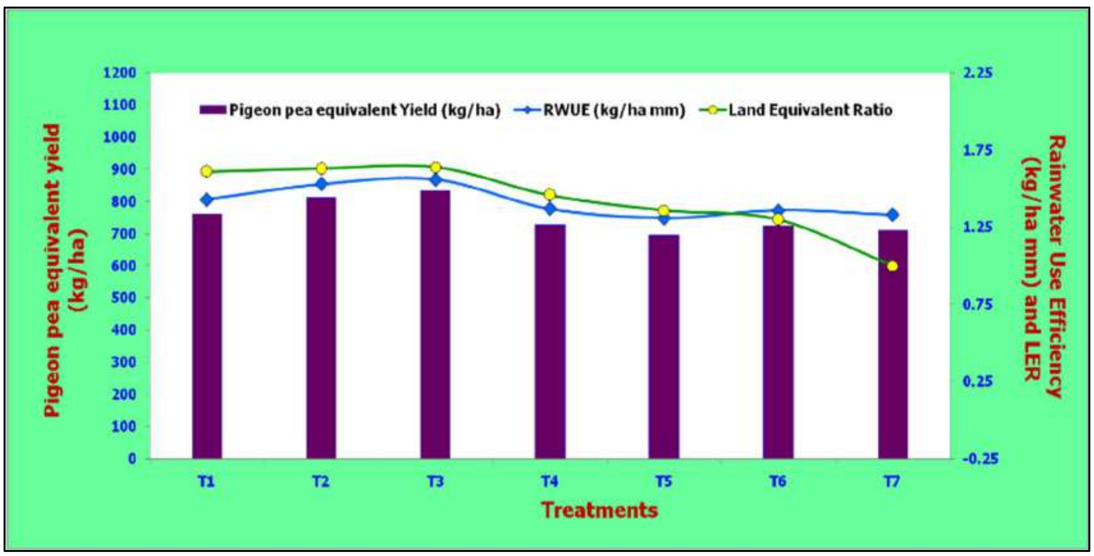
Results

In accordance to the study, the highest yield of 710 kg/ha was obtained by the sole pigeon pea crop. Following that, pigeon pea interplanted with proso millet (T4) recorded a yield of 550 kg/ha. Pigeon pea yields were comparable to other combinations, with the exception of T6 (pigeon pea + pearl millet), which yielded the lowest of 330 kg/ha. Among the inter crops, pearl millet recorded the highest intercrop yield of 1210 kg/ha which significantly differed from all other intercrops. This was followed by kodo millet yielding 886 kg/ha. The lowest intercrop yield of 490 kg/ha was recorded in little millet. There were notable differences in the intercropping systems based on the equivalent yield of pigeon pea. With an equivalent yield of 833 kg/ha, the pigeon pea + kodo millet (T3) system produced the highest yield, which was comparable to that of the pigeon pea + foxtail millet (T2) system. At 696 kg/ha, the pigeon pea + small millet system (T5) produced the lowest pigeon pea equivalent yield.

In terms of economics, the Pigeonpea + Kodo Millet intercropping system gave greater net and gross returns of Rs. 20863/ha and Rs. 45,813 respectively. Pigeon pea + foxtail millet yielded the next-best gross and net return, at Rs. 44660 and Rs. 19710/ha. The pigeon pea + little millet intercropping method yielded the lowest gross and net returns. Rainwater use efficiency also showed a similar trend. The RUE varied from 1.31 to 1.56 kg ha-mm^{-1}, with the pigeon pea + kodo millet intercropping system recording the highest RUE of 1.56 kg ha-mm^{-1}.

Effect of intercropping of nutri cereals with medium duration pigeon pea on yield and RUE under rainfed *Vertisols*

Treatments	Pigeon pea Yield (kg/ha)	Inter Crop Yield (kg/ha)	Pigeon pea Equivalent Yield (kg/ha)	Rainwater Use Efficiency (kg/ha-mm)
T_1- Pigeon pea + Barnyard millet (CO2) (2:6)	530	710	762	1.43
T_2 -Pigeon pea + Foxtail millet (CO 7) (2:6)	542	825	812	1.53
T_3 -Pigeon pea + Kodo millet (Paiyur 1) (2:6)	543	886	833	1.56
T_4 -Pigeon pea + Proso millet (CO 5) (2:6)	550	540	727	1.37
T_5 -Pigeon pea + Little millet (CO 5) (2:6)	536	490	696	1.31
T_6 -Pigeon pea +Pearl millet (CO 10)	330	1210	726	1.36
T_7 -Pigeon pea sole crop (Co (Rg7)	710	0	710	1.33
SEd	27	22	29	
CD (P = 0.05)	63	45	65	



Effect of intercropping of nutri cereals with pigeon pea on RUE and Pigeonpea equivalent yield under rainfed Vertisols

Conclusion

Among the pigeon pea based intercropping systems, the pigeon pea + kodo millet system with a row ratio of 2:6recorded the highest pigeon pea equivalent yield of 833 kg/ha, with a net returns of Rs. 20863/ha, and rain water use efficiency of 1.56 kg/ha mm under rainfed vertisol conditions of southern agroclimatic zone of Tamil Nadu.

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UID: 1297

Yield Enhancement of Rabi Sorghum (Sorghum bicolor L.) through Foliar Application of NPK Under Rainfed Condition

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Sorghum is one of the most important staple crops for millions of people living in semi-arid regions. It thrives under a wide range of temperatures and can withstand drought, which adds to its appeal in regions with erratic weather. It is resilient to conditions of both water logging and drought. The macronutrients are taken by the plants in comparatively large quantities however, available nitrogen and phosphorus are usually deficient in most soils. Yield enhancement of *rabi* sorghum is a big challenge in rainfed areas where the availability of soil moisture is a main constraint for the split application of plant nutrients. Plant nutrients, viz. NPK gets easily available to the plants through foliar application and in turn increase the yield and quality of crop. Keeping in view the above fact, the present study was under taken during *rabi*-2023 at Sorghum Research Station, VNMKV, Parbhani.

Methodology

A field experiment was conducted during *rabi* season of 2023-24 at the experimental farm of Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra. The experiment was laid out in randomized block design with seven treatments viz. T_1: RDF (40:20:20 NPK kg ha^{-1}), T_2: RDF + spray of Nano urea @ 4 ml $liter^{-1}$ of water at panicle initiation stage (PI), T_3: RDF + 2 % spray of DAP panicle initiation stage (PI), T_4: RDF + 2 % spray of KCL panicle initiation stage (PI), T_5: T_2+ 2 % spray of DAP at panicle initiation stage (PI),T_6: T_2 + 2% spray of KCL at panicle initiation stage (PI) and T_7: Control (No fertilizer and no spray) and replicated thrice. The sowing was done on 17th October, 2023 by dibbling the seeds at the spacing of 45 x 15 cm. The complete RDF i.e. 40:20:20 NPK kg ha^{-1} was applied at the time of sowing.

Results

Results of the experiment revealed that application of 40:20:20 NPK kg ha^{-1} (RDF) + foliar spray of nano urea @ 4 ml $liter^{-1}$ of water + 2 % foliar spray of DAP at the panicle initiation stage recorded significantly higher yield contributing characters such as grain yield $plant^{-1}$ and number of grains $earhead^{-1}$, grain yield (2037 kg ha^{-1}) and fodder yield (6286 kg ha^{-1}) however, it was comparable with RDF + foliar spray of nano urea @ 4 ml $liter^{-1}$of water at panicle initiation stage + 2 % spray of KCL at panicle initiation stage (T6), RDF + 2 % foliar spray of DAP at panicle initiation stage (T3) and RDF + 2 % foliar spray of KCL at panicle initiation stage (T4). The improvement in grain yield of *rabi* sorghum might be due to significant effect of foliar spray of nutrients which might have enhanced chlorophyll synthesis, enzyme activity, stomata regulation, starch translocation and assimilation into grains. This cumulative effect might have reflected in more accumulation of photosynthates and their translocation from sink to reproductive parts like grain of *rabi* sorghum. Such a trend of increase in yield of sorghum was also reported by Satish and Sudharani (2021), Balachandar *et al.* (2023) and Chinnappa *et al.* (2023). A similar trend was observed in respect of GMR, NMR and B:C ratio of rabi sorghum.

Conclusion

The application of 40:20:20 NPK kg ha^{-1} (RDF) + spray of nano urea @ 4 ml $liter^{-1}$ of water + 2 % foliar spray of DAP at panicle initiation stage or RDF + foliar spray of nano urea @ 4 ml $liter^{-1}$ of water at panicle initiation stage + 2 % foliar spray of KCL at panicle initiation stage or RDF + 2 % foliar spray of DAP at panicle initiation stage or RDF + 2 % foliar spray of KCL at panicle initiation stage were found equally effective in achieving higher yield and economics of *rabi* sorghum.

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UID: 1303

Assessment of Heavy Metals in Soil and Finger Millet Due to Long-Term Nutrient Management Practices

Fathima A.

Continuous application of chemical fertilizers results in the accumulation of heavy metals in soils and plants; hence the study was conducted in an ongoing long-term fertilizer experiment in AICRP on dryland agriculture, GKVK, Bangalore to assess the total and available heavy metals in soil and finger millet. The experiment was initiated in 1978, consisted of eight treatments and three replications with monocropping of finger millet. Soil samples were collected at two depths (0-15 and 15-30 cm), before and after sowing and these samples were analyzed for total and available arsenic, cadmium, chromium, and cobalt. Finger millet roots, stems, leaves, grains, and straw were collected at 30, 60 and 90 DAS, and at harvest, to analyze macronutrients and heavy metals. The results revealed that macronutrients, total and available heavy metals were highest in FYM @10 t ha^{-1} + 100% RDF, followed by FYM @10 t ha^{-1} + 50% RDF. In finger millet, the uptake of all nutrients and heavy metals was higher in the treatment with FYM @10 t ha^{-1} + 100% RDF. Among different parts of finger millet, the root accumulated the highest concentration of heavy metals, followed by leaves, stems, straw, and grains. The surface soil in all treatments showed relatively higher heavy metal accumulation than the subsurface. The BCF values exceeded 1 in all parts of the finger millet except the grains. Non-carcinogenic hazards were high (>1) in all treatments except the control. However, DTPA-extractable heavy metals in soil, and heavy metals in grains, were within permissible limits.

UID: 1306

Establishment of a Fertility Gradient for Evaluating Soil Nutrient Dynamics and Fodder Maize Productivity

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A fertility gradient experiment was conducted in 2023 to create an artificial soil fertility gradient and nullify the residual effects of previous agricultural practices. Three strips were

established and fertilized with increasing levels of N, P_2O_5 and K_2O (0-0-0, 150-0-200 and 300-0-400 kg ha^{-1} for strips I, II and III, respectively). Additionally, farmyard manure (FYM) was applied at 5, 10 and 20 t ha^{-1} to strips I, II, and III, respectively. The FYM contained 0.55% N, 0.29% P and 0.53% K. An exhaustive crop of fodder maize (variety: African Tall) was grown and harvested at 60 days after sowing to allow nutrient transformations by plant uptake and microbial activity. Post-harvest, soil samples (0–15 cm) were collected and analyzed for available N, P and K. Available N was determined using the alkaline $KMnO_4$ method, available P by Bray's extractant and colorimetric ascorbic acid method, and available K using 1 N ammonium acetate extraction followed by flame photometry. Results revealed significant fertility variations across the strips, with strip III recording the highest soil nutrient levels (245.20, 450.94, and 389.10 kg N, P_2O_5, and K_2O ha^{-1}, respectively), followed by strip II and strip I. A similar trend was observed for fodder yield, with strip III achieving 67.63 t ha^{-1} compared to 54.56 t ha^{-1} and 43.19 t ha^{-1} in strips II and I, respectively. The experiment effectively established a fertility gradient, demonstrating its utility for assessing nutrient uptake and soil fertility responses in subsequent test crops. These findings provide valuable insights for nutrient management strategies aimed at optimizing crop productivity while ensuring sustainable soil fertility.

UID: 1307

Effects of Water Conservation on Productivity, Profitability, Energy and Carbon Use Efficiencies of Sunflower and Pigeonpea Intercropping in Vertisols of Karnataka

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Field experiments on to find out effects of water conservation and stress mitigation measures on crop performance, economics, energy and carbon use efficiency of rainfed sunflower + pigeonpea in *Vertisols* of Northern Karnataka, Experiment was conducted during *Kharif* 2020 and 2021 at University of Agricultural Sciences, Raichur, Karnataka. Experiment was laid out in split plot design with moisture conservation practices as main plots and cropping systems in sub plots replicated three times. Results showed ridge and furrow recorded significantly improvement in sunflower (59.6-66%) and pigeonpea (85.2-128.7%) grain yield over flatbed sowing. It also exhibited greater output energy (37.8-83.0%), energy use efficiency (4.2 kg/GJ) and least C-footprints (182 kg CE kg^{-1} grain). Among the input energy sources, chemical fertilizers accounted 53.6 % of the total input energy. Intercropping has yield advantage in terms of greater pigeonpea equivalent yield (PEY) (0.53-1.13 Mg ha^{-1}), profitability, output energy (42.4 GJ ha^{-1}), energy ratio and least C- foot print (0.248 kg CE

kg^{-1} grain). Combination of intercropping on ridge and furrow obtained higher PEY (2,392 kg ha^{-1}), land equivalent ratio (1.54), output energy (54,707 MJ ha^{-1}) energy ratio (5.04), net returns (₹1,20,308 ha^{-1}) and B: C ratio (4.18) over the rest of the combinations. Results confirmed sunflower and pigeonpea intercropping on ridge and furrow was productive, energy saving, C-footprint reduction and economical practice under rainfed condition.

Irregular rains and moisture stress at critical growth stages of crops are affecting productivity. Soil moisture is most important limiting factor in pigeonpea production. Its early growth is very slow offers an opportunity to include fast growing, short duration and short statured non-competitive crops including sunflower as an intercrop for complimentary use of natural resources. Pigeonpea and sunflower intercropping has shown best combination due to its wide spatio-temporal differences. Primary objective of various moisture conservation studies to conserve moisture under limited rainfall events. In drylands, availability of soil water in the profile from sowing to harvest especially at critical stages of sunflower and pigeonpea was most critical. Impact of these conservation measures in sole crop is well documented in several crops and soil types. A systematic assessment of energy, carbon budgeting and the economic feasibility of this system can provide insights on the environmental impacts associated with the crop management practices. For sustainable crop combinations, analysis of energy input-output relationship, energy productivity, and specific energy are useful parameters. However, crops performance under intercropping in *Vertisol* particularly in pigeonpea and sunflower is not much evaluated. It was hypothesized that soil moisture conservation measures for intercropping can enhance yield, saves energy and minimize C-footprint under rainfed ecosystem. Objectives of the current study was to evaluate the performance of pigeonpea + sunflower intercropping different moisture conservation for productivity, profitability with energy and carbon budgeting.

Methodology

Field experiment was conducted in 2021 and 2022 at research Farm University of Agricultural Sciences, Raichur, India. The soil of the experimental site was clayey texture, slightly alkaline (pH 8.2), low organic carbon, low in available N, high in P and K. The split plot design was adopted replicated thrice in fixed plots in both the years. Main plots were raised bed, ridges and furrow, tie ridges and furrow, conservation tillage, flatbed sowing and opening furrow after every three rows at 30 DAS compared with flatbed sowing. Subplots were sunflower and pigeonpea (1:1) compare with sole pigeonpea and sunflower. After land preparation fresh raised beds were created every season using a tractor drawn bed former having 1.2 m bed width, with a furrow of 0.45 m top width and 0.15 m furrow depth. Agronomically both crops were raised as per the university production recommendations for the region. The input energy was separated into direct and indirect forms. The direct energy consists of diesel, human power, bullocks, while the indirect energy consist of seeds, fertilizers, chemical, machinery and equipment, pesticides. Carbon equivalents (CE) were estimated by multiplying the inputs (seed, fuel, water, residues, fertilizers, pesticides) with their respective carbon emission coefficients. Yield of individual crop was converted into equivalent yield on the basis of prevailing market price of the crop. Net returns and BC ratio were worked out based on cost of cultivation and output market price.

Results

Averaged over 2-years, grain yield improvement in ridge and furrow was 109 % higher over flatbed. Ridges and furrows created a favourable microclimate required for better plant growth, effective utilization of soil moisture that might resulted 59.6-66% yield improvement. Further sunflower, pigeonpea and pigeonpea equivalent yields were greater in ridge and furrow practice over flatbed. Intercropping system has the 27.8% and 86% yield advantage over pigeonpea and sunflower sole crops respectively.

Yield, economics, carbon and energy efficiencies of sunflower and pigeonpea under soil moisture conservation and cropping systems (Average data of two years)

Treatment	Sunflower (Mg ha^{-1})	Pigeonpea (Mg ha^{-1})	Biological yield (Mg ha^{-1})	PEY (Mg ha^{-1})	Net returns (Rs./ha)	BC ratio	C-Efficiency	C-Sustainable Index	C-footprint kg CE kg^{-1} PEY grain)	EUE (kg GJ^{-1})
Soil Moisture conservation										
C_1-Raised bed	1.03^b	2.01^a	10.19^b	2.07^b	70,774	3.12	7.39^b	6.39^b	0.22^b	3.97^b
C_2-Ridge and furrow	1.28^a	2.23^a	11.50^a	2.39^a	86,866	3.61	8.50^a	7.494^a	0.182^b	4.61^a
C_3-Tied ridges and furrow	1.03^b	1.98^a	10.19^b	2.05^b	68,925	3.02	7.63^b	6.633^b	0.214^b	3.91^b
C_4-Conservation tillage	1.02^b	1.56^a	8.65^c	1.76^c	56,238	2.74	2.42^e	1.414^e	0.627^a	3.48^c
C_5-Flatbed sowing and opening furrow after every three rows at 30 DAS	1.02^b	1.58^b	8.79^c	1.77^c	56,149	2.69	6.76^c	5.758^c	0.23^b	3.47^c
C_6-Flatbed sowing	0.78^b	1.07^c	6.26^d	1.27^d	31,528	1.98	5.10^d	4.103^d	0.299^b	2.52^d
Cropping system										
I_1: Sunflower + pigeonpea	0.82^b	1.57^b	8.08^a	2.44^a	84,221	3.23	6.95^b	5.947^b	0.248^b	4.30^a
I_2: Sole pigeonpea	-	1.91^a	6.95^b	1.91^b	65,133	3.14	8.59^a	7.586^a	0.235^b	3.98^b
I_3: Sole sunflower	1.23^a	-	3.50^c	1.31^c	35,886	2.22	3.36^c	2.364^c	0.403^a	2.86^c

Note: PEY- Pigeonpea equivalent grain yield, EUE- Energy use efficiency, within a column means followed by the same letter are not significantly different at p=0.05.

Higher output energy (42.1 GJ ha^{-1}), net energy (32.9 GJ ha^{-1}) specific energy (4.44 MJ kg^{-1}) EUE (4.66) were in ridge and furrow practice, lowest in flatbed sowing. Ridges and furrows practice has showed greater C-output (83.56%), C-efficiency (8.50), CSI (7.49) as well as lowest C-footprint (0.182 CE kg^{-1} PEY) over traditional flatbed practice. The C-input and C-output differences were also influence on C- efficiency, CSI and C-footprint. Intercropping has produced grater output energy (42.4 GJ ha^{-1}), net energy (32.2 GJ ha^{-1}), EUE (4.2), energy productivity (240.6 GJ ha^{-1}) over respective sole stands. Lower specific energy (3.7 GJ kg^{-1}) and EIPT (0.95×10^{-3} GJ ha^{-1}) were recorded in pigeonpea.

Conclusion

Overall, results of the study conclude that production of sunflower and pigeonpea intercropping under rainfed condition on ridges and furrow method has resulted in greater productivity. It has showed greater advantage in terms of yields enhanced system profitability than those of the sole crops. Intercropping exhibited reduced C-footprint and increased system EUE while sustained production through higher productivity under the present scenario of climate change and limited water resource availability. This system could be a focal recommendation in the agricultural policy planning to achieve the targets of a profitable economy, sustain soil quality and safe and cleaner agricultural practices towards achieving sustainable development goals in the similar semiarid rainfed agro-ecosystems.

UID: 1308

Application of Nano formulated herbicide on weed dynamics, control efficiency, growth and yield of hybrid maize in deep *Vertisols* of Karnataka

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A field experiment was conducted at Bheemarayanagudi, Karnataka to study the impact of nano-formulated herbicides on weed flora, weed control efficiency, productivity and economics of maize during *Kharif* 2021 and 2022. At 20, 40, 60 days after sowing weed flora, weed density, weed dry weight was recorded. The results showed lowest weed density, dry weight and the highest weed-control efficiency by combined application of either nano-metolachlor 50% EC @ 600 ml ha^{-1} or nano-alachlor 50% EC @ 1.5 L ha^{-1} as PE followed by tembotrione 34.4 SC @ 120 g *a.i.* ha^{-1} as PoE at 30 DAS. Weed infestation has reduced 54.6% maize yield. Significant changes in microbial population and enzymatic activity was observed in herbicide applied treatments. Highest net returns and benefit: cost ratio was found in above combined herbicide application in maize production. It can be concluded that combined application of herbicides may be recommended in hybrid maize production in *Vertisol* areas of Southern India.

Methodology

Field experiment was conducted during rabi 2021 and 2022 at College of Agriculture, Bheemarayanagudi, Karnataka (16º 15’ N, 77º 20’ E 389 m). Soil was clay with soil pH 8.26

and EC of 0.29 dS m^{-1}. The soil was 0.47% organic carbon, low in available nitrogen (237 kg ha^{-1}), low in available phosphorus (17.3 kg ha^{-1}) and high in available potassium (315 kg ha^{-1}). Variation in the weather parameters during the crop growth period was observed from August to December. During the crop growth period 331 mm of rainfall was received in 2021 and 465.4 mm in 2022. The crop was sown on 20th August in both the years. Irrigation was provided during dry spells to avoid water stress free condition. The experiment was laid out in RCBD with three replications. The experiment consists of Atrazine 50% WP Alachlor 50% EC, Metolachlor 50% EC as pre-emergent and these were in combination with Tembotrione 34.4 SC as PoE at 30 DAS, compared with Nano form of Alachlor, Metolachlor followed by Tembotrione 34.4 SC, hand weeding at 20 and 40 DAS, weed free weedy treatment. Conventional metalochlor and alachlor were converted to nano formulation under laboratory. The concentration of herbicides was standardized from the feeler trial before the regular field experimentation. Maize hybrid 900 M Gold was sown at a spacing of 60 cm x 30 cm maintained at 5.5 plants/m^2 at seed rate of 12.5 kg/ha. Application of pre and post-emergence herbicides were applied according to the treatments using knap-sack sprayer fitted with flat-fan nozzle. Species-wise weed density and their dry weight were measured at 20, 40, 60 DAS by placing a quadrate of 0.50 m × 0.50 m. A recommended fertilizer rate at 150- 75-37.5 kg N-P_2O_5-K_2O was applied through urea, Diammonium phosphate and muriate of potash during both the years. Full dose of P and K were applied basal, while N was applied half basal and the remaining in two equal splits– at knee high stage and silking stages of maize. Biometric characters *viz*. yields were recorded at maturity. Prevailing price of inputs in the market during 2022 and 2023 were used to calculate the economics of weed-management treatments. Net returns and benefit: cost ratio were worked out on the basis of gross returns (Rs./ha) and cost of cultivation (Rs./ha). Weed control efficiency (WCE) was calculated from the mean data over 2 years. The data were statistically analyzed in RCBD design using analysis of variance (SAS 9.4 version) and means of treatments were compared based on critical difference test at p=0.05. Weed density and biomass data were subjected to square root transformation and the transformed values were used in analysis. The biometric data on weed growth and yield averaged for two years for statistical analysis.

Results

The dominant broad-leaved weeds were, Sessile joyweed (*Alternanthera sessilis)*, False amaranth (*Digera arvensis*), Wild poinsettia (*Euphorbia geniculata*), Asthma plant (*Euphorbia hirta* L.), Carrot grass (*Parthenium hysterophorus* L.) and Madras leaf-flower (*Phyllanthus maderaspatensis* L.) and major grassy weeds were, Signal grass (*Brachiaria eruciformis)*, Viper grass *(Dinebra retroflexa)* and Jungle rice (*Echinochloa colona)* were noticed. A significant reduction in weed number and weed dry weight at 60 DAS by application of nano formulated either anno metolachlor or alachlor along with application of tembotrione 34.4 SC @ 120 g *a.i.* ha^{-1} as PoE at 30 DAS. Further it resulted significant impact on weed control efficiency and weed index of maize at 60 days after sowing.

Weed control efficiency (WCE), yield and economics of maize as influenced by application of nano formulated herbicides in Vertisols of Karnataka (pooled data of two years)

Treatment	Weed density at 60 DAS (no./m^2)	Weed dry weight (g/m^2) 60 DAS	WCE (%)	Weed index	Grain yield (kg/ha)	Net returns (Rs./ha)	B: C ratio
Atrazine 50% WP @ 2.5 kg ha^{-1} as PE *fb* IC at 20, 40 DAS	4.48 (19.17)	3.11 (8.68)	32.99	20.15	6339	58108	2.43
Alachlor 50% EC @ 2.5 L ha^{-1} as PE *fb* IC at 20, 40 DAS	4.41 (18.44)	3.12 (8.73)	32.60	19.90	6358	57453	2.39
Metolachlor 50% EC @ 1.0 L ha^{-1} as PE *fb* IC at 20, 40 DAS	4.34 (17.87)	3.24 (9.50)	26.68	19.86	6361	60503	2.45
Tembotrione 34.4 SC @ 120 ml ha^{-1} as PoE at 20 DAS	5.19 (25.96)	3.27 (9.66)	25.42	30.18	5542	53698	2.27
Atrazine 50% WP @ 2.5 kg ha^{-1} as PE *fb* Tembotrione 34.4 SC @ 120 ml ha^{-1} as PoE at 30 DAS	3.41 (10.59)	2.03 (3.13)	75.85	9.74	7165	74836	2.63
Alachlor 50% EC 2.5 L ha^{-1} as PE *fb* Tembotrione 34.4 SC @ 120 ml ha^{-1} as PoE at 30 DAS	3.29 (9.83)	1.94 (2.77)	78.62	9.63	7174	74313	2.59
Metolachlor 50% EC @ 1.0 L ha^{-1} as PE *fb* Tembotrione 34.4 SC @ 120 ml ha^{-1} as PoE at 30 DAS	3.16 (8.97)	1.91 (2.67)	79.44	9.34	7197	74329	2.59
Nano Alachlor 50% EC @ 1.5 L *a.i* ha^{-1} as PE *fb* IC at 20, 40 DAS	4.23 (16.95)	2.48 (5.15)	60.32	19.82	6365	63840	2.63
Nano Metolachlor 50% EC @ 0.6 L *a.i* ha^{-1} as PE *fb* IC at 20, 40 DAS	4.11 (15.99)	2.41 (4.81)	62.90	19.50	6390	64078	2.59
Nano Alachlor 50% EC @ 1.5 L *a.i* ha^{-1} as PE *fb* Tambotrione 34.4 SC @ 120 g *a.i*ha^{-1} as PoE at 30 DAS	3.00 (8.06)	1.84 (2.40)	81.47	9.20	7208	76136	2.68
Nano Metolachlor 50% EC @ 0.6 L *a.i* ha^{-1} as PE *fb*Tambotrione 34.4 SC @ 120 g *a.i* ha^{-1} as PoE at 30 DAS	2.81 (6.99)	1.81 (2.27)	82.49	9.06	7219	76233	2.68
Hand weeding at 20 and 40 DAS	4.63 (20.44)	2.83 (6.99)	46.05	30.33	5531	49464	2.11
Weed free check	1.00 (0.00)	1.00 (0.00)	100.00	0.00	7938	75647	2.54
Weedy check	6.00 (34.99)	3.74 (12.97)	0.00	54.56	3608	30036	1.82
S. Em. ±	0.15	0.02	1.27	1.64	237	1038	0.02
C. D. at 5%	0.26	0.15	3.85	4.98	721	3148	0.08

Significantly higher grain and stover yield was produced in weed free check over rest of the chemical weed management treatments. However, it was comparable to application of nano formulated herbicides over conventional weed management practices. Significant reduction in grain yield was observed by the weed infestation. Application of either nano metolachlor 50 EC @ 600 ml *a.i.* ha^{-1} or nano alachlor 50 EC @ 1.5 L *a.i.* ha^{-1} as PE *fb* tembotrione 34.4

SC @ 120 g *a.i.* ha^{-1} as PoE at 30 DAS followed intercultivation was found effective in management of weeds.

Conclusion

The results of the study confirmed that application of nano formulated alachlor 50 EC @ 1.5 L *a.i.* ha^{-1} or metolachlor 50 EC @ 600 ml *a.i.* ha^{-1} as pre-emergent herbicide followed by tembotrione 34.4 SC @ 120 ml *a.i.* ha^{-1} as PoE at 30 DAS was effective in reducing weed density, minimize crop injury and sustain maize yield. Application of these herbicides minimized the effect on microbial population and enzymatic activity in maize. It also results in greater economic returns over presently available conventional herbicides for maize.

UID: 1310

Effect of Split Application of Nitrogen on *kharif* Pearlmillet (*Pennisetum glaucum* L.) on Vertisols

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Pearlmillet (*Pennisetum glaucum* L.) holds a significant position as the fifth most crucial cereal crop globally, following rice, wheat, maize, and sorghum. Renowned for its exceptional drought tolerance among cereals and millets, this crop boasts a low water requirement. This resilient cereal showcases an impressive tolerance to extreme climatic conditions and biotic stress, adapting seamlessly to stress-intensive environments. Despite its ability to thrive in harsh conditions, pearlmillet remains versatile, responsive to inputs, and maintains a high-quality status among cereals. It defies the odds, surviving in the harshest conditions, encompassing low soil fertility, high soil pH, scanty soil moisture, elevated temperatures, high soil salinity, and unpredictable rainfall patterns. The paramount factor influencing the enhancement of pearlmillet yield revolves around the meticulous management of fertilizers, a pivotal aspect that has manifested a noteworthy contribution of 27 percent. Among these elemental protagonists, nitrogen stands out as both a decisive and economically demanding input, wielding a profound impact on the production dynamics of cereal crops. Nitrogen, recognized for its swiftness in effectuating pronounced outcomes on plant growth, assumes a critical role in steering the destiny of crop yields. Inadequate nitrogen levels pose a perilous threat, potentially precipitating a drastic reduction in yield and the deterioration of produce quality. Present investigation was carried out with an objective to optimize dose and splitting of nitrogen for maximum productivity of pearlmillet.

Methodology

An experiment was carried out on experimental field of National agricultural Research Project, Chh. Sambhajinagar during the year 2023 in *kharif* season.The experimental design was SPD with twelve treatments of nitrogen levels. The experimental plot, characterized by its levelled and well-drained conditions, with clay texture. The chemical composition of the soil showed a medium level of organic carbon (0.63%), low available nitrogen (157.0 kg ha-1), medium available phosphorus (20.11 kg ha-1), very high available potassium (395 kg ha-1), and an alkaline reaction with a pH of 8.59. The concentrations of zinc, iron, manganese, copper, and boron in the soil were 0.39, 4.14, 5.79, 2.01, and 0.29 ppm, respectively. However, variations in monsoon patterns make crop production uncertain. The pearlmillet was sown on 29th June 2023 by dibbling method and harvested at 27th September 2023. The experiment consists of total twelve treatments of nitrogen levels *viz.,* N_1 (100% RDN), N_2 (112.5% RDN), N_3 (125%RDN) and split application of nitrogen *viz*., S_1(Entire dose of nitrogen at sowing), S_2 (50% at sowing + 50% at tillering), S_3(50% at sowing + 50% at boot stage), S_4 (25% at basal + 50% at tillering stage + 25% at boot stage) combination were demonstrated in three different replications under split plot design. The gross and net plot sizes were 4.5×5.0 m^2 and 3.6×4.8 m^2 respectively. Rainfall received during growth period was 396 mm. Irrigation was given in dry spell in the month of August.

Results

A) Effect of nitrogen levels

Treatment N_3 (125% RDN) recorded significantly highest grain weight earhead^{-1}(32.12g) over rest of the treatment On the contrary treatment N_1 (100% RDN) recorded lowest grain weight earhead^{-1}(25.27g). Grain weight plant^{-1} of pearl millet was significantly highest (70.19g) in treatment N_3 (125%) over other treatments. On the other hand treatment N_1 (100%) detected lowest grain weight plant (35.54g). Test weight of pearl millet noted significantly highest test weight 15.52g in treatment N_3 (125% RDN) and was at par with treatment N_1 (100% RDN) and N_2 (112.5% RDN) i.e.14.37g and 15.44g respectively. Grain yield of pearl millet recorded significantly highest grain yield (2395 kg ha^{-1}) in Treatment N_3 (125% RDN) . Parallel results were found by Geren *et al.* (2014) . Effect of nitrogen levels on harvest index of pearlmillet was found non-significant.

B) Effect of split application of nitrogen

Number of tillers per plant of pearl millet showed significantly highest number of tillers plant^{-1} (4.67) in treatment S_2 (50% at sowing + 50% at tillering) over other treatments. On the hand treatment S_1(entire dose of nitrogen at sowing) reported lowest number of tillers plant^{-1} (4.09). Number of effective tillers per plant of pearl millet recorded significantly highest number of effective tillers plant^{-1} (3.167) in treatment S_2 (50 at sowing + 50% at tillering) over other treatments. However, treatment S_1 (entire dose of nitrogen at sowing) reported lowest number of effective tillers plant^{-1}(2.56). Grain weight per earhead (29.96g) of pearl millet was significantly highest in treatment S_2 (50% at sowing + 50% at tillering) . Treatment S_1 (entire dose of nitrogen at sowing) recorded lowest grain weight earhead^{-1}

(26.30g). Effect of split application of nitrogen recorded significantly highest grain weight plant^{-1} (60.60g) in treatment S_2 (50% at sowing + 50% at tillering). Effect of split application of nitrogen on grain yield of pearlmillet was significant. Significantly highest grain yield (2557 kg ha^{-1}) was recorded by treatment S_2 (50% at sowing + 50% at tillering) . On the other hand treatment S_1 (entire dose of nitrogen at sowing) reported lowest grain yield (2082 kg ha^{-1}). Parallel results found by Dalal *et al.* (2024), Choudhary *et al.* (2014). Effect of split application of nitrogen on harvest index of pearlmillet was found non-significant.

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UID: 1321

Effect of Nano-Urea on The Productivity of Rainfed Maize (*Zea Mays* L.)

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Maize (*Zea mays* L.) is the world's most widely cultivated food crop providing ample food calories and protein for more than one thousand million human beings in the world. America has been the leading maize producer, followed by Asia, accounting for about 52% and 29.4% respectively (FAOSTAT, 2022). However, India is the 6th largest producer of maize in the world with 2% contribution to the world maize production with a quantum of 31.5 million MT in 2021-22 from 9.9 million hectares (GOI, 2022) and engaging 15 million farmers with 650 million person-days employment at farming and related industry level. Maize being an exhaustive crop requires a large quantity of nutrients during entire growth periods. The productivity of the crop depends on optimum nutrient management system. Urea is the most important nitrogenous fertilizer which mostly supply almost entire requirement of nitrogen by maize. Farmers apply huge quantity of urea in their crop and as urea is very soluble in water;

so considerable amount of urea is lost to the environment via various mechanisms like volatilization, leaching, runoff, denitrification and creating pollution besides increasing cost of cultivation. Nutrient management practices are very crucial for enhancing productivity of *kharif* maize. Effective nitrogen management is the key to increase the nitrogen use efficiency (NUE) through minimizing losses and enhanced the yield and profit. Nanotechnology is a new technique that uses nano-particles to improve compound surface area, absorption, and availability. Nano fertilizers minimizes the possible harmful effects of fertilizer over dosage and hence their toxicity in soil, while also reducing the frequency of application and maximizing net monetary returns (Sekhon, 2014). In compared to traditional urea, foliar application of Nano-urea developed by Indian Farmers Fertilizer Cooperative (IFFCO) at critical crop growth stages of a plant successfully fulfills its nitrogen need and leads to improved crop yield and quality. Because Nano-urea is a new product, there have been limited research on the rate and time of application. The effect of Nano-urea on maize must also be validated under various field circumstances. Keeping above facts in view experiment entitled “Effect of nano-urea on the productivity of rainfed maize’’ was undertaken.

Methodology

A Field experiment was conducted at ICAR-Indian Agricultural Research Institute, Jharkhand during *kharif* season 2022. The experiment was conducted at research farm 24°16' N latitude, 85°21' E longitude and 395 m above mean sea level. Soil of the experimental field belongs to the order Alfisol and moderately acidic in pH. The field experiment was laid-out in randomized block design in fixed layout with 10 treatments comprising 4 rates of N (0, 50, 75 and 100% of recommended N) and 3 combinations of spray (simple water spray, Nano-urea spray and Commercial urea spray) with 3 replications. Maize variety ‘DHM 121’ was used for experimentation. Recommended dose of nitrogen is applied in split 1/3 at basal, 1/3 at 30 DAS top dressed and 1/3 at 50 DAS top dressed. Spray of Nano-urea and Commercial urea was coincided with top dressing *i.e.*, 30 DAS and 50 DAS. Yield was recorded at maturity and expressed as ton per hectare (t/ha).

Results

Fertilizer N rates and nano-fertilizers influenced significantly on grain yields of maize (Table 1). Grain yield under no N was 2.62 t/ha, which was increased to 5.30 t/ha with the application of 50% RDN + 25% RDN at 30 DAS + 1 spray of nano-urea at 50 DAS. Yield increased due to incremental N was significant up to the highest application rate.

Conclusion

On the basis of the results obtained from the present one-year field experiment, it can be concluded that higher grain yield from rainfed maize could be obtained by applying 100% RDN (5.80 t/ha) through commercial urea in acidic soils of Jharkhand. However, the application of 50% RDN (basal) + 25% RDN (30 DAS) + 1 NUS (50 DAS) in rainfed maize resulted comparable yield with 100% RDN.

Effect of nano-urea application on the productivity of rainfed maize

Treatments	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index
100% RDN	5.80	11.08	16.88	0.34
50% RDN + 2 NUS	4.86	9.18	14.04	0.35
50% RDN + 2 CUS	4.77	8.91	13.68	0.35
50% RDN + 25% RDN + 1 NUS	5.30	10.35	15.64	0.34
50% RDN + 25% RDN + 1 CUS	5.12	10.27	15.39	0.33
75% RDN + 2 NUS	5.25	10.31	15.55	0.34
75% RDN + 2 CUS	5.08	10.21	15.29	0.33
SDNU + 2 NUS	3.07	5.93	9.01	0.34
SDCU + 2 CUS	2.93	5.83	8.76	0.33
Control + 2 WS	2.62	5.24	7.86	0.33
SEm±	0.26	0.37	0.61	0.01
LSD (P=0.05)	0.82	1.18	1.95	NS

Note: RDN-Recommended doses of nitrogen, NUS-Nano-urea spray, CUS-Commercial urea spray, SDNU-Seed dressing with nano-urea, SDCU-Seed dressing with commercial urea, WS-Water spray

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Influence of Spacing and Nutrient Management on the Performance of Fodder Cowpea Intercropped in Coconut Garden

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At present, the country faces a net deficit of about 30.6 per cent of green fodder and 11.9 per cent of dry crop residues. The area under fodder crop is estimated to be only 4.9 per cent of total cropped area. Allocation of more land under fodder crop alone is not possible hence intercropping with other cropping systems is one of the best ways to intensify fodder production. A sole crop of coconut does not fully utilize the available resources which suggests the feasibility of growing intercrops. To optimize fodder yield under rainfed conditions, the selection of drought-tolerant and fast-growing fodder crops such as fodder cowpea (*Vigna unguiculata*) is one of the important annual, fast-growing, leguminous fodder crops. It fixes atmospheric nitrogen and enhances the physical, chemical and biological properties of soil. The nutritive value of fodder cowpea is very high. It contains crude protein content of 18.5% and crude fibre of 20% on a dry-weight basis. It is also free from any type of toxicity. With this background, the present study was undertaken to identify the optimum spacing and nutrient requirement for higher green fodder yield of fodder cowpea intercropped in coconut garden.

Methodology

The field experiment was conducted at Instructional Farm, College of Agriculture Vellayani during *Rabi* 2022. Vellayani, Thiruvananthapuram, Kerala, India. A total rainfall of 50 mm was received during the experimental period. The experiment was laid out in randomized block design with three replications. The treatments consisted of two factors, namely spacing (S) (s_1- 20 cm × 15 cm, s_2- 30 cm × 15 cm, s_3- 40 cm × 15 cm and s_4- broadcasting) and nutrient levels (N) [n_1-75% RDF (18.75: 45: 22.5 kg N: P_2O_5: K_2O ha^{-1}), n_2 100% RDF (25: 60: 30 kg N: P_2O_5: K_2O ha^{-1}), n_3 -125% RDF (31.25: 75: 37.5 kg N: P_2O_5: K_2O ha^{-1})]. FYM @ 10 t ha^{-1} was uniformly applied to all the plots at the time of final preparation of land.

To measure the growth parameters such as plant height, number of branches and leaves per plant five plants were randomly selected to record the observations. To measures the yield attributes viz. green and dry yield of fodder cowpea, plants were freshly cut from the base and weighted with the help of weighing machine from each net plot having different treatments and computed to t ha^{-1} to obtain green fodder yield of fodder cowpea. For dry fodder yield oven dried sampled plants were weighted with the help of weighing machine taken from each net plot having different treatments and computed to t ha^{-1}.

Result

Interaction effect of Spacing and Nutrient Levels

The treatment combination, s_1n_3 recorded higher plant height (82.50 cm) which was on par with s_2n_3. Increased plant height in narrow spacing with high nutrient dose might be due to increased competition for light, improved nutrient availability and uptake with incremental nutrient level. Similar results were observed by Fayique and Thomas (2019) in fodder rice bean.

Higher number of branches per plant (4.87) was recorded in treatment combination s_3n_3 (40 cm x 15 cm with125%RDF) which was on par with s_2n_3 (4.80). More number of leaves per plant (14.3) was observed in s_2n_3 which was on par with s_3n_3 (40 cm x 15 cm with 125%RDF). The favourable influence of inter row spacing and higher nutrient dose might have enhanced the cell division and elongation resulting in more number of functional leaves that were retained for a longer period. Similar results were reported by Yashas (2016) and

Poudel *et al*. (2024). The treatment combination, s_2n_3 registered the highest green fodder yield and dry fodder yield (15.94 t ha^{-1} and 2.73 t ha^{-1}) respectively. This might be due to optimum plant population maintained which led to better availability of space, nutrients and aeration that increased number of branches, leaves and enhanced nutrient uptake which led to improved photosynthetic rates resulted in increased green fodder yield. Similar conclusions were reported by Yashas (2016) and Naik and Thomas (2024).

Effect of spacing, nutrient levels and their interaction on the growth and yield attributes of fodder cowpea in *Rabi* (2022)

Treatments	Plant Height (cm)	Number of branches per plant	Number of leaves per plant	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})
Spacing x Nutrient levels (SxN)					
S_1N_1	51.67	4.03	9.00	9.74	1.53
S_1N_2	65.70	4.27	10.60	10.47	1.69
S_1N_3	82.50	5.10	10.87	11.57	2.12
S_2N_1	53.93	4.17	10.80	10.18	1.76
S_2N_2	69.63	5.10	11.17	12.93	2.07
S_2N_3	79.10	6.03	14.30	15.94	2.73
S_3N_1	50.10	4.23	9.60	9.66	1.45
S_3N_2	58.97	5.17	12.30	10.61	1.92
S_3N_3	75.10	6.87	13.07	13.23	2.42
S_4N_1	31.23	3.37	7.67	7.92	1.19
S_4N_2	41.17	3.83	8.80	9.11	1.46
S_4N_3	41.50	4.07	10.13	9.33	1.57
SEm (±)	3.00	0.28	0.42	0.563	0.09
CD (0.05)	8.807	0.825	1.22	1.652	0.261

n_1:75% RDF (18.75:45:22.5 kg N: P_2O_5: K_2O ha^{-1}), n_2: 100% RDF (25:60:30 kg N: P_2O_5: K_2O ha^{-1}) , n_3: 125% RDF (31.25:75:37.5 kg N: P_2O_5: K_2O ha^{-1})

Conclusion

Based on the study, it could be concluded that spacing of 30 cm x 15 cm along with nutrient recommendation of 31.25:75:37.5 kg N: P_2O_5: K_2O ha^{-1} (125% RDF) as basal dose could be recommended for getting the highest green fodder yield and dry fodder yield in fodder cowpea intercropped in coconut garden.

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UID: 1327

Nitrogen Management on Growth and Yield of Wheat Chickpea Strip Cropping in Kymore Platue of MP

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Nitrogen, being a dominant and major nutrient, occupies a central role in crop nutrition to enhance productivity. Nitrogen use efficiency would definitely be increased by the crop nitrogen as per crop need is the most appropriate fertilizer N management strategy to improve nitrogen use efficiency. Strip cropping of cereals and legumes may be used to generate profitable relationship towards increased yield, stability, better use of available resources, reduced weed interaction and keeping soil and plants healthy. Therefore, it becomes necessary to know the suitable combination of inorganic, organic and biofertilizers sources of nutrients for profitable wheat and chickpea production under wheat + chickpea strip cropping of both these crops.

Methodology

The experiment has been carried out at research farm JNKVV, college of Agriculture Rewa in 2021-22, the soil characteristics of the experimental field were available nitrogen 220.6, available P2O5 14.8 and available k2o 240.2 kg/ha with organic carbon 0.5, pH value 6.8. There were eight treatments of INM with the variety of wheat HI 1544 and chickpea variety JG – 12 were sown on 20 November 2021.

Results

The highest vegetative growth of wheat and chickpea is under 100% nitrogen through inorganic sources. The combined input of nutrient sources provided maximum availability of nitrogen and other nutrients in addition to the improvement of physio - chemical and biological properties of the soil. The yield obtained under both the crops in strip cropping significantly higher 11.5 q/ha with a 32.5% harvest index. Application of 100% N by inorganic sources provided a maximum net return of Rs. 32402/ha with a 1.88 B:C ratio.

Conclusion

From this study, it was concluded that combined use of 50% inorganic+ 50% compost + Rhizobium/Azotobacter biofertilizers could efficiently enhance the soil fertility and productivity thereby achieving maximum yield of wheat and chickpea under wheat + chickpea strip cropping system.

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UID: 1328

Enhancing Soil Aggregation and Carbon Stability Through Long-Term Nutrient Management in Central Indian Vertisols

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Soil aggregates are critical for soil health, serving as physical structures that enhance organic carbon retention and soil fertility. Intensive tillage and nutrient depletion degrade soil organic matter and physical stability, particularly in tropical soils. The study emphasizes improving aggregate stability and soil organic carbon (SOC) preservation using integrated nutrient management (INM) strategies in the semi-arid tropics, where Vertisols dominate.

This study investigates the long-term impact of various nutrient management practices on soil aggregation and carbon (C) stabilization in Vertisols of Central India. Over a 35-year period, a cotton-greengram intercropping system was used to examine the effects of INM approaches, combining organic (farmyard manure or gliricidia) and inorganic (NPK fertilizers) amendments, on soil aggregate stability and carbon distribution in aggregate fractions.

Methodology

The long-term field experiment, initiated in 1987 at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, involved randomized block designs with eight treatments. These included control, sole NPK, and various combinations of NPK with farmyard manure (FYM) or gliricidia. Soil samples from the 0-15 cm layer were analyzed for aggregate size distribution, water-stable aggregates (WSA), SOC concentration, and carbon preservation capacity (CPC) using established wet sieving methods.

Results

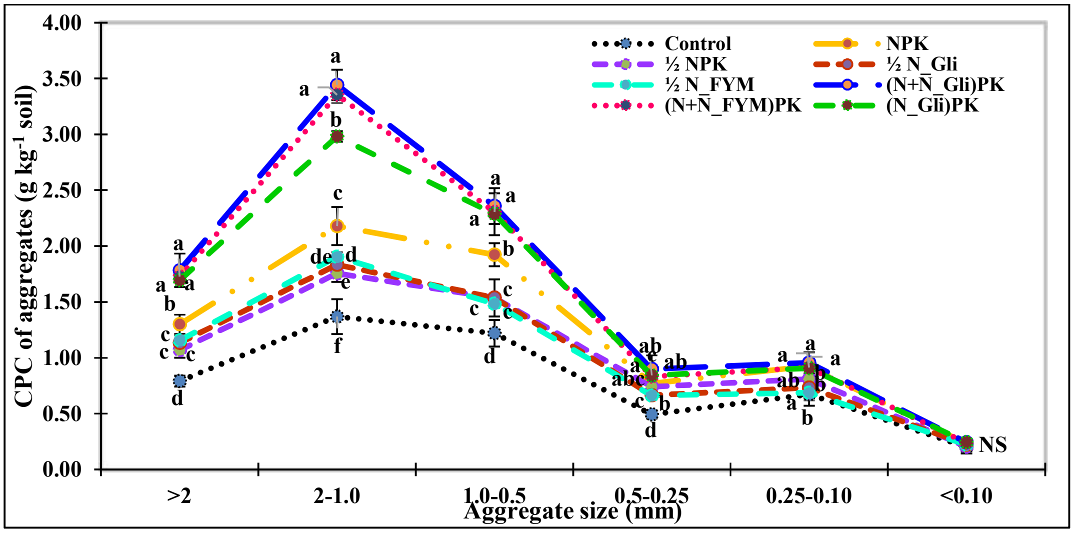
Macro-aggregates (>0.25 mm) were the dominant fraction, comprising up to 72% of total aggregates under INM treatments, while control plots showed a lower proportion (56%). INM treatments increased WSA by 15% compared to control and 6.5% over sole NPK treatments, demonstrating enhanced structural stability. Organic carbon concentration was highest in macro-aggregates, particularly in the 2.0–1.0 mm fraction. INM treatments increased SOC in macro-aggregates by up to 79% compared to control. Micro-aggregates (<0.25 mm) retained less carbon, suggesting that carbon stabilization primarily occurred in larger aggregates.

CPC was significantly higher in macro-aggregates under INM treatments, with increases of up to 144% compared to control as shown in the figure below. SOC and CPC showed strong positive correlations with aggregate stability indices, such as mean weight diameter (MWD) and aggregate ratio (AR). INM treatments combining FYM or gliricidia with NPK enhanced soil aggregation and carbon stabilization better than sole applications of either organic or inorganic sources. SOC content increased proportionally with larger aggregate sizes, indicating physical protection of organic carbon within stable aggregates.

The results highlight that INM practices, through partial substitution of N with organic amendments, significantly improve soil structure and carbon sequestration in Vertisols. This approach provides a sustainable nutrient management alternative for enhancing soil health, boosting productivity, and mitigating atmospheric CO_2 levels in semi-arid tropical regions.

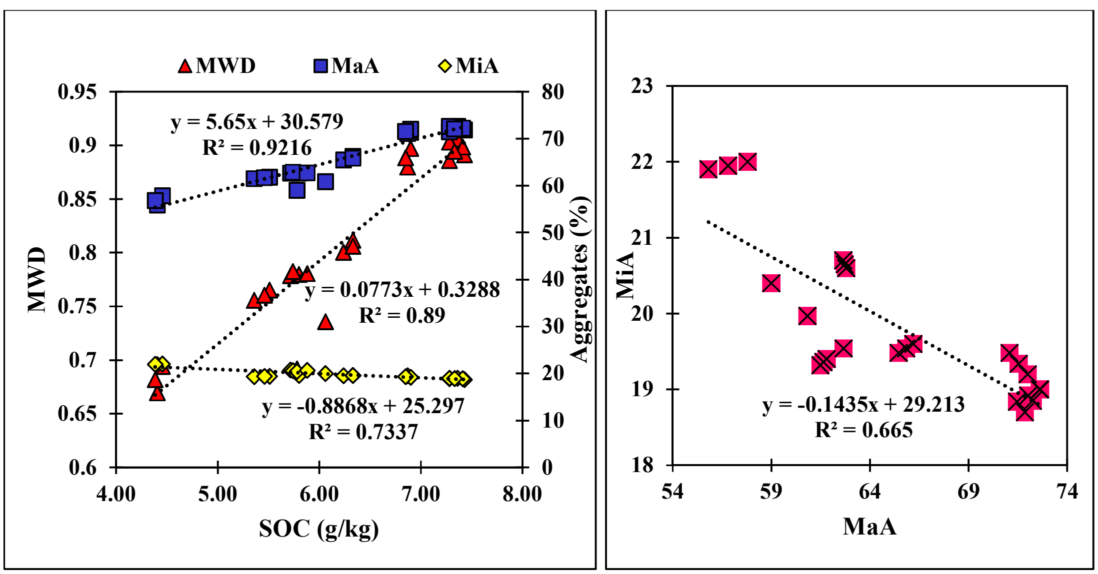
Conclusion

The study underscores the role of long-term INM in improving soil aggregation, organic carbon stabilization, and physical fertility in Vertisols. The findings advocate for incorporating organic amendments like FYM and gliricidia in conventional NPK regimes to enhance soil resilience and productivity in dryland agricultural systems. This research contributes to sustainable soil management strategies, aligning with global efforts to combat soil degradation and enhance carbon sequestration in agricultural ecosystems.



Effect of nutrient management practice on carbon preservation capacity (CPC) of different size aggregates

Vertical bars are the standard errors of the mean. Means followed by the same letter on a line are not significantly different at *P*< 0.05, by Duncan's multiple range test (DMRT). NPK: 100% RDF, ½ NPK: 50% RDF, ½ N_{Gli}: 50% N ha^{-1} through gliricidia, ½ N_{FYM}: 50% N ha^{-1} through farm yard manure (FYM), $(N+N_{Gli})PK$: 50% N $_{Fertilizers}$ + 50% $N_{gliricidia}$ + 100% P_2O_5 $_{Fertilizers}$ + 100% K_2O $_{Fertilizers}$, $(N+N_{FYM})PK$: 50% N $_{Fertilizers}$ + 50% N_{FYM} + 100% P_2O_5 $_{Fertilizers}$ + 100% K_2O $_{Fertilizers}$, $(N_{Gli})PK$: 100% $N_{gliricidia}$ + 100% P_2O_5 $_{Fertilizers}$ + 100% K_2O $_{Fertilizers}$



Relationship between soil organic carbon (SOC) of bulk soil and mean weight diameter (MWD) and aggregates (left) and between macro and micro-aggregates (right)

MaA: macro-aggregates (>0.25 mm); MiA: micro-aggregates (0.25-0.10 mm); Data pooled across treatments.

UID: 1341

Effect of Integrated Applications of Nutrient on Yield Economics and Nutrient Uptake in Maize Under Rainfed Condition of Jammu Region

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Globally maize is grown on an area of about 197.19 million hectares with production of 1125.03 million tones and the average productivity is 5.71 t ha^{-1}. In India, it is cultivated on an area of 9.21 million hectare with production of 25.13 million tones and productivity of 2.63 t ha^{-1} (Anonymous, 2020). In J&K Union Territory, maize is grown on an area of about262.35thousand hectares with a production of 5744 thousand tones and productivity of 2.12 t ha^{-1} (Anonymous, 2019). Application of organic sources of nutrients not only supply N, P and K but also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate to plant to absorb the nutrients (Ahmad *et al.*, 2018). The use of inorganic fertilizer has not been helpful because it is associated with soil acidity, nutrient imbalance and reduction in crop yield. The application of organic manure to meet the nutrient requirement of crop would be an inevitable practice since organic manures generally improve the soil physical, chemical and biological properties along with conserving capacity of the moisture holding capacity of soil and this, resulting in enhanced crop productivity along with maintain the quality of crop produce (Singh *et al.*, 2020). Although organic manures contain plant nutrients in small qualities compared to inorganic fertilizers, the presence of growth promoting principle like enzymes and hormones, besides plant nutrient make them essential for improvement of soil fertility and productivity.

Methology

A field experiment was conducted under rainfed condition during *kharif* season of 2022 and 2023 at Research farm of Advanced Centre for Rainfed Agriculture Rakh-Dhiansar of SKUAST-Jammu (32° 39” N 74° 53” E 332 m amsl), under rainfed condition. The soil of experimental site was sandy loam in texture, with a pH 6.5, low in organic carbon (0.18), and available nitrogen (178 kg/ha), and medium available phosphorus (18 kg/ha) and potassium (108 kg/ha). The experiment consisted of ten treatments of inorganic and organic combinations of nutrient sources, viz T_1: Control; T_2: 100 % recommended fertilizer dose-RFD (60:40:20 NPK kg/ha); T_3: 50 % RFD NPK; T_4: 50 % N (crop residue); T_5: 50 % N (FYM); T_6: 50 % RFD + 50 % N (crop residues); T_7: 50 % RFD + 50 % N (FYM); T_8: FYM 10 t/ha; T_9: 100 % RFD + $ZnSO_4$ 20 kg/ha and T_{10}: Farmers practice (FYM 4 t/ha + urea 40 kg/ha). Maize (var *Mansar*) was shown in the month of June- July and harvested in September-October during *kharif* seasons2022 and 2023, respectively. The crops were sown in lines with a spacing of 60 cm x 20 cm, respectively.

Results

The results revealed that the maximum grain yield of maize (27.03 q/ha) and stover yield 53.98 q/ha was obtained with the application of 50 % recommended NPK + 50% N FYM (T_7) which was statistically at par with FYM @ 10 t/ha (T_8) and 50 % recommended NPK + 50% N Crop Residue (T_6) with grain yield of 25.87 and stover yield 52.09, grain yield 24.51 and stover yield 49.25 q/ha. Over rest of the combinations of organic and inorganic. The minimum grain yield of 11.84 q/ha and stover yield 24.74 q/ha was obtained in the control (unfertilized plot). Similarly highest net returns to the tune of Rs 45896/ ha were realized with the application of application of 50 % recommended NPK + 50% N FYM (T_7) with corresponding benefit: cost ratio of 2.82. The application of 50 % recommended NPK + 50% N FYM (T_7) also recorded maximum RWUE of 3.68 while control evinced the minimum RWUE of 1.59. Similar results were observed by and Gupta,*et.al*(2014). The increase in yield with addition of FYM alone or in combination of inorganic fertilizers may be attributed to the fact that FYM being the store house of nutrients also made release of applied nutrients at its optimum at the same time improved the soil physical conditions.

Effect of integrated applications of nutrient on yield, economics, RWUE and nutrient uptake (Two year mean)

Treatment	Grain	Stover	Net income (Rs/ha)	B:C ratio	RWUE (kh/ha/mm)	Nutrient uptake (kg/ha)		
						N	P	K
T_1	11.84	24.74	12431	1.66	1.59	36.33	7.51	28.63
T_2	21.64	43.96	34899	2.57	2.92	72.22	14.47	54.33
T_3	17.70	34.67	25621	2.23	2.35	55.48	10.77	42.35
T_4	19.13	38.07	27354	2.19	2.55	63.83	12.16	46.88
T_5	19.14	37.35	26577	2.13	2.57	64.68	12.38	46.62
T_6	24.51	49.25	39531	2.58	3.34	85.13	16.24	62.97
T_7	27.03	53.98	45896	2.82	3.68	95.37	18.26	70.40
T_8	25.87	52.09	42151	2.62	3.52	91.54	17.22	69.22
T_9	24.11	48.04	40764	2.80	3.28	81.37	15.47	60.58
T_{10}	20.40	40.49	30420	2.31	2.74	67.45	12.66	46.15
Mean	21.14	42.26	32564	2.39	2.85	71.34	13.71	52.81
CD	3.42	3.36	-	-	-	12.29	2.46	10.69

Nutrient uptake

The uptake of N, P and K varied significantly among different integrated nutrient management treatments owing to the varying levels of fertilizer doses as well as sources of nutrients. This might be due to effect of rhizospheric conditions, as a result of varying levels of fertilizer doses and nutrient sources, on the extent and pattern of transformation, mineralization and transport of nutrients to the plant system. Significantly higher uptake of N, P and K by maize was observed in the treatment comprising of 50 % RFD + 50 % N (FYM) which was statistically at par with FYM @ 10 t/ha (T_8) and 50 % recommended NPK + 50% N Crop Residue (T_6). The lowest values of N, P and K uptake were observed in control. Higher uptake of N, P and K may be attributed to the favorable effect of incorporation of organic sources along with inorganic nutrients which was earlier reported by Sharma *et al.* (2013).

Conclusion

It can be safely concluded that with the application of 50 % recommended NPK through inorganic fertiliser in commination with application of 50% N through FYM was found to be best in terms yield, economics , RWUE and uptake nutrient on N,P and K of maize under rainfed conditions of Jammu resion.

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A Comparative Study of Fertilizer Recommendations to Optimize Groundnut Yield in Southern Karnataka

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The farming community needs to apply the fertilizer nutrients scientifically and balanced through soil testing to achieve sustainable yield. However, it is challenging to convince the farmers about the soil test-based fertilizer application, since, it is a tedious process. In this regard, the All India Coordinated Research Project on STCR, University of Agricultural Sciences, Bangalore, has developed web / mobile software Dhartimitra where soil test report including fertilizer recommendations based on either STCR approach or through soil fertility rating approach could be downloaded by fetching the geocoordinates of the location or survey number of the farmer's field. In the above context the present study was conducted to evaluate Dhartimitra app for groundnut crop at southern ten districts of Karnataka during *kharif* 2022, by taking 8 treatments *viz.*, T_1: STCR approach of NPK application through Dhartimitra software for yield target of 25 q ha^{-1}, T_2: STCR approach of NPK + FYM through Dhartimitra software for yield target of 25 q ha^{-1}, T_3 : STCR approach of NPK application based on actual analytical data, T_4 : STCR approach of NPK + FYM application based on actual analytical data, T_5 : General Recommended Dose, T_6: Soil fertility rating, T_7: Farmer's practice and T_8: Absolute control. The mean yield of 12 trials indicated that the significantly that highest pod yield of 25.06 q ha^{-1} was recorded in actual soil test-based fertilizer recommendation followed by software-based fertilizer recommendation (24.61 q ha^{-1}). which were higher compared to GRD (21.57 q ha^{-1}), SFR (22.25 q ha^{-1}) and farmers practice (18.25 q ha^{-1}). The value cost ratio (VCR) was higher in actual STV based fertilizer recommendation through STCR approach (5.59) followed by software-based fertilizer recommendations through STCR approach.

UID: 1346

Improving Soil Status, Productivity and Farmers Income under Climate Resilience conditions in Gram Farming: A Comparative Study of HC-7 and Local Varieties in NICRA Villages of KVK Kathua

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Gram (Cicer arietinum), commonly known as chickpea, is one of the most important pulse crops in India, for its high nutritional value. It gives millions of rural households a crucial source of minerals and protein (Singh et al., 2017). It is an essential crop for sustainable farming in rainfed areas because of its high nutritional content, capacity to flourish in low water situations, and function in enhancing soil fertility through nitrogen fixation. Moreover, shifting climatic patterns, such as delayed monsoons and uneven rainfall distribution, increase the vulnerability of rainfed systems. India is the world's greatest producer of gram, although the crop faces issues such as erratic rainfall, drought, and pest outbreaks, especially in rain fed areas. These challenges are worsened by climate change, necessitating the development and promotion of climate-resilient crop varieties such as HC 7.

The HC 7 variety of chickpea (Cicer arietinum) is a drought-resistant, high-yielding cultivar developed for rain fed agriculture, aimed at boosting crop production and productivity in regions with limited water availability, including semi-arid and arid regions. This variety, issued by the Indian Council of Agricultural Research (ICAR), has gained popularity because of its resilience to water-limited conditions, making it an essential crop for smallholder farmers in regions where irrigation is either scarce or unavailable. (ICAR, 2012). The HC 7 variety has a shorter growing cycle, which allows it to avoid the adverse impacts of prolonged dry spells and assure timely harvesting. (Kumar et al., 2015). In addition to drought tolerance, HC 7 has become known for its higher resistance to common diseases, including Fusarium wilt and Ascochyta blight, which frequently reduce gram productivity in rainfed environments.

The purpose of this research is to analyze HC 7's agronomic performance, yield, economics adaptability, and prospective impacts on rain fed gram cultivation in NICRA villages with local gram varieties, as well as its role in supporting climate-resilient farming systems.

Methodology

Study Area

The front line demonstrations were carried out by Krishi Vigyan Kendra Kathua in different NICRA villages during the gram growing season from past 2 years 2022-23 to 2023-24 in rain-fed farming situation. These villages are located in rain-fed regions prone to drought and climate variability, at an altitude of 450 m making them ideal for testing climate-resilient crop varieties like HC-7. For carrying out the frontline demonstrations, farmers were selected on the basis of interest towards adoption of improved varieties, and technical know-how of farmer. Selected farmers received all of the necessary inputs, while scientists paid regular visits to the exhibited field. The scientists at KVK Kathua arranged trainings, grouped meetings, and field days on a regular basis to spread awareness of technologies among farmers and provide remedies to their concerns.

Experimental Design

Crop Varieties: HC-7 (improved variety) and local gram varieties (control).

Field Trials: Field trials were conducted over two cropping seasons (2022-2023 and 2023-2024) to assess the performance of HC-7.

Results

Yield Comparison

Data presented in Table 2 revealed that the average yield of HC-7 was found to be 30% higher than that of farmers practice/ local gram varieties in both years. During the year 2022-23, the average seed yield of HC-7 variety was 14.7 q/hectare in NICRA village, compared to 11.2 q/hectare for the local varieties/farmers check and in 2023-24 average yield of HC-7 were 15 q/hectare in NICRA village, compared to 11.5 q/hectare for the local varieties. On average, HC-7 produced 1.8 tons/hectare, compared to 1.5 tons/hectare for the local varieties (Singh *et al.,* 2020). The improved yield was attributed to its drought tolerance and higher disease resistance. The similar findings of yield enhancement in frontline demonstration of pulse crop have been documented by Dwivedi *et.al.,*2014.

Economics

Data revealed in Table 3 showed that the economics during different year under front line demonstrations revealed that HC-7 was best net income compared to local varieties/farmers check During year 2022-23, the average net return of HC-7 were Rs. 51,700 per hectare in NICRA village, compared to local varieties/farmers check was Rs 32120/- per hectare and in 2023-24 average yield of HC-7 were Rs. 54000/- per hectare in NICRA village, compared to local varieties/farmers check was Rs 36100/- per hectare.

The B:C ratio was higher in NICRA village , compared to local varieties/farmers check in both year 2022-23 and 2023-24. Similarly, income increases with the implementation of improved agricultural practices was also reported by Yadav et al., (2020).

Table 1. Technological intervention in FLD's and Farmer's Practices

Sl. No.	Practice	Technological Intervention	Farmer'sPractice
1	Land preparations	Ploughing and Harrowing	Ploughing
2	Variety	HC-7	Local
3	Sowing method	Sowing	Broadcasting
4	Seed Treatment	Trichoderma@4g/kgof seed + Pseudomonas fluorescens @4g/kg of seed	No Seed Treatment applied
5	Fertilizer Applications (NPK)	20:40:20	Imbalanced use
6	Weed management	Pre-emergence application of Pendimethalin @ 3lt/ha	No pre-emergence
7	IPM Practices	IPM Practices like use of Sticky traps, Pheromone traps, sticky traps and neem oil	Indiscriminate of application of pesticides

Table 2. Status of Gram (HC-7) crop in NICRA village of KVK Kathua

	2022-23			2023-24		
	Area (ha)	Production (q/ha)	Productivity (q/ha)	Area	Production (q/ha)	Productivity (q/ha)
Improved variety (HC-7)	15	220	14.7 q/hec.	20	300	15 q/hec.
Farmers practices/Local check	15	168	11.2 q/hec	20	230	11.5 q/hec

Conclusion

As a result, the HC 7 variety of gram has consistently outperformed the native check in terms of yield, economics, drought tolerance, disease resistance, and soil fertility enhancement. Its implementation in rainfed agricultural systems has the potential to strengthen productivity, food security, and sustainability in areas with water constraints and variable rainfall. Future research should look on further optimizing agronomic methods for HC 7 and assessing its performance under various climatic scenarios in order to optimize its benefits for farmers in diverse rainfed environments.

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Integrated Plant Nutrient Supply for Enhancing the Growth and Yield of Groundnut in Rainfed *Alfisols* of Southern Zone of Tamil Nadu

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Groundnut is an important oil seed crop in India which occupies first position in terms of area (14% of the world area) and second in terms of production (10.13 million tonnes) accounting for 19 percent of total world production of 54.29 million tonnes in 2022 (Groundnut outlook, 2024). According to the all India *rabi* crop coverage report, GOI as on 2nd February 2024 out of 4.88 lakh hectares of groundnut, Karnataka stood first with 1.11 lakh ha followed by Odisha and Tamil Nadu (0.96 lakh ha). India requires around 28.5 million tonnes of edible oil to meet the ICMR recommended consumption of 30g edible oil /day/person by 2030AD (ICMR- NIN, 2024). To meet this demand, it is essential to enhance the productivity of pro nutrient oil seed crops of the country like groundnut through location specific Integrated Nutrient Management strategies for maintenance of soil fertility at a fairly high level. However, the resource poor farmers of dryland supply only limited source of nutrient and this the groundnut crop suffers from multi nutrient deficiencies resulting in lower yields. Though many studies have been carried out on agronomic aspects of groundnut crop, the location specific study on integrated nutrient supply especially for nitrogen to the farmers of dryland region in the southern agroclimatic zone of Tamil Nadu is lacking. Therefore, a study was taken up to evaluate the effects various sources of nutrients on soil properties, growth and yield of *rabi* season groundnut (VRI-8) under AICRPDA at Kovilpatti Main Centre, Thoothukudi district of Tamil Nadu.

Methodology

A field experiment on groundnut was conducted at the red soil farm of Agricultural Research Station, AICRPDA farm unit, Kovilpatti (October to February) during *rabi* season under rainfed conditions. This region received rainfall of 320.9 mm and 344.5 mm during 2022, 2023 respectively. The daily mean, maximum and minimum temperatures for the cropping period were 33.5^oC and 21.8^oC during 2022 and 33.0^oC and 21.2^oC during 2023 respectively. The experimental soil was sandy clay loam, neutral in reaction (pH 7.57), non saline (EC 0.27 dsm^{-1}), low in organic carbon (2.4 g kg^{-1}), low in available nitrogen (157 kg ha^{-1}) and available phosphorous (10.2 kg ha^{-1}) and high in available potassium (385 kg ha^{-1}). The treatments consisted of recommended dose of fertilizer (10:10:45 kg ha^{-1}) as per CPG, 2020, 100% RDF along with 25 kg $ZnSO_4$ and 10 kg borax per ha and two organic manures *viz.*, FYM @ 12.5 t ha^{-1} and vermicompost @ 5 t ha^{-1} combined with 3 levels of inorganic fertilizers (75%, 100% and 125%) along with control that received no manures and fertilizers. The RDF and organic manures as per the treatment were applied at the time of sowing. Gypsum was applied uniformly @ 400 kg ha^{-1} at 45th day after sowing uniformly. FYM and vermicompost contained 0.42 & 0.58% N, 0.26 and 0.45% P and 0.60 and 0.76% K respectively. The experiment was laid out in RBD with 3 replications. Changes in soil fertility status, growth, yield attributing characters and yield as influenced by the treatments were recorded and statistically interpreted. The rain water use efficiency and economics were also worked out using standard formula and market price of inputs and output.

Results

The different combination of fertilizers and manures had significant influence on the soil fertility status *viz.,* soil organic carbon, available N, P, K and Zn. Each successive increase from control to 75% RDF and from 75% RDF to 125% significantly increased groundnut crop growth, yield attributes and pod yield/plant in combination with FYM and Vermicompost. Application of 125% RDF + Vermicompost @ 5 t ha^{-1} recorded significantly higher average organic carbon content in soil (3.8 g kg^{-1}) available N (216 kg ha^{-1}) available P (15.4 kg ha^{-1}) available K (415 kg ha^{-1}) and bacterial population of 7.9X10^6 $CFUg^{-1}$of soil indicating the positive influence of combined application of organic manures and inorganic fertilizers on soil nutrient status and biological properties compared to other treatments. Also the association of nutrients from inorganics and organics produced significantly higher plant height and leave area index among all the treatments while unfertilized control had the lowest values. Similar observation has been made by Brar *et.al,* (2015). The combination of zinc sulphate (25 kg ha^{-1}) and borax (10 kg ha^{-1}) exerted positive influence necessitating the integration of Zinc and Borax nutrition for higher yield in groundnut. Regarding pod yield, 125% RDF+ Vermicompost and 125% RDF + FYM during both the years were on par followed by 100% RDF +25 kg $ZnSO_4$ + 10 kg borax (Table 2). The positive influence of these treatments through immediate supply of nutrients from inorganic fertilizers especially at early stage of the crop and slow and steady supply of nutrients from vermicompost and FYM throughout the crop growth period might have resulted in higher pod yield and haulm yield. Earlier reports also confirmed the significant increase in pod yield of groundnut due to organic manure application (Srinivasa Rao *et.al.,* 2012).

Table 1. Effect of integrated nitrogen fertilization on soil parameters in groundnut under rainfed *alfisols*

Treatments	Organic carbon (g kg^{-1})	Available Nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available Zn (ppm)	Bacteria (CFU $g^{-1}$of soil) x 10^6
T_1 - Control	1.10	151	8.2	0.56	4.0
T_2 - 100% RDF + 25kg $ZnSO_4$ + 10kg borax/ha	3.52	210	14.5	0.93	5.2
T_3 - 75% RDF + FYM	2.41	174	10.1	0.65	5.8
T_4 - 100% RDF + FYM	2.84	182	11.0	0.62	5.7
T_5 - 125% RDF + FYM	3.12	190	12.2	0.58	6.0
T_6 - 75% RDF + VC	3.40	196	13.6	0.70	6.8
T_7 - 100% RDF + VC	3.65	210	14.0	0.81	6.5
T_8 - 125% RDF + VC	3.82	216	15.4	0.86	7.2
SEd	0.05	2.28	0.14	0.003	0.05
CD (0.05)	NS	4.54	0.30	0.12	0.12

Table 2. Effect of integrated nitrogen fertilization on growth and yield of groundnut under rainfed Alfisols

Treatments	Plant height	No. of pods/plant	100 seed weight	Pod yield (kg/ha)
T_1 - Control	25.2	10.8	51.7	712
T_2 - 100% RDF + 25kg Znso4 + 10kg borax/ha	27.0	16.2	62.5	1128
T_3 - 75% RDF + FYM	25.5	15.2	58.2	1100
T_4 - 100% RDF + FYM	25.1	16.5	60.0	1165
T_5 - 125% RDF + FYM	24.8	17.0	63.6	1020
T_6 - 75% RDF + VC	26.2	16.0	60.5	1182
T_7 - 100% RDF + VC	26.8	17.6	62.5	1295
T_8 - 125% RDF + VC	28.3	18.5	64.8	1427
SEd	1.4	0.18	0.98	13.4
CD (0.05)	2.9	0.39	2.11	28.8

The economics data revealed that the net returns and B:C ratio were higher with the application of 100 % and 125% RDF during both the years. The higher cost of cultivation with organic manures viz., FYM/Vermicompost (Rs. 3,500 for 12.5 tonnes FYM) to (Rs.8000 for 5 tonnes vermicompost) and their combination with various levels of fertilizers proved less profitable. However, if the manures are provided under subsidized schemes of the State Government of Tamil Nadu/ AICRPDA / AICRPAM / NICRA projects, the manuring share in the cost of cultivation will result in 125% RDF + Vermicompost as the most profitable treatment for obtaining higher yields in groundnut in rainfed *Alfisols*. Also, the use of organic manures produced impact equivalent to 25% additional RDF and for this the vermicompost proved superior to FYM.

Conclusion

In regions where organic manures are available at cheaper prices, the farmers can opt for phosphorus enrichment of organic manures and adopt 100% or 125% RDF along with 5 tonnes of vermicompost or 5 tonnes P enriched FYM and where organic sources are unavailable or could not be recycled, RDF ie.,10:10:45 NPK kg ha^{-1} along with $ZnSO_4$ (25 kg ha^{-1}) and borax (10 kg ha^{-1}) be recommended for higher yield and higher net profit in groundnut crop in rainfed *alfisols* of southern agroclimatic zone of Tamil Nadu.

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Performance Evaluation of Horizontal Filter for Groundwater Recharge

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Water resources pose the greatest challenge due to variation in spatial and temporal availability. The total quantity of water in the earth is estimated to be around 1386 million cubic kilometres (M km^3). About 96.5 per cent of this water is contained in the oceans as saline water. Subsequently just around 41 M km^3 of fresh water is accessible out of which 31.4 M km^3 is present in the polar districts, mountains and ice sheets in solidified state. About 70 per cent of the fresh water consumed worldwide is used for irrigation and only 20 per cent of fresh water is being utilized for industrial purposes (Gleick, 2013). The groundwater level in various part of India is declining at an alarming rate, as per the ministry of water resources, around 56 per cent of the wells which are examined to keep a tab on groundwater level indicate drop in its level in 2013 as compared to the average of previous 10 years. The horizontal filter is an efficient and economic method for recharging groundwater. In order to avoid clogging of the well and to ensure that pollutant free water is recharged into the aquifer; an efficient filtering unit must be incorporated with recharge structures. The filtration unit must perform efficiently to get maximum benefits from the installed recharge structures. The current research was to develop and evaluate the hydraulic and filtration efficiency of horizontal well recharge filter for groundwater recharge. The objective is to evaluate the performance of developed horizontal well recharge filter.

Methodology

The experimental set up for evaluating the working efficiency of horizontal filter was developed in the laboratory. This set up consist of a water sample tank, inflow water pipe connected to water sample tank and one end of filter, a filter unit and outflow pipe connected to the other end of filter. There was a provision of two tanks (Tank1 and Tank 2) for supplying constant water (sedimented water) to the water sample tank. The capacity of each tank is 200 litres. A horizontal filter unit consisting of various filter media is placed such that the inflow water coming from water sample tank can passes through it safely. For such condition, a slope of 2 per cent was providing to the filter unit. The filter media used in horizontal filter are gravel (G), coarse sand (CS), charcoal (c) and bricks (B) in different combination as treatments. Size of the filter materials (Gravel and Sand) were selected according to the standard criteria for design of filter materials as proposed by United States Bureau of Reclamations (USBR). Based on the standard design criteria, filter media were selected and three treatments are fixed for evaluating the filter performance by changing media combinations. Filter materials should be permeable, easily and commercially available, cheap, environment friendly, more durable, and easy to handle during the experiment. The materials selected were,

T_1: Coarse Sand, Gravel, Bricks, Gravel.

T_2: Coarse Sand, Gravel, Charcoal, Gravel.

T_3: Coarse Sand, Gravel, Bricks, Gravel.

The observations were recorded for each treatment.

Results

Inflow rate to the filter unit was calculated and found to be 0.284 lps respectively. Constant inflow rate of 0.284 lps was given to the filter unit during the study and the outflow rate was calculated from measuring cylinder by recording the time to fill the 1000 ml measuring cylinder and hydraulic efficiency of each treatment was calculated by using the inflow and outflow rates.

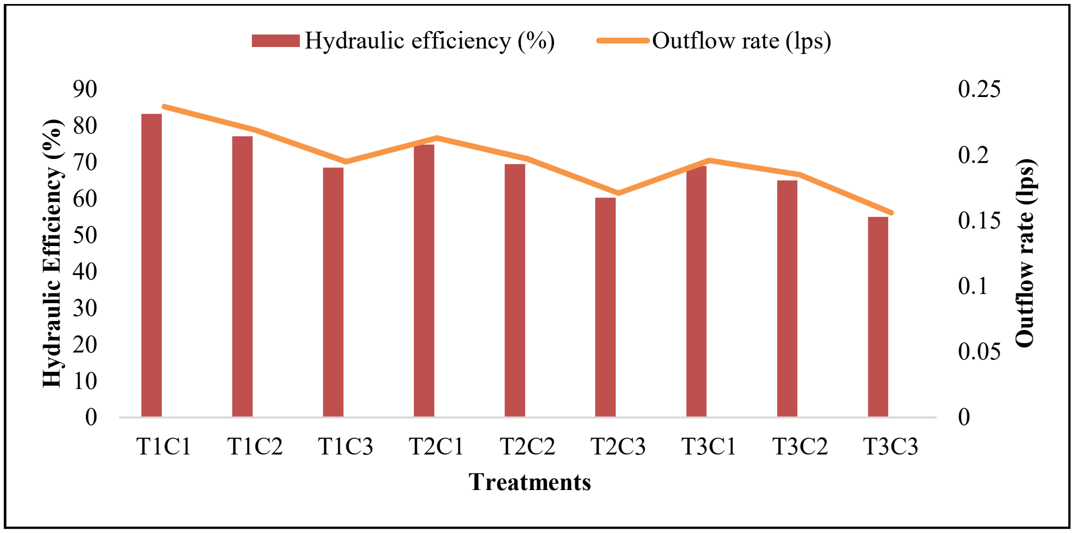

Fig 1: Effect of different filter media combinations on hydraulic efficiency and outflow rate

Filtration efficiency or Pollutant removal efficiency was calculated. Here, one thing must to know that the sediment concentration of inflow water samples for treatments T_1, T_2 and T_3 were 500 ppm, 1000 ppm and 1500 ppm respectively. The outflow sediment concentration and filtration efficiency are given in Fig 1.

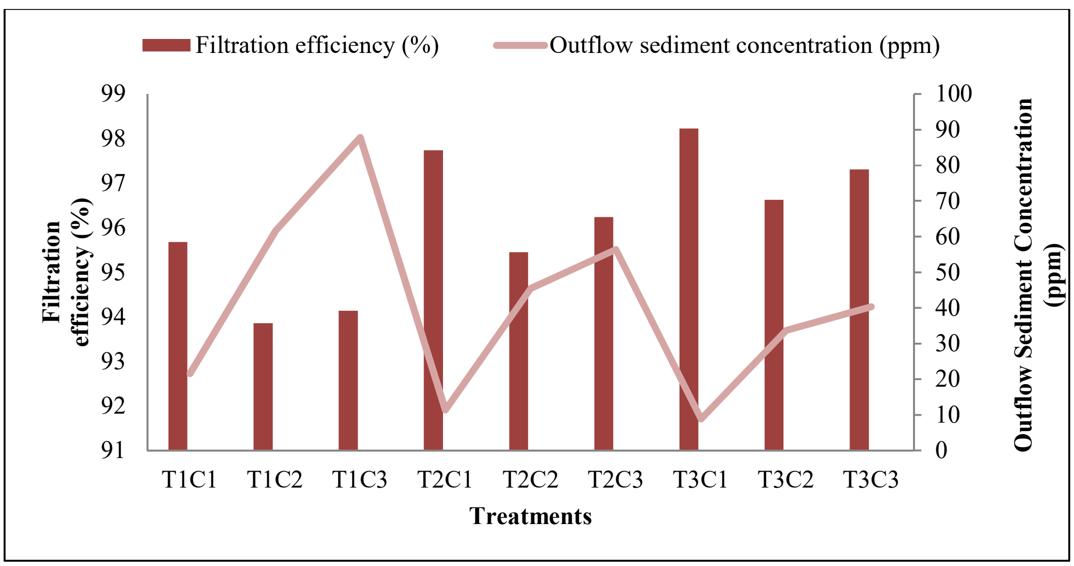

Fig 2. Effect of different filter media combinations on sediment concentration and filtration efficiency

The water quality parameters like pH, EC, Ca^{++}, Mg^{++}, Na^{+}, K^{+} TDS, TSS etc. were analysed and from the analysing that filter media combination CS: G: B: G observed best for pH normalising efficiency, filter media combination CS: G: Ch: G observed best for EC, Ca^{++},

Mg^{++}, Na^{+}, K^{+} and TDS removal efficiencies. This is due to the presence of charcoal as a filtration media in CS: G: Ch: G as charcoal is very effective in the removal of the saline parameters contained in the water as compared to the bricks. It was also recorded that more the coarse sand media length increases the filtration efficiency but decreases the hydraulic efficiency. Rank values of efficiencies corresponding to the specific treatments were added together and the overall rank value of treatments were found out. Results obtained from the DMRT test showed that (Table) T_2C_1 and T_2C_2 treatments got lowest overall rank value 22 and these filters performed well during the experiment.

Overall rank values of different treatment combinations

Treatments	Total rank value
T1C1	40
T1C2	44
T1C3	58
T2C1	22
T2C2	22
T2C3	38
T3C1	41
T3C2	46
T3C3	45

Conclusion

Based on the DMRT result, filter media combination CS: G: Ch: G (mean rank 26.67) was the best combination for the horizontal filter for groundwater recharge method. As the filter media combination, coarse sand media length increases the filtration efficiency also increases but the hydraulic efficiency decreases and vice versa.

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UID: 1353

Impact of Long-Term Integrated Nitrogen Management on System Productivity, Carbon Sequestration and Sustainability Yield Index of Rainfed Maize-Wheat Cropping System

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Rainfed agriculture is the system where crop production is solely based on the rainfall which is, in general, scarce and erratic. Rainfed agrosystems comprise around 58 percent of the net cultivated area of Indian agriculture and have a huge potential for development as major food producing regions because of their lion's share in the total area of the country. Rainfed agriculture is not only practiced in arid and semi-arid climatic zones but also in sub-humid zones of India (Srinivasarao et al. 2013). Nutrient management is imperative to increase productivity of maize-wheat rotation, a prominent multiple cropping system operational in dryland areas of the northwest India. Increasing the productivity of maize-wheat system is the national target to bridge the gap between demand and output especially in rainfed ecologies. Thus, it is extremely important to sustain the fertility of soil for better growth of crops in attaining quantitative and qualitative yield (Sheoran et al. 2017).

With a view to attain higher yield of crops and improve soil quality, manure-based fertilization represents an alternative to sole mineral fertilization (Geng et al. 2019). Accordingly, integrated nutrient management (INM) seems to be the best alternative to sustain soil quality and crop yields (Sarwar et al. 2021). The alterations in soil fertility and subsequent crop productivity could be associated with nutrient imbalances which are the key determinants limiting agricultural productivity. Long-term field experiments ensure a strategy of analysis regarding the effect of organic amendments and chemical fertilizers on crop productivity and soil attributes. So far, relatively meagre information is available regarding changes in soil properties and sustainable yield index in response to usage of manures along with or without mineral fertilizers and biofertilizers in maize-wheat system under dryland agrosystems. Therefore, the present study was intended to evaluate an optimal nitrogen fertilizer to sustain agricultural productivity without harming environment and simultaneously to increase yield and carbon sequestration in agriculture land.

Methodology

The study was undertaken in an on-going experiment, on maize-wheat rotation, started in 2017 (7-year long experiment) at Punjab Agricultural University-Regional Research Station, Ballowal Saunkhri. The experimental region is geographically situated between 30° 44' and 32° 32' N and 75°52' E and 76°43' E at an altitude of 337 m above mean sea level. The study area lies in the foothills of Shivaliks of Punjab where maize-wheat is the prominent cropping system. The soil of experimental site is classified as Fluventic Ustochrept. The field trial consists of eleven treatments (T_1–T_{11}) including unfertilized control, sole fertilizer nutrients (N, NP, NPK, NPK + $ZnSO_4$) and substitution of nitrogen with FYM, sole FYM and FYM combined with biofertilizers under maize-wheat system and was set-up in a randomized complete block design replicated thrice. From the outset, all the treatments were conducted in identical replicate plots. The plots were 8 m long and 5.4 m wide with a 0.5-metre buffer between them. Ploughing of each plot was done in such a way that no mixing of soil among the plots takes place.

Results

The results are presented in table below. Soil organic carbon stocks varied positively across inorganic, organic and integrated treatments as compared to control. In control plots, the mean SOC stock was 9.23 Mg ha^{-1} which improved to 11.96 Mg ha^{-1} in 100%NPK + FYM 10 t ha^{-1} (T_8).

Effect of nitrogen management on systems productivity, carbon sequestration and sustainability yield index of maize-wheat system

Treatments	System Productivity (kg ha^{-1})	SOC (g kg^{-1})	SOC Stock (Mg ha^{-1})	Sequestration Rate (kg ha^{-1} yr^{-1})	Sutainability Yield Index	
					Maize	Wheat
T_1	3031^{e}	4.18	9.23	114.24	0.26	0.27
T_2	4879^{d}	4.28	9.34	131.81	0.42	0.39
T_3	5212^{cd}	4.45	9.62	179.52	0.45	0.41
T_4	6785^{abc}	5.19	11.07	417.71	0.61	0.46
T_5	6575^{abc}	5.19	11.16	432.37	0.62	0.47
T_6	6982^{ab}	5.18	11.07	417.12	0.65	0.54
T_7	6404^{abcd}	5.35	11.50	487.95	0.65	0.49
T_8	7569^{a}	5.67	11.96	560.25	0.72	0.58
T_9	7048^{ab}	5.62	11.95	564.63	0.66	0.49
T_{10}	5252^{cd}	5.28	11.22	442.10	0.53	0.44
T_{11}	5502^{bcd}	5.41	11.50	490.93	0.55	0.44

There was significantly greater SOC accumulation (stock) in T_8 against control, 100%N (T_2) and 100%NP (T_3) treatments, storing almost 2.72, 2.61 and 2.33 Mg ha^{-1} more carbon than respective treatments but had only numerical advantage over other treatments. In all manured applied plots, SOC stock was higher compared with inorganic fertilizer treated plots. The annual rate of increase in SOC as a result of synthetic fertilization ranged between 78 to 540 kg ha^{-1} yr^{-1}; whereas for integrated plots and organic plots, the rate varied from 442 to 560 kg ha^{-1} yr^{-1}. The system productivity of maize-wheat sequence was highest under the conjoint use of 100%NPK + FYM 10 t ha^{-1} (T_8) which was significantly superior to control (T_1), T_2, T_3, T_{10} and T_{11} but was statistically similar with other treatments, however, there was numerical advantage in T_8 as compared to these treatments. This indicates the significance of adequate amount of NPK fertilizers along with FYM for maintaining the maize-wheat system productivity. Sustainability yield index is a quantitative measure to assess the sustainability of agricultural practices. The SYI for maize and wheat ranged between 0.26 to 0.72 and 0.27 to 0.58, respectively in response to individual or conjoint application of chemical fertilizers and organic manures. The highest SYI was recorded in T_8 and lowest in control for both the crops.

UID: 1354

Study on Salt Accumulation in Soil under Drip Fertigation of Citrus Crop

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In India, the area under acid lime was 327 thousand hectares with a production of 3548 thousand tonnes and productivity of 10.85 tonnes/ha. India (NHB,2020). Enhancing the productivity is a prime objective to feed the ever growing population from shrinkage resources. There is an imperative need to produce more from less arable land and water. Soil salinity in India is not a very rare phenomenon. It is a natural phenomenon where soluble salts of ions like Sodium, Potassium, Calcium, and Chloride accumulate in the soil. The major advantages of fertigation are in saving of labour, appropriate timing of application of water and nutrients and their uniform distribution (Raina, 2002). Acid lime is an important fruit crop. The area under acid lime in Maharashtra as about of 34.18 thousand hectares with annual production of 346.32 thousand metric tonnes and productivity of 10.13 MT/ha. In drip irrigation, salt accumulation occurs via two processes. First, the soil becomes saturated with saline water and solutes are spread throughout the soil, saturating neighboring voids. In the second process, which occurs between consecutive irrigation cycles, both evaporation of water from the soil and the uptake of water and nutrients by plants are occurring.

Methodology

Soil samples was collected at 0, 15, 30, 45, 60 cm along and across the emitter and it was analysed for different parameters such as EC (dS/m), pH, Calcium, Magnesium, Sodium, Potassium, Carbonate, Biocarbonate, Chloride and Sulphate in the wetted zone of emitter, to study the salt accumulation due to drip fertigation. The contour maps of salt accumulation is drawn by using surfer software. The experiment consists of two treatments for comparisons, the details of which were as 75 % of RDF through drip fertigation and Control – Traditional method of fertilizer application at 100 % of RDF (i.e. through soil application of solid fertilizer)

Biometric Observations

Various tree characters plant height ,(m) and canopy diameter , tree volume (m3) Leaf area (Cm^2) No. of fruits per plant and fruit yield per plant (kg) characters was recorded during growing of plant.

Results

Salt accumulation in soil under drip fertigation of acid lime

The same amount of water, having EC of 0.75 dS/m was applied to all treatments under drip fertigation. For accumulation of salts observations recorded form different depths at 0, 15, 30, 45, 60 cm along and across the emitter and it was analysed for different parameters such as EC (dS/m), pH, Calcium, Magnesium, Sodium, Potassium, Carbonate, Biocarbonate, Chloride and Sulphate. The Fig 1 to 6 shows the accumulation of salts on horizontal axis of the figures shows radial distance from the dripper (near the plant) and vertical axis shows depth from the soil surface. Thus, the salt accumulation patterns under alternate day irrigation are shown in Fig 1 to 6.

From contour maps of figures, it was observed that as the distance increased from dripper the salts accumulation increased in the rootzone but the more salts accumulated at the outer periphery at 45 to 60 cm distance of wetting zone as compared to near the dripper (plant). The salts accumulation is higher under traditional method because the dissolved in soil with higher time period remains over upper crust of soil but as compare to fertigation method all values are less in meq/l.

The plant height shows the significant response during the growth period under fertigation. The fertigation has recorded the maximum plant height (3.65 m) as compared to traditional method as shows in table. The plant volume had showed maximum plant volume was recorded with fertigation (35.24 m^3) followed by traditional method. The result in respect of leaf area is significantly influenced due to the fertigation. Though, the leaf area show significant increase in fertigation (19.15 cm^2). On perusal of data in respect of fruit set percentage indicated that, the result due to the fertigation uring experimentation was noted (43.63 %) as in fertigation. Though, the micro-irrigation do not influenced the fruit set but, the higher moisture might have helped in higher vegetative growth than reproductive growth. The more flower showed gradual increase in fruit set at lower irrigation regime. The result pertaining to fruit yield per plant showed the significant response to the fertigation (22.17 Kg) .The data regarding per hectare fruit yield was influenced due to the fertigation , it was recorded maximum (5.88 t/ha) and less in traditional method of fertilizer application at 100 % of RDF.

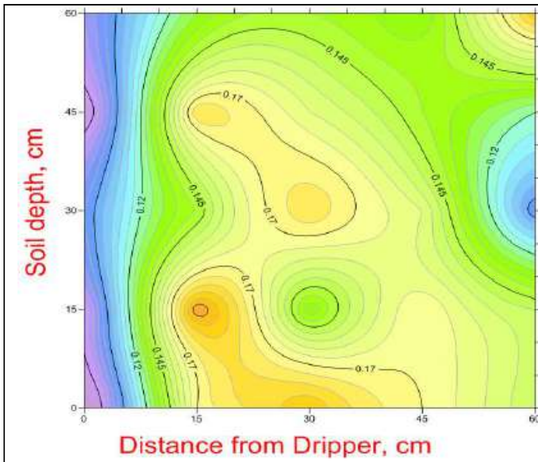

Fig 1. Ca (meq/l) from dripper distance in soil under fertigation

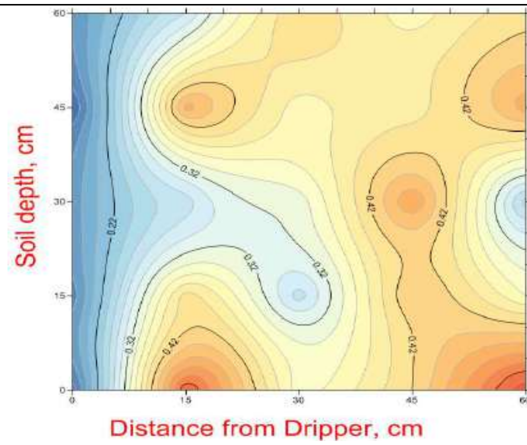

Fig 2. Mg (meq/l) from dripper distance in soil under fertigation

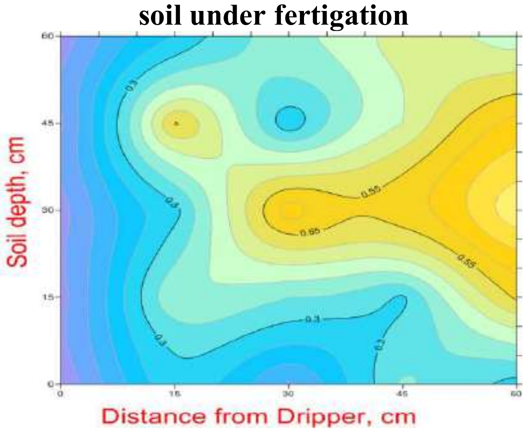

Fig 3. Na (meq/l) from dripper distance in soil under fertigation

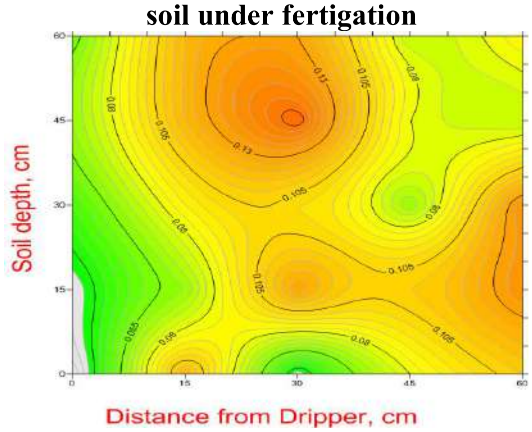

Fig 4. K (meq/l) from dripper distance in soil under fertigation

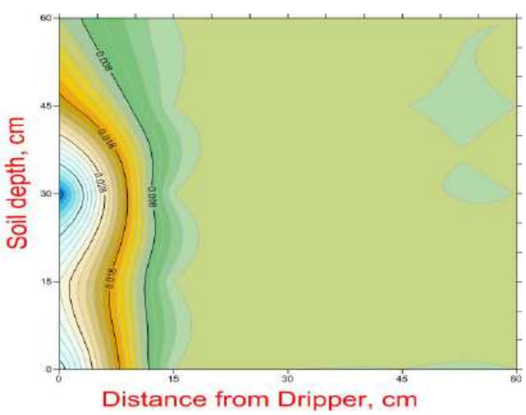

Fig 5. CO_3 (meq/l) from dripper distance in soil under fertigation

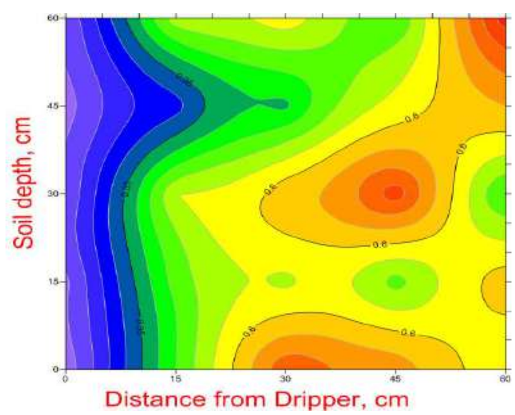

Fig 6. HCO_3 (meq/l) from dripper distance in soil under fertigation

Effect of drip fertigation and traditional fertilization method on growth and yield of acid lime

Treatment	Plant height (m)	Plant Volume (m3)	Leaf area (cm2)	Fruit Set (%)	No. of fruits/plant	Fruit yield /plant(kg)	Fruit yield (tons/ha)
Fertigation	3.65	35.24	19.15	43.63	598.54	22.17	5.88
Traditional method	3.45	33.36	18.53	42.31	585.50	18.45	5.01

Conclusion

It was observed that as the distance increased from dripper the salts accumulation increased in the rootzone but the more salts accumulated at the outer periphery at 45 to 60 cm distance of wetting zone as compared to near the dripper (plant).The salts accumulation is higher under traditional method because the dissolved in soil with higher time period remains over upper crust of soil but as compare to fertigation method. The growth of acid lime was found maximum under fertigation i.e. 75 % of RDF through drip fertigation and yield was recorded as (5.88 tons/ha).

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UID: 1356

Effect of Zinc Fertilization on Yield and N, P, K Uptake in Maize Under Rainfed Conditions of Jammu Region

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Maize is the third most significant cereal crop, next to wheat and rice across the globe as well as in Indian agricultural economy. Consumed both as food for human and feed for animals it is also a predominant crop of rainfed areas of Jammu and Kashmir. In J&K Union Territory, an area of about 289.1 thousand hectares is under maize cultivation with a production of 5.09 thousand quintals and productivity of 1.7 t ha^{-1} (Anonymous, 2021). The maize productivity in rainfed areas is declining as compared to other regions due to improper nutrient management practices and zinc deficiency in soil crop system. According to reports, zinc deficiency reduced the quality and yield of maize by 25-35% thus possessing a significant impact on food security. Zinc is a pivotal micronutrient and performs various plant physiological functions, such as the maintenance of structural and function of protein synthesis, carbohydrate metabolism, photosynthesis, chlorophyll formation, auxin metabolism, pollen formation and has a positive impact on crop yield (Suganya *et al*., 2020,). Thus, the application of zinc fertilizer is an effective approach to improve qualitative and quantitative yield of maize under rainfed conditions of Jammu.

Methodology

The field investigation was conducted at research farm of Advanced Centre for Rainfed Agriculture, Rakh-Dhiansar, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu during the *kharif* season of 2022. The experimental soil was sandy loam in texture, neutral in reaction (pH 6.64), low in organic carbon, available nitrogen and DTPA extractable zinc but medium in available phosphorus and potassium. The experiment comprised of twelve treatments of zinc fertilization laid in Randomised block design (RBD) and replicated thrice. Maize was sown with the spacing of 60 × 20 cm .Zinc (Zinc sulphate heptahydrate) was applied to the crop alone or in combination through seed treatment, seed priming and foliar application along with recommended package practices.

Results

The findings of the experiment revealed that among all the various zinc fertilization treatments applied seed treatment with $ZnSO_4$ @ 4g kg^{-1} seed + foliar application of 0.5% $ZnSO_4$ at tasseling and silking stage resulted in significant higher grain yield.

Effect of zinc fertilization on grain yield and N, P, K uptake in maize during *kharif* 2022 under rainfed conditions

Treatments	Grain yield (kg ha^{-1})	N uptake	P uptake	K uptake
T_1 - Control	3664	44.99	13.69	34.00
T_2 - Recommended $ZnSO_4$ @10 kg ha^{-1}	4277	72.96	23.20	49.95
T_3 - Seed Priming with water	3815	50.06	14.85	36.02
T_4 - Seed Priming with 1% $ZnSO_4$	3910	53.63	15.33	38.74
T_5 - Seed Priming with 2% $ZnSO_4$	3912	56.00	17.11	40.16
T_6 - Seed Treatment with $ZnSO_4$ @ 2g kg^{-1} seed	3938	59.05	18.23	41.55
T_7 - Seed Treatment with $ZnSO_4$ @ 4g kg^{-1} seed	4005	62.13	19.48	44.52
T_8 - Seed Priming with water + foliar application of 0.5% $ZnSO_4$ at tasseling and silking stage	4166	71.41	22.86	49.07
T_9 - Seed Priming with 1% $ZnSO_4$ + foliar application of 0.5% $ZnSO_4$ at tasseling and silking stage	4313	73.86	24.86	52.35
T_{10} - Seed Priming with 2% $ZnSO_4$ + foliar application of 0.5% $ZnSO_4$ at tasseling and silking stage	4698	84.03	28.72	59.05
T_{11} - Seed Treatment with $ZnSO_4$ @ 2g kg^{-1} seed + foliar application of 0.5% $ZnSO_4$ at tasseling and silking stage	4387	75.75	25.24	53.79
T_{12} - Seed Treatment with $ZnSO_4$ @ 4g kg^{-1} seed + foliar application of 0.5% $ZnSO_4$ at tasseling and silking stage	4774	86.11	30.12	61.44
CD (5%)	365.26	5.92	2.39	5.30

Note: *Recommended dose of N, P and K (@ 60,40 and 20 kg ha^{-1}) was be applied uniformly to all the treatments*

Further, the results also depicted significantly higher N, P and K uptake was recorded under seed treatment with $ZnSO_4$ @ 4g kg^{-1} seed + foliar application of 0.5% $ZnSO_4$ at tasseling and silking stage. These results are also in consonance with those reported by Kandali *et al*. (2021) and Shivay *et al*. (2014).

Conclusion

Based on experimental findings of study , it can be concluded that combined application of zinc via seed treatment (4g kg^{-1} seed) and foliar spray (0.5%) resulted in higher uptake of nutrients along with enhanced yield of maize under rainfed conditions of Jammu.

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UID: 1358

Impact of INM on Yield and Nutrient Uptake by Rice at Rewa District of Madhya Pradesh

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Rice is the staple food crop of more than half of the world population. Nutrient management is a major factor governing soil health status and crop productivity as most of the Indian soil are multinutrient deficient. Dry land ecosystem important hold pivotal importance as they contribute major share to the food basket of the nation. These agro ecosystem need to be developed with efficient management practices as they hold the meet the increasing demand of growing population but crop production in these regions is constrained by various factors

Integrated Nutrient Management system has been promoted in dryland ecosystem as it take the advantages of locally available organic resource along with fertilizer nutrients towards sustainability of dryland system in India. This system is also enhance yield as well as quality and achieving sustainability in direct seed rice crop.

Methodology

The present field experiment was taken at research farm Rewa during 2022-23. the experimental field was clayey in texture neutral in soil reaction and low to medium in organic carbon, available nitrogen, phosphorus and potash. Nine treatments were taken in randomized block design under factorial concept. Grain yield,nutrient content and uptake in rice crop were also analysed.

Results

The data on study the effect of organic and inorganic source of nitrogen fertilizer on yield and nutrient content and uptake in rice crop in kharif 2022. With the integrated use of inorganic and organic sources of nitrogen, the rice crop responded positively in terms of yield and other attributes. The highest yield of rice (1985kgha^{-1}) was recorded when recommended dose of nitrogen was supplied with 50% through inorganic and 50% through compost along with Azotobactor as compare to control (1200 kgha^{-1}) Similarly, the nutrient content and uptake were found to be maximum when nitrogen was applied in 50% through inorganic and 50% through organic (compost). However, the productivity of rice was found to be highest when compost and biofertilizer were integrated in to the rice crop.

Conclusions

The study concluded that compost application led to higher yield, NPK content and uptake in rice grain and straw over RDF and other treatment. This show the importance of compost manure over RDF is improving the nutrient use efficiency of NPK fertilizer in direct seeded rice crop.

UID: 1372

Long-Term Effect of Different Cropping Systems on Soil Water Characteristics in North-Western India

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Rice-wheat is the dominant cropping system in northwestern India, mainly in Punjab state. Puddling in rice forms a hardpan below the surface layer of soil, increases the soil compaction, and affects the growth of succeeding crops (Singh *et al*., 2009). Continuous cereal-cereal rotations, removal of crop residues and other inappropriate tillage practices cause depletion of soil organic matter, increases the soil compaction, reduces the soil porosity and permeability, and affects its ability to drain water and exchange air with the atmosphere. Addition of soil organic matter through crop residues and root biomass of different crops has significant effect on soil water characteristics. Inclusion of green manures, legume and fodder crops adds higher amount of organic matter to the soil, which improves the soil physical attributes, and affects the flow and storage of water in the soil (Ram *et al*., 2022). In this context, the present study was conducted by inclusion of green manure/legume/fodder crops under different cropping systems to find their effect on soil water characteristics. The objective of the study was to compare the soil water characteristics under different cropping systems with inclusion of green manure/legume/fodder crops compared to rice-wheat cropping system.

Methodology

The present investigation was undertaken during 2020-21 in an ongoing long-term experiment at the School of Organic Farming, Punjab Agricultural University, Ludhiana, since 2017. The experiment comprised ten different cropping systems viz., rice-wheat (CS_1), maize-wheat (CS_2), basmati rice-wheat-cowpea green manure (CS_3), maize-mustard-cowpea green manure (CS_4), maize-potato-spring groundnut (CS_5), maize-peas-spring groundnut (CS_6), (maize+cowpea fodder)-maize fodder-oats fodder-sathi maize fodder (CS_7), sorghum multicut fodder-barseem fodder (CS_8), maize-potato-onion (CS_9), baby corn-potato-okra (CS_{10}) in a randomized block design. Soil samples were collected from 0-7.5, 7.5-15, 15-22.5 and 22.5-30 cm soil depths after *kharif* season. The experiment site had the soil texture of loamy sand. Maximum water holding capacity (MWHC) was determined using Keen's box method (Richards, 1954). Soil moisture retention (SMR) was determined using pressure plate apparatus (Richards, 1949). Drainage rate was calculated by Ogata and Richards (1957) method.

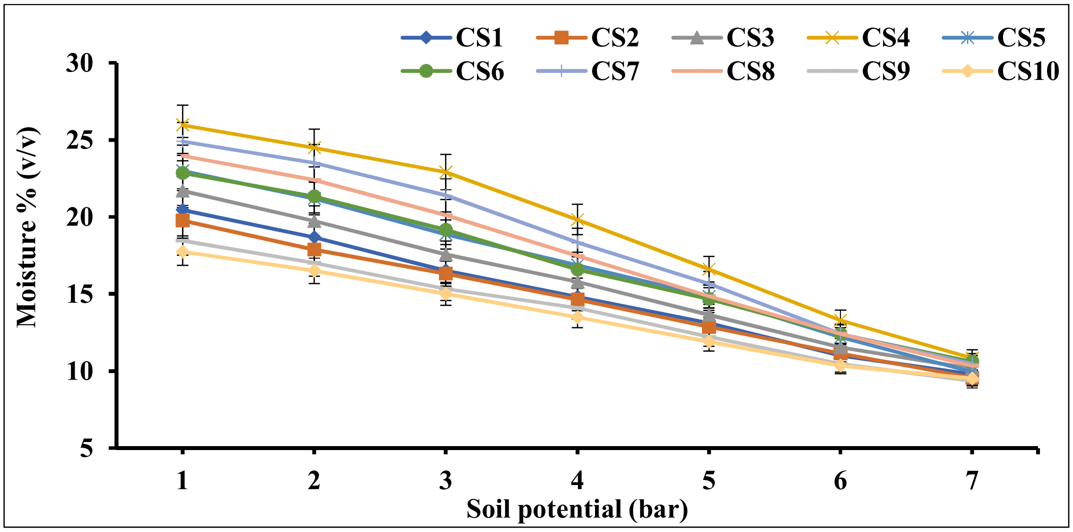
Results

Maximum water holding capacity

Comparing the mean values for cropping systems, MWHC was significantly higher in CS_4 (44.24%) followed by CS_7, CS_8, CS_6 and CS_5, while lowest in CS_1. Depth-wise, it was significantly higher by 16% at 0-7.5 cm than sub-surface (22.5-30 cm). It was found that organic matter addition through green manuring and maize residue incorporation in CS_4, and root biomass by forage crops in CS_7 and CS_8 increased their MWHC.

Soil moisture retention

The data for SMR for different cropping systems is represented in the Fig 1. At 0-15 cm soil depths, SMR was significantly higher in CS_4 followed by CS_7 and CS_8. The cropping systems with green manure/fodder/legume crops in rotation resulted higher SMR compared to rice-wheat and other non-green manured cropping systems. CS_1 showed higher retention than CS_9 and CS_{10} due to more soil microporosity resulted from puddling.



Effect of different cropping systems on soil moisture retention at 0-15 cm soil depth

Effect of different cropping systems on maximum water holding capacity (%)

Cropping systems	Soil depth (D), cm				Mean*
	0-7.5	7.5-15	15-22.5	22.5-30	
CS_1	33.40	32.20	31.40	30.22	**31.81cd**
CS_2	39.35	38.79	37.34	36.98	**38.11b**
CS_3	36.65	35.81	34.58	34.38	**35.36c**
CS_4	45.30	45.09	43.89	42.69	**44.24a**
CS_5	39.29	39.14	38.12	37.72	**38.56b**
CS_6	40.75	39.09	38.38	36.34	**38.89b**
CS_7	42.42	40.05	39.93	38.08	**39.87b**
CS_8	41.53	39.25	38.40	37.42	**39.40b**
CS_9	37.84	37.31	36.15	35.32	**36.65bc**
CS_{10}	33.61	32.98	32.67	31.98	**32.81c**
Mean* (D)	**39.01a**	**37.97ab**	**37.18b**	**32.81c**	
CD (p=0.05)	T=2.69, D=1.70, T*D=NS				

**Means followed by small alphabet letters are significantly different at a 5% level of significance*

Conclusion

It was concluded that, puddling practices in Rice-wheat cropping systems resulted hardpan, which affected the water flow and storage characteristics of the soil. However, cropping systems with inclusion of green manure/fodder/legume crops added higher quantity of organic matter into the soil, improved the aggregation, water holding capacity, moisture retention, the movement of water to the lower layers of soil, and ultimately showed better soil water characteristics.

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UID: 1373

Assessment of the Effect of Conservation Tillage Practices on Water Use Efficiency on Paddy-Wheat-Green gram Cropping System in Koshi Region

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Water is one of the most critical inputs for agriculture, naturally available on the globe, hence seems to be conserved and to be utilized economically. Nearly 80 per cent of water is utilized for crop production and this share seems to be minimized due to increasing demands from other segments of the societies like social, industrial sectors. The increasing demand for crop production for the growing population is causing the rapid expansion of irrigation throughout the country as well as the world. There is high demand of water for preparation fields particularly for paddy cultivation and depletion of soil moisture is also observed in preparation of fields during cultivation of wheat and green gram besides the irrigation demand of crops. By the practice of conservation tillage, the water loss may be reduced with in soil water storage. Considering these points of water requirement for crop production in view and one of the popular cropping systems of the Koshi Region of Bihar i.e. "Paddy-Wheat-Green gram", a study was done to assess the effect of conservation tillage practices on water use efficiency on paddy-wheat-green gram cropping system in the seven selected villages of Saharsa district by the team of KVK, Saharsa from 2020-21 to 2023-24. The cultivation practices of direct seed sowing of paddy (DSR) in Kharif season followed by sowing of wheat by zero tillage method in *rabi* season followed by sowing of green gram by zero tillage method in Summer was taken for study in comparison to traditional crop establishment practice of paddy by transplanting in Kharif season followed by sowing of wheat by broadcasting after field preparation in *rabi* season followed by sowing of green gram by broadcasting in Summer season. Field water use efficiency was observed crop (season) wise as well as for the cropping system. It was observed that an average increase of 6.03 per cent in field water use efficiency for paddy cultivation, 7.40 per cent in wheat cultivation and 25.10 per cent in green gram cultivation by following conservation tillage practices in comparison to traditional cultivation practices. Thus, an average increase of 12.84 per cent in field water use efficiency was observed for the whole season (cropping System) with conservation tillage practices.

UID: 1374

Impact of Molybdenum Application on Yield and Nutrient Availability in Cauliflower Cultivation on Acid Alfisols

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Molybdenum, a vital trace element, is essential for the growth of plants and animals. In agricultural soils, it predominantly exists as Mo (VI), with its availability influenced by soil pH, oxides (like Fe), drainage, and organic matter. Alkaline soils enhance molybdenum solubility, facilitating plant uptake as $MoO4^{2-}$ ions, while acidic soils reduce availability due to adsorption by soil oxides. Molybdenum occurs naturally in the lithosphere at up to 23 mg kg^{-1} (Fortescue, 1992), primarily in minerals like molybdenite (MoS_2), wulfenite ($PbMoO_4$), and ferrimolybdenite (Reddy et al., 1997). Weathering drives its release into soil, forming soluble $MoO4^{2-}$ complexes, whose availability depends on adsorption/desorption reactions and soil pH (Lindsay, 1979).

Molybdenum plays a crucial role in plant metabolic pathways through molybdoenzymes like nitrate reductase and nitrogenase, which are integral to nitrogen assimilation (Din et al., 2007). Deficiency symptoms include leaf chlorosis, cupping, and "whiptail," particularly in sensitive crops like cauliflower (*Brassica oleracea* var. *botrytis*). This economically significant vegetable requires optimal nutrients, including molybdenum, for healthy curd development. Deficiencies hinder growth and yield, making precise molybdenum supplementation essential. This study evaluates the impact of molybdenum application on soil nutrient status and its availability in cauliflower to address nutrient deficiencies and enhance productivity.

Methodology

The experiment on cauliflower was conducted at the experimental farm of CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur, situated at 1,290.8 meters above sea level (32°09′N, 76°55′E). The region receives 2500-3000 mm annual rainfall, with 868.4 mm recorded during the cropping period (*rabi* season, 2021-2023). The soil, classified as Alfisols, had a pH of 5.29, low nitrogen (224 kg ha⁻¹), medium phosphorus (23.2 kg ha⁻¹), and potassium (174 kg ha⁻¹).

The experiment followed a Randomized Complete Block Design (RCBD) with ten treatments, including recommended fertilizer doses (NPK: 115:75:70 kg ha⁻¹), farmyard manure (FYM: 20 t ha⁻¹), and varying molybdenum levels (0.5–20 kg ha⁻¹) applied as ammonium molybdate. Parameters like soil nutrient concentrations (N, P, K, Fe, Mn, Cu, Zn, and Mo) were measured, along with yield. Observations were recorded from five plants per treatment across three replications, and data were statistically analyzed using ANOVA at a 5% significance level. Results revealed that molybdenum application significantly influenced soil nutrient status and plant yield, demonstrating its critical role in enhancing cauliflower growth and productivity under varying soil conditions.

Results

The experiment revealed that molybdenum application significantly enhanced soil nutrient status and cauliflower yield. Treatments with Mo improved curd and total yields, with the highest yield observed at 5.0 kg Mo ha⁻¹ (T8), a 43.2% increase in curd yield and 36.6% in total yield over the control. Optimal Mo dosage likely ranges between 2.0 and 5.0 kg ha⁻¹.

Table 1. Effect of graded doses of Mo application on curd yield, gross yield and N, P, K at harvest

Treatments	Curd yield	Gross yield	N	P	K
	(q ha-1)		(kg ha^{-1})		
T_1 (RDF)	165.0^{g*}	346.4^{f}	217^{e*}	23.8^{d}	173^{d}
T_2 (GRD)	189.0^{ef}	393.8^{e}	230^{ab}	24.8^{a}	185^{a}
T_3 (GRD + Mo @ 0.5 kg ha^{-1})	193.3^{de}	401.5^{de}	229^{ab}	24.6^{ab}	183^{ab}
T_4 (GRD + Mo @ 1.0 kg ha^{-1})	205.1^{cd}	418.3^{cde}	229^{ab}	24.5^{abc}	180^{bc}
T_5 (GRD + Mo @ 1.5 kg ha^{-1})	212.9^{bc}	429.3^{bc}	225^{bc}	24.5^{abc}	179^{c}
T_6 (GRD + Mo @ 2.0 kg ha^{-1})	220.8^{ab}	443.9^{abc}	223^{cd}	24.2^{bcd}	176^{cd}
T_7 (GRD + Mo @ 2.5 kg ha^{-1})	229.0^{a}	455.3^{ab}	221^{cde}	24.0^{cd}	174^{d}
T_8 (GRD + Mo @ 5.0 kg ha^{-1})	231.7^{a}	459.4^{a}	219de	23.9^{d}	174^{d}
T_9 (GRD + Mo @ 10 kg ha^{-1})	210.9^{bc}	426.7^{cd}	230^{ab}	24.7^{ab}	186^{a}
T_{10} (GRD + Mo @ 20 kg ha^{-1})	176.2^{fg}	364.5^{f}	233^{a}	24.9^{a}	187^{a}
LSD (P=0.05)	15.6	27.0	5.51	0.5	4.2

The study revealed the effects of varying molybdenum (Mo) doses on soil nutrient levels at harvest. Available nitrogen ranged from 217 kg ha⁻¹ in T1 to 233 kg ha⁻¹ in T10, with T10 showing the highest nitrogen, comparable to T3 and T4. Phosphorus levels varied from 23.8 kg ha⁻¹ in T1 to 24.9 kg ha⁻¹ in T10, with T10 having the highest phosphorus, similar to T2 and T3, while T8 and T7 showed reduced levels due to higher yields. Potassium levels ranged from 147 kg ha⁻¹ in T10 to 173 kg ha⁻¹ in T1, with T8 and T7 exhibiting the lowest levels due to nutrient uptake for high yields. Available Mo content ranged from 0.139 mg kg⁻¹ in T1 to 0.307 mg kg⁻¹ in T10, with T10 showing the highest Mo due to substantial application. T2 indicated increased Mo due to FYM supplementation alongside NPK. The increased DTPA extractable Fe, Mn, Cu, and Zn levels across treatments compared to initial soil status, except in T1. T10 exhibited the highest levels of Fe (21.7 mg kg⁻¹), Mn (15.5 mg kg⁻¹), Cu (0.49 mg kg⁻¹), and Zn (0.91 mg kg⁻¹). T8 showed lower micronutrient availability due to higher yields.

Table 2. Effect of graded doses of Mo application on available Mo, DTPA extractable iron, manganese, zinc and copper at harvest

Treatment	Available Mo	DTPA - Fe	DTPA - Mn	DTPA - Zn	DTPA - Cu
			(mg kg^{-1})		
T_1 (RDF)	0.139^{i*}	18.1^{c*}	13.5^{d}	0.84^{c*}	0.44
T_2 (GRD)	0.148^{h}	21.5^{a}	15.7^{a}	0.91^{a}	0.50
T_3 (GRD + Mo @ 0.5 kg ha^{-1})	0.151^{gh}	21.1^{a}	15.6^{a}	0.90^{ab}	0.50
T_4 (GRD + Mo @ 1.0 kg ha^{-1})	0.158^{g}	20.6^{ab}	15.2^{ab}	0.89^{ab}	0.49
T_5 (GRD + Mo @ 1.5 kg ha^{-1})	0.167^{f}	20.1^{ab}	14.9^{abc}	0.88^{abc}	0.48
T_6 (GRD + Mo @ 2.0 kg ha^{-1})	0.178^{e}	20.1^{ab}	14.8^{abc}	0.88^{abc}	0.48
T_7 (GRD + Mo @ 2.5 kg ha^{-1})	0.189^{d}	19.2^{bc}	14.2^{bcd}	0.87^{abc}	0.47
T_8 (GRD + Mo @ 5.0 kg ha^{-1})	0.203^{c}	18.9^{bc}	14.0^{cd}	0.86^{bc}	0.47
T_9 (GRD + Mo @ 10 kg ha^{-1})	0.232^{b}	20.6^{ab}	15.2^{a}	0.90^{ab}	0.49
T_{10} (GRD + Mo @ 20 kg ha^{-1})	0.307^{a}	21.7^{a}	15.5^{a}	0.91^{a}	0.49
LSD (P=0.05)	0.008	1.69	1.01	0.04	NS
Initial value	0.143	18.3	13.8	0.84	0.46

Conclusion

This study highlights the critical role of molybdenum in enhancing nutrient availability, uptake, and crop yield in cauliflower cultivation. Optimal molybdenum application (e.g., GRD + Mo @ 20 kg ha⁻¹) significantly improved nutrient availability compared to RDF alone. These findings emphasize molybdenum's importance in sustainable and efficient nutrient management practices.

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Sustainable Maize Production: Influence of Conservation Agriculture Practices on Growth and Yield of Rainfed Maize

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Maize is one of the most important cereal crops of the world agricultural economy, both as food for man and feed for animals. It is a miracle crop that has a very high yield potential. There is no cereal on the earth which has so immense potentiality, and that is why it is called queen of cereals. Maize is grown in almost all the states of India. Over 85 % of maize produced in the country is consumed as human food. Several food dishes are prepared out of maize flour and grains (Singh *et al*., 2015). In India it is cultivated over an area of 6.4 million hectares with total production of about 11.5 million tonnes. The leading maize growing states are U.P, Bihar, Rajasthan, M.P and Punjab. The challenge for agricultural scientists to increase food production to meet food security needs and even more still persists even after the green revolution. The increasing population of the world is leading to stress on the planet and its resources. Conservation Agriculture can enhance productivity of farm land already in use and can regenerate land left in poor condition by past misuse. Conservation agriculture has been highlighted as a key route to sustainable intensification (Hobbs *et al*., 2008). The use of conservation agriculture practices can help achieve this goal as practices like zero tillage and residue retention are both associated with substantial change in physical and chemical soil characteristics which could influence the growth and yield of maize, while integrated use of tillage and mulch also helps in improving the input use efficiency of all production inputs (Jat *et al*., 2012). As the research regarding effect of different conservation agriculture practices in respect of yield sustainability of maize in maize-wheat cropping system is lacking with respect to rainfed sub-tropics of Jammu and Kashmir. An experiment was therefore planned to find out to study the effect of tillage, intercropping, mulching and residue retention ongrowth and yield of maize.

Methdology

The experiment comprised of three different tillage practices *viz;* conventional tillage, minimum tillage and zero tillage. The variety which was sown for the experiment was Kanchan 517, and PU-31 variety of mash was used as an intercrop. For mulching *Adhatoda vasica* was used @ 7 tonnes/ha on fresh weight basis and 30 % residue from the previous wheat crop was also retained in the desired plots. Ten treatments were laid out in randomized block design with three replications *viz;* CT: Conventional tillage, CTm: Conventional tillage + Mulching, CTi: Conventional tillage +Intercropping (Mash), MT: Minimum tillage, MTm: Minimum tillage +Mulching, MTi: Minimum tillage +Intercropping (Mash), MTr: Minimum tillage+ Residue (30 %), ZT: Zero tillage, ZTm: Zero tillage + Mulching, ZTr: Zero tillage + Residue (30 %) at the research farm, Advanced Centre for Rainfed Agriculture, Rakh Dhiansar, SKUAST- Jammu

Results

It is evident from table above that different conservation agriculture practices had a significant effect on the cob length and 100 grain weight (g). The minimum tillage + mulching treatments showed higher cob length (16.26 cm) as compared to other treatment. Hundred grain weight explains the nature and extent of grain development. It is the function of many production factors which influence the grain development and filling pattern. Minimum tillage and mulching (24.56 g) treatments showed higher grain weight as compared to other treatments, while the lowest values for 100 grain weight was observed in the zero tillage (19.66 g) treatments. Different conservation agriculture practices had significant effect on the grain and stover yield of the crop. Minimum tillage + mulching treatments showed significantly higher seed and stover yield (3433 kg/ha and 6555 kg/ha respectively) as compared to other treatments. While the lowest seed and stover yield was recorded in the zero tillage (1763 kg/ha and 3366 kg/ha respectively) treatments.

Effect of different conservation agriculture practices on yield attributes and yield of maize

Yield attributes and yield of maize				
Treatments	**Cob length (Cm)**	**100 grain weight (g)**	**Grain yield (kg/ha)**	**Stover yield (kg/ha)**
CT	14.26	20.20	2733	5323
CTm	16.13	21.33	3300	6421
CTi	15.73	20.06	3200	5888
MT	14.20	19.63	2733	5127
MTm	16.26	24.56	3433	6555
MTi	15.53	20.33	3000	5755
MTr	14.73	20.16	2866	5583
ZT	12.96	19.66	1763	3366
ZTm	13.00	21.36	2290	4441
ZTr	13.00	20.13	1963	3783
S.E(m) ±	0.77	0.85	112.38	411.58
CD (5%)	2.31	2.55	6.83	13.64

Conclusion

Based on one year study, it was concluded that minimum tillage along with mulching is a better proposition to get higher grain and stover yields in maize under rainfed conditions.

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Ridge and Furrow Method of Pigeon Pea Cultivation as A Climate Resilient Practice

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Pigeon pea, *Cajanus cajan (L)* Millsp is the second most important pulse crop in India after chickpea. Even though India is a largest producer of pigeon pea in world, India is importing pigeon pea from various other countries to meet its domestic demand. The production gap is mainly because it is cultivated under rain fed condition (Saxena, 2008). Pigeon pea crop experiences both drought and flood as Indian rainfall being un favorable in nature (erratic and improper distribution). So, production cultivation practice must focus to tackle un favorable nature of Indian rainfall. The best possible solution to tackle this problem is Ridge and furrow method of cultivation as furrows can acts as in situ water harvesting structure during low rainfall conditions and same furrow can acts drainage channel during heavy rainfall to remove excess water from the field there by maintains the luxurious growth of plant.

Methodology

Participatory Rural Appraisal (PRA) method and group discussions with identified progressive farmers were held by the team of scientists to identify the various problems faced by farmers in getting potential yield of pigeon pea. The problem noticed are about use of local varieties and water stagnation in pigeon pea field due to heavy rainfall and also sometimes drought during various stage of crop growth at the field level apart from pest and diseases. Front line demonstration on ridge and furrow method of cultivation was conducted at 40 farmer's fields of Suntnoor village in Kalaburagi district during *kharif* 2024-25 using GRG-811 variety under National Innovations in Climate Resilient Agriculture (NICRA). There were two treatments *viz.,* flat land cultivation and ridge and furrow method of cultivation. In ridge and furrow method of cultivation the seeds are sown with the help of tractor drawn ridges and furrows maker along with sowing. Each demonstration was conducted in an area of 0.4 ha adjacent to the plots of check. Data on yield attributes and economics were collected and average data are tabulated.

Results

In the present demonstration, there was a heavy rainfall during the vegetative stage of crop (i.e., around 160 mm rainfall within 1 week) hence, there was a water stagnation in flat land cultivation, due to water stagnation optimum plant population was not maintained as pigeon pea crop highly sensitive to water logging (Khare *et al.,* 2002) whereas, in ridge and furrow method of cultivation the water stagnation in furrows does not affected the growth of crop due to presence of plants on ridges. Due to maintenance of optimum plant population and luxurious growth higher yield is expected in ridges and furrow method of pigeon pea cultivation as compared to flat land cultivation.

Overview of ridges and furrows

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Effect of Integrated Nutrients Management on the Soil Carbon Pool and its Fractionations of Soil in *Vertisols*

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Soil health indicates the capability of a soil to provide ecosystem services. The health of a soil reflects how well the soil can carry out its environmental functions. A soil is evaluated as healthy if it provides comparable or better ecosystem services relative to undisturbed reference soils of similar type in the same region. Otherwise, the soil is unhealthy, unable to perform the normal environmental functions of similar soils in the inherent ecosystem.the effect of nutrient management practices on different pools of soil organic carbon (SOC) under rainfed paddy farming, dataset on on-farm fertilizer experiment plot from 2010-2013 from Cachar district of Assam, India were utilized. Different pools of SOC viz. C Very Labile (VL), C Labile (L), C Less Labile (LL), C Non Labile (NL) were studied because of their sensitivity to the influence of agricultural management on soil quality. The study further revealed that the integrated use of organic with inorganic fertilizer enhanced the productivity and SOC over control treatment.

Methodology

The present study was conducted at the research farm of AICRP on Dryland Agriculture, College of Agriculture, Indore,(M.P)India. The experimental area is situated at 22.43° N latitude and 75.66° E longitude and at elevation 555.5 meter above mean sea level in the Western part of the Madhya Pradesh.

Chemical Analysis of soil

Representative soil samples (0-10, 10-20, 20-30, and 30-45 cm depth) were collected with the help of stainless steel auger from the experimental plot before sowing and after harvesting of crop. Determine the soil organic carbon by wet oxidation method walkley and black (1934) the total organic carbon and Inorganic carbon was determined by. Using total carbon (TOC) analyser on TOC SHIMADZU, TOC analyser 5000 A. The content of oxidizable carbon and its different fractions in the soil were estimated through the Walkley and Black (1934) method as modified by Chan *et al.* (2001) using 5, 10, and 20 ml of concentrated (18.0 M) H_2SO_4 and $K_2Cr_2O_7$ solution. This resulted in three acid-aqueous solution ratios of 0.5:1, 1:1, and 2:1 that corresponded to 6.0, 9.0, and 12.0 M H_2SO_4, respectively, and caused the production of different amounts of heat of reaction to bring about oxidation of SOC of different oxidizability. The amounts of oxidizable carbon thus determined allowed separation of total organic carbon into the following four fractions of decreasing oxidizability as defined by Chan *et al.* (2001):

Experimental details : Design : Randomized Block Design (RBD)
Replication :03 (Three)
Treatment : 09 (Nine)
Plot size : Gross: 10 m X 7.2m **Net:** 9m X 6.4m
Variety : RVS-24

Details of the treatment

Symbol	Treatments
T_1	Control
T_2	N_{20} P_{13} (Fertilizer N and P @ 20 and 13 kg ha^{-1})
T_3	N_{30} P_{20} (Fertilizer N and P @ 30 and 20 kg ha^{-1})
T_4	N_{40} P_{26} (Fertilizer N and P @ 40 and 26 kg ha^{-1})
T_5	N_{60} P_{35} (Fertilizer N and P @ 60 and 35 kg ha^{-1})
T_6	FYM 6 t ha^{-1} + N_{20} P_{13} (FYM @ 6 t ha^{-1} in rainy season on Only plus fertilizer N and P @ 20 and 13 kg ha^{-1})
T_7	Residues 5 t ha^{-1} + N_{20} P_{13} (Crop residues of soybean @ 5 t ha^{-1} plus fertilizer N and P @ 20 and 13Kg ha^{-1})
T_8	FYM 6 t ha^{-1} (Farmyard manure @ 6 t ha^{-1})
T_9	Residues 5 t ha^{-1} (Crop residues of soybean @ 5t ha^{-1})

Very labile carbon: Organic C oxidizable under 6.0 M H_2SO_4

Labile carbon: The difference in C oxidizable under 9.0 M and that under 6.0 M H_2SO_4

Less labile carbon: The difference in C oxidizable under 12.0 M and that under 9.0 M H_2SO_4 (the 12.0 M H_2SO_4 is equivalent to the standard (Walkley and Black method)

Non-labile carbon: Residual organic carbon after oxidation with 12.0 M H_2SO_4 when compared with total organic carbon.

Hot water soluble carbon was extracted by hot water extraction as described by McGill *et al.* (1986). Permanganate oxidizable soil carbon (POSC) in soil sample was analyzed as per procedure outlined by Blair *et al.* (1995).

Results

Soil organic carbon

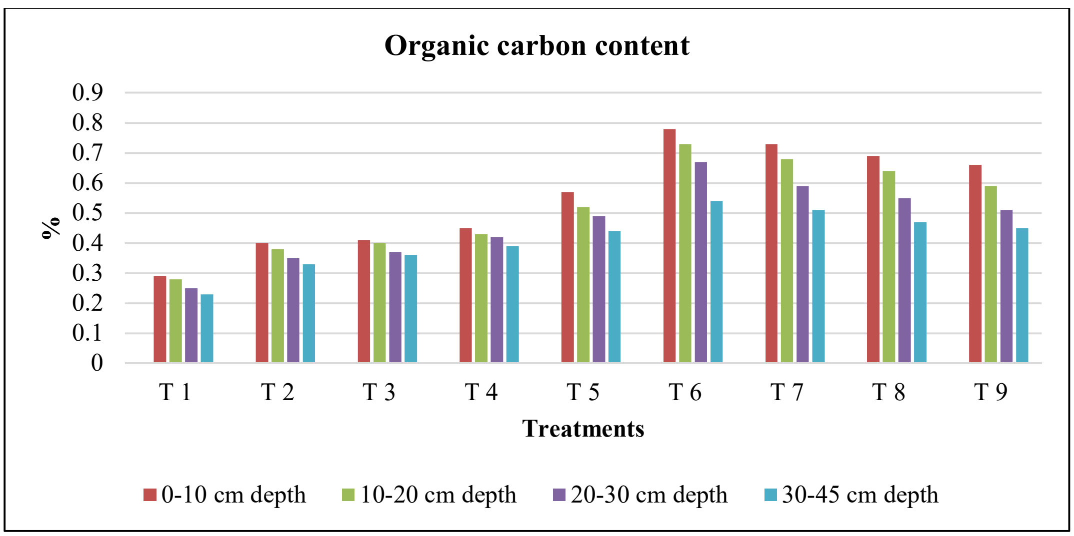
The soil organic carbon ranged 0.29-0.78, 0.28-0.73, 0.25-0.67, 0.23-0.54 % at 0-10, 10-20, 20-30 and 30-45 cm depth of soil under application of solo fertilizers and integrated fertilizers. It has been observed that the treatment receiving integrated fertilizers (T6 and T7) and sole organic inputs (T8 and T9) showed significant as compared to sole inorganic fertilizer application and the control (Fig). Patidar *et al.* (2021) Organic carbon content of soil had increased significantly and attained a maximum value of 8.58 g kg^{-1} in the treatment that has received integrated fertilizers (100% NPK along with FYM).

Total organic carbon

The total organic carbon ranged 9.67-16.48, 8.32-13.43, 6.97-11.89 and 5.93-9.38 g kg $^{-1}$ at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of inorganic and organic fertilizers. The total organic carbon of soil at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil showed significant under integrated fertilizers treatments. The treatments receiving under integrated fertilizers (T6 and T7) or organic inputs (T8 and T9) showed significantly higher total organic carbon as compared to the rest treatments including control.

Very labile carbon

The Very labile carbon of soil under different quantity of solo fertilizer application and integrated fertilizer application including control ranged 2.50-3.86, 2.19-3.52, 1.46-2.78 and 1.42-2.34 g kg^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of inorganic and organic fertilizers. It has been observed that the treatment receiving integrated fertilizers (T6 and T7) and sole organic inputs (T8) showed significant increases in Very labile carbon as compared to sole inorganic fertilizer application and the control.



Impact of Integrated Nutrient Management on organic carbon of soil

Labile carbon

Labile carbon of soil ranged 1.49-3.24, 1.14-2.63, 0.95-2.22 and 0.53-1.40 g kg^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of inorganic and organic fertilizers. The treatments receiving under integrated fertilizers (T6 and T7) or organic inputs (T8 and T9) showed significantly higher labile carbon as compared to the rest treatments including control.

Less labile carbon

The less labile carbon of soil ranged 0.70-0.88, 0.56-0.73, 0.47-0.65 and 0.41-0.58 g kg^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of solo fertilizers and integrated fertilizers treatments. It has been observed that the treatment receiving integrated fertilizers (T6 and T7) showed significant lower value of less labile carbon of soil as compared to sole fertilizer application and the control.

Non labile carbon

Non labile carbon of soil mean value ranged 4.89-8.77, 4.35-6.71, 4.00-6.50 and 3.49-5.32 g kg^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of inorganic and organic fertilizers. It has been observed that the treatment receiving integrated fertilizers (T6 and T7) showed significant higher non labile carbon of soil as compared to sole fertilizer application and the control.

Total carbon

Total carbon of the soil ranged 24.25-28.26, 23.06-25.35, 21.62-24.13 and 20.99-22.98 g kg^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of soil. The Total carbon of soil at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil showed significant under solo fertilizers and integrated fertilizers treatments. The treatments receiving under integrated fertilizers (T6 and T7) or organic inputs (T8) showed significantly higher total organic carbon as compared to the rest treatments including control.

Total inorganic carbon

Total inorganic carbon of soil ranged 11.78-14.58, 11.92-14.91, 12.24-15.38 and 13.60-15.80 g kg^{-1} at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of solo fertilizers and integrated fertilizers treatments. It has been observed that the treatment receiving integrated fertilizers (T6) showed significant lower value of total inorganic carbon of soil as compared to sole fertilizer application and the control.

Permanganate oxidizable soil carbon

Permanganate oxidizable soil carbon mean value ranged 781.28-934.15, 688.47-921.44, 571.31-720.20 and 497.04-674.21 mg kg^{-1}at 0-10, 10-20, 20-30 and 30-45 cm depth of the soil respectively under the treatments receiving various dose of inorganic and organic fertilizers. The significantly higher permanganate oxidizable soil carbon of soil was recorded under the treatments receiving integrated fertilizers treatments (T6 and T7) and sole organic inputs (T8 and T9) compared to the control.

Conclusion

The study provides information that the application of integrated nutrients inputs (FYM @6 t ha^{-1} + N_{20} P_{13}) positively influenced the soil carbon pool or carbon fractionations. Among the studied treatments, the application of FYM @6 t ha^{-1} combination with chemical fertilizer (T6) showed positive influence on soil properties. Through enhancement of SOC and its fractionations by INM increases soil nutrient availability and it is having positive impact on soil health.

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UID: 1393

Effect of Planting Geometry and Age of Seedling on Growth of Rice

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Crop geometry plays a significant role for optimization of rice yield due to efficient utilization of solar radiation as well as nutrients in rice. Closer spacing hampers intercultural operations and as such more competition arises among the plants for nutrients, air and light as a result, plant becomes weaker and thinner producing lower yield. The plant geometry and spatial configuration exploit the initial vigor of the genotypes with enhanced soil aeration creating congenial condition for better establishment. When seedlings stay for a longer period in the nursery beds, the primary tiller buds on the lower nodes of the main culm become degenerated leading to reduced tiller production. Also, early transplantation allows better plant growth with short phyllochrons interval due to less transplanting shock. Keeping the above fact in view my objective is to study the effect of planting geometry and age of seedling on plant height and dry matter accumulation of rice.

Methodology

The experiment was laid out during kharif-2019 at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj (Ayodhya) U.P. Geographically, Ayodhya (Kumarganj) falls in sub-tropical climate and is situated at $26^{0}.47^{`}$

North latitude, $82^0.12^`$ East longitudes with an altitude of 113 meters above mean sea level. The experimental site is situated in main campus of university on left side of Raebareli road at the distance of 42 km from Ayodhya district headquarter.

The experiment was laid out in split plot design (SPD) with 12 treatment combinations and replicated three times. The treatments were allotted randomly to various main plots and sub plots. In all, there were 12 treatment combinations in the experimental field. The details of treatment with their symbols have been given in Table 1.

Results

Data pertaining to plant height (cm) has been presented in table 2 and depicted in Fig 1. An examination over data presented in table revealed the effect of age of seedlings on plant height was found significant at harvest stage. At harvest stage the taller plant height (cm) was recorded under three weeks age of seedlings (S_1) which was at par with four weeks of age of seedlings while significantly superior over five weeks age of seedlings (S_3). The effect of planting geometry was found significant at harvest stage. The planting geometry 20 cm x 10 cm (A_1) was found significantly taller over rest of the treatments and the lowest plant height was recorded with 25 cm x 15 cm (A_4) at harvest.

Table 1. Detail of treatments with their symbols

Sl. No.	Treatments	Detail of treatments
(A) Main plot (Age of seedlings)		
1.	S_1	Three weeks old seedlings
2.	S_2	Four weeks old seedlings
3.	S_3	Five weeks old seedlings
(B) Sub plot (Planting geometry)		
1.	A_1	20 cm × 10 cm
2.	A_2	25 cm × 10 cm
3.	A_3	20 cm × 15 cm
4.	A_4	25 cm × 15 cm

Data pertaining to number of tillers (m^{-2}) has been presented in table 2. The effect of age of seedlings on numbers of tillers (m^{-2}) was found significant at harvest stage. The three weeks old seedlings (S_1) was recorded significantly highest number of tillers (m^{-2}) which was at par with the four weeks old seedlings (S_2) while significantly superior over the five weeks old seedlings (S_3) and the lowest number of tillers (m^{-2}) was recorded with the five weeks old seedlings (S_3) at 60 harvesting stage. The effect of planting geometry on numbers of tillers (m^{-2}) were found significant at harvest stage. At harvesting stage the planting geometry 20 cm x 10 cm (A_1) was found to be significantly highest numbers of tillers (m^{-2}) which was at par with planting geometry 25 cm x 10 cm (A_2) while significantly superior over rest of planning geometry. The lowest numbers of tillers (m^{-2}) was recorded with planting geometry 25 cm x 15 cm (A_4).

Table 2. Plant height (cm) of rice as influenced by different treatments

Treatments	Plant height (cm)	Number of tillers (m^{-2})
	At harvest	At harvest
Age of seedlings		
S_1: Three weeks old seedlings	92.48	290.89
S_2: Four weeks old seedlings	89.70	288.32
S_3: Five weeks old seedlings	85.20	281.90
S.Em±	1.432	2.744
C.D. at 5%	3.628	5.954
Planting geometry		
A_1: 20 cm x 10 cm	96.83	283.94
A_2: 25 cm x 10 cm	87.10	279.76
A_3: 20 cm x 15 cm	91.97	276.90
A_4: 25 cm x 15 cm	80.60	246.88
S.Em ±	1.432	2.674
C.D. at 5%	3.626	5.802

Conclusion

Taller plant height (cm) was recorded under three weeks age of seedlings which was at par with four weeks of age of seedlings while significantly superior over five weeks age of seedlings. Three weeks old seedlings was recorded significantly highest number of tillers (m^{-2}) which was at par with the four weeks old seedlings while significantly superior over the five weeks old seedlings.

UID: 1404

Effect of Differential Nutrient Doses on Yield and Economics of Barnyard Millet Under Rainfed Conditions of Jammu

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Barnyard millet cultivated across India from the Northern Himalayas to the Deccan plateau represents a vital option for crop diversification in marginal lands (Sood *et al*. 2015). With an area of 0.146 million hectares and a production of 0.147 million tonnes, India is the leading producer of barnyard millet, achieving an average productivity of 1034 kg/ha (IIMR 2018). The *Kandi* area of Jammu, characterized by dry semi-hilly terrain, comprises approximately twelve per cent of the region's total land area and relies on monsoon rains for agriculture (Singh *et al*. 2020). Predominant crops possess low level of capability to withstand drought or adverse climatic conditions. Hence barnyard millet can transcend in this tract. However, the low productivity levels and poor economic returns hinder barnyard millet adoption. Nutrient stress remains a significant constraint to its productivity. Hence, an effort has been made to boost productivity by demonstrating and exploring the intricate dynamics of nutrient management in barnyard millet cultivation.

Methodology

The field experiment was conducted at Research farm of Advanced Centre for Rainfed Agriculture, Rakh Dhiansar, SKUAST-Jammu, J&K (UT) during *kharif*-2023 under rainfed conditions. The experiment was conducted in Randomized Complete Block Design on soil having a sandy loam texture, slightly acidic to neutral in reaction (6.53 pH), low in organic carbon (2.50 g/kg), available nitrogen (165.68 kg/ha) and potassium (99.60 kg/ha) but medium in available phosphorus (14.15 kg/ha). The experiment comprised of thirteen treatments *viz.*

T_1- Absolute control,
T_2- 30:10:10 kg NPK/ha, **T_3-** 40:10:10 kg NPK/ha, **T_4-** 50:10:10 kg NPK/ha,
T_5- 30:20:10 kg NPK/ha, **T_6-** 40:20:10 kg NPK/ha, **T_7-** 50:20:10 kg NPK/ha,
T_8- 30:10:20 kg NPK/ha, **T_9-** 40:10:20 kg NPK/ha, **T_{10}-** 50:10:20 kg NPK/ha, **T_{11}-** 30:20:20 kg NPK/ha, **T_{12}-** 40:20:20 kg NPK/ha and **T_{13}-** 50:20:20 kg NPK/ha with each treatment replicated thrice. 2/3rd dose of N, full dose of P_2O_5 and K_2O were applied as basal through urea, DAP and MOP at the time of sowing and the remaining 1/3rd dose of N was top dressed in all the treatments.

Results

Among the different nutrient doses, the 40:20:20 kg NPK/ha (T_{12}) application resulted in significantly higher grains/panicle (1112.66), grain yield (1959.43 kg/ha) and straw yield (4677.73 kg/ha) with the corresponding highest values of net returns and B:C ratio of ₹ 74,115/ha and 3.52, which was found statistically at par with the application of 50:20:20 kg NPK/ha treatment (T_{13}). However, the absolute control (T_1) evinced the lowest grain yield, straw yield, net returns and benefit-cost ratio values among different treatments. Excess nitrogen may have led to increased internodal length, while insufficient phosphorus application could have hindered root development. Consequently, plots receiving a nutrient dose with suboptimal nitrogen and supererogatory potassium levels experienced lodging, resulting in fewer grains/panicle. Kumar *et al*. (2020) reported lodging due to excessive fertilizer application. The higher yield observed at 40:20:20 kg NPK/ha (T_{12}) fertilizer level might be attributed to the higher biomass accumulation in the reproductive organs and better nutrient uptake which led to improved yield attributes. Higher grain and straw yields under the 40:20:20 kg NPK/ha treatment likely contributed to increased net returns and B:C ratio. The findings align with the earlier studies of Triveni *et al*. (2023).

Effect of differential nutrient doses on yield and economics of barnyard millet

Treatments	No. of grains/ panicle	Grain yield (kg/ha)	Straw yield (kg/ha)	Net returns (₹/ha)	B: C ratio
T_1- Absolute control	759.07	1000.50	2492.74	30959	1.74
T_2- 30:10:10 kg NPK/ha	842.40	1432.59	3052.56	49173	2.47
T_3- 40:10:10 kg NPK/ha	852.41	1452.92	3179.78	50150	2.51
T_4- 50:10:10 kg NPK/ha	846.62	1445.95	3104.45	49594	2.46
T_5- 30:20:10 kg NPK/ha	1009.97	1765.91	4073.00	65194	3.20
T_6- 40:20:10 kg NPK/ha	1024.31	1800.69	4201.49	66824	3.26
T_7- 50:20:10 kg NPK/ha	1018.39	1788.89	4183.96	66138	3.20
T_8- 30:10:20 kg NPK/ha	927.41	1594.59	3496.21	56562	2.77
T_9- 40:10:20 kg NPK/ha	935.14	1623.31	3642.83	57946	2.82
T_{10}- 50:10:20 kg NPK/ha	930.78	1610.79	3599.45	57188	2.76
T_{11}- 30:20:20 kg NPK/ha	1013.07	1776.83	4147.77	65232	3.11
T_{12}- 40:20:20 kg NPK/ha	1112.66	1959.43	4677.73	74115	3.52
T_{13}- 50:20:20 kg NPK/ha	1099.00	1941.55	4595.28	73058	3.45
SEm±	25.14	48.15	107.56		
CD (0.05)	73.39	140.53	313.96		

Conclusion

On the basis of a one-year study, it can be inferred that application of 40:20:20 kg NPK/ha in barnyard millet var. DHBM 93-3 would increase its productivity under the rainfed conditions of Jammu.

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UID: 1410

Effect of Different Planting Techniques, Irrigation Regimes and Water Use on Yield and Nutrient Uptake of Sugarcane (*saccharum officinarum* L.)

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A field experiment was conducted to study the nutrient uptake and yield of Sugarcane of Different Planting Techniques and Irrigation Regimes and water use with their interactions on yield of Sugarcane during the year January 2013 to December 2013 (Plant Cane) and January 2014 to December 2014 (Ratoon cane). The experiment was laid out in Split Plot Design comprised of two main plot treatments, five sub plot treatments and one control treatment. 10 month old canes from seed plot of sugarcane cv.COM-0265 used as source of seed material for plantation. About 1.5 tons of cane was used for plantation. The trash and green leaves were hand stripped to avoid damage to the eye buds. After discarding the bottom 3-4 nodes single eye bud setts were made by making a cut at 2 to 3 cm above the growing ring keeping the internodes 5-8 cm below the bud. The sets were treated for 10 minutes in 0.1% solution of carbendanzim to protect the crop from smut disease. Before planting sugarcane, sets were treated with 100 liter water + 300 ml melathion + 100 g Bavistin fungicide and afterwards the sets were also treated with Acetobacter @ 10 kg and PSB culture @ 1.25 kg per 100 liters of water for 30 minutes before planting. . The results of this study indicated that overall mean yields of 149.21,141.57 and 145.36 t ha^{-1} were obtained in plant, ratoon cane and on pooled mean basis, respectively. The wider row planting of 150 cm produced 3.6 and 3.3% more yield than 90-180x30cm paired row planting in sugarcane. The mean N, P and K uptake (cane + top) at harvest in plant cane and ratoon was 223.19 and 208.19 kg ha-1, 93.93 and 87.42 kg ha-1 and 291.96 and 270.82 kg ha-1, respectively.

In case of water use it was revealed that the 100% ETc with drip irrigation (DI) gave significantly higher yield of sugarcane in plant cane (168.99 t ha-1) and ratoon cane (163.93 t ha-1) as compared to other irrigation regimes but, it was on par with 85% ETc. The severe stress of 40 to 55% (I1 and I2) produced significantly lowered (17.5 to 37.6%) cane yields in plant and ratoon yield, respectively; however, the minor stress of 85% (I4) produced non-significant reduction of 2 to 3% in cane yields. The single row planting used slightly more water than paired row planting. The total water use in drip irrigation with 100% ETc was 1072.42 mm as compared to 2450.85 mm in conventional method of irrigation and thus, resulted into 59 % water saving and 19% more cane productivity than conventional method. Whereas, 85% ETc treatment produced 16% more cane with 65% water saving. The 55% ETc treatment produced maximum Water Use Efficiency 202.15

UID: 1411

Crop Productivity Enhancement in Direct Seeded ahu Rice Based Cropping System Through Harvested Rain Water in Rainfed Upland Condition of Assam

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The rice based cropping system of Assam is predominantly rainfed with monocropping of rice. The North Bank Plains Zone of Assam receives good amount of rainfall during *Pre-kharif* (March-May) and *Kharif* season (June-September) which can be harvested in farm ponds for utilization during dry periods (early, mid and terminal dryspells during kharif and in winter). There is ample scope to go for double or triple cropping system with efficient utilization of rainwater. Potential productivity and monetary benefits act as guiding principles while opting for a particular crop/cropping system (Baishya *et al.,* 2016). The present study is formulated to increase the crop productivity of rice (direct seeded) based cropping sequences (300% CI) by efficient utilization of harvested rainwater considering two irrigation methods viz. flood and drip in comparison to rainfed situation.

Methodology

The field experiment was conducted at the experimental field of All India Coordinated Research Project for Dryland Agriculture, Biswanath College of Agriculture, Biswanath Chariali, Assam Agricultural University, during 2019-20 to 2023-24 in two factorial randomized block design with 3 replications.

The treatments are I_0C_1- Rainfed- *Ahu* rice -green gram-toria, I_0C_2-Rainfed-*Ahu* rice -green gram-rajmah, I_0C_3-Rainfed-*Ahu* rice -green gram-potato, I_1C_1-Flood - *Ahu* rice -green gram-toria, I_1C_2- Flood - *Ahu* rice -green gram-rajmah, I_1C_3-Flood - *Ahu* rice -green gram-potato, I_2C_1-Drip- *Ahu* rice -green gram-toria, I_2C_2-Drip -*Ahu* rice -green gram-rajmah and I_2C_3-Drip- *Ahu* rice -green gram-potato. The individual plot size was 50 m^2 (10m x 5m) and the variety selected for ahu rice, green gram, toria, rajmah and potato are Inglongkiri, SGC-16, TS-38, Arun and Kufri Pokhraj, respectively. Recommended dose of fertilizer has been applied to all the crops.

Life saving irrigation was applied to toria, rajmah and potato during rabi season from the concrete lined water harvesting tank covering an area of 450 m^2 each for flood (surface) and drip irrigation respectively. The concrete farm pond has harvest potential of 528 m^3 which is sufficient to irrigate the crops during dryspells in rabi season. Rain water use efficiency (RWUE) has been calculated by dividing Crop productivity (kg/ ha) by total crop seasonal rainfall (mm).

Results

1. Life saving irrigation was applied to toria, rajmah and potato during rabi season from the concrete lined water harvesting tank covering an area of 450 m^2 each for flood (surface) and drip irrigation respectively. An increase of 16%, 27% and 35% in system yield was observed in ahu rice- green gram-toria, ahu rice- green gram-rajmah and ahu rice- green gram-potato sequence with surface irrigation, respectively over rainfed crop. Similarly, 5%, 13% and 14% yield increase was observed in drip irrigated ahu rice- green gram-toria, ahu rice- green gram-rajmah and ahu rice- green gram-potato sequences over rainfed crops. Highest mean B:C of 2.0 was observed in *ahu* rice -green gram-rajmah with surface irrigation during dryspells.

System yield and economics of different cropping systems under study

Sl. No.	Treatments	Pooled system yields of 5 years (kg/ha)	Mean BC ratio	RWUE (%)
1	I_0C_1- No Irrigation- *Ahu* rice -green gram-toria	6644	1.44	4.1
2	I_0C_2-No Irrigation *Ahu* rice -green gram-rajmah	8778	1.53	5.4
3	I_0C_3-No Irrigation *Ahu* rice -green gram-potato	10539	1.08	6.7
4	I_1C_1-Flood - *Ahu* rice -green gram-toria	7705	1.65	4.9
5	I_1C_2- Flood - *Ahu* rice -green gram-rajmah	11172	2.00	7.0
6	I_1C_3-Flood - *Ahu* rice -green gram-potato	14236	1.69	9.0
7	I_2C_1-Drip- *Ahu* rice -green gram-toria	7042	1.53	4.5
8	I_2C_1-Drip -*Ahu* rice -green gram-rajmah	9904	1.77	6.1
9	I_2C_1-Drip- *Ahu* rice green gram-potato	11984	1.30	7.6
CV		11.4		
CD (5%)	Years	828.9	--	--
	Treatments	828.9	--	--
	Year X Treatment	1435.7	--	--

2. The concrete farm pond has harvest potential of 528 m3 which is sufficient to irrigate the crops during dryspells in rabi season. The average water applied in toria, rajmah and potato

are 28 m3, 29 m3 and 37m3 respectively through surface irrigation and 23m3, 25m3 and 25 m3 in toria, rajmah and potato, respectively through drip irrigation during 2020-21 to 2023-24. 31.25% water saving was recorded in drip irrigation over surface irrigation irrespective of crops.

3. During rabi season, higher soil moisture was observed in surface (10.51%) followed by drip irrigation (9.96%) and lowest in rainfed (9.01%) irrespective of the crops.

Conclusion

Among the different cropping sequences, it has been observed that the *ahu* rice -green gram-rajmah sequence is economically feasible for both surface and drip irrigation. However, in terms of system yield, surface irrigation in potato was found to be better than that of the other cropping sequences under study. Rain water use efficiency is also found to be better in surface irrigated *ahu* rice -green gram-potato sequence as compared to drip and rainfed crops respectively. Water saving was highest in drip irrigation in potato than rajmah and toria over flood irrigation.

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UID: 1414

Study on the Effect of NPK Briquettes and Nano Urea on Yield of Tomato

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Tomato (*Lycopersicon esculentum*) is one of the most important vegetable crops of India with production estimated to about 20 million metric tonnes in the financial year 2023. India ranks second in the production of tomato only after China. Vegetable crops are very responsive to soil fertility status, so nutrient management strategies should be used on vegetable farms to maximize the benefits of fertilizer application on crop yields and fruit quality while minimizing nutrient loss to the environment. Since fertilizer briquettes applied into the ground reduce runoff, fixation, leaching, and volatilization loss so their application has proved to be profitable in different crops like brinjal, tomato, cabbage, cauliflower, potato, maize and banana. The rapid rise of environmental problems like global warming caused by nitrous oxide gas emitted from fertilizer like urea has also led scientists to develop crop nutrient management practices on different crops including vegetables. On an average deep placement of NPK briquette saves about 35% of fertilizer and increase yield up to 15%–25%

(Savant *et al*., 1992). However, deep placement of fertilizers is a labour intensive process. Therefore, the use of briquette applicator could be encouraged which is an effective mode of briquette placement in the standing crop.

Jian *et al.,* (2009) studied the application of nano-biotechnology to increase vegetable production and the results showed that the nano fertilizer promoted the growth of the crops, came into the market 5 to 7 days ahead of time, and increased yield upto 20% to 40%. Liquid nano fertilizer is currently the best alternative to urea fertilizer. One bottle of nano urea (500 ml) is equivalent to a bag of urea fertilizer (45 kg). Foliar application of nano urea liquid at critical crop growth stages of a plant effectively fulfils its nitrogen requirement and leads to higher crop productivity and quality in comparison to conventional urea.

Methodology

A field experiment was carried out at three farmer's field at Gerua Baligaon village in Sonitpur district under Krishi Vigyan Kendra, Sonitpur. Tomato variety Anup was cultivated in 0.3 ha of land in each farmer's plot where 0.1 ha was cultivated by the farmer through conventional practices, 0.1 ha was cultivated by application of NPK briquettes at recommended dose and 0.1 ha was cultivated by application of recommended basal dose of fertilizers along with Nano urea as first and second split. The experiment was carried out in Randomized Block Design.

Tomato seedlings of variety Anup were first raised in pro trays and a potting mixture was prepared with coco peat and vermicompost. Briquettes were prepared in a briquette making machine following standard procedures. Nano urea was procured from market according to the recommended dose. Broadcasting of Nitrogen, Phosphorous and Potassium fertilizers in the recommended rate of 12:20:20 was applied in the 0.1 ha plot as 50% basal, 25% first and 25% second split where cultivation was done conventionally by the farmer. In Fertilizer Deep Placement (FDP) plot of 0.1 ha, NPK briquettes weighing 2.7 g each were applied at the rate of 10-12 briquettes per plant at a depth of 7-10 cm one to seven days after planting. The briquettes were applied in a ring around the stem at 9-10 cm from the base of the plant. In another 0.1 ha plot, 33% Nitrogen fertilizer was applied as basal along with 100% Phosphorous and Potassium fertilizers at recommended dose. Nitrogen fertilizer in the form of Nano urea was applied as foliar spray at the rate of 34% as first split and 33% as second split.

Results

From the mean data, it was found the highest grain yield of 383.72 q/ha was obtained in FDP plot where fertilizers were applied as briquettes whereas the lowest grain yield of 354.58 q/ha was obtained in control plot.

Table 1. Effect of NPK briquettes and nano urea on yield attributing characters of tomato

Sl. No	Name of demonstration	Plant Height (cm) (Mean)	No. of main branches (Mean)	Fruits per plant (Mean)	Weight per fruit (g) (Mean)	Gross income (Rs) (Mean)	Net income (Rs) (Mean)	B:C
1	FDP plot (0.1 ha)	110.16	4	28	109.928	40000	32000	4.4:1
2	Basal + Nano urea (0.1 ha)	106.36	3	26	106.435	32000	24000	3:1
3	Farmer's practice (0.1 ha)	98	3	21	103.82	18000	10000	1.3:1

NPK briquette applied crop obtained higher grain yield because of little leaching, runoff losses, volatilization due to slow release nature of the NPK briquettes (Owusu and Adu-Gyamfi, 2024).

Table 2. Effect of NPK briquettes and nano urea on yield of tomato

Sl. No	Name of demonstration	Yield (q/ha)			
		Farmer 1	Farmer 2	Farmer 3	Mean
1	FDP plot (0.1 ha)	365.32	380.52	405.32	383.72
2	Basal + Nano urea (0.1 ha)	376.56	379.36	388.26	381.39
3	Farmer's practice (0.1 ha)	348.02	330.27	385.45	354.58
	SE(m)	-	-	-	**7.727**
	SE(d)	-	-	-	**10.928**
	CV (5%)	-	-	-	**3.586**

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Optimizing Resource use Efficiency through *In-situ* Rainwater Harvesting Systems in Bundelkhand Region

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The Bundelkhand region of central India faces significant challenges in agricultural productivity due to erratic rainfall, moisture deficit, and poor soil fertility. The region's soils are characterized by low organic matter content, limited plant growth, and high oxidation rates, compromising their ability to hold water and nutrients. This, coupled with the region's sloping topography and rocky terrain, makes it prone to drought and water scarcity. Crop cultivation during the kharif season is further limited by the decline in productivity, attributed to the region's inherent soil fertility issues and the impact of climate variability. To address these challenges, the integration of *in-situ* rainwater harvesting techniques and diversified cropping systems can be sustainable strategy. These approaches have the potential to enhance soil health, improve water and carbon dynamics, and increase system productivity in the region. However, the complex interplay between these interventions and their combined influence on soil health, water utilization efficiency, and climate resilience which is inadequately explored Bundelkhand region.

Methodology

Experiment details

The field experiment was conducted during 2021-22 at the research farm of Rani Lakshmi Bai Central Agricultural University, Jhansi, India (25°27'N, 78°35'E, 271 m above mean sea level). The experimental site is characterized by a semi-arid climate with an average annual rainfall of 870 mm, of which approximately 80% occurs during the monsoon season (July-September). The soil was classified as *Inceptisol* with sandy loam texture. The experiment was laid out in split plot design to evaluate the response of *in-situ* rainwater harvesting methods (Conventional tillage (CT), Residue mulching (RM), Broad bed and furrow (BBF) and Ridge and furrow (R&F)) in main plot and three cropping systems (Groundnut–Wheat, Sorghum–Chickpea and Maize–Mustard–Sesbania) as sub-plot, replicated thrice. Crop management practices were standardized across treatments.

Data collection and analysis

Kharif crop's physiological responses *viz*., chlorophyll content and relative water content (RWC) were measured using SPAD meter, and leaf area analysis, respectively at 45 and 75 DAS. Soil organic carbon, available N, P and K levels were measured using standard methods at 0-20 cm soil depth. Water productivity of the cropping system was calculated based on system productivity verses total water applied. The total carbon footprint was assessed by converting all inputs and outputs into CO_2 equivalents using established emission factors. Soil organic carbon stock changes were monitored to estimate carbon sequestration potential.

Results

Crop Response

The implementation of conservation tillage practices, such as residue mulching (RM) and ridge and furrow (R&F), led to significant improvements in crop growth metrics. Chlorophyll content, measured via SPAD readings, was 15-20% greater in RM and R&F systems, reflecting superior nitrogen assimilation and photosynthetic capacity. During periods of moisture stress, relative water content (RWC) remained above 75% in conservation tillage plots, compared to 60% in CT, highlighting improved drought resilience. The maize-mustard-sesbania cropping system exhibited the best adaptation, maintaining 12-15% higher RWC than other systems.

Soil nutrient availability, WUE and carbon footprint

Soil nutrient availability and resource use efficiency significantly varied under cropping systems and land configurations (Fig 2). The nutrient availability under RM was improved significantly compared to CT and BBF & R&F. The WUE recorded under the R&F system improved by 13.9, 5.6 and 35 over CT, RM and BBF, respectively. The highest WUE was recorded in groundnut under R&F with a value of 3.12 as compared to that under CT at 2.78, thus showing that this crop used moisture better under the altered land configurations. Soil organic carbon stock increased significantly under RM treatment, with a maximum of 23.82% increase compared to CT, and maximum values under maize (7.68) followed by groundnut (7.25). Carbon footprint under RM resulted 54% reduction compared to CT while same under R&F and BBF was ~30%, depicting environmental sustainability under changed land configurations. The increase in SOC stock under RM and other modified land configurations not only enhances soil fertility but also contributes to climate change mitigation by reducing atmospheric carbon levels (Pramanick et al., 2024).

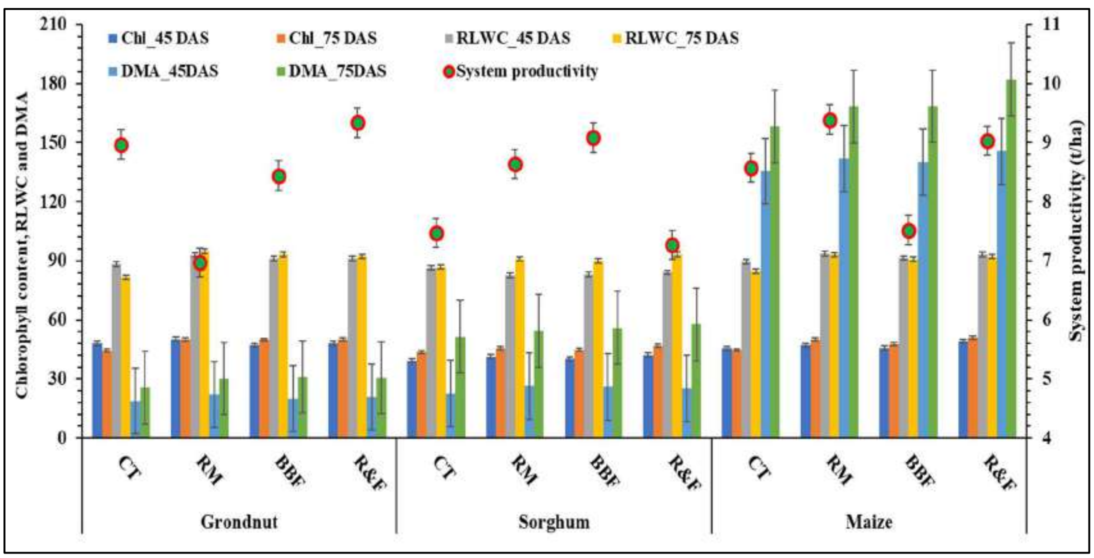

Fig 1. Kharif crops responses and cropping system productivity under In-situ rainwater harvesting approaches

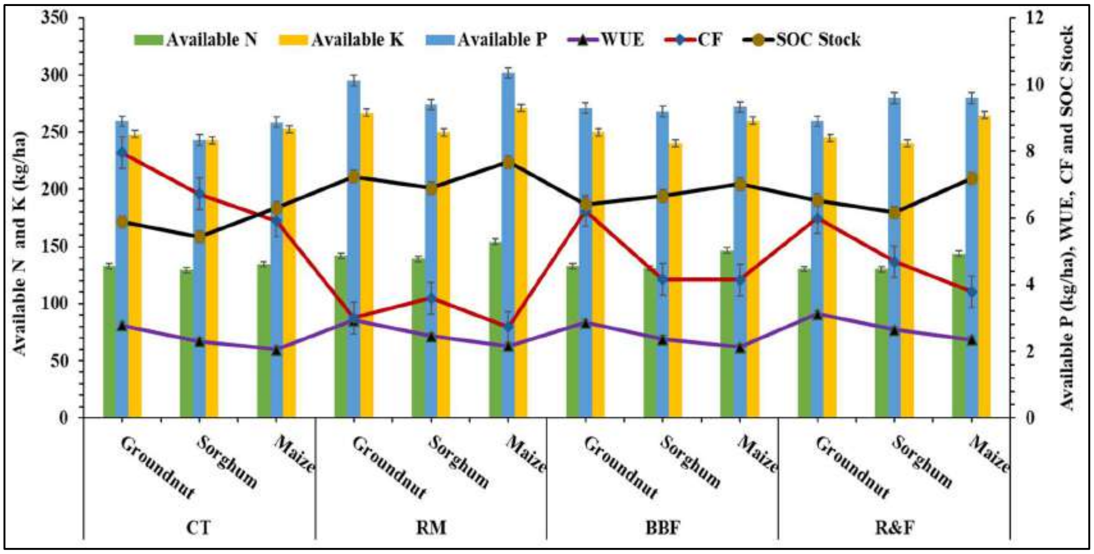

Fig 2. Soil Nutrient availability, water productivity, carbon footprint and soil carbon stock increase under in-situ rainwater harvesting approaches after two years cropping system

Conclusion

The RM and R&F enhanced the health of soil, crop response and water productivity under both water deficit and excess conditions, while RM increased the SOC by 18-22% and reduced emission by 55%. Such configurations combined with cropping system diversifications potentially optimize resource use, increase yield, and reduce the environmental impact of semi-arid agriculture.

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Enhancing Crop Productivity and Soil Nutrient Availability through INM in Bundelkhand Region

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Bundelkhand is hot and semi-humid region which comprises 7 districts each from Madhya Pradesh and Uttar Pradesh. Annual temperature in Bundelkhand varied from 3.0°C to 47.8°C hottest during the month of May and the coldest during the period of December to January, with the annual rainfall 800 – 900 mm. In this area the relative humidity varies from 26% to 88%. This brings a sort of limitations on cropping choice by a farmer. The prominent crops grown are sorghum, pigeon pea, urdbean, mungbean, sesame, soybean and rice during Kharif and wheat, chickpea, fieldpea, lentil, linseed and mustard during Rabi season. However, sorghum and black gram are most prominent Kharif season crop in this region while chickpea and mustard during Rabi season. Poor soil health and inadequate nutrient management brought on by a lack of moisture availability have the potential to significantly increase crop output and soil productivity without degrading the quality of the soil (Das et al., 2022). Nearly half of Uttar Pradesh's entire chickpea production comes from the Bundelkhand region, which is poorly managed and fertilizes the crop unevenly. There are four main types of soils in this area: clay loam (*Kabar*), sandy loam (*Parwa*), sandy soil (*Rakar*), and heavy soil (*Mar*). This area has a cropping intensity of roughly 111%. The greatest way to increase crop productivity and the sustainability of such systems would be to apply STCR and fertilize using yield equations.

Methdology

A field experiment has been conducted at Research Farm of the Rani Lakshmi Bai Central Agricultural University, Jhansi during 2020-2021. The experiment consisted of seven treatments namely T_1–Control, T_2 - 100 %RDF, T_3 - 75% RDF + FYM @ 5t/ha, T_4 - 100% RDF + FYM @ 5t/ha, T_5 – STCR based nutrient recommendations, T_6 - 75% RDF+ Crop residue @ 4t /ha and T_7 - 100% RDF+ Crop residue @ 4t /ha. The *Kharif* crop residue has been applied for *rabi* season crop. These treatments were replicated three times in RBD design. Crop yield attributes and soil nutrient availability was recorded.

Results

Crop response

The INM techniques significantly increased soil health and crop output. T4 - 100% RDF + FYM @ 5t/ha in urd-mustard system, gave the highest grain yield (25.95 q/ha), which was 108.10% above the control, 12.47 q/ha. Biomass output increased with 85.33 q/ha; 93.93% more than the control. For the sorghum-chickpea system, T3 was the most effective integration, which brought up the grain production by 84.41% of the control (15.367 q/ha), while biomass increased by 124.76% (55.067 q/ha) over the control.

Effect of STCR based nutrient management on soil health under two years Urd-Mustard and Sorghum-Chickpea cropping system in Bundelkhand

Treatment	SOC (%)		Nitrogen (kg/ha)		Phosphorus (kg/ha)		Potassium (kg/ha)		Sulphur (mg/kg)	
	U-M	S-CP	U-M	S-CP	U-M	S-CP	U-M	S-CP	U-M	S-CP
T_1- Control	0.34	0.30	44.37	39.0	4.0	4.55	306.9	343.2	5.4	3.46
T_2- 100 % RDF	0.35	0.31	77.43	61.4	9.4	12.87	345.2	347.27	8.7	7.72
T3- 75% RDF + FYM @ 5t/ha	0.41	0.36	87.6	72.0	12.6	18.24	339.8	360.47	9.9	6.43
T_4- 100% RDF + FYM @ 5t/ha	0.46	0.46	79.67	98.6	18.0	17.39	370.6	368.6	9.1	7.24
T_5- STCR based fertilizer recommendation	0.34	0.45	97.27	68.0	16.9	13.82	393.7	330.6	11.5	12.48
T_6- 75 % RDF +Residue @ 4t/ha	0.46	0.42	76.23	70.4	17.3	18.59	346.6	348.47	8.7	8.20
T_7- 100% RDF +Residue @ 4t/ha	0.44	0.43	69.97	62.6	14.4	16.29	395.2	373.27	8.4	8.27
C.D.	0.08	0.08	6.97	12.6	2.9	1.04	11.4	N/A	1.8	0.92

Soil health

Under combined treatments, soil health metrics improved significantly. Nitrogen increased to 128.6 kg/ha under T7 as compared to 99.0 kg/ha in control, phosphorus increased to 18.6 kg/ha under T6 from 8.6 kg/ha, and sulfur increased to 8.48 mg/kg under T5 from 5.46 mg/kg, which indicated a significant improvement in the available nutritional status. INM increases crop yield and soil health significantly, especially with chemical fertilizers and organic sources (Das et al., 2022; Kharlukhi et al., 2024). This is because cropping system-specific nutrient management strategies are needed. Higher soil organic carbon enhances CEC, facilitating better retention and availability of essential nutrients like nitrogen, phosphorus, and sulphur (Singh et al., 2023; Pramanick et al., 2024). These enhancements suggest that lower chemical fertilizer inputs can successfully maintain soil fertility and agricultural productivity when combined with organic additions (Hasanain et al., 2024).

Conclusions

The study brings out how coordinated nutrient management can enhance soil health and crop output. Even though T3, which is 75% RDF + FYM @ 5t/ha, was found to be ideal for the sorghum-chickpea system, it was the urd-mustard system that fetched maximum yields under 100% RDF + FYM @ 5t/ha (T4). There was a significant increase in soil pH, organic carbon, and nutrient availability by these treatments. The results point out that an organic way of increasing agricultural productivity and maintaining soil fertility is by using a combination of organic inputs along with fewer chemical fertilizers.

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Enhancing the Productivity of Turmeric through Organic Mulching in NICRA Adopted Villages of Assam

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Rainwater harvesting plays a vital role in enhancing agricultural productivity, particularly in regions like Assam where a significant portion of crops depend on rainfall. In areas covered by the National Initiative on Climate Resilient Agriculture (NICRA), the practice of growing turmeric has been integrated with rainwater harvesting and mulching techniques. Turmeric cultivation in NICRA villages benefits from the careful use of organic mulching materials including rice husk, water hyacinth, straw, and toria stover, all locally available. Mulching, which involves covering the soil with these organic materials, serves multiple functions. First, it helps conserve moisture by reducing evaporation, keeping the soil more hydrated for longer periods, which is crucial in rainfed agriculture. By maintaining soil moisture, crops like turmeric can grow more consistently and thrive despite the erratic rainfall that characterizes many parts of Assam. Another important benefit of mulching is weed suppression. The layer of organic matter blocks sunlight from reaching weed seeds, thereby reducing their germination and growth. This decreases competition for nutrients and water between the weeds and the crops. As the mulching materials decompose, they also enrich the soil by releasing organic matter and essential nutrients, acting as natural fertilizers. This nutrient cycling enhances soil fertility and supports healthier crop growth, further improving the productivity of rainfed agricultural systems. The objective is to study the effect of yield in turmeric under locally available organic mulches.

Methodology

The NICRA (National Initiative on Climate Resilient Agriculture) project, implemented in cluster of five villages (Chamua, Borbali, Borkhet, Nogaya and Jakaipelua), Lakhimpur district of Assam, is focused on addressing several challenges related to agriculture, including weather variability, soil health, and water stress. Villages are situated in the North Bank Plain zone of Assam, with an altitude ranging from 83 to 90 meters. The village has a total cultivated area of 287 ha, all rainfed. The major soil type in the region is *Inceptisols*, which are sandy loam to silty clay loamy, with a pH range of 4.65 to 6.38.Organic matter content in the soil varies between 0.34% and 3.03%.The village receives a mean annual rainfall of 1987 mm, with the bulk of the rainfall occurring during the *Kharif* season (June-September) at 1958 mm and 397 mm during the *Rabi* season (October-February).Apparent drought is a major weather aberration affecting the region, especially during the *Rabi* season. High rainfall intensity during the *Kharif* season and periodic soil moisture stress during winter contribute to challenges in agricultural productivity. Nitrogen, potassium, phosphorus levels in the soil are medium (275–540 kg/ha, 138–330 kg/ha and 21.4–54.0 kg/ha, respectively).

Results

Paddy straw, water hyacinth or toria stover were spread on bed such as to form 5-10 cm thick layer. Mulching was done between April and May, before the crops emerged. Treatment wise observations of the crop were recorded from 2021-24. Table 1 shows the pooled values of rhizome yield under different treatments. Highest average yield (30893 kg/ha) was recorded in T_1 (Organic mulching) as compared to 19808 kg/ha in T_2 (without mulching). Highest net return, B:C ratio and rain water used efficiency (RWUE) was also recorded in T_1.

Chitra *et al* (2020) indicated that highest yield was recorded in mulching with dry grass and paddy straw as compared to non mulching. This remarkable increase in yield could be attributed to the extended harvesting period or longer crop duration, as the mulch provided more consistent moisture, temperature and nutrients which helped the crops thrive for a longer time. This technique demonstrates the critical link between water conservation and agricultural productivity in rainfed farming systems.

Table 1. Rhizome yield (kg/ha) of turmeric with mulching and without mulching during 2022-24

Treatments	Chamua	Borbali	Borkhet	Jakaipelua	Nogaya	Average
T_1	30593	30691	32116	30834	30229	30893
T_2	19713	20861	19436	18449	20580	19808
CV						3.9
CD (5%)						1746

T_1: Organic mulching in turmeric (Megha turmeric-1) T_2: Farmers' practice without mulching

Table 2. Performance of turmeric with mulching and without mulching during 2022-24

Village	Treatments	Net returns (kg/ha)	B:C ratio	RWUE (kg/ha/mm)
Chamua	T_1	223500	3.9	13.0
	T_2	105240	2.5	7.6
Borbali	T_1	227150	3.7	13.1
	T_2	126500	2.8	8.5
Borkhet	T_1	229500	3.5	13.2
	T_2	92550	2.3	7.1
Jakaipelua	T_1	212550	3.8	12.5
	T_2	100540	2.4	7.4
Nogaya	T_1	200400	3.6	12.0
	T_2	105660	2.5	7.6

Conclusion

Rainwater harvesting with mulching techniques not only aids in moisture conservation but also boosts soil health and suppresses weeds, making it an effective approach for improving the sustainability and productivity of turmeric farming in regions like Assam.

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Influence of Manuring, Partial Liming and Seed Hydro-Priming on Growth and Productivity of Lentil

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Lentil (*Lens culinaris* Medik) is one of the important food grain crops. It is a valuable human food mostly consumed as a dry seed (whole decorticated and split). Lentil flour also used for preparations of various snacks and sweet food. And in India it is mostly consumed as dal. Dehulled lentil seeds contain 24-26% protein,1.3% fat and rich source of calcium of 68mg/100gm of seed.

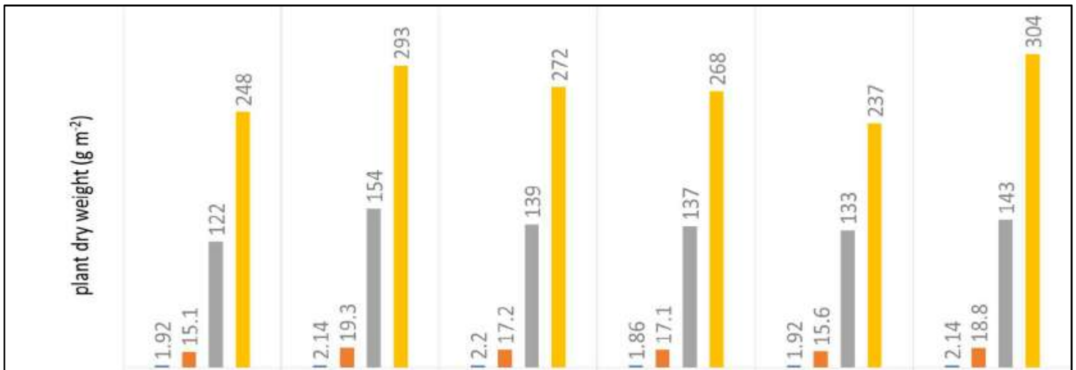
In North Eastern region of India, where a large part of the area remains fallow after the kharif season rice (Das et al., 2012), lentil has a very good potential for increasing farm income as well as cropping intensity (Das et al., 2013). Despite of the various scope, for cultivation of pulses in rice-fallow areas, their cultivation is restricted due to different constraits related to soil, crop, and socio-economic factors (Panda et al. 2000). Lack of irrigation facilities and poor soil moisture, thus constitute main limiting factor for production of pulses/ oilseed in rice–fallows. Along with multiple nutrient deficiency (P, Zn, S, B, Mo), soil acidity and low soil organic carbon (SOC) directly affect pulses production in rice–fallows (Pande et al. 2012). Thus, introduction of lentil in rice fallows with appropriate production technologies may usher in another green revolution in the backward, poverty ridden and deprived region of the country.

Methodology

A field experiment was conducted during rabi season of 2019-20 at Agriculture Farm of Palli Siksha Bhavana, Visva-Bharati to evaluate the effect of manuring, partial liming, and seed hydro-priming on performance of lentil grown under rice-fallow in acidic soils of red and lateritic zone of West Bengal. The experiment was laid out in split-plot design with three replications. The main plot treatment comprised of four factorial combinations of two levels of liming (i.e. no liming and liming @ 0.2LR) and two levels of manuring (i.e. no manuring and manuring @ 5 t FYM ha^{-1}) and sub-plot treatments included two levels of seed priming (i.e. non-primed and hydro-primed seeds).

Result

The experimental findings showed that there was no significant effect of manure @ 5 t FYM ha^{-1} . However, partial application of lime @ 0.2LR i.e. 225 kg CaCO3 ha^{-1} which was also applied at the time of seed broadcasting, recorded significant improvement in growth attributes. Sowing of lentil with hydro-primed seeds recorded significantly higher plant population, nodule number and dry matter production at harvest stage.



	L0: No liming	L1: Liming @0.2LR	M0: No manuring	M1: Manuring @ 5 t FYM ha-1	P0: Non-primed seeds	P1: Hydro-primed seeds
15DAS	1.92	2.14	2.2	1.86	1.92	2.14
30DAS	15.1	19.3	17.2	17.1	15.6	18.8
45DAS	122	154	139	137	133	143
Harvest	248	293	272	268	237	304

Plant dry matter of lentil as influenced by partial liming, manuring and seed hydro-priming treatments

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In-situ Soil Moisture Conservation: Utilization and Management of Rainwater for Groundnut Production

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The success of rainfed agriculture depends on the in general, even after adoption of primary terrace level practices to conserve soil and water, still an estimated 25–40% of the rainwater remains unconserved. In rainfed regions, due to the temporal and spatial variability, and skewed distribution of rainfall, crops invariably suffer from moisture stress at one or the other stages of crop growth. Since, water being the critical input for rainfed agriculture, effective rainwater management, particularly, *in situ* moisture conservation, is critical for successful rainfed agriculture. The focus should be on building *in situ* moisture reserves to tide over the recurring drought spells, disallowing subsequent loss of soil-profile stored moisture and in avoiding inundation/waterlogging. Agroecology-specific (soil type, rainfall pattern and physiography based), *in-situ* moisture conservation (IMC) measures are promoted on seasonal basis for improved and adequate rainwater retention and distribution. The IMC measures can be for a) enhancing moisture with more opportunity time for infiltration such as tillage, contour cultivation, conservation furrow, green manuring, mulching, raised and sunken bed system, broad bed and furrows system, compartmental bunding, cover cropping, scooping etc.; b) to reduce/minimize loss of soil stored moisture like efcient cropping systems (intercropping, strip cropping etc.), mulching, wider row spacing with frequent deep intercultivation etc and c) to permit safe disposal of runoff (in a situation when rainfall exceeds infiltration capacity of the soil) through furrow systems (graded/contour/ wider furrows). *In-situ* moisture conservation practices improve soil structure, porosity, increase infiltration and hydraulic conductivity, and consequently increase the soil water storage that helps the crops to withstand moisture stress Hence, an experiment was planned to study In-situ soil moisture conservation: utilization and management of rainwater for groundnut production under rainfed condition of Gujarat (Bako *et al.,* 2022).

Methodolody

A field experiment was conducted during the kharif season of the years 2019-20 to 2023-24. At All India Coordinated Research Project for Dryland Agriculture, Main Dry Farming Research Station, Junagadh Agricultural University, Targhadia (Rajkot). The soil of the experimental field was clayey in texture, BD was 1.36 (g/cm3) and alkaline in reaction (pH of 8.27 and EC of 0.27 dS/m). The experiment was laid out in a Large plot technique with

FCRD design with four replications, comprising six treatments viz., Main two factor are A) Water conservation Practices: 1. Sowing on tied ridge (S1), 2. Sowing on tied ridge and plot bunding (S2), 3. Conventional Sowing (S3) and B) Mulching: 1. Without mulch (M0), 2. Mulch with agricultural waste (M1). Groundnut shown during Kharif 2019-2023 was carried out with a spacing of 60 cm. The gross plot size was 20.0m x 4.8m for each treatment and net: 3.0m x 2.4m for sampling. The Groundnut GG-22 variety was grown using standard package of practices. The total rainfall received was 1360.4, 1160.4, 1100.8, 742.4 and 587.5 mm in 41, 45, 33, 46 and 32 rainy days in the year of 2019, 2020, 2021 2022 and 2023 respectively. Data on growth, yield, haulm yield as well as economic of groundnut production was pooled over 5 years.

Results

The data depicted in table below revealed that the effect of water conservation practice (S) on plant height, number of pods per plant were found significant. While, number of branches per plant of groundnut were found non-significant.

Effect of treatments on Pod yield, Haulm yield, Rain water use efficiency, growth and yield attributes and economics of groundnut (Pooled mean of 5 years)

Sr. No.	Treatments	Yield	Haulm yield	RWUE	Plant height (cm)	No. of branches /plant	No. of pods /plant	Net returns (Rs./ha)	B:C ratio
A.	Water conservation practice (S): Three								
1	Sowing on tied ridge (S_1)	1748	4036	3.67	44.42	4.5	10.0	69955	1.92
2	Sowing on tied ridge and plot bunding (S_2)	2055	4474	4.35	47.64	4.6	11.9	90748	2.15
3	Conventional sowing (S_3)	1554	3632	3.26	42.54	4.7	7.7	56080	1.76
	S.Em.+	39	165		0.5	0.14	0.42		
	C.D.at 5%	110	539		1.4	NS	1.38		
B.	Mulching (M): two								
1	Without mulch (M_0)	1599	3745	3.36	43.28	4.3	8.9	63971	1.91
2	Mulch with agricultural waste (M_1)	1972	4350	4.16	46.45	4.8	10.8	80551	1.98
	S.Em.+	32	72		0.4	0.14	0.39		
	C.D.at 5%	110	465		1.4	0.50	1.67		
C.	Interaction effect of S x M								
	S.Em.+	119	249		0.50	0.5	0.5		
	C.D.at 5%	NS	465		0.46	NS	NS		
	C.V.%	13.88	13.86		9.71	17.5	7.25		

In pooled results significantly the highest plant height (47.64 cm) and number of pods per plant (11.9) was found in treatment of sowing on tied ridge and plot bunding (S2). The effect of mulching (M) on plant height, number of pods per plant and number of branches per plant of groundnut were found significant. In pooled results significantly the highest plant height (46.45 cm), number of pods per plant (10.8) and number of branches per plant (4.8) was found in treatment of mulch with agricultural waste (M1). The pod yield of groundnut was affected significantly due to water conservation practice and application of mulching during all the years as well as in pooled results. significantly the highest pod yields (2055 kg/ha) were recorded in treatment of sowing on tied ridge and plot bunding (S2) and 1972 kg/ha were recorded under application of mulch with agricultural waste (M1). with maximum net return (Rs.90778/ha), B:C ratio (2.15) and rainwater use efficiency (4.35 kg/ha-mm) Similar results have been reported by Goverdhan & Ramanjaneyulu (2015).

Conclusion

On the basis of five years pooled results, it can conclude that the farmers grow groundnut by sowing on tied ridge with plot bunding and apply agricultural waste (Groundnut Shells-1.5 t/ha) as mulch to conserve moisture and obtaining maximum rain water use efficiency, higher productivity and net returns under dry farming conditions.

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Effect of Establishment Methods and Irrigation Scheduling (WUE) on Performance of Wheat in North Bihar (*Triticum aestivum* L.)

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Wheat plays an important role in national food adequacy and stabilizing the food grain production in the country with ascending levels. At present, the country occupies the second highest position after China among wheat growing nations of the world. The area under wheat cultivation in India has been increased very rapidly from 12.6 to 29.25 million hectares since 1965 to 2010, and production has gone up from 10.4 to 85.93 million tonnes. Similarly, productivity has also jumped from 827 to 2938 kg/ha during aforesaid period. In Bihar, it is grown in 2.16 million hectares area with production and productivity of 5.05 million tonnes and 2335 kg/ha, respectively (Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Govt. of India, 2015-16) which is much below the level of national as well as world average productivity. According to Kumar *et al.*, 2017; Idnani and Kumar (2012), under Zero tillage condition, it was found that if stubbles from the previous crop were left and perennial weeds were controlled, there was hardly any need for additional soil cultivation to realize high yields.

Proper establishment methods with matching agronomic management practices particularly irrigation levels could pave the way for increasing economic wheat production in rice-wheat cropping system. Mehta *et al.*, (2000) suggest that the timely sown ZT wheat crop yielded 6 per cent and 15 per cent improvement in the more productivity than the timely sown CT wheat crop, because of more efficient fertilizer use and less germination of grassy weeds. Sidhu *et al.*, 2015 and Singh *et al.*, 2016; devised that the gain yield from timely planted, ZTD was 9 per cent and in bed planting Furrow Irrigated Raised Bed (FIRB) practise, it has increased dramatically in the high yielding irrigated wheat growing areas of north western Mexico. This system is getting increased attention as it promotes crop diversification and provides an alternative means of increasing productivity and growth for wheat crop. Bed planting system is now being assessed for suitability in the Indian Subcontinent. Two of the major constraints to high yields in north Western India and Pakistan are weeds and lodging. Both can be reduced in bed planting system. System of Wheat Intensification (SWI) method also created very good growing conditions for wheat through modified soil, water, plant and nutrient management. In the second method, pre-germinated seeds primed in hot water, cow urine, vermicompost, jaggery along with bavistin are sown by dibbling method at 20 cm row to row and plant to plant spacing with seed rate of 25 kg/ha. About 70% area under wheat in India is said to have irrigation facility. Besides, it is also essential to assess accurately the drop in yield with reduction in number of irrigation, which will present a clear picture about the water use efficiency. Recent study on timely sowing and irrigation, tillage interactions are likely to play a significant role in improving the productivity of wheat, where irrigation levels and crop establishment methods can play a dominant role in maximizing the wheat yield and water use efficiency.

Materials and methods

The field experiment was conducted during the *Rabi* season of 2011-2012 at Pusa research farm of Dr. Rajendra Prasad Central Agricultural University, Bihar. In respect of mean temperature and relative humidity at 7 AM. The maximum temperature during the crop season varied from 20.3 to 36.2^{0}C which was 0.9 to 3.9^{0}C less than normal from November 2011 to March 2012 but during April 2012 was only 0.1^{0}C higher than normal. The minimum temperature during the crop period varied from 9.2 to 20.7^{0}C which was 0.3 to 1.3^{0}C higher than normal except during February and March 2012 in which month minimum temperature was 0.6 to 2.2^{0}C less than normal. Rainfall became the major factor as 41.0 mm of rainfall was received during 1st and 2nd week of January 2012 which coincided tillering stage. The results of soil analysis presented in Table 3.1 and 3.2 indicated that the soil of the experimental plot was sandy loam in texture, alkaline in reaction and low in available nitrogen, phosphorus and medium in potassium content. The wheat variety HD 2733 had sown in split plot design with three replications. The plot has 4 main and sub plot treatments. The gross and net plot size was 5.0 m x 4.0 m and 4.0 m x 3.0 m respectively. The common fertilizer dose was 120kg N, 60kg P_2O_5 and 40kg K_2O/ha. The total number of replications were three. Establishment methods – Four (Main plot): E_1: Conventional tillage; E_2: Zero tillage sowing; E_3: Bed planting; E_4: System of Wheat Intensification (SWI method). Irrigation levels – Four (Sub plot): I_1: 3 irrigations at 20, 50 and 80 DAS; I_2: 4 irrigations at 20, 40, 70 and 90 DAS; I_3: 5 irrigations at 20, 40, 60, 80 and 100 DAS; I_4: IW/CPE ratio 1.0 (after first irrigation at 20 DAS).

Harvest index (%)

Then the grains and straw were weighed separately and the harvest index was calculated with the help of the following formula.

$$\text{Harvest Index} = \frac{\text{Grain yield}}{\text{Grain yield} + \text{Straw yield}} \times 100$$

Soil moisture studies

$$\text{Moisture}(\%) = \frac{\text{Weight of wet soil} - \text{Weight of dry soil}}{\text{Weight of dry soil}} \times 100$$

Water requirement

$$\text{WR} = \text{IR} + \text{ER} + [\sum \frac{\text{Mbi} - \text{Mei}}{100}] \times \text{BDi} \times \text{Di}$$

Water use efficiency (WUE) (kg/ha-cm)

It is calculated by the ratio of grain yield (kg/ha) and total water requirement per cm area.

$$\text{WUE (kg/ha–cm)} = \frac{\text{Y (kg/ha)}}{\text{WR (cm)}}$$

Where,

WUE = Water use efficiency (kg/ha-cm)

Y stands for grain yield (kg/ha) and WR stands for total water requirement (cm).

Result and discussion

In the present study, growth characters like plant height, number of tillers/m^2, leaf area index, dry matter production and crop growth rate which are directly or indirectly responsible for modifying the yield attributing characters and finally the grain yield were studied at different growth stages. Tillering per unit area is the function of plant density and tillering ability of the crop. The tillers/m^2 were higher in Zero tillage (ZT) compared to Bed planting and SWI method. The maximum numbers of tillers were recorded at 60 DAS (Thapa *et al.*, 2010; Sidhu *et al.*, 2015). LAI is closely related to grain production because this affects the amount of photosynthate accumulation. LAI increased up to 60 DAS, highest LAI was observed with CT at all the growth stages (Mukherjee, 2008). The maximum value of dry matter (g/m^2) and CGR (g/m^2/day) were recorded in CT. Growth characters studied except at early stages showed variation due to irrigation levels. The highest plant height, number of tillers/m^2, LAI, dry matter accumulation and CGR were recorded with the irrigation level I_3 receiving 5 irrigations at 20, 40, 60, 80 and 100 DAS which was higher than irrigation level I_1 receiving 3 irrigations at 20, 50 and 80 DAS and I_4 receiving 4 irrigations based on IW/CPE ratio of 1.0.

The number of panicles/m^2 was higher with CT, as the crop geometry helped to have more plant population in CT and ZT methods. The number of panicles/plant was the highest in SWI method. (Singh *et al*., 2006 and Sagar *et al*., 2017). The highest 1000-grain weight was recorded with Bed planting. Among the establishment methods the highest grain yield, straw yield was recorded with CT (Jha *et al.* 2011; Victor *et al*., 2012 and Sidhu *et al*., 2015). The growth and yield attributes were best expressed under higher levels of irrigation i.e. five irrigations applied at 20, 40, 60, 80 and 100 DAS (*Singh et al.*, 2016).

Table 1. Grain yield (q/ha) as influenced by establishment methods and irrigation levels and their interaction

Establishment methods	Irrigation levels				Mean
	I_1	I_2	I_3	I_4	
E_1 (Conventional tillage)	38.60	41.77	43.71	40.94	41.25
E_2 (Zero tillage)	39.27	40.74	41.52	38.92	40.11
E_3 (Bed planting)	33.39	36.35	37.69	35.74	35.79
E_4 (SWI method)	26.87	31.92	38.71	25.46	30.74
Mean	34.53	37.69	40.41	35.27	
Source			S.Em. ±		CD (P=0.05)
Establishment methods (E)			0.88		3.06
Irrigation levels (I)			0.78		2.27
Sub treat. mean at same level of main			1.56		4.54
Main treatment mean at same or different level of sub treatment			1.61		4.96

Table 2. Benefit: Cost ratio as influenced by establishment methods and irrigation levels and their interaction

Establishment methods	Irrigation levels				Mean
	I_1	I_2	I_3	I_4	
E_1 (Conventional tillage)	1.78	1.86	1.66	1.80	1.78
E_2 (Zero tillage)	1.98	1.94	1.86	1.81	1.90
E_3 (Bed planting)	1.38	1.48	1.45	1.42	1.43
E_4 (SWI method)	0.47	0.69	0.97	0.35	0.62
Mean	1.40	1.49	1.49	1.35	

Source	S.Em. ±	CD (P=0.05)
Establishment methods (E)	0.06	0.20
Irrigation levels (I)	0.05	NS
Sub treat. mean at same level of main	0.10	0.28
Main treat. mean at same or different level of sub treat.	0.10	0.29

The treatments having higher number of ear heads per unit area, higher number of grains per ear head and greater test weight were bound to give comparatively higher yields. (Parihar and Tiwari, 2003; Kumar *et al.* 2017). The maximum grain yield was recorded with irrigation level I_3 receiving 5 irrigations in CT. The soil moisture study was conducted to investigate water use efficiency. Although the available soil moisture content before sowing (82.04%), at first irrigation (72.04 %) and other irrigations was the highest in zero tillage. After first irrigation, the available soil moisture content was above 60 % in all the irrigation levels except in irrigation level I_4 receiving 4 irrigations at 20, 65, 89 and 105 DAS in Zero tillage and at 20, 61, 84 and 102 DAS in other establishment methods. The highest water requirement was at irrigation level I_3 receiving 5 irrigations followed by I_2 and I_4 both receiving 4 irrigations and I_1 receiving 3 irrigations. The highest water use efficiency (WUE) was recorded with CT method of establishment (Singh *et al.*, 2016). Higher WUE was recorded with ZT at irrigation level I_1 receiving 3 irrigations at 20, 50 and 80 DAS. This shows that grain yield was higher per unit of water use at this level of irrigation in ZT and CT.

The highest gross, net return (₹/ha) and B: C ratio was obtained with CT, which was higher than bed planting and SWI method. The maximum gross and net return was recorded with irrigation level I_3 receiving 5 irrigations which was superior over all other irrigation levels. The maximum B: C ratio was recorded equally with I_2 receiving 4 irrigations and I_3 receiving 5 irrigations. The maximum net return of 39015 ₹/ha with B: C ratio 1.66. However, the maximum BCR of 1.98 with net return of 35973 ₹/ha was fetched with ZT. (Idnani and Kumar, 2012; Sagar *et al.* 2017). Consequently, growth, yield attributes and yield sowing of wheat by ZT as compared to CT method appears to be more beneficial. 5 irrigations applied at 20, 40, 60, 80 and 100 DAS or 4 irrigations applied at 20, 40, 70 and 90 DAS is found to be optimum.

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Evaluation of Foliar Application of Super Nano Urea Plus in *Rabi* Sorghum in the Northern Dry Zone of Karnataka

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Sorghum (*Sorghum bicolor* L.) holds a distinctive position among major cereals globally, ranking fifth after wheat, maize, rice, and barley. This versatile crop serves as both a staple food and valuable fodder in arid and semi-arid tropical regions. In Northern Karnataka, sorghum is predominantly grown as a rainfed crop during the *rabi* season with minimal irrigation, focusing on districts such as Vijayapura, Bagalkot, Bellary, Belgaum, Bidar, Dharwad, Gadag, Haveri, Kalburgi, Koppal, and Yadgiri. To enhance yields, farmers often apply excessive fertilizers, which adversely impact the environment. The nutrient use efficiency (NUE) for nitrogen (N) is approximately 30-35%, and for phosphorus (P) and potassium (K), it ranges from 18-20% and 35-40%, respectively. This reduced efficiency has led to a decline in crop response to fertilizer application over the years. Moreover, inefficient fertilizer management has also compromised soil health, further diminishing yield responses. In addressing these challenges, strategies such as foliar nutrient spraying combined with conventional basal fertilization offer significant advantages. In India's dryland areas, where moisture deficits are common, this approach ensures more efficient nutrient utilization and enables quicker correction of deficiencies. Recently developed special fertilizers, particularly nanofertilizers, have emerged as promising solutions. Nanofertilizers are vital tools in agriculture by enhancing nutrient use efficiency and decreasing nutrient losses and cultivation costs (Singh, 2017). Nanofertilizers aim to make nutrients more available to leaves, consequently increasing nutrient use efficiency and crop productivity.

To meet higher fertilizer requirements during crop growth while addressing environmental and economic concerns, the use of nitrogen nan-ofertilizer is essential. Products like nano-urea and nano-DAP fertilizers, developed by IFFCO, are now being used by farmers for foliar application, demonstrating significant potential in boosting crop growth and productivity. IFFCO recently developed an advanced product known as super nano urea plus. Understanding the impact of super nano urea plus on sorghum growth and yield is essential, not only to address current agricultural challenges but also contributes to sustainable farming practices by reducing environmental impacts associated with fertilizer use. This study investigated the effects of super nano urea plus on *rabi* sorghum grown under rainfed conditions, focusing on key growth, yield parameters, as well as its economic viability.

Methodology

Experiment was conducted during *rabi* season of 2023-24 at the Regional Agricultural Research Station, Vijayapura, using a randomized complete block design (RCBD) with nine treatments, each replicated three times. The treatments includes various nutrients application doses, which are as follows; T_1: Recommended N, T_2: 75% rec. N + 2 sprays of super nano urea plus @ 0.7% during critical stages, T_3: 50% rec. N + 2 sprays of super nano urea plus @ 0.7% during critical stages, T_4: 25% rec. N + 2 sprays of super nano urea plus @ 0.7% during critical stages, T_5: 75% rec. N + 2 sprays of urea @ 2% during critical stages, T_6: 50% rec. N + 2 sprays of urea @ 2% during critical stages, T_7: 25% rec. N + 2 sprays of urea @ 2% during critical stages, T_8: Rec. N + 2 sprays of 0.5% ammonium sulphate and T_9: Control (No N). Nitrogen and phosphorus were supplied through urea and Di-ammonium phosphate (DAP), applied at the rate of 50:25:0 N:P_2O_5:K_2O kg ha^{-1} (Recommended Dose of Fertilizer, RDF). According to the treatment, the full dose of phosphorus and different levels of nitrogen (25%, 50%, 75%, and 100% of the recommended dose) were applied at the time of sowing. The data collected from the experiment at different growth stages were subjected to statistical analysis.

Results

Analysis of data revealed that application of recommended nitrogen with two sprays of 0.5% ammonium sulphate (T_8) recorded significantly higher plant height (192.9 cm) and TDMP (66.87 g $plant^{-1}$) at harvest, ear head length and breadth (14.67 and 12.27 cm, respectively), grain and stover yield (1214 and 4572 kg ha^{-1}, respectively) and gross returns (Rs. 46,145 ha^{-1}), respectively. It is on par with application of recommended N (T_1) and 75% rec. N + two sprays of super nano urea plus @ 0.7% during critical stages (T_2). Further, higher net returns (Rs. 21,654 ha^{-1}) and benefit-cost ratio (BCR, 1.92) were recorded with T_1 which is statistically similar to T_8, T_2 and T_5 (75% rec. N + 2 sprays of urea @ 2% during critical stages) as compared to other treatments.

Effect of nutrient application on growth, yield attributes, yield and economics of *rabi* sorghum

Treatment	Plant height (cm)	TDMP (g plant^{-1})	Ear head		Yield (kg ha^{-1})		Returns (Rs. ha^{-1})		B-C ratio
	At harvest		Length (cm)	Breadth (cm)	Grain	Stover	Gross	Net	
T_1	192.2	65.73	14.61	11.77	1191	4524	45245	21654	1.92
T_2	190.8	65.82	14.47	12.17	1207	4528	45866	20382	1.80
T_3	180.9	59.53	13.77	11.33	1073	4256	40761	15735	1.63
T_4	172.7	54.51	13.07	10.90	969	3991	36835	12265	1.50
T_5	188.2	60.44	13.90	11.23	1116	4365	42408	18174	1.75
T_6	178.8	55.13	13.48	10.97	1031	4080	39191	15414	1.65
T_7	171.2	50.65	12.60	10.61	918	3826	34897	11577	1.50
T_8	192.9	66.87	14.67	12.27	1214	4572	46145	21404	1.87
T_9	165.3	45.92	11.93	10.18	767	3504	29159	7397	1.34
S.Em±	3.8	1.59	0.37	0.35	46	125	1752	1752	0.07
C.D. (p=0.05)	11.4	4.75	1.12	1.05	138	376	5254	5254	0.21

Note: TDMP: Total dry matter production; DAS: Days after sowing; B-C: Benefit cost ratio

The increase in growth and yield parameters can be attributed to the positive effects of nitrogen supplementation, particularly through foliar applications such as ammonium sulfate and super nano urea plus. These applications likely facilitated by larger photosynthetic surface area, enhancing radiant energy absorption, carbohydrate accumulation, prolonged green leaf retention and improved nitrogen use efficiency. Interestingly, T_8 demonstrated a 1.3% increase in grain yield compared to the treatment with recommended nitrogen alone (T_1). This suggests that applying 75% of the recommended nitrogen through conventional fertilizer sources, supplemented with two foliar sprays of super nano urea plus, effectively enhances grain yield in calcareous vertisols. The improvement in yield can be attributed to enhanced nitrogen utilization affecting yield attributing characters. The positive impact on yield components likely contributed to the overall yield advancement in sorghum. Further, it's noteworthy that the net returns and BCR were lower in treatments that performed better than recommended N. This can be attributed to the higher grain yield of sorghum combined with higher cultivation costs in the treatment receiving recommended N along with foliar sprays. While treatments like T_8 led to higher gross returns due to increased yields, treatments like T_1 demonstrated superior net returns and BCR by balancing yield improvements with lower cultivation costs.

Conclusion

The study highlights the beneficial effects of super nano urea plus in *rabi* sorghum cultivation. Treatments combining recommended nitrogen levels with foliar sprays of 0.5% ammonium sulphate consistently enhanced plant growth, total dry matter production, ear head length and breadth. These improvements translated into higher grain and stover yields, comparable to treatments using full and reduced nitrogen applications with foliar sprays of super nano urea plus. The economic analysis emphasized that while treatments with supplemented ammonium sulfate and super nano urea plus achieved higher gross returns, treatments using recommended nitrogen alone maximized net returns and benefit-cost ratio by optimizing yield with reduced cultivation costs. Notably, applying 75% of recommended nitrogen alongside super nano urea plus further boosted grain yield compared to recommended nitrogen alone, demonstrating its potential to enhance both productivity and economic sustainability of rainfed sorghum farming in Northern Dry Zone of Karnataka.

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Response of Foliar Application of Different Nanofertilizers on Productivity and Economics of *Rabi* Sorghum in Rainfed Ecosystems

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Sorghum (*Sorghum bicolor* L. Moench) is an important crop for small and marginal farmers in semi-arid regions and grains are primarily used for human consumption and stover for livestock feed. Under rainfed conditions, it is mainly grown in *rabi* season under residual moisture conditions. Sorghum, being a nutrient exhaustive crop, demands a relatively higher amount of fertilizers; however, unscientific fertilizer management has adversely affected soil health and resulted in avert yield responses to applied fertilizer. In order to complement the nutritional needs of crops, foliar application of nutrients coupled with the basal application of conventional fertilizers provides several benefits. India's dryland regions often experience moisture deficits, which limit nutrients availability and reduce crop production.

With this combined application nutrients, nutrients are utilized more effectively and deficiencies are quickly corrected. The use new generation special fertilizers, such as nanofertilizers (NFs), has emerged as an effective alternative solution for addressing crop nutritional deficiencies through enhanced bioavailability of nutrients and limited losses to the environment. The application of NFs represents a significant advancement in agricultural nanotechnology, leveraging their unique characteristics, such as large specific surface area, magnetic or optical properties, electronic states, and catalytic reactivity to enhance nutrient uptake and plant growth (Agrawal and Rathore 2014). Studies have shown that foliar application of NFs leads to notable improvements in biomass, chlorophyll content, and photosynthetic attributes. Additionally, it mitigates the adverse effects of salt stress on plants while boosting crop yield. One significant advantage of NFs is their ability to release nutrients slowly, reducing nutrient loss and enhances nutrient availability to plants. This in turn, increases nutrient use efficacy. Farmers are using urea and zinc sulphate fertilizers for both soil and foliar applications to crops; however, their efficacy remains is low. Therefore, an alternative approach is the use of nano-nitrogen and nano-zinc fertilizers as foliar applications, combined with basal application conventional fertilizers to meet crop nutrient demand while increasing nutrient use efficiency. In this study, our primary objective is to assess how foliar applications of nano N and Zn sources impact both the yield and economic aspects of sorghum cultivation.

Methodology

The experiment was carried out over two consecutive years (2021-22 and 2022-23) at the Regional Agricultural Research Station, Vijayapura. It was laid out in a Randomized Complete Block Design (RCBD), replicated thrice with 18 different nutrient treatments containing liquid nano-nitrogen and nano-zinc along with different recommended doses of fertilizers. The details of the treatments includes, T_1: Recommended P and K, T_2: 100% recommended NPK, T_3: Recommended PK and Zn, T_4: 50% recommended N + recommended PKZn, T_5: 75% recommended N + recommended PKZn, T_6: 100% recommended NPKZn, T_7: Recommended PKZn + spraying of Nano-N (twice), T_8: 50% recommended N + Recommended PKZn and spraying of Nano-N (twice), T_9: 75% recommended N + Recommended PKZn and spraying of Nano-N (twice), T_{10}: 100% recommended N PKZn and spraying of Nano-N (twice), T_{11}: Recommended PK and spraying of Nano-Zn (twice), T_{12}: 50% recommended N + recommended PK and spraying of Nano-Zn (twice), T_{13}: 75% recommended N + recommended PK and spraying of Nano-Zn (twice), T_{14}: 100% recommended N PK and spraying of Nano-Zn (twice), T_{15}: Recommended PK and spraying of Nano-N + Nano-Zn (twice), T_{16}: 50% recommended N + recommended PK and spraying of Nano-N + Nano-Zn (twice), T_{17}: 75% recommended N + recommended PK and spraying of Nano-N + Nano-Zn (twice), T_{18}: 100% recommended NPK and spraying of

Nano-N + Nano-Zn (twice). The foliar application of nano-nitrogen and nano-zinc particles was done twice (at 20-25 and 40-45 DAS).

Results

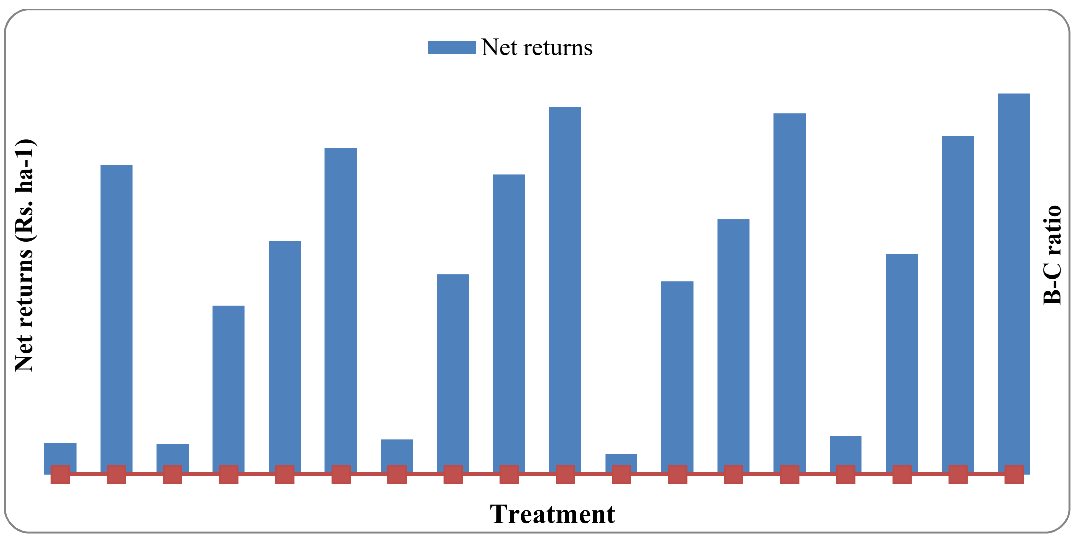
The pooled data on plant height recorded at harvest indicated that the treatment comprising 100% recommended NPK + Nano-N + Nano-Zn foliar sprays (T_{18}) resulted in significantly taller plants (251.8 cm). The relative chlorophyll content (SPAD value) recorded before and after the first spray exhibited significant variation due to different treatments.

Effect of different nanofertilizers on growth and yield ofrabi sorghum (2 years pooled data)

Treatment	Plant height at harvest (cm)	SPAD value				Yield (kg ha^{-1})		% yield increase/ decrease over T_2
		Before 1st spray	After 1st spray	Before 2nd spray	After 2nd spray	Stover	Grain	
T_1	182.3	27.0	29.6	30.7	31.7	2080	537	-62.0
T_2	236.2	33.9	38.1	39.6	41.9	3888	1412	0.0
T_3	187.5	30.7	33.3	35.0	35.4	2231	541	-61.7
T_4	224.6	32.0	36.3	38.1	40.0	3381	985	-30.2
T_5	232.9	32.7	37.2	39.2	41.3	3774	1208	-14.4
T_6	243.2	34.7	39.3	41.4	43.6	4167	1471	4.2
T_7	196.2	30.8	34.2	36.0	37.8	2550	622	-56.0
T_8	228.4	31.9	36.4	38.2	40.4	3552	1094	-22.5
T_9	240.1	32.8	37.4	39.4	41.8	4031	1423	0.8
T_{10}	249.3	34.2	39.7	41.9	44.2	4547	1595	13.0
T_{11}	189.8	30.3	33.9	35.7	37.1	2354	584	-58.6
T_{12}	226.9	31.3	35.4	37.3	39.0	3463	1054	-25.3
T_{13}	235.2	32.4	37.1	39.0	41.1	3807	1276	-9.6
T_{14}	245.4	33.9	39.5	41.6	43.9	4475	1556	10.2
T_{15}	199.2	30.2	34.4	36.1	37.7	2607	652	-53.8
T_{16}	231.0	31.9	36.7	38.7	41.1	3672	1156	-18.1
T_{17}	242.6	32.4	38.5	40.7	43.6	4423	1516	7.4
T_{18}	251.8	33.9	40.5	42.8	46.2	4618	1639	16.1
S.Em±	4.5	1.0	0.8	0.8	1.0	159	53	-
C.D. (p=0.05)	12.8	2.8	2.2	2.3	3.0	457	153	-

Before the spray, the treatment receiving 100% recommended NPKZn (T_6) recorded the highest mean SPAD value (34.7), which was statistically on par with treatments T_{10}, T_2, T_{18}, T_{14}, T_{17}, T_9, T_5, T_{13}, T_4, T_{16}, and T_8. After the first spray, treatment with 100% recommended NPK + Nano-N + Nano-Zn foliar sprays (T_{18}) recorded the highest mean SPAD values (40.5), which were on par with T_{10}, T_{14}, T_6, and T_{17}. The treatment T_{18} recorded the highest mean SPAD value (42.8) and (46.2) before and after second spray respectively, which was statistically on par with treatments T_{10}, T_{14}, T_6, and T_{17}. The highest grain yield of 1636 kg ha^{-1} was recorded with the T_{18}, which was statistically on par with T_{10}, T_{14}, and T_{17}. This best-performing treatment demonstrated a 16.1% increase in grain yield over 100% of recommended NPK (T_2). Similarly, the highest mean stover yield of 4618 kg ha^{-1} was recorded with the T_{18}, which was statistically on par with T_{10}, T_{14}, T_{17}, and T_6. The treatment T_{18} exhibited the highest net (Rs. 34,744 ha^{-1}) returns, which is statistically similar to T_{10}, T_{14} and T_{17}..However, this treatment also recorded the maximum mean benefit-cost ratio of 2.43, which was statistically similar to treatments T_{14}, T_{10}, T_6, T_{17}, and T_2.

The combined application of conventional and nanofertilizers (nano urea and nano zinc) ensured optimum and balanced nutrient availability throughout the crop period, especially during the critical stages. This is attributed to the smaller size and larger effective surface area of nano particles, which can easily penetrate into the plant and enhance uptake of nutrients. The higher uptake results to optimal plant growth and metabolic processes, such as photosynthesis that increase photosynthates accumulation and translocation to the economically productive parts of the plant, which results in increased biomass, yield attributing characters and finally leading to increase in yield. (Chinnappa *et al*., 2023)



Effect of different nanofertilizers on economics of *rabi* sorghum (2 years pooled data)

Conclusion

The highest grain yield, net returns, and benefit-cost ratio were recorded with the treatment N_{100}PK + Nano-N + Nano-Zn (twice), which was statistically comparable to T_6, T_{10}, T_{14}, and T_{17}. Additionally, it exhibited a 16.1% increase in seed yield over the recommended level. Applying 100% of the recommended nitrogen through convetional fertilizer combined with twice the application of nano-N and nano-Zn proves to be an effective strategy for optimizing nutrient management in sorghum. Alternatively, applying 75% of the recommended nitrogen with the same nanofertilizer foliar sprays can improve growth and yield, conserve nitrogen by 25% and maintain optimum benefit-cost ratio. These findings suggest that optimizing nutrient management by integrating nano-N and nano-Zn applications can significantly enhance sorghum growth and yield. By tailoring fertilizer application rates and utilizing nanotechnology, farmers can achieve higher productivity while ensuring efficient use of resources and maximizing economic returns.

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Effect of Enriched Nano-DAP on Maize Productivity and Profitability

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Maize (*Zea mays* L.) is considered the "Queen of Cereals" due to its immense productivity and versatile nature. In India, it ranks fourth after rice, wheat, and sorghum. It consists of 72% starch, 10% protein, 8.5% fiber, 4.8% oil, 3.0% sugar, and 1.7% ash, which together make up a remarkably high nutritional profile, emphasizing the crop's nutritional significance for food and agriculture (Hokmalipour *et al*., 2010). Currently, nearly 37.66 million metric tons of maize is produced from an area of 11.24 million hectares, with an average productivity of 3.35t/ha (GOI, 2023-2024). This versatile crop not only fulfills essential dietary and nutritional needs but also highlights its value as a vital resource for numerous industrial and energy-related projects, underscoring its overall economic and agricultural importance in the country. Since maize is a heavy feeder of nutrients, requiring fertile soil, managing nutrients is crucial to its productivity (Kannan *et al*., 2013). To fulfill its nutrient requirements, large amounts of fertilizers need to be applied; however, the efficiency of applied fertilizers is decreasing. Foliar feeding has been shown to be the most effective method for addressing nutritional deficits, and with nanotechnology, fertilizer application efficiency drastically increases due to the smaller size and higher surface area of the particles, and also reduces losses from runoff, leaching, and volatilization. In comparison to traditional urea and di-ammonium phosphate, the foliar application of Nano-DAP developed by Indian Farmers Fertilizer Cooperative (IFFCO) at critical crop growth stages successfully fulfills the plant's nitrogen and phosphorus needs, leading to improved crop yield and quality. Since this is a new product, very little research has been conducted on it. Keeping this in mind, an experiment entitled "Effect of Enriched Nano-DAP on Maize Productivity and Profitability" has been undertaken.

Methodology

A Field experiment was conducted at ICAR-Indian Agricultural Research Institute, New Delhi during *kharif* season 2024 28°38'10"N latitude and 77°09'08"E longitude. The prevailing climate of experimental site is semi-arid and sub-tropical type and it is situated 228.6 meters above mean sea-level. It falls under the Trans-Gangetic Plains of agro-climatic zones with slightly alkaline in pH. The field experiment was laid-out in randomized block design in fixed layout with 10 treatments comprising of T1: Only RDK; T2: RDF;T3: 50% RDN & 50% RDP; T4: 50% RDN & 50% RDP + 2 - Nano DAP; T5: 75% RDN & 75% RDP; T6: 75% RDN & 75% RDP + 2 - Nano DAP; T7: 75% RDN & 75% RDP + 1 - Nano DAP; T8: 60% RDN & 60% RDP; T9: 60% RDN & 60% RDP + 2 - Nano DAP; T10: 75% RDN & 100% RDP + 2 - Nano DAP. Maize variety 'DKC 9144' was used for experimentation. Recommended dose of nitrogen is applied in split 1/3 at basal, 1/3 at 30 DAS top dressed and 1/3 at 50 DAS top dressed. Spray of Nano-DAP coincided with top dressing *i.e.*, 35 DAS and 50 DAS. Yield was recorded at maturity and expressed as ton per hectare (t/ha).

Results

Fertilizer N and P rates and Nano DAP influenced significantly on grain yields of maize (Table 1). Grain yield under Only RDK was 2.74 t/ha, which was increased to 5.43 t/ha with the application of 75% RDN & 75% RDP + 2 - Nano DAP.

Table 1. Effect of Nano-DAP application on the productivity of maize

Treatments	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index
T1: Only RDK	2.74	4.47	7.21	0.38
T2: RDF	5.74	8.26	14.00	0.41
T3: 50% RDN & 50% RDP	4.15	5.89	10.03	0.41
T4: 50% RDN & 50% RDP + 2 - Nano DAP	4.52	6.36	10.88	0.41
T5: 75% RDN & 75% RDP	5.07	6.57	11.64	0.43
T6: 75% RDN & 75% RDP + 2 - Nano DAP	5.43	7.80	13.23	0.41
T7: 75% RDN & 75% RDP + 1 - Nano DAP	5.08	7.31	12.39	0.41
T8: 60% RDN & 60% RDP	4.62	6.37	10.99	0.42
T9: 60% RDN & 60% RDP + 2 - Nano DAP	4.95	7.11	12.06	0.41
T10: 75% RDN & 100% RDP + 2 - Nano DAP	5.46	7.86	13.32	0.41
SEm±	0.21	0.28	0.48	0.01
LSD (P=0.05)	0.63	0.89	1.54	NS

Note: RDF-Recommended doses of fertilizer, RDK-Recommended dose of potassium, RDP- Recommended dose of phosphorus, RDN- Recommended dose of nitrogen

Conclusion

Based on the results obtained from the present one-year field experiment, it can be concluded that higher grain yield from hybrid maize could be obtained by applying 100% RDF (5.74 t/ha) through conventional fertilizers. However, the application of 75% RDN & 75% RDP + 2 - Nano DAP in maize resulted in a comparable yield with 100% RDF.

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Phosphorus Management strategies to Improve Rice Productivity in Rice-Chickpea Cropping System

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In India, rice-wheat farming is the predominant cropping pattern, accounting for 25–28% of the country's food basket on 10.5 mha of land (Bhatt et al., 2021). But over the past 20 years, this cropping system has not been sustainable and is susceptible to a number of problems, including low yield, low partial factor productivity, increased weed pressure, multiple nutrient deficiencies, low water productivity, poor nutrient use efficiency, and climate change (Bhatt et al., 2021). Reduced yield and profit from rice production are solely caused by inefficient nutrient use (Singh et al., 2015). Diversifying rice-wheat cropping to rice-pulse based systems can improve yield, resource efficiency, soil health, pest control, and reduce synthetic fertilizer use, enhancing crop resilience (Kumar et al., 2020). Rice-chickpea is a diversified system because it includes pulse crop to boosting yield as well as improve soil health and nutrient use efficiency (Nath et al., 2023). In comparison to nitrogen and potassium nutrients, the hardy 15–18% utilization efficiency of phosphorus (P) fertilizers is extremely low. They are available for a variety of reasons, such as soil biology and mineralogy, pH-dependent availability, and more fixation nature. The efficiency of phosphorus fertilizers in fostering plant development is further diminished by their propensity to be readily lost through leaching and runoff. The implementation of strategies to improve phosphorus use efficiency, such as soil testing and the use of other sources of P, such as triple super phosphate, can minimize these challenges and maximize crop productivity. Enhancing phosphorus fertilizer efficiency can boost rice production yield and profitability, while sustainable practices and technologies are crucial for long-term cropping system success.

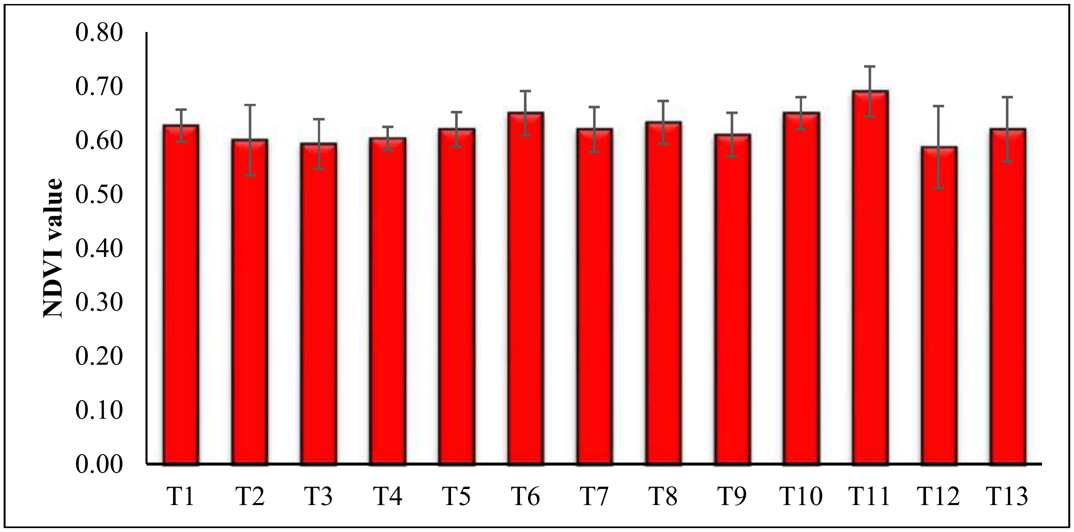
Methodology

A field experiment was conducted during *Kharif* season of 2024 on the topic entitled "Effect triple super phosphate sources of fertilizers on Rice productivity". The field experiment was conducted at Main Research Farm of IARI, R.S. Pusa Samastipur (Bihar). The experiment was conducted in Randomized block design with 3 replications and 13 treatments viz., T1: Control (Only N and K) No P; T2: Recommended N and P (FP); T3: Recommended N (urea), P (DAP)and S (no-K); T4: Recommended N(Urea), P (DAP) and K (MOP)+ S; T5: Recommended N(Urea), P (SSP) and K (MOP); T6: Recommended N(Urea), P (TSP) and K (MOP)+ S; T7: Recommended N(Urea),P (complex P source-NPK) and K + S; T8: Recommended N(Urea), P (TSP) and K (MOP) with PSB + S; T9: Recommended N(Urea), P (TSP) and K (MOP) +10 t/ha FYM + S: T10: Recommended N(Urea), P (TSP) and K (MOP) with 5.0 kg/ha MAP foliar spray + S; T11: Recommended N(Urea), P (TSP) and K (MOP) with N fixing microbes + S; T12: No N + Recommended P through TSP+ N fixing microbes + Recommended K and S and T13: No N + Foliar spray of nano urea + Recommended P through TSP + Recommended K and S. The data were analysed statistically by applying "Analysis of Variance" (ANOVA).

Results

In genereal, P application through Diammonium phosphate (DAP) and triple super phosphate (TSP)fertilzers, than TPS treatment had recoreded higher value of NDVI than DAP applied plot. It was found that maxumum NDVI value with NM11 followed by NM10>NM6>NM8 and remaining other treatment while lowest value of NDVI were noted with NM12 (0.59) and NM13 (0.62) treatment at flowering stage. If we had compare the NDVI value between T1 and T2 than T1 has found higher value over T2 (fig. 1).

Grain yield (GY) of rice had influed due to varous treatment combination of triple super phasphate (fig 2). In general, the grain yield were higher with P applied over control plot (T1) by ~15.34% . Similerly, grain yield had higher with T11 over T12 by ~41.43% where T12 treatment had no application of N fertilezers. The signifiacntly enhances rice yield with triple super phasphate fertilzers over DAP fertilzers. The signifiacntly maximum grain yield ($p \leq 0.05$) with T11(5.017 t/ha) treatment over other treatment while T10 (4.817) did not differ signioacntly due to different treatment combination. The lowest grain was recorded with T12 (2.94 t/ha) and T13 (3.27 t/ha) treatment, respectively.



Effect of triple super phasphate on NDVI value of rice

Conclusion

The experiment demonstrated that various phosphorus management techniques significantly influence rice grain yield and NDVI value during flowering. Rice's NDVI value was greater under the Recommended N(Urea), P (TSP), and K (MOP) with N fixing microorganisms + S treatment than under the remaining treatments. This was followed by the Recommended N(Urea), P (TSP), and K (MOP) with 5.0 kg/ha MAP foliar spray + S treatment. When N fixing microbes + S were used instead of other treatments, rice grain yield was found to be higher with the recommended N (urea), P (TSP), and K (MOP). Phosphorus management techniques like N fixing microorganisms and foliar sprays enhance rice cultivation's NDVI values and grain yield, but further research is needed to determine optimal approaches.

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Insitu Moisture Conservation Technologies and Nitrogen Fertilization for Sustainable Production of Maize and Pigeon Pea Intercropping under Rainfed Alfisols

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The present-day agriculture is facing a tremendous problem in achieving the global food security in the context of the climate change scenario with ever-increasing human population. India being an important sector in Indian economy with 33 % of small holders contributing to 41% of grain production. Increasing the productivity is one the greatest concerns with the growing population particularly in India. Crop intensification using sustainable agricultural practices is the best solution to increase the food production and reduce land degradation. Cereal-legume based intercropping is recognized as one of the best ways of intensification as it helps to improve long term soil fertility through biological nitrogen fixation of legumes (Kiwia *et al.,*2019). Rainfed/dryland eco-system of India which is characterized both by erratic rainfall and extreme weather conditions intercropping provides insurance against the crop failure. Keeping all in view the present research was conducted with an objective to find out the effect of *in situ* moisture conservation technologies and nitrogen fertilization for sustainable production of maize and pigeon pea intercropping under rainfed Alfisols.

Methodology

Field experiment was conducted during *kharif* seasons of 2023-24 at the Gunegal Research Farm (GRF) of CRIDA, Santoshnagar, Hyderabad. The soil of the experimental field is sandy loam in texture with medium organic carbon content (0.64 %), low in available nitrogen (144.65 kg ha^{-1}), medium in available phosphorus (28.54 kg ha^{-1}) and potassium (236.53 kg ha^{-1}). The experiment was laid out in split plot design with moisture conservation technologies as main plot (flat bed sowing 2:1, flat bed sowing with conservation furrow (CF), raised bed (2:2) and paired row (2:2), nitrogen levels in sub plots (control, 75 % RDN, 100% RDN and 125 % RDN). The maize and pigeonpea varieties were DHM-117 and WRGE-97 respectively.

Flat bed sowing was done with the help of CRIDA 6 row planter, Flatbed with conservation furrow and paired row were sown with ridge planter, raised bed was sown with raised bed planter. Recommended dose of phosphorus and potassium @ 60:60 kg P_2O_5, and K_2O ha^{-1} in the form of single super phosphate and muriate of potash respectively were applied basally. Nitrogen was applied as per the treatments. Nitrogen was top dressed twice in equal splits at knee height and tasseling stages of maize based on the moisture availability and receipt of rainfall. The cobs were harvested from the net plot separately from each plot, leaving one border row on either side. The grain yield was recorded after shelling the cobs with power operated sheller and threshing of pigeonpea was done manually.

Results

Moisture conservation practices had significant influence on the equivalent yields of maize in maize-pigeonpea intercropping system. Among different moisture conservation practices paired row cropping resulted in highest equivalent yield of 2659 kg ha^{-1} which is 22 % higher compared to flat sowing with a yield of 2078 kg ha^{-1}. Among different nitrogen levels 125% RDN recorded highest equivalent yield of 3134 kg ha^{-1}.

In case of land equivalent ratio highest LER was found in insitu moisture conservation plots compared to flat sowing treatment. Among different moisture conservation technologies raised bed sowing resulted in higher total LER (1.66) followed by paired row cropping (1.63). With respect to nitrogen levels total LER was higher (1.77) with 125% RDN. In situ moisture conservation practices recorded lower GHGI, higher EUE, energy output.

Effect of insitu moisture conservation practices and nitrogen levels on equivalent yield of maize and land equivalent ratio in maize-pigeonpea intercropping system

Treatments	Maize Equivalent Yield	Land equivalent ratio
Main plots		
Flat sowing	3119	1.45
Flat sowing with CF	3986	1.57
Raised bed	3858	1.66
Paired row	4062	1.63
LSD	195	-
Subplots		
Control	2322	1.42
75 % RDN	3480	1.56
100% RDN	4295	1.57
125% RDN	4927	1.77
LSD	166	-

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Impact of Integrated Nutrient Management on Soil Fertility and Productivity of Safflower + Chickpea (2:4) Intercropping System

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Recycling of crop residues and plant biomass in the field is a viable option for replenishing soil fertility, improving soil physico-chemical and biological properties, rehabilitating degraded lands and sustaining crop yields (Das *et al.* 2014). Conservation of soil moisture offers an opportunity for stabilising and increasing yields of winter season crops in rainfed areas. Thus, conservation effective soil and nutrient management practices are needed to improve input use efficiency (Das *et al.,* 2020). Mulching by green leaf manure crop (Sunhemp and *Glyricidia*), crop residues (sorghum stubbles), FYM and Vermicompost improvement in soil moisture content and recycles plant nutrients upon decomposition. Common inter cropping systems in the region are safflower +chickpea (2:4), Rabi sorghum + chickpea (1:3 or 2:4). With the above background, the present investigation was carried out to study impact of soil properties and productivity of safflower and chickpea through integrated nutrient management.

Methodology

A field experiment was carried out during the *Rabi* season of 2017-18 to 2022-23 under the Northern dry zone of Karnataka at All India Coordinated Research Project for Dryland Agriculture, Vijayapura centre. The experiment was laid out in a randomized complete block design (RCBD) with three replications and seven treatments (T1 – Control, T2 – Recommended package practices (RPP), T3 - 50% N through FYM + 50% inorganic sources, T4 - 50% N through vermicompost + 50% inorganic sources, T5 - 50% N through sunhemp + 50% inorganic sources, T6 - 50% N through Glyricidia loppings + 50% inorganic source, T7 - 50% N through crop residues + 50% inorganic sources). The safflower + chickpea (2:4) intercropping system was rotated with *Rabi* Sorghum + Chickpea (2:4) next year and birotational system continuous.

Results

Results of pooled data indicated that application of 50% N through FYM + 50% N through inorganic sources was recorded the significantly higher safflower equivalent yield (1092.4 kg/ha), B:C ratio (2.82) and rain water use efficiency (13.0 kg/ha-mm) in safflower + chickpea intercropping system and statistically on par with 50% N through vermicompost +

50% inorganic sources and 50% N through sunhemp + 50% inorganic sources with respect to safflower equivalent yield (1092.4kg/ha) and B:C ratio (2.80) as compared to control (Table 1).

Table 1. Safflower equivalent yield, B:C ratio and RWUE as influenced by integrated nutrient management on Safflower + chickpea (2:4) intercropping system (Pooled: 2017-18 to 2022-23)

Treatment	Safflower equivalent yield (kg/ha)	B:C ratio	RWUE (kg/ha-mm)
T1 - Control	701.1	2.20	7.9
T2 - RPP: 3 t/ha FYM + 50: 25: N: P kg/ha	1029.1	2.80	11.2
T3 - 50% N through FYM + 50% N inorganic sources	1215.0	2.82	13.0
T4 - 50% N through vermicompost + 50% N inorganic sources	1092.4	2.80	11.6
T5 - 50% N through Sunhemp + 50% N inorganic sources	1062.2	2.61	11.7
T6 - 50% N through Glyricidia loppings + 50% N inorganic sources	978.1	2.79	12.6
T7 - 50% N through crop residues + 50% N inorganic sources	921.7	2.53	10.5
Mean	999.9	2.74	11.2
Sem±	43.3	0.12	0.7
CD (p=0.05)	125.6	0.34	2.0
CV (%)	10.6	9.21	15.0

RPP: 3 t/ha FYM + 50: 25:0: N: P_2O_5: K_2O kg/ha

Table 2. Soil chemical properties as influenced by integrated nutrient management on Safflower + chickpea (2:4) intercropping system

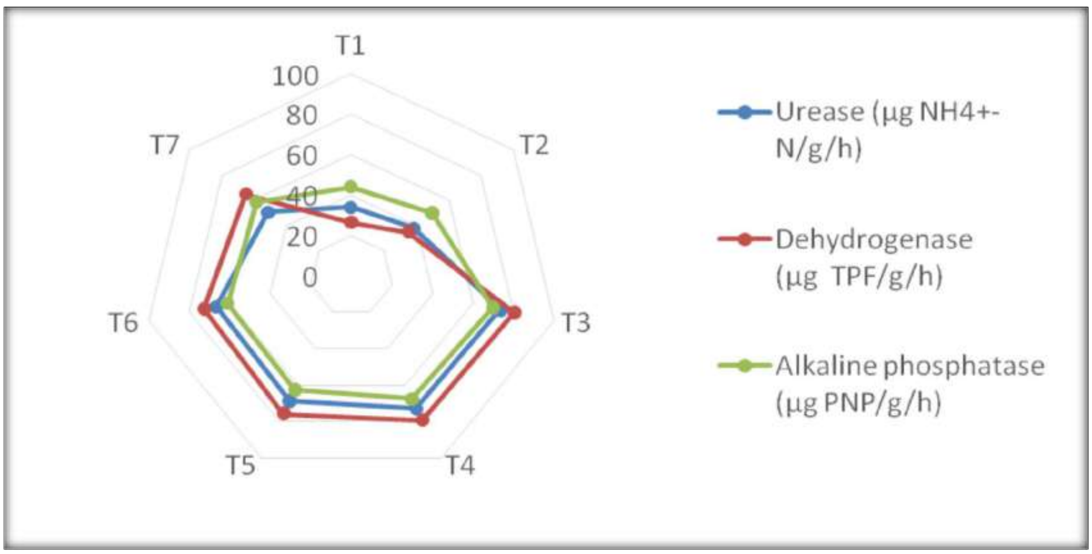
Treatment	pH	Organic C (%)	Av. nutrient (kg/ha)			Micronutrient (ppm)			
			N	P_2O_5	K_2O	Zn	Fe	Cu	Mn
T1	8.09	0.42	185.1	13.3	373.9	0.37	1.75	0.60	2.85
T2	8.07	0.44	196.9	14.8	388.6	0.43	2.16	0.64	3.23
T3	7.92	0.52	219.7	18.2	421.6	0.50	2.54	0.78	3.48
T4	7.88	0.51	215.3	17.8	421.1	0.49	2.46	0.77	3.52
T5	7.91	0.48	206.5	17.2	410.8	0.49	2.25	0.72	3.40
T6	7.97	0.46	199.6	16.3	398.3	0.46	2.24	0.67	3.25
T7	8.02	0.44	192.8	15.4	385.4	0.44	2.10	0.65	3.13
Mean	7.98	0.47	202.3	16.1	399.9	0.45	2.21	0.69	3.26
Sem±	0.04	0.009	3.0	0.43	2.9	0.007	0.07	0.013	0.08
CD (p=0.05)	0.10	0.03	8.5	1.3	8.4	0.022	0.2	0.04	0.24
CV (%)	7.8	6.9	7.1	8.5	9.3	6.9	7.1	8.1	7.7
Initial value of soil properties	7.92	0.43	191.0	13.3	424.0	-	-	-	-

RPP: 3 t/ha FYM + 50: 25:0: N: P_2O_5: K_2O kg/ha

The improved soil chemical properties like decrement of pH from 7.92 to 7.88, organic carbon (0.52 %), available N (219.7 kg/ha), available P_2O_5 (18.2 kg/ha), available K_2O (421.6 kg/ha); and DTPA extractable Zn, Fe, Cu and Mn values of 0.50, 2.54, 0.78 and 3.48 mg/kg, respectively; (Table 2). The impact of integrated nutrient management on soil enzymes activities depicted in Fig. The soil enzyme activities like urease (73.7 µgNH^{4+}-N/g/h), dehydrogenase (80.6 µg TPF/g/h) and alkaline phosphatase (70.1 µg PNP/g/h) were recorded with the application of 50% N through FYM + 50% N through inorganic sources as compared to control.

Conclusion

Permanent manorial trials assess the long-term effects of organic and inorganic sources of nutrients on yield, chemical properties of soil. The present study conducted for six years with 3 sets of birotational systems indicated that 50% N through FYM or vermicompost or sunhemp along with 50% N through inorganic sources improved yield and soil chemical properties in safflower + chickpea (2:4) intercropping systems of Northern dry zone of *Vertisols.*



Effect of integrated nutrient management on soil enzymes activities

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Comparative Study of Sewage Sludge And its Derived-Biochar on Soil Properties and Nutrient Content in Rice Crop

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Sewage sludge is a waste product from wastewater treatment plants and contains various organic compounds, trace elements, and macro and micronutrients. Direction application of sewage sludge to the soil can lead to nutrient leaching and heavy metal accumulation. However, the conversion of sludge into biochar would be an alternate and viable strategy to use in agricultural practices. Biochar is a pyrolyzed organic material formed by the process of pyrolysis in the absence of oxygen. The pyrolysis process significantly minimizes the volume of SS, kills pathogens and parasites, and reduces the significant level of organic pollutants (Devi and Saroha, 2014). Moreover, biochar amendment can improve soil physicochemical properties, increase soil fertility, enhance soil microbial activities, and overcome global warming. It is also cost-friendly and available year-round. In addition, conversion into biochar will serve as a dual purpose for waste management and improve soil fertility.

Methodology

Sewage sludge (SS) was collected from the Sewage Treatment Plant (STP) of Hyderabad Metro Water Supply and Sewage Board (HMWSSB), Amberpet, Hyderabad, India. The part of the SS was converted into biochar by placing it in a muffle furnace, pyrolyzing at various temperatures of 300-700°C. Further, the pot experiment was conducted in a glasshouse facility at the Indian Institute of Rice Research (IIRR) Hyderabad, India with different levels of SS and sewage sludge biochar (SSB). The experimental soil was collected from Rajendranagar farm of IIRR and DRR DHAN 55 was used as a test crop. The pot experiments were arranged in Completely Randomized Block Design (CRBD) with different doses of SS and SSB along with RDF as follows: T1 (Absolute Control), T2 (100% NPK), T3 (2t SS/ha+80% NPK), T4 (4t SS/ha+80%NPK), T5 (2t SS/ha+60%NPK), T6 (4t SS/ha+60% NPK), T7 (2t SSB/ha+80% NPK), T8 (4t SSB/ha+80%NPK), T9 (2t SSB/ha+60%NPK) and T10 (4t SSB/ha+60% NPK). This study aimed to examine the effect of spiked SS and SSB on soil properties and plant nutrient concentrations. Destructive soil and plant samples were collected at 55 days after transplanting (DAT) and estimated for N, P, and K content in straw, root, and soil, respectively.

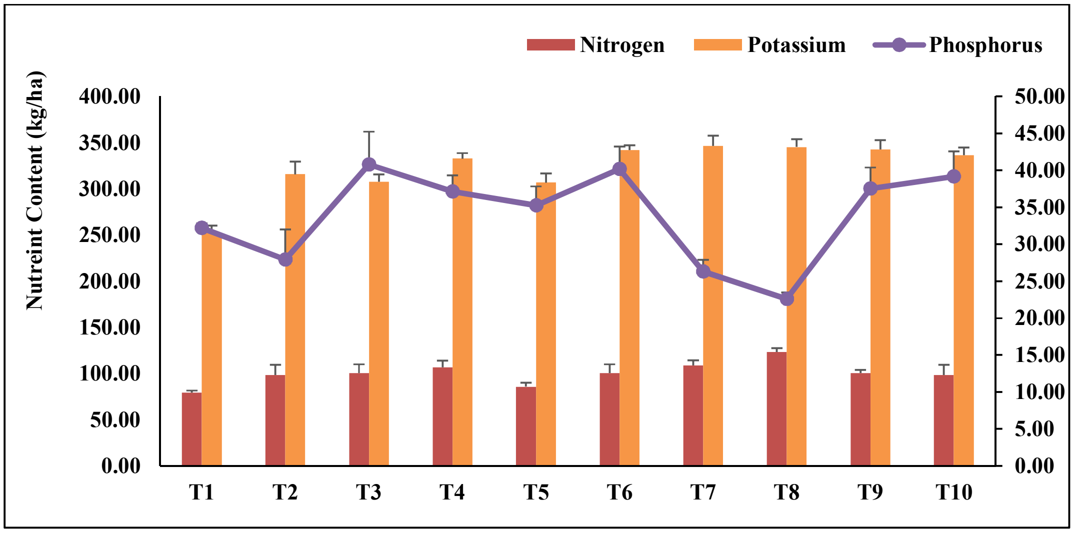
Results

The application of SS and SSB resulted in significantly higher concentrations of nutrients in both straw and root compared to conventional NPK treatment, but higher concentration (%)

of N, P, and K was reported in straw than in root (Table 1), where T8 recorded the highest concentration of N and P (1.54%, 0.18% respectively) and T3 recorded the highest concentration of K followed by T9 (1.07% and 1.06% respectively) in straw, while in root the higher concentration of N and P was recorded in T5 (1.243% and 0.087%, respectively) and T7 showed higher concentration of K (0.237%), which could be linked to higher N uptake for protein production being utilized in crop development, while P is mostly required to boost early root development and higher K content could explain enhanced photosynthetic activity (Gwenzi et al, 2016). In soil, the N content was reported to be the highest in T8 (123.35 kg/ha) followed by T7 (108.71 kg/ha); highest K content was observed in T7 (346.42 kg/ha) followed by T8 (345.33 kg/ha) in the soil blended with 2t SSB/ha and 4t SSB/ha with 80% NPK, respectively than other treatments (fig 1), which validates biochar's potentiality for retention and slow release. It was observed that the maximum amount of P was reported in T3 (40.79 kg/ha) followed by T6 (40.18 kg/ha) blended with 2t SS/ha and 4t SS/ha with 80% and 60% NPK, respectively. Further, suggesting that the conversion of SS into biochar transforms P into a more stabilized form characterized by a slow release of P with a long-lasting effect on providing P to plants (Dai et al, 2016).

Effect of sewage sludge and sewage sludge biochar addition on N, P and K concentrations in different parts (straw and root) of rice crop

Treatments	Straw (%)			Root (%)		
	N	P	K	N	P	K
T1-Absolute Control	0.70	0.12	0.68	0.877	0.045	0.111
T2-100% NPK	1.04	0.11	0.96	1.036	0.044	0.205
T3-2t SS/ha+80%NPK	1.08	0.16	1.07	0.896	0.065	0.126
T4-4t SS/ha+80%NPK	1.12	0.16	0.89	1.055	0.063	0.123
T5-2t SS/ha+60%NPK	1.11	0.18	1.00	1.241	0.090	0.145
T6-4t SS/ha+60%NPK	0.95	0.17	0.95	0.989	0.080	0.149
T7-2t SSB/ha+80%NPK	1.26	0.14	0.91	1.204	0.077	0.236
T8-4t SSB/ha+80%NPK	1.54	0.18	0.94	0.943	0.075	0.182
T9-2t SSB/ha+60%NPK	1.45	0.17	1.06	0.952	0.069	0.141
T10-4t SSB/ha+60%NPK	1.24	0.15	0.94	1.027	0.084	0.141
SE(m)	0.14	0.02	0.04	0.078	0.012	0.016
CD (P=0.05)	0.41	0.05	0.13	0.229	0.038	0.046



Effect of sewage sludge and sewage sludge biochar addition on N, P and K content in soil

Error bars denote the standard error of the mean.

Conclusion

The results showed that conjoint application of SS or SSB with conventional NPK fertilizers improved the soil properties and nutrient content in rice. Moreover, this study showed that conversion of SS into biochar will reduce the negative impacts of SS and improve the characteristics of sewage sludge which could support the plant growth and nutrient content in major cereal crops.

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Effect of Tillage, Residue and K Management on Productivity, Profitability and PFP of Nutrients Under Maize-Wheat-Mungbean System in Trans IGPs of India

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The Indo-Gangetic Plain (IGP) of India belongs to a semi-arid agroecosystem, wherein, rice–wheat is the dominant (third most important) cropping system. Farmers burn crop residues in open fields in this region, which leads to emission of harmful gases and air pollutants into the atmosphere with loss of plant nutrients. It needs crop and soil appropriate management techniques with a focus on conservation agriculture (CA) that can maintain soil health which in turn is essential for long-term sustainability of intensive cereal-based systems. Potassium (K) is an essential plant macronutrient and plays a key role in the synthesis of cells, enzymes, protein, starch, cellulose, and vitamins, in nutrient transport and uptake, in conferring resistance to abiotic and biotic stresses, and in enhancing crop quality. On-farm K response studies in rice, wheat and maize, spread across the IGP, highlighted that grain yield response to fertilizer K is highly variable and is influenced by soil, crop and management factors. However, the information on the effect of tillage, residue and K management in the maize-wheat system is lacking. Therefore, field investigation was conducted to evaluate the effect of such variables on productivity, economics and nutrient use efficiency of maize and wheat.

Methodology

An experiment was conducted during the two successive *kharif-rabi* seasons of the year 2023-24 to examine the effects of tillage, residue, and K management on the productivity and profitability of the maize-wheat-mungbean system at ICAR-Indian Agricultural Research Institute, New Delhi, in the Trans-Indo-Gangatic Plains of India. The texture of the soil of the experimental field was sandy clay loam, slightly alkaline in reaction (pH 8.0), low in organic carbon (0.33%), available nitrogen (163.3 kg/ha), available phosphorus (17.3 kg/ha), and medium in available potassium (303 kg/ha). The climate of the region is characterized by a humid subtropical climate with a semi-arid influence with an average precipitation of 774.4 mm. The experiment was laid out in a split-plot design with two levels of tillage practices as main plots, i.e., conventional tillage (CT) and zero tillage with residue at 3 t/ha (ZT+R), and six levels of potassium management as sub-plots, i.e., no K (PM_0), 50% K through POLY4 and 50% K through MOP (PM_1), 75% K through POLY4 + KSB (PM_2), 75% K through MOP

+ KSB (PM_3), 100% K through POLY4 (PM_4), and 100% K through MOP (PM_5), in three replications. A general package of practices was followed for all crops, with the exception of tillage and K management, which were implemented as per the treatments. The recommended doses of fertilizer of 150:80:60 and 150:60:50 kg $N:P_2O_5:K_2O$ ha^{-1} were applied in maize and wheat, respectively. Combined system productivity was computed by converting wheat grain yield into maize-equivalent yield. Afterwards, the maize-equivalent yield of wheat grain is added to the maize grain yield to compute the productivity of the system. Maize-wheat system economic parameters were computed based on prevailing market prices of inputs and minimum support prices for outputs of the respective years. The partial factor Productivity was calculated as crop yield per unit of applied nutrient (Sarkar *et al*., 2021). The analysis of variance (ANOVA) approach was used to statistically examine all of the data using the split plot design (Gomez and Gomez, 1984).

Results

Systems productivity, Systems production efficiency and Systems monetary efficiency

Results revealed that among tillage management options, ZT+R recorded significantly higher system productivity (12.3 t/ha), system production efficiency (44.8 kg/ha/day), and system monetary efficiency (₹ 621.5/ha/day) as compared to CT. Among K management options, PM1 had significantly maximum system productivity (12.8 t/ha), system production efficiency (46.5 kg/ha/day), and system monetary efficiency (₹ 609.6/ha/day), which was at par with treatment PM4 regarding system productivity and system production efficiency, while it was at par with PM5 regarding system monetary efficiency. Minimum were found with PM0 (Fig 1). Zero tillage and CR retention have been found to improve overall soil condition, with higher soil water content and other physical, chemical, and biological properties of soil. Consequently, ZT, along with residue retention throughout the cropping cycle of wheat and maize, was most productive, showing the highest system productivity (Das et al. 2013). Additionally, sufficient potassium nutrition supplied to maize and wheat improved growth and yield attributes, likely contributing to a significant increase in overall maize-wheat system productivity.

System's economics

Among tillage management options, significantly higher systems gross return (₹ 257938/ha), systems net return (₹ 164066/ha), and systems B:C ratio (1.77) were achieved under ZT+R compared to CT. Among potassium management, treatment PM_1 showed the highest systems gross return (₹267744/ha) and systems net return (₹160932/ha), being comparable to PM_4 regarding gross return and to PM_5 regarding net return. The net B:C ratio of the system was significantly maximum (1.72) for PM_5, being at par with PM_1. PM_0 yielded the lowest results across these metrics (Fig 2). The beneficial impact of ZT with residue retention on productivity also led to improved economic outcomes, making ZT with residue retention the most profitable tillage practice in the maize-wheat system (Raghavendra *et al.* 2017). Parihar *et al*. (2019) reported similar findings for CA-based ZT with crop residue retention in the maize-based rotation. The minimum net B:C of the system under PM5 might be due to higher productivity in this treatment and low cost of MOP compared to POLY-4.

Partial factor productivity (PFP) of nutrient

The maximum PFP of nitrogen, phosphorus and potassium for maize and wheat (39.2 and 39.6 kg/kg N; 78.4 and 99.0 kg/kg P_2O_5; 112.0 and 141.4 kg/kg K_2O, respectively) were obtained under ZT + R, in comparison to CT. When compared among K management options, significantly maximum PFP of nitrogen and phosphorus for maize and wheat (41.6 and 40.2 kg/kg N; 83.2 and 100.6 kg/kg P_2O_5, respectively) were gained for treatment PM_1 being at par to PM_4 and PM_5. Conversely, the highest PFP of potassium for maize and wheat (95.2 and 116.8 kg/kg K_2O, respectively) were obtained under treatment PM_2 followed by PM_3 (Fig 3 and 4). Tillage methods and nutrient levels had a significant impact on the PFPs of wheat crops. Zero tillage with residue retention improves soil structure, moisture retention and nutrient cycling, leading to higher nutrient use efficiency and PFP for maize and wheat. The balanced K management with 50% K from POLY4 and MOP enhances nutrient synergy, maximizing PFP of crops for nitrogen and phosphorus. The highest PFP for K under 75% K through POLY4 + KSB was likely results from enhanced potassium availability due to the combined effects of KSB and the multi-nutrient support from Poly-4.

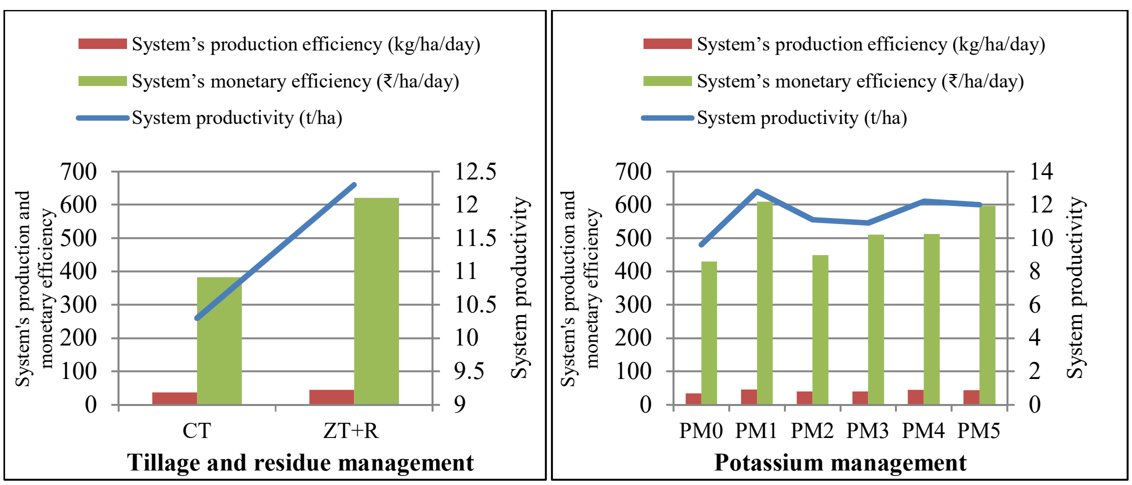

Fig 1. Effect of tillage, residue and K management on systems productivity, systems production efficiency and systems monetary efficiency in maize-wheat-mungbean system

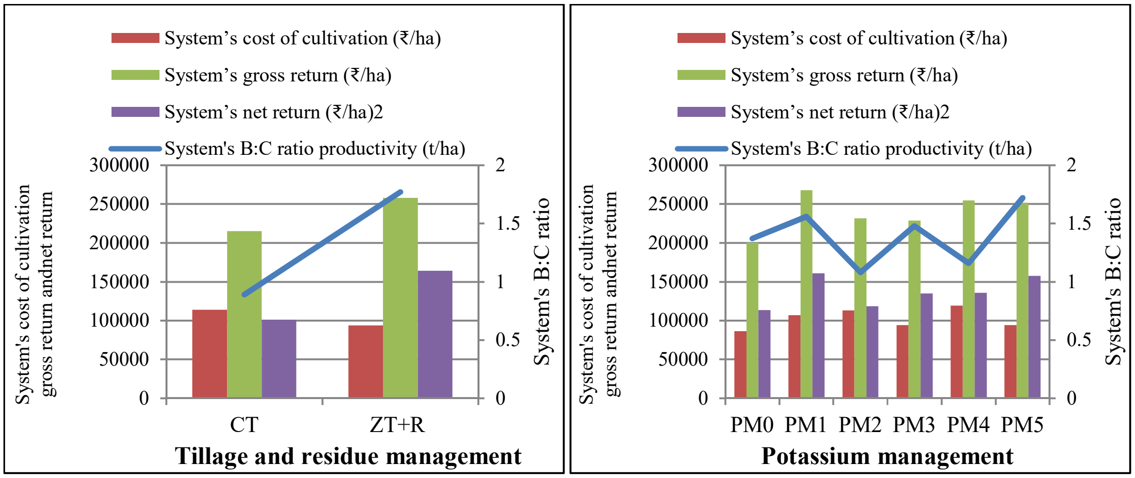

Fig 2. Effect of tillage, residue and K management on system's economics in maize-wheat-mungbean system

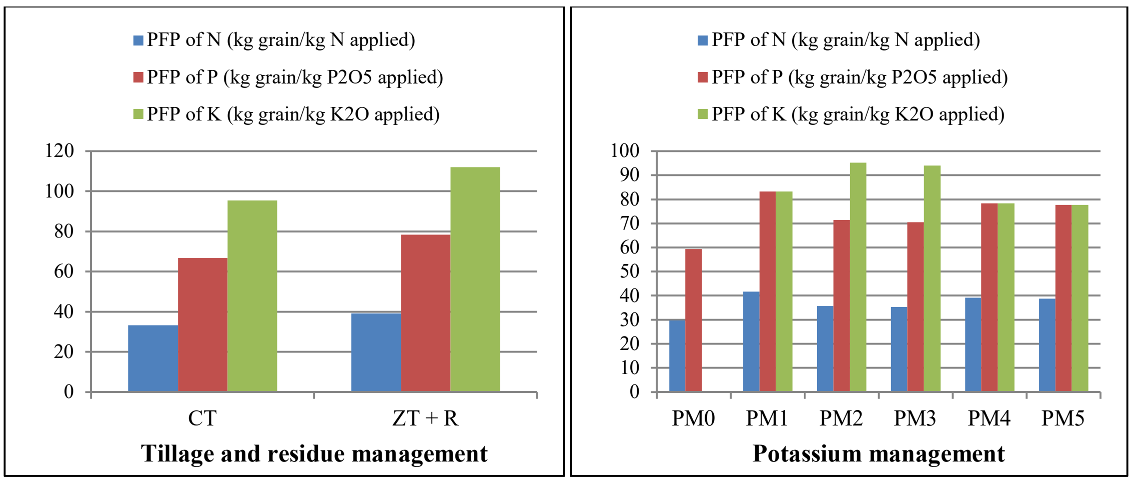

Fig 3. Effect of tillage, residue and K management on PFP of nutrients for maize in maize-wheat-mungbean system

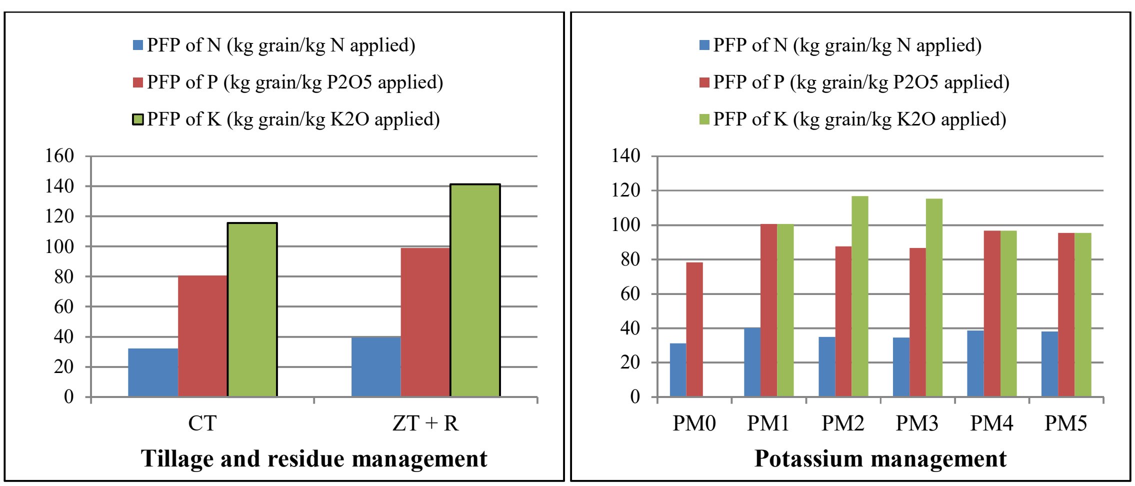

Fig 4. Effect of tillage, residue and K management on PFP of nutrients for wheat in maize-wheat-mungbean system

Conclusion

The experiment showed that ZT with 3 t/ha residue significantly improved productivity, profitability and efficiency across the maize-wheat-mungbean system compared to conventional tillage. The K management treatment combining 50% K through POLY4 and 50% K through MOP, achieved the highest systems productivity, production efficiency, gross return, and partial factor productivity of N and P, comparable to 100% K through POLY4. For the system's monetary efficiency and net returns, this treatment was comparable to 100% K through MOP, which also led to a maximum net B:C. The highest K use efficiency was observed in the 75% K from POLY4 + KSB treatment, followed closely by 75% K from MOP + KSB.

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Improving Nutrient Use Efficiency of Rainfed Maize by Using ALDOR- A Multi Nutrient Fertilizer

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In India, maize is the third most important food crops after rice and wheat. Maize qualifies as a potential crop for doubling farmer's income. According to 3rd advance estimates of production of food grains for 2022-23, all India maize production estimate was 35.91 MT (Indiastat, 2023). Among the fertilizers, nitrogen (N) is a major factor in agricultural production. The maize plant is a heavy feeder, requiring an intelligent fertilizer program. It responds very well to heavy nitrogen fertilization. Nitrogen deficiency is widespread, and it accounts for 89% of deficiency (63% low and 26% medium) (Shukla et al., 2021). Besides conventional fertilizers, other multi-nutrient compositions like ALDOR (30-00-05+7S) could be potential sources for nutrient management in maize and for maintaining soil fertility. ALDOR is a natural combination of three nutrients (N, K, and S) and contains N in larger chunk. The present study was undertaken to study the effect of ALDOR on yield and nutrient uptake of maize.

Methodology

A field experiment was conducted during *kharif,* 2023 at Gungal Research Farm (GRF), ICAR-CRIDA, Hyderabad to study the effect of ALDOR on yield and nutrient uptake of rainfed maize (cv. DHM 117). The experiment laid out in a randomized block design with three replications. The treatments include: T_1: Control (Only Recommended P and K – No Nitrogen), T_2: Control (No N through urea, Recommended P and K through DAP and MOP), T_3: Nitrogen equal to applied in T_9 and DAP Farmer Practice (only Urea and DAP), T_4: 100% Nitrogen based Farmer Practice (only Urea and DAP), T_5: 125% Nitrogen based Farmer Practice (only Urea and DAP), T_6: Nitrogen equal to applied in T_9 + Rec. P & K, T_7: 100% RDN + Rec. P & K, T_8: 125% RDN + Rec. P & K, T_9: ALDOR equivalent to Urea applied in T_4 and T_7 + Rec. P & K, T_{10}: ALDOR equivalent to Urea applied in T_5 & T_8 + Rec. P & K T_{11}: ALDOR equivalent to Nitrogen applied in T_4 & T_7 + Rec. P & K and T_{12}: ALDOR equivalent to nitrogen applied in T_5 & T_8 + Rec. P & K. Sowing was done with tractor-drawn seed drill at a spacing of 60 cm x 25 cm. The recommended dose of NPKS was 90:45:45:12.5 kg N, P_2O_5, K_2O and S/ha. All the nutrients except N was applied as basal dose at the time of sowing. N was applied in three equal splits i.e., basal, knee-high stage (35 DAS) and flowering stage of crop (55 DAS) respectively.

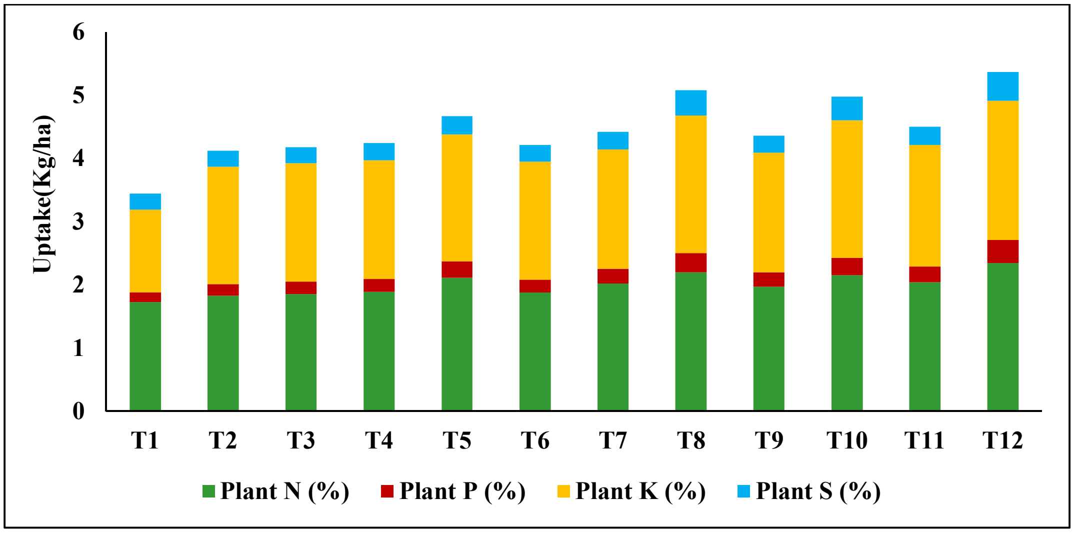
Results

Application of ALDOR had significant effect on yield and nutrient uptake of maize. The results showed that applying ALDOR at 125% of the recommended nitrogen dose (RDN), along with the recommended phosphorus (P) and potassium (K) resulted in the highest yield attributes (Table 1), including no. of cobs /plant (2), cob weight (183.9 g), no. of grains /cob (497), 100-seedweight (21.0 g) and higher grain yield (6283 kg/ha).

Effect of ALDOR on yield attributes of maize

Treatment	No. of cobs per plant	Cob weight (g)	No. of grains per cob	100-seed weight (g)	Grain yield (kg/ha)
T_1	1	55.3	147	13.7	1665
T_2	1	122.7	309	15.2	2291
T_3	1	190.8	342	16.5	3615
T_4	1	174.5	357	17.1	4023
T_5	1	231.8	415	19.2	5036
T_6	1	178.2	344	16.9	3975
T_7	1	193.9	384	18.6	4521
T_8	2	209.2	469	20.6	6201
T_9	1	172.0	372	17.7	4105
T_{10}	1	164.1	422	19.8	5320
T_{11}	1	164.91	397	19.0	4887
T_{12}	2	183.9	497	21.0	6283
CD (P=0.05)	0.38	49.9	44.24	4.51	746.14
CV%	20.23	17.35	7.04	14.85	10.19

The highest nutrient uptake of N, P, K, and S (2.34%, 0.37%, 2.20% and 0.46%) was obtained with the application of ALDOR at 125% of the RDN, along with the P and K (Fig.1). The slower nutrient release in ALDOR and the presence of multiple micronutrients from 35% of POLY4 in the product could have addressed any deficiencies in the soil, providing essential elements for optimal plant health (Singh et al., 2023; Sunitha et al., 2023). This balance and availability of nutrients are likely contributing to the observed increase in maize uptake and yield.



Effect of ALDOR on plant uptake of maize

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UID: 1498

Effect of Tillage and Nutrient Management Practices on Soil Bulk Density in Vertisols Under Dryland Agriculture

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Bulk density is the most important indicator of soil compaction. It generally affects infiltration rate, available water capacity, rooting depth, soil porosity, soil aeration, soil microorganisms and available nutrients for plant use. Soil bulk density is essential in determining the soil quality and capability to serve the ecosystem). Different management practices can alter bulk density by altering soil porosity, soil compaction, soil cover, etc. Tillage is the major operation that triggers the processes affecting the soil bulk density. Tillage also disrupts plant and animal communities responsible for aggregation and tends to decrease soil organic matter. Conservation tillage techniques, such as limited tillage and residual mulch, significantly help to improve soil health. For example, minimum tillage leads to improved soil water and carbon storage, better aggregate stability, and reduced bulk density compared to conventional tillage (Dak Ferro et al. 2023; Meena et al. 2023). Furthermore, adding crop residues in the field has a direct or indirect positive impact on soil quality by reducing bulk density & increasing porosity & infiltration (Zhu et al. 2023). Therefore, combining conservation tillage with inorganic & organic plant nutrients helps to improve soil health and crop productivity, which will be helpful for the sustainable management of soils. This study aims to understand the effect of different tillage and nutrient management on soil bulk density.

Methodology

The study was conducted in a long-term experiment started in 2001-02 in a Vertisols at Regional Research Station, Vijayapura situated in the Northern Dry Zone of Karnataka State of India (160 46’ N, 750 46’ E and 594 m above mean sea level) under all India co-ordinated research project on dryland agriculture (AICRPDA). The crops grown were sorghum and sunflower in a yearly rotational system. The experiment was laid out in a split plot design with three replications. Tillage treatments were allocated to main plots which includes T1-Conventional Tillage (CT) (1 ploughing before onset of monsoon + 2 harrowing before sowing of crop + 2 hoeing + 1 hand weeding; T2 - Reduced tillage (RT) (2 harrowing (15 days before sowing) + 1 hoeing (45 DAS) + hand weeding (45 DAS); T3 – Minimum Tillage

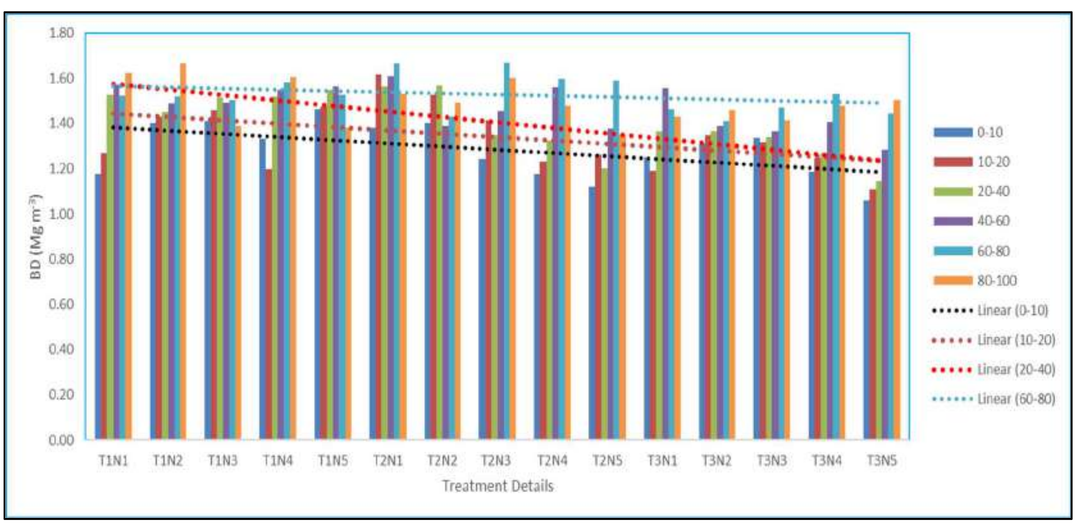
(MT) (1 harrowing (15 days before sowing) + 1 hoeing (45 DAS) + 1 herbicide application). The sources of nutrients were assigned to sub plots and consist of N1- Sunhemp incorporation @ 5 t/ha; N2 - Sunhemp incorporation @ 2.5 t/ha + 50% RDN through fertilizer + RD of P/K ; N3 - 100% RDF through inorganic fertilizer (100% RDF: 35, 50, 35 kg N, P_2O_5, K_2O ha^{-1} in case of sunflower and 50, 25 kg N, P_2O_5 ha^{-1} in case of sorghum); N4 - Farmers' practice (FP) of applying chemical fertilizers (40-30 kg of N, P_2O_5 ha^{-1} in case of sunflower and sorghum), T5 - Farmers' practice of fertilizer application + sunhemp green manuring (FP+SH@5 t ha-1).

Soil Sampling: Soil samples were collected from the profile of each treatment with the depth of 0-10 cm, 10-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, 80-100 cm and >100 cm. The bulk density was determined using the core sampler method developed by Baver (1956). The core sampler was pushed into the different depths, and the collected soil core sample was transferred into a moisture box, weighed and dried at 105^0 C for 48 hours. In order to calculate the bulk density (Mg m^{-3}), the soil's calculated dry weight was divided by the volume of the soil core.

Bulk density (Mg m^{-3}) = $\frac{Oven\ dry\ weight\ of\ soil}{Volume\ of\ soil}$

Results

Figure shows the mean value of bulk density of the soil under different tillage and nutrient management at varying depths. The bulk density values vary from 1.06 to 1.67 Mg m-3 in all the treatments. The higher values of bulk density (1.17 to 1.67 Mg m^{-3}) were observed in conventional tillage treatments compared to the reduced tillage and minimum tillage treatments (Fig). The lower bulk density values were found in the minimum tillage treatments ranged from 1.06 to 1.48 Mg m^{-3}. In all the treatments, the bulk density values increase with increasing depth due to the soil compaction common in Vertisols.



Effect of different tillage and nutrient management on soil bulk density

Conclusion

Under long-term fertiliser trial, we assessed the impact of different tillage and nutrient management on soil bulk density. The results indicated higher bulk density values were found in conventional tillage treatments compared to reduced and minimum tillage treatments. Therefore, the study indicates that minimum tillage along with sun hemp application helps reduce the bulk density of soil, which helps to improve soil structure, protect soil moisture, and increase crop yield.

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UID: 1500

Effect of conservation agriculture practices on crop yields and labile carbon under rainfed alfisols of semi-arid regions

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Conservation agriculture practices potentially increase soil organic carbon, mitigate climate change, and ensuring the long-term sustainability of agricultural systems under assured moisture conditions, but the impact is not known under rainfed conditions. Soils are the largest reservoir carbon (C) and play an important role in the global C cycle. Soils can be either a source or sink for atmospheric CO_2 depending on land usage and management practices (Lal 2016). Intensive tillage cause depletion of soil organic matter and alters the distribution and stability of aggregates in the soil leads to increase of CO_2 emissions to the atmosphere. Reduction in CO_2 emissions could be possible through minimization of tillage operations and retention of crop residue on the soil resulting in the accumulation of soil organic carbon (SOC). Most of the soils in rainfed regions are poor in fertility and low in productivity too. It has been reported that SOC content in these soils is less than 1% (Lal 2017). Maintenance of optimum levels of SOC in soil can done by reducing the tillage intensity, increasing moisture retention, enhancing residue retention on the surface leading to improvement in availability of nutrients to the crop and enhance yield and productivity. Conservation Agriculture (CA) practices can potentially minimize land degradation, enhance soil carbon and productivity through improvement of soil health by favourably increasing the soil physical, chemical and biological properties of soils under assured irrigated conditions but their impact under rainfed conditions are not known. Therefore, conservation agriculture practices like reduced tillage and residue retention levels were studied with the following objective of studying the effect of reduced tillage and residue retention levels on the crop yields and labile carbon under rainfed conditions.

Methodology

The experiment was carried out during two consecutive years 2022-23 and 2023-24 at Gunegal Research Farm of Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad which is located at about 45km from the main campus of ICAR-CRIDA in southern India. The experiment was laid out in split plot design assigning four tillage operations as main plots T1. Conventional tillage (CT) T2. Minimum tillage (MT) T3. Zero tillage (ZT) and T4. ZT with ridge and furrow (ZTRF). Three residue retention levels as sub plots. 1. S1- Harvesting of the crop close to the ground (Farmers' practice), 2. S2- Crop was harvested at a height of 20 cm above ground leaving a standing residue, 3. S3- Only panicles were harvested in case of foxtail millet leaving the entire stubbles as such in the field and in case of greengram only pods were harvested leaving the entire biomass in the field. The cropping system was foxtail millet-greengram sequence.

Results

Foxtail millet system productivity

Foxtail millet system productivity was recorded significantly higher in zero tillage with ridge and furrow (14.4%) followed by minimum tillage (13.4%) compared to conventional tillage and S3 recorded 10.8% higher system productivity followed by S2 (8.0%) compared to S1 (figure 1).

Labile carbon

Zero tillage (T3) recorded 29.7%, 25.1% and 34.4% higher labile carbon (mg kg^{-1}) followed by zero tillage with ridge and furrow (T4) 25.7%, 22.5% and 25.5% compared to conventional tillage (CT) and retention of entire residue on field (S3) observed 21%, 15.3% and 15.57% higher labile carbon (mg kg^{-1}) compared to little amount of residue retention

(S1) treatments at 0-5cm, 5-10cm and 10-15cm depth of soil. Lower profile of soil (15-60 cm) was not influenced by tillage and crop residue retention level practices (figure 2)

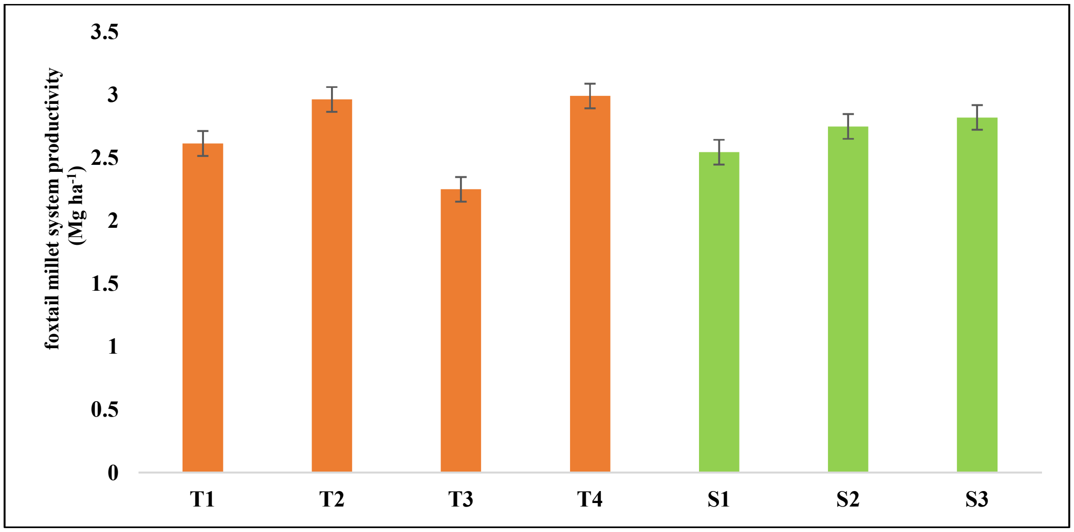

Fig 1. Effect of tillage and crop residue retention levels on foxtail millet system productivity

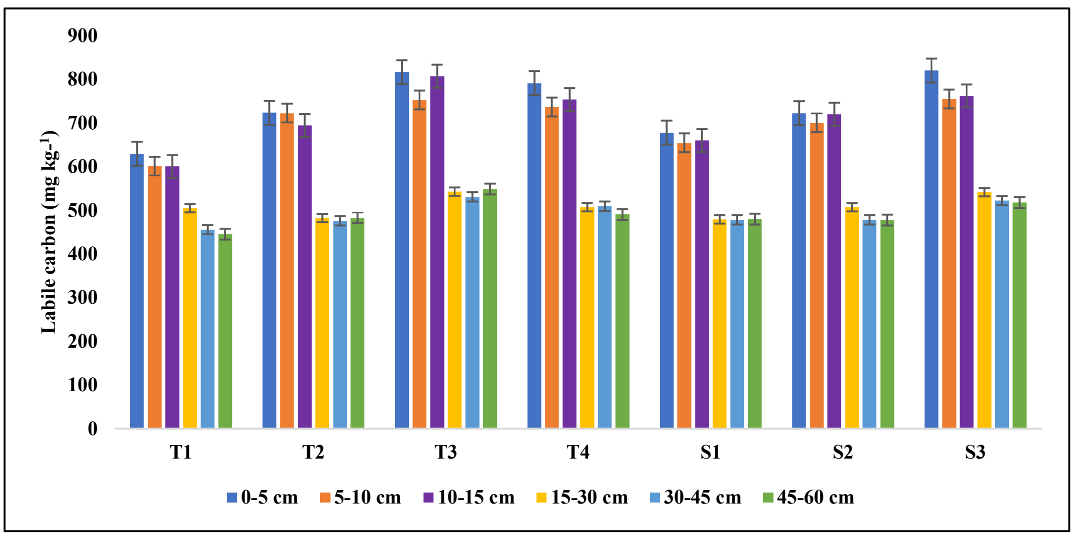

Fig 2. Effect of tillage and crop residue retention levels on labile carbon under foxtail millet system productivity.

Conclusion

It can be concluded that zero tillage with ridge and furrow (*in-situ* moisture conservation measure) and zero tillage along with retention of entire crop residue on the field increased foxtail millet system productivity and labile carbon, respectively, in rainfed alfisols.

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UID: 1503

Water Saving and Yield Increment by Straw Mulching Technique in Watermelon Cultivation

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Watermelon (*Citrullus lanatus*) is a very common fruit worldwide, especially in arid and semiarid climate environments. Watermelons can survive desert climate regions when groundwater is available, and the mean optimum minimum and maximum base temperature for watermelon growth are about 18 °C and 35 °C respectively. Watermelon (*Citrullus lanatus*) is a monoecious vine, a scrambling and trailing vine in the flowering plant family Cucurbitaceae. During the drought season, watermelons' fruit is used as a source of drinking water in portions of Indian subcontinent. Deficit irrigation allows the farmer to stabilize the crop yield using less water when available irrigation water is insufficient to cover the full crop water requirement and the most common method of irrigation application for watermelon crops is furrow. Deficit irrigation has been widely investigated as a valuable, and sustainable production strategy in dry regions, and this practice aims to maximize water productivity. Over the world, soil mulching in irrigation or rain-fed agriculture is used as water-saving technology in drought-prone areas by creating favorable soil conditions. In arid or semiarid regions, mulch has been used to conserve water through reduced evaporation while also increasing yields and it is used to control weeds and reduce soil compaction. The other role of soil mulching practice on agricultural land is to increase soil fertility and that may have different thicknesses, colors, and raw materials. Fruit, and vegetable production in water-limiting areas can be increased by adapting straw mulching field management with a 50–75 % deficit irrigation level.

Effect of Straw Mulching

Krishi Vigyan Kendra, Supaul is implementing NICRA project at Kalyanpur village in Supaul district of Bihar. The source of irrigation in this village is boring. Irrigation facility in the watermelon crop is only limited during good rainfall year. Farmers tend to waste precious groundwater by flood irrigation frequently in order to save the crop. In view of this, the straw mulching was used to promote water saving to reduce the frequency of flood irrigation.

Features and specification of straw mulching

Demonstrations of straw mulching in watermelon crop for water saving improved water retention and reduced frequency of irrigation. This method gave higher fruit yield (238.7q/ha) with more net return (Rs 567334/ ha) with a B: C ratio (4.65).

Verification trial on straw mulching in watermelon crop under NICRA Project

Crop Establishment methods	Yield (q/ha)	Variable cost (Rs/ha)	Net return (Rs/ha)	BCR	% increase	Water use (lakh lit/ha)	Total water use (cm)
Straw mulching in watermelon	238.7	218425	567334	2.59	10.08	18	18
Conventional Sowing	214.83	238850	490056	2.05		24	24

The following outcomes were observed in bed planting of watermelon:

- Time saving (25-30 %) i. e. took less time of 2.43/hrs/ha/irrigation
- Water saving was up to 25-30%
- Better water management resulted as increased water use efficiency
- Less incidence of weed
- Reduced attack of disease and pests
- Less competition for light and nutrients and better light penetration within the canopy.
- Obtained 10% higher yield.

UID: 1512

Effect of Foliar Application of Nano-NPK on Growth and Yield of Rainfed Maize

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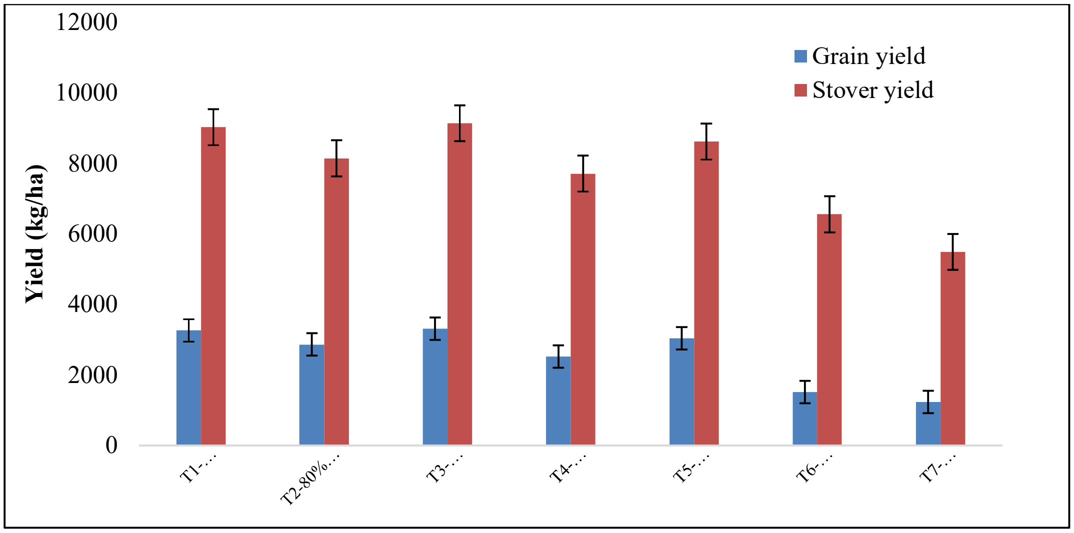
Maize is the one of the important crops which can be cultivated under varied climatic conditions. It is one of the most important strategic crops which has multiple benefits for agriculture as well as industrial field. Among the cereal crops, maize is the only cereal which has ability to attain the highest yield potential (Siatwiinda *et al*., 2021). Therefore, to meet the food demand of rapidly growing population, there is need to narrow the yield gap in maize (Samui *et al*., 2022). Adequate supply of nutrients at right time through the right source is one of the best strategies to bridge the gap between actual and potential yield. Adoption of nanotechnology as a source of N, P and K could be an appropriate alternative to N, P and K fertilizers at macro scale (Madzokere *et al*., 2021). In comparison to the inorganic fertilizers, the nanofertilizers minimize the fertilizer requirement due to its nano-size which increases the surface to volume ratio. Recently, Indian Farmers Fertiliser Cooperative Ltd. (IFFCO) has introduced its nanotechnology-based products including nano-NPK for initial testing as part of its efforts to cut usage of chemical fertilizers and boost farmers' income. The present study was undertaken to study the effect of foliar spray of nano NPK on maize growth and yield under rainfed conditions.

Methodology

The experimental was conducted at Gunegal research farm (GRF), ICAR-Central Research Institute for Dryland Agriculture (ICAR-CRIDA), Hyderabad during *kharif,* 2024 under rainfed conditions. The climate of the experimental area is classified as semi-arid and tropical (SAT). Winter is generally mild which is during December-January and temperature begins to rise from second fortnight of January and reaches its peak by May. The experiment was conducted on a sandy loam soil, classified as Alfisols. The soil is sandy loam and slightly acidic in reaction (pH 5.6), with EC value of 0.16 dS/m, low available nitrogen (169 kg N/ha), high available phosphorus (25 kg P_2O_5/ha), and high in available potassium (323 kg K_2O/ha). The treatments comprised of T1:100 per cent recommended dose of fertilizer (RDF), T2:80%RDF, T3:80%RDF+two foliar sprays @1% during V6-V8 and V11-V12 stages, T4:70%RDF, T5:70%RDF+two foliar sprays @1% during V6-V8 and V11-V12 stages, T6: Control + two foliar sprays @1% during V6-V8 and V11-V12 stages, T7: Control. The recommended dose of nutrients for maize was 90:45:45 kg/ha of N: P_2O_5: K_2O respectively. After land preparation, the maize variety DHM-117 was sown on 8th July 2024 with a spacing of 60 cm × 20 cm.

Results

Growth attributes namely plant height (cm), leaf area, test weight, grain yield, stover yield and harvest index were significantly influenced by different treatments. The treatment receiving 80% of recommended NPK + 2 sprays of nano-NPK @ 1% during V6-V8 and V11-V12 stages (T_3) recorded significantly greater plant height at 90 days after sowing (DAS) (117 cm), which was comparable to treatment receiving 100% recommended NPK and significantly superior to the other treatments. Significantly higher leaf area (4846 cm^2) was recorded with 80% of recommended NPK + 2 sprays of nano-NPK @ 1% during V6-V8 and V11-V12 stages (T_3) compared to other treatments. The grain yield and stover yield were significantly influenced by NPK levels and foliar application (Figure 1). The highest grain and stover yield were achieved with the treatment receiving 80% of recommended NPK + 2 sprays of nano-NPK enriched @ 1% during V6-V8 and V11-V12 (T3), yielding 3313 and 9139 kg/ha, respectively. The treatment recorded marginally higher grain yield compared to application of recommended NPK (T_1).



Effect of foliar application of nano-NPK on yield of maize

Conclusion

The initial results of the study indicate that application of 80% RDF along with two foliar sprays of nano-NPK @ 1% during V6-V8 and V11-V12 stages of maize gave higher grain and stover yield compared to recommended NPK application.

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UID: 1532

Conservation Agriculture: A Sustainable Approach for Enhancing Soil Health, Productivity and Profitability in Rainfed Ecosystem

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Rainfed agro-ecosystems, the purported grey patches untouched during Green Revolution or most technological advances, occupy a prominent position in Indian agriculture. Rainfed regions of India are characterized by erratic and poor distribution of rainfall, degraded soils, and the low socio-economic position of the farmers. Cropping intensities and crop yields are low and unstable in these areas due to unpredictable patterns of rainfall, a host of biotic and abiotic stresses and adherence to traditional farm practices. With degraded soils and unreliable weather patterns, return on investment is uncertain and likely to be much lower than irrigated conditions with better soils. Rainfed agriculture is at the cross roads with 82 percent of cropland area in the world and 60 percent in India. Therefore, it is essential to enhance, improve and sustain the productivity of rainfed eco-systems under associated problems of water stress and soil degradation. Under such conditions, one approach to achieve improved crop production is to minimize soil and other natural resource degradation by adopting a set of crop-nutrient-water-land system management practices, such as conservation agriculture. Conservation agriculture primarily aimed at curtailing production cost and GHGs emission, improving soil health, total factor productivity and coping with impacts of climate change. Conservation agriculture has great potentials for impressive and overturning the downward twisting of resource scarcity, receding factor productivity and retreating cultivation costs making rainfed agriculture more resource use-efficient, competitive and sustainable.

UID: 1533

Impact of Cropping System and Phosphorus Management on Yield and Phosphorus Use Efficiency in Maize-Based Systems under Conservation Agriculture

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Phosphorus (P) is an essential macronutrient that significantly influences plant growth and productivity. In Indian agricultural systems, its availability is often a limiting factor, with

60% of Indian soils categorized as low to medium in available phosphorus (Das *et al*., 2022). This limitation arises because of low P use efficiency. The situation is exacerbated by the rapid depletion of global phosphate reserves. This underscores the urgent need to enhance phosphorus use efficiency through innovative management practices and sustainable alternatives. These include the development and adoption of efficient crops and cropping systems, adding legumes in cropping system, selecting the right sources and methods of phosphorus application, and leveraging phosphorus-solubilizing microbes to improve availability in the soil. Such integrated strategies can significantly reduce dependency on synthetic fertilizers, mitigate environmental impacts, and ensure sustainable agricultural productivity. Maize-wheat (MW) system is third most important cropping system which is occupying an area of ~1.83 Mha and has potential to expand in the Indo-Gangetic Plains. In this cropping system, maize–a wide-spaced crop with slow early growth–is particularly well-suited for intercropping with short-duration legumes. The roots of legumes release exudates that mobilize phosphorus beyond their own needs, which can benefit phosphorus-inefficient crops such as wheat. Additionally, the mineralization of root-derived organic phosphorus and the incorporation of legume residues into the soil further enhance phosphorus availability for subsequent crops in the cropping system (Yang *et al*., 2024). The use of phosphate-solubilizing microorganisms represents another sustainable strategy for enhancing phosphorus availability. These microorganisms convert insoluble phosphorus in the soil into plant-accessible forms, thereby reducing the dependency on chemical fertilizers and promoting environmentally friendly agricultural practices. Thus, to achieve sustainable maize and wheat production along with higher phosphorus use efficiency, it is crucial to evaluate the interactive effects of phosphorus management in different maize-based systems under conservation agriculture practices. Therefore, present study was conducted to enhance phosphorus use efficiency and yield in maize-wheat cropping system under conservation agriculture.

Methodology

A field experiment was carried during 2022-23 and 2023-24 at ICAR-Indian Agriculture Research Institute New Delhi during. The experiment was laid out in split-plot design with three replications, comprising 18 treatment combinations. Three cropping systems, viz. Maize–Wheat, Maize+Cowpea–Wheat, Maize+Greengram–Wheat were assigned to the main plot and six phosphorus management practices, viz. No phosphorus, 100% RDP in Maize–100 % RDP in Wheat, 75 % RDP in Maize–75 % RDP in Wheat, 75 % RDP in Maize (+PSB)–75 % RDP in Wheat (+PSB), 50 % RDP in Maize–50 % RDP in Wheat and P5-50 % RDP (+PSB) in Maize–50 % RDP (+PSB) in Wheat assigned in sub plots. One row of cowpea and one row of green gram was sown in between two rows of maize in Maize+Cowpea–Wheat and Maize+Greengram–Wheat treatments, respectively. PSB was applied through seed treatment at the time of sowing in both maize and wheat.

Results

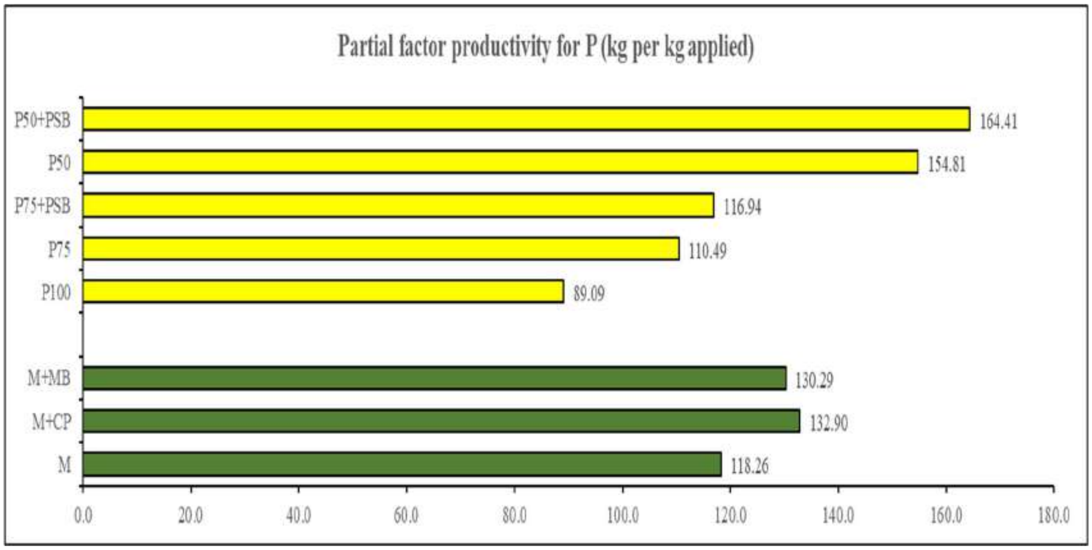
A critical analysis of the data revealed that the cropping system and phosphorus management significantly affected yield, phosphorus use efficiency, and economic returns. Among the cropping systems, the Maize+Cowpea-Wheat system recorded a 9.31% higher maize yield, a 13.04% higher wheat yield, and a 43% higher system productivity compared to the sole Maize-Wheat cropping system, while remaining at par with the Maize+Mungbean-Wheat cropping system (Table). Application of 75% RDP in maize (+PSB) followed by 75% RDP in wheat (+PSB) resulted in statistically similar maize yield, wheat yield and system productivity compared to the application of 100% RDP in both maize and wheat. Conversely, the lowest values for all these parameters were observed in the control treatment (no-P). 50% RDP+PSB recorded more than 80% higher partial factor productivity of P than the application of 100% P in wheat (Fig).

Effect of cropping systems and phosphorus management in grain yield of maize, wheat and system productivity

Treatments	Maize grain yield (t/ha)	Wheat grain yield (t/ha)	System productivity (MEY), (t/ha)
Cropping system			
Maize-Wheat	5.37	4.57	9.62
Maize+Cowpea-Wheat	5.87	5.11	12.56
Maize+Mungbean-Wheat	5.73	5.02	13.77
Sem±	0.08	0.10	0.09
LSD (p=0.05)	0.32	0.37	0.36
Phosphorus management			
Control	4.60	4.26	10.14
100% RDP-100% RDP	6.27	5.35	13.15
75% RDP-75%RDP	5.81	4.97	12.18
75%RDP+PSB-75%RDP+PSB	6.21	5.26	12.96
50% RDP-50%RDP	5.33	4.64	11.42
50%RDP+PSB-50%RDP+PSB	5.72	4.93	12.06
Sem±	0.10	0.09	0.10
LSD (p=0.05)	0.29	0.25	0.28

Conclusion

From the above findings, it can be concluded that the inclusion of legumes in the cropping system, coupled with the application of PSB, can significantly enhance system productivity, economic returns, and phosphorus use efficiency.



Effect of cropping systems and phosphorus management on partial factor productivity of phosphorus in wheat

Reference

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Climate Resilient Traditional Farming System in Eastern Himalayas and its Ecosystem Services

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Ensuring sustainable food production is one of the key challenges of the 21st century, influenced by global environmental crises such as climate change, population growth, depletion of natural resources; climate change stands as a major threat to agricultural systems and agriculture is highly influenced by change in weather and temperature (Singh and Singh, 2017). Recent years, due to various anthropogenic activities it has caused climate change due to which it has caused serve challenges in the agricultural practices. Climate change significantly impacts agriculture, affecting crop yields, food security, and the livelihoods of farmers worldwide. Agricultural ecosystems, or agro ecosystems, are essential in supporting human well-being and contribute to the production of various food and non-food products, provide employment opportunities in rural areas, and, most importantly, help sustain biodiversity and essential ecosystem services (Plieninger *et al.,* 2019). Agricultural production dependent on ecosystem services such as soil structure, fertility, nutrient cycling, pollination and pest control and agriculture serves dual purpose by both providing and relying on ecosystem services (Power, 2010 and Garbach *et al*., 2014) and these services of ecosystem regulates the entire growth of crops and improving these related services helps in increasing the productivity and reduces the dependence of agriculture on external inputs which can solve the problem between agricultural production and environmental problems (Liu *et al.,* 2022 and Dyer, 2014). Ecosystem services are vital in addressing climate change through both mitigation and adaptation strategies (Turner *et al.,* 2009). Traditional agricultural practices have regained the increased attention worldwide as climate-smart approach (Singh and Singh, 2017). Key characteristics of traditional agricultural systems include high production, biodiversity conservation, minimal energy inputs, and climate change mitigation (Srivastava *et al*., 2016). Unlike modern commercial agriculture focuses on yield maximization where as traditional agriculture is considered a more sustainable practice because traditional agriculture utilizes local knowledge and resources, reduces dependency on external inorganic inputs, encourages the recycling of agricultural waste and adaptive strategies (Mylliemngap, 2021).This lead paper enumerates the traditional farming in Eastern Himalayan region and its resiliency and sensitivities and vulnerability under changing climatic conditions.

The North Eastern region of India is rich is biodiversity and the region is also culturally diverse with 200 culturally distinct ethnic communities and the region can be categorized as the Indian Eastern Himalayas covering about 52% of the entire Eastern Himalayas and comprises of 8 states such as Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. Several traditional agricultural systems, including paddy-fish cultivation by the Apatani tribe in Arunachal Pradesh, the Zabo system and Alder-based farming in Nagaland, jhum, continue to be practiced today. Incorporation of traditional ecological knowledge applied in traditional agriculture with scientific knowledge has a great scope for improvement. Some of the traditional agricultural farming systems are as follows:

1. **Apatani Farming System:** It is one of the most advanced traditional farming systems practiced by the Apatani tribes of Arunachal Pradesh. Paddy-cum-fish cultivation involves the simultaneous farming of paddy and fish, with millets grown on the bunds. In Apatani, it is standard practice to grow millets (sarse) on strong dykes or bunds to stop water leaks and also a variety of vegetables, including cauliflower, cabbage, tomatoes, radish, pumpkin, cucumber, beans, and more, can be grown on bunds thus, turning no plot of the field unutilized (Yani *et al.,* 2018). Different types of fishes are reared, during the monsoon season

when there is abundant of water supply, the paddy is kept under submergence of 5 to 10 cm and the fishes can move freely and in drier seasons the fishes moves back to the trenches where they continue to grow (Rai, 2005). Paddy and fish both are produced together by proper management of rainwater. There is no need for extra fish feed because paddy field manuring serves as a source of nutrients for the fish. Water management in the paddy field is accomplished using channels. Apatani farming system is a multipurpose management strategy that integrates agricultural operations, water, and land to reduce soil erosion, preserve irrigation water, and encourage paddy-fish integrated farming.

2. Zabo System: The term "Zabo" refers to “impounding runoff water” in the local Chakhesang dialect, is a traditional farming system with its origin from Kikruma village under Phek district of Nagaland. In the Kikruma region of Phek, despite receiving ample rainfall, residents face significant water scarcity due to surface runoff and this challenge led the community to develop an intricate water harvesting system known as Zabo, which is recognized as one of the most effective methods for managing land and water resources (Singh *et al.,* 2012). Zabo farming is the most practical method of agriculture for the hilly terrain in Nagaland which relies on the concept of integrated farming, which encompasses all crops, livestock, and fishery and supports ecological balance, maintains biodiversity, and conserves water resources for effective use and Zabo farming system is an integrated farming system comprising of protected forest on hill top where vegetation is allowed to grow and it serves as a catchment area with water harvesting pond at the mid elevation, the water stored in the water harvesting ponds is diverted to paddy fields and the water acts a source of irrigation and water management for livestock and cultivation of crops and the irrigation water stored in the water harvesting storage channels are permitted to pass through the animal yard, allowing them to carry animal urine and dung along with irrigation water to the paddy fields, thereby enriching the soil fertility of the lower-elevation fields. (Murray and Das, 2021). The system consists of water harvesting pond for rainwater collection and there is provision for controlling soil erosion, soil fertility management and also biodiversity conservation (Pulamate, 2008).

3. **Bari farming system**: Bari is an operational unit in which a number of crops including trees are grown with livestock, poultry and fish production for the purposes of meeting the basic requirements of the rural household. Crop diversity is highest near the homes and reduces with increase in the distance and few species are found at the extreme end of the garden. A small area surrounding the home, is the first zone which shows maximum diversity of crops often featuring only one or two plants of each species which allows cultivation of maximum crops in a compact space, common plants such as fragrance plants, spices, medicinal herbs, and vegetables are found which is easily accessible for instant vegetables, herbs, the second zone includes crops like bananas, plantains, and citrus fruits, while the next zone is dominated by tree species such as arecanut, jackfruit and other tree species,

pisiculture is a widespread with fish often raised in dugout ponds situated behind the main homestead garden (Barooah and Pathak, 2009). Bamboo is commonly found throughout and is an important component which exists at the border and adjoining areas and Bari system promotes high crop diversity, biodiversity, reduces reliance on external inputs, and supports soil conservation, serves as a carbon sink playing a vibrant ecological role in the current climate change scenario helps in efficient utilization of water, provides food security, income, and employment, particularly for women (Barua *et al*., 2019).

4. **Alder based farming system**: It is a unique self-sustainable farming practiced by Angami tribes of Khonoma village, Kohima district, Nagaland. Alder trees are among the greatest tree species for reviving jhum areas since they can grow on deteriorated land. Alder trees, approximately 10 years old, are pollarded at a height of 1.7 to 2.0 meters above the ground before the initiation of jhum cultivation, a practice that can be sustained for 3 to 4 years. depending on land productivity, in some areas it may last only 2 years, as the trees are cut at the trunk alder trees remain alive and contribute to soil stabilization, preventing erosion, root system enhances water infiltration, and after each cultivation cycle, the field is left fallow for 3 to 4 years to restore soil fertility and allow alder and other vegetation to regenerate, they provide fuel wood to farmers but also helps in nitrogen fixation which helps in maintaining soil fertility, fallen leaves helps in increasing organic matter of soil also helps in soil recovery during fallow period enhances crop yields compared to traditional jhum farming (Singh and Devi, 2018 and Mylliemnap, 2021).

5. **Jhum Farming System:** Shifting cultivation, is popularly known as Jhum cultivation In North-East India, and is prevalent in the states of Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Tripura and hill districts of Assam. It provides livelihood to many tribals in this region. In the jhum cultivation process, first the land is cleared by cutting trees, bushes. etc. up to stump level in December and January and they keep the cut biomass for drying and final burning to make the land ready for planting of the crops before the onset of monsoon season and usually the jhum cycle takes place for two to three years and after three years the jhum cultivated land is left for rejuvenation for retaining its soil fertility until next cultivation takes place (Singh and Devi, 2018). The important features of jhum farming system is no tillage, use of traditional implements such as dribbling sticks and hoes, dependent on manual labor, no use of manuring or irrigation, involves mixed cropping, short-term use of land, followed by long fallow periods, crops are mainly grown for household consumption surplus is bartered or sold for small cash income and the farming system involves mixed cropping where different types of crops are grown such as paddy, millets, maize along with legumes, roots and tuber crops and leafy vegetables (Mylliemngap, 2021).

Climate Resiliency of Traditional Farming Systems

Climate change is causing serious threats and challenges around the globe by affecting food security and nutrition, soil, water, human health, environment and also socio-economic development. There is seen decrease in crop yields due to rise in temperature. Traditional farming system contains valuable knowledge that can help in enhancing the resiliency of modern agricultural systems to extreme climatic conditions, several agro ecological strategies used in these systems helps in mitigating the impacts of climate vulnerability which includes diversification of crops, preservation of local genetic diversity, integration of livestock, management of organic soil matter, water conservation and harvesting techniques. Understanding the agroecological features of traditional agroecosystems is important as it can serve as the basis for developing climate change-resilient agriculture systems (Swiderska, 2011). In recent years, it is seen that the traditional agricultural practices of small holder farmers has attracted worldwide in the context of climate change, use of energy and also in relation to the economics (Rai *et al.,* 2018). Through their indigenous knowledge and experience, smallholder farmers adapt to environmental changes by growing adapted crops and altering farming methods (Lasco *et al*., 2014). Traditional agricultural practices are often location specific which is evolving over time to fit to particular environments and cultures and these practices share common agroecological traits that studies have shown can enhance the stability and resilience of agricultural systems and reviving traditional farming methods alongside adopting agroecological management practices could be the most effective and sustainable way to boost the productivity, resilience, and sustainability of agriculture, which will also help in mitigating climate changes (Altieri and Nicholls, 2013). A review of 172 global case studies highlights that traditional farmers enhance resilience through strategies like ecosystem protection, soil and water management, agroforestry, diversification of farming system, adjusted cultivation practice, use of stress-tolerant crops and crop improvement (Mijatovic *et al.*, 2013). The indigenous farmers of north east region of India has diverse knowledge for water conservation, soil fertility management, disease and pest management, organic farming, incorporation of fish and animal components and forestry. Indigenous farmers of North east farmers have rich repository of traditional knowledge which helps them to adapt to climate variations by their management techniques and crop varieties choices. In order to adapt to climate change, indigenous communities employ traditional farming techniques like mixed cropping, agroforestry, and growing drought-resistant crops are employed by indigenous communities in order to adapt to climate change as these techniques, which have their roots in traditional knowledge, improve biodiversity, sustain ecosystems, and increase resilience against environmental challenges. Indigenous cultures' farming methods are intricately linked to their beliefs and cultural legacy (Lotha *et al.,* 2024). Traditional farming system like Apatani farming system of Arunachal Pradesh is requires low inputs and provides food security, water management, improves land productivity, conserves biodiversity, nutrient cycling, soil fertility maintenance and also supports economy locally. Zabo farming of Nagaland where rainwater is harvested on mountain slopes for agriculture and domestic use, ensuring a sustainable water source for hilly communities (Lotha *et al*., 2024). Alder farming of Nagaland converts wasteland into agricultural land and Jhum cultivation, these practices are essential for ensuring food security in communities and fostering genetic diversity, which is a key factor in adapting to climate change (Saharia, 2024).

Ecosystem services in Agricultural landscape

Ecosystem services refer to the advantages that people derive from ecosystems, the services include provisioning, regulating, and cultural benefits that directly impact human well-being, as well as supporting services that are essential for maintaining the other ecosystem functions. According to Millennium Ecosystem Assessment (MEA) 2005, provisioning services are services which are obtained from ecosystem (food, fiber, fresh water etc.), regulating services obtained from the regulation of ecosystem processes (climate regulation, erosion regulation etc.), cultural services are nonmaterial benefits obtained from the ecosystem which includes (recreation, aesthetic experiences, spiritual etc.) and supporting services are services that is necessary for the production of all other ecosystems (soil formation, primary production etc). Agricultural landscape provides ecosystem services that benefit the society by not only providing food but also other non-food ecosystem services which includes erosion and food control, pollinators habitats, storage of carbon, scenic and recreation opportunities and also a strong sense of community for individuals (Malinga *et al.,* 2018). Agroecosytem not only relies or gets benefitted from various ecosystem services but in turn provides many ecosystem services itself. Natural habitat provides supporting services like soil fertility, nutrient cycling, water and genetic diversity and regulating services such as soil protection, pollination, control of pest, water purification to agroecosytem and agrocosystem in turn provides food, regulation of climate conservation of soil, aesthetics landscape and maintenance of habitat (Zhang *et al.*, 2007 and Power, 2010). Ecosystems plays a major role in climate change mitigation by its ability to absorb and store carbon from atmosphere (Locatelli, 2016). Agro ecosystem services focus more on restoring ecological functions and obtaining environmental benefits that contribute to the achievement of various Sustainable Development Goals (SDGs) (Liu *et al*., 2022).

Conclusion

Traditional farming system plays an important role for enhancement of agricultural growth which helps in promoting food and nutritional security, income generation, while providing various essential ecosystem services. These systems have inbuilt feature for conservation of biodiversity, soil and water conservation. Traditional agricultural systems have been more focused since they are sustainable which uses indigenous knowledge, low inputs, and locally available resources. Thus, combining modern agriculture with traditional farming systems, which offer numerous ecosystem services, can not only boost agricultural output but also develop more climate-resilient and sustainable farming methods while preserving and conserving biodiversity. It can also secure livelihood for farmers and promotes environmental sustainability. Even policy makers and other stakeholders must prioritize strategies in order to make the system more efficient for climate change mitigation and adaption.

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Effect of Split Application of Vermicompost on Productivity of Winter Paddy in Assam

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Rice (*Oryza sativa* L.) is the second largest consumed cereal staple food for 60% of Indians and source of livelihood for 120-150 million rural households. During 2020-21, in India, rice was cultivated in an area of 45.07 Mha producing 122.27 MT with a productivity of 2713 kg/ha. Improper nitrogen (N) management in paddy has become a growing concern among the stakeholders of agriculture production around the world. Optimizing N management in agriculture is crucially important for food security, environmental protection as well as sustainable development. In recent times to increase the production in rice, farmers are retorting to blanket fertilization practices specifically nitrogen that leads to imbalanced and inefficient use of nitrogen, wastage of fertilizers and thus hampering soil health. When application of N is non-synchronized with crop demand, N losses from the soil plant system are large (Nayak *et.al*. 2023). Along with chemical fertilizers indigenous sources of nutrients like FYM, vermicompost and biofertilizers should be encourage as it supply plant nutrient, improve the soil biodiversity and thereby increase the productivity and fertility of the soil. Bio-fertilizers is an essential components of organic farming play vital role in maintaining long term soil fertility and sustainability by fixing atmospheric nitrogen. Biofertilizers keep the soil environment rich in all kinds of micro- and macro-nutrients via nitrogen fixation, phosphate and potassium solubalization or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil (Sinha *et al.,* 2014). Vermicompost is the microbial composting of organic wastes by earthworm activity to form organic fertilizers which contain higher level of organic matter, organic carbon, total and available N, P, K and micronutrients, microbial and enzyme activities (Parthasarathi *et al.,* 2007). To study the effectiveness of split application of vermicompost on crop growth and yield as well as soil physicochemical activities an experiment was designed at Research Farm of AAU- Zonal Research Station, North Lakhimpur.

Methodology

Experimental Site and Design

The field experiment was carried out at the experimental farm of the Assam Agricultural University- Zonal Agricultural Research Station (AAU-ZRS, North Lakhimpur), Assam, India ($27^0$14’16’’ N $94^0$08’39’’ E), over three consecutive years from 2020-2022. The experimental design was a Randomized Block Design (RBD) with seven treatments and three replications.

Details of the Treatments:

T1: Control

T2: RDF + Vermicompost @ 1 t/ha at land preparation

T3: RDF + Split application of Vermicompost @ 1 t/ ha (75% at land preparation and 25% at Tillering stage)

T4: INM + Vermicompost @ 1 t/ha at land preparation

T5: INM + Split application of Vermicompost @ 1 t/ ha (75% at land preparation and 25% at Tillering stage)

T6: Enriched vermicompost @ 1t/ ha

T7: Enriched vermicompost @ 2 t/ ha

Half of the N and full P & K were applied in T_2 and T_3 as basal. The remaining half N was applied in two splits in active tillering and PI stage of the crop. Integrated nutrient management (INM) was performed with organic manure @ 1 t/ha (on dry weight basis) mixed inoculum of Azospirillium *amazonense* A-10 and *Bacillus megaterium* P-5 @ 4 kg/ha, rock phosphate @ 10 kg P_2O_5 (56 kg/ha), MOP @ 40 kg K_2O/ha (67 kg Potash/ha). Enriched vermicompost was prepared by incubating 2% mixed inoculum of *Azospirillium amazonense* A-10 and *Bacillus megaterium* P-5 for 15 days and applied as basal.

Results

Three years data reveals that, T_3 *i.e.* RDF + Split application of Vermicompost @ 1 t/ ha (75% at land preparation and 25% at Tillering stage) produced highest yield with the highest B: C ratio (2.82) followed by T4 where INM was practiced with application of vermicompost 1t/ ha as basal (B: C 2.75). The plant height, No. of effective tillers, No. of filled grains/ panicle etc growth attributing parameters are also significantly higher in T3. It may be due to continuous contribution in supplying added plant nutrients due to split application (Aechra *et.al.*)

Pooled yield and yield attributes of paddy (2020- 22)

Treatments	Plant Height (cm)	Noof effective tillers	No of filled grain/panicle	Grain yield t/ha	Straw yield t/ha
T1	120.83	9.75 d	167.64 d	3.82 d	8.67 e
T2	129.076	12.06 bc	218.72 bc	4.71 c	12.00 cd
T3	132.753	13.9 a	274.75 a	5.87 a	16.45 a
T4	127.173	12.44 b	244.12 ab	5.59 b	14.39 ab
T5	127.49	11.88 bc	231.84 abc	5.46 ab	14.01 bc
T6	123.156	11.29 c	187.12 cd	4.426 c	11.213 d
T7	128.81	12.05 bc	198.21 bcd	4.303 cd	10.356 de
CV	3.237	5.09	13.11	6.537	9.8
CD (0.05)	NS	1.079	50.75	0.566	2.17

B: C ratio

Treatments	Vermicompost (Commercial)			Vermicompost (On farm)		
	GC	GR	B:C	GC	GR	B:C
T1	31230.00	74108.00	2.37	31230.00	74108.00	2.37
T2	45400.00	91374.00	2.01	40400.00	91374.00	2.26
T3	45400.00	113878.00	2.51	40400.00	113878.00	2.82
T4	44497.00	108446.00	2.44	39497.00	108446.00	2.75
T5	44497.00	105924.00	2.38	39497.00	105924.00	2.68
T6	41530.00	85864.40	2.07	36530.00	85864.40	2.35
T7	51530.00	83478.20	1.62	41530.00	83478.20	2.01

Conclusion

Split application of vermicompost has tremendous effect on yield and yield attributing characteristics of paddy. In split application, loss of N reduces as well as nutrients get available at proper time for higher productivity.

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Biochar for Boosting Crop Yield and Soil Health in Dryland Agriculture

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Dryland, immense tracts of agricultural land in India are faced with innumerable constraints that curtail agricultural productivity and sustainability. High evapotranspiration rates are a direct correlation of high temperature and lowered humidity, hence a less water availability for the crops. The growing season is mainly short and dictated by the occurrence and amount of rainfall, thus limiting crop grown. Soils found in dryland have low organic matter and essential nutrients to facilitate crop growth and productivity. These soils usually have poor structure, resulting in unsutaible conditions, such as crust phenomena that inhibit infiltration. Understanding of the limitations posed to dryland areas and the implementation of effective strategies overcoming such limitations is very important for sustainable development of agriculture in these regions. Application of biochar improve soil health that, in turn, enhances crop production and helps build resilience against climatic variability. Biochar is rich in carbon having higher porosity and CEC also, biochar increases the pH due to its high pH value (Hussain *et al*. 2017). Additionally, biochar can boost soil carbon stocks, retain soil nutrients, and improve soil fertility which considerably augments crop productivity and crop quality (Basso *et al*. 2013; Khan *et al*. 2022).

Methodology

During rabi season 2023-24, experiment trail was evaluated at the Research Farm of Advanced Centre for Rainfed Agriculture, Rakh Dhiansar of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, J&K. Soil samples were taken oven dried, crushed & sieved. Soil pH was evaluated through 1:2.5 soil/water ratios. The bulk density was estimated through oven-dry mass to volume of the soil (g cm^{-3}).

Results

As shown in table below, numerically higher pH was recorded in B_{12} (7.05) whereas the lower pH was evaluated in B_1 (6.75). Similarly, higher bulk density' was observed in B_1 (1.50 g $cm^{-3.}$) and the lower bulk density was estimated in B_{12} (1.36 g $cm^{-3.}$) and B_6 (1.36 g $cm^{-3.}$). This is likely due to high biochar porosity, which increases soil porosity, reduces its bulk density. It may be due to alkaline pH, of biochar improved the soil pH where as application of synthetic fertilizers formed the acidic conditions which results in lowering the soil pH. Hussain *et al*. (2017) and Khan *et al*. (2022) was also recorded similar findings.

Effect of biochar's applications over soil properties

Treatments	pH	Bulk density (g cm^{-3})
B_0 (Absolute control)	6.94	1.47
B_1 (100% RDF (N, P & K Inorganic))	6.75	1.50
B_2 (*Lantana camara* biochar (2t/ha) + 50%RDF)	6.90	1.39
B_3 (*Lantana camara* biochar (2t/ha) + 100%RDF)	6.95	1.41
B_4 (*Lantana camara* biochar (4t/ha) + 50%RDF)	6.96	1.40
B_5 (*Lantana camara* biochar (4t/ha) + 100%RDF)	6.91	1.40
B_6 (*Lantana camara* biochar (6t/ha) + 50%RDF)	7.02	1.36
B_7 (*Lantana camara* biochar (6t/ha) + 100%RDF)	6.95	1.39
B_8 (*Adhatoda vasica* biochar (2t/ha) + 50%RDF)	6.94	1.40
B_9 (*Adhatoda vasica* biochar (2t/ha) + 100%RDF)	6.89	1.43
B_{10} (*Adhatoda vasica* biochar (4t/ha) + 50%RDF)	6.96	1.40
B_{11} (*Adhatoda vasica* biochar (4t/ha) + 100%RDF)	6.95	1.41
B_{12} (*Adhatoda vasica* biochar (6t/ha) + 50%RDF)	7.05	1.36
B_{13} (*Adhatoda vasica* biochar (6t/ha) + 100%RDF)	6.96	1.39
B_{14} (FYM (25% N) + 75%RDF)	6.98	1.38
B_{15} (FYM (50% N) + 50%RDF)	6.96	1.37
SE(m)	0.047	0.059
CD	NS	NS

The analysis of wheat yield attribute and yield across various treatment shown in table 2, indicates that significantly higher effective tillers were found in treatment b_{13} (392.6) which further followed by treatment b_{12} (376.3) and b_6 (377.7). In case of grain yield significantly higher grain yield was recorded in b_{13} (4780.25 kg ha^{-1}) is at par to b_7 (4720.22 kg ha^{-1}) which is further followed by b_6 (4459.49 kg ha^{-1}) and b_{12} (4466.14 kg ha^{-1}) whereas significantly lower grain yield recorded in b_0 (2991.82 kg ha^{-1}) is at par with b_2 (3200.11 kg ha^{-1}). The analysis of straw yield shows that treatment b_{13} (5713.58 kg ha^{-1}) produced statistically higher straw yield, closely followed by treatment b_7 (5653.55 kg ha^{-1}). In contrast, treatment b_0 (3925.15 kg ha^{-1}) yielded significantly lower straw output which is at par to treatment b_2 (4133.44 kg ha^{-1}). Wang *et al*. (2019) and, Zhang *et al*. (2016) also evaluated similar result.

Effects of biochar application on yield attribute and wheat yield.

Treatments	Effective tillers (m^{-2})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
B_0 (Absolute control)	228.67^{g}	2991.82^{f}	3925.15^{f}
B_1 (100% RDF (N, P & K Inorganic))	345.67^{cd}	4108.32^{bc}	5041.65^{bc}
B_2 (*Lantana camara* biochar (2t/ha) + 50%RDF)	257.33^{fg}	3200.11^{f}	4133.44^{f}
B_3 (*Lantana camara* biochar (2t/ha) + 100%RDF)	316.33^{cde}	3498.32^{ef}	4431.65^{de}
B_4 (*Lantana camara* biochar (4t/ha) + 50%RDF)	345.67^{d}	3775.55^{cd}	4708.88^{cde}
B_5 (*Lantana camara* biochar (4t/ha) + 100%RDF)	364.33^{c}	3839.82^{cd}	5026.15^{bc}
B_6 (*Lantana camara* biochar (6t/ha) + 50%RDF)	377.67^{ab}	4459.49^{b}	5392.82^{ab}
B_7 (*Lantana camara* biochar (6t/ha) + 100%RDF)	287.67^{ef}	4720.22^{a}	5653.55^{a}
B_8 (*Adhatoda vasica* biochar (2t/ha) + 50%RDF)	312.67^{de}	3240.32^{ef}	4173.65^{ef}
B_9 (*Adhatoda vasica* biochar (2t/ha) + 100%RDF)	328.67^{d}	3520.20^{def}	4453.53^{de}
B_{10} (*Adhatoda vasica* biochar (4t/ha) + 50%RDF)	356.33^{cd}	3823.23^{cd}	4756.56^{cd}
B_{11} (*Adhatoda vasica* biochar (4t/ha) + 100%RDF)	365.00^{bc}	4140.00^{c}	5073.33^{bc}
B_{12} (*Adhatoda vasica* biochar (6t/ha) + 50%RDF)	376.33^{ab}	4466.14^{b}	5399.47^{ab}
B_{13} (*Adhatoda vasica* biochar (6t/ha) + 100%RDF)	392.67^{a}	4780.25^{a}	5713.58^{a}
B_{14} (FYM (25% N) + 75%RDF)	364.67^{b}	4092.82^{bc}	4773.15^{cd}
B_{15} (FYM (50% N) + 50%RDF)	351.33^{bc}	4440.22^{ab}	5373.55^{ab}
SE(m)	9.58	102.97	145.59
CD	27.82	298.85	425.65

Conclusion

In dryland condition, the biochar help to retains nutrient and prevent their loss through leaching is vital for maintaining fertility of soil and ensuring sustainable crop productions. Furthermore, use of biochar can reduce the need for chemical fertilizers, thereby lowering agricultural inputs and minimizing environmental pollution. This highlights the need for biochar in India's dryland agriculture as a multifaceted tool to improve soil health, and promote sustainable agricultural practices.

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Impact of Differential Substitution of Nutrients Through Organics on System Productivity and Soil Microbial Population in Rice Based Cropping System under Subtropical Shiwalik Foothills

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Rice based cropping system is the foremost food production system in the world with rice as the main crop. The cereal-cereal based cropping system is low-yielding and highly nutrient exhaustive resulting in declining of soil fertility .Therefore, crops that can improve the fertility status should be included in the cropping system. Diversification of rice based cropping system with inclusion of pulses/legumes and a short duration vegetable is one of the best options for horizontal expansion. Furthermore, imbalanced and inappropriate use of inorganic nutrients devoid of requisite quantity of organics has not only worsened the soil resource base by reducing the population of beneficial micro-organisms and the factor productivity of most of the crop lands but also deteriorated the quality of the crops. Further, it is not affordable for an average Indian farmer to jump immediately from inorganic source of nutrients to organics in their crop production programme as it may lead to unbearable drastic reduction in crop yields in the initial years. This may become possible through the differential substitution of organic sources of nutrients in place of inorganics to meet crop nutrient requirement for attaining higher and stable crop yield of better quality with an improvement in soil health. Therefore, high diversified and intensified cereal-vegetable-vegetable-legume cropping system was studied for two years under irrigated shiwalik foothills.

Methodology

The experiment was conducted for two years from *kharif* 2015-Summer 2017 at research farm of Division of Agronomy at Skuast-Jammu. The soil of the experimental field was sandy clay loam in texture with slightly alkaline in reaction (pH 7.81) Organic carbon (0.45 percent) and available nitrogen (249.88 kg/ha).The experiment was laid out in randomized block design with sixteen treatments.T_1-100 % NPK (Recommended dose of fertilizer), T_2-75% NPK+25% N through vermicompost,T_3-50% NPK+50 % N through vermicompost, T_4-25 % NPK+75% N through vermicompost, T_5-100 % N through vermicompost, T_6-25 % yearly replacement of RDF through vermicompost on N basis ,T_7-75 % NPK+ 25 % N through Fym ,T_8-50 %NPK+50% N through Fym , T_9-25% NPK+75% N through Fym ,T_{10}-100% N through Fym, T_{11}-25% yearly replacement of RDF through Fym on N basis, T_{12}-75 % NPK+25 % N through vermicompost and Fym (1:1), T_{13}-50 % NPK+50 % N through Vermicompost and Fym (1:1), T_{14}-25% NPK+75% N through vermicompost and Fym (1:1), T_{15}-100% N through vermicompost and Fym (1:1) , T_{16}-25% yearly replacement of RDF through vermicompost and Fym (1:1) on N basis. Four crops rice (Basmati rice), knolkhol (G40), knolkhol(G40) and green gram (SML-668) were taken in sequence for two years. All the crops taken in the system were grown as per their respective recommended packages of cultivation except for the nutrient-N and its organic sources which were applied as per the treatments.System productivity on grain yield basis in terms of rice equivalent yield (REY) was worked out by pooling the rice equivalent yields calculated separately for all the three crops in sequences of rice consecutively for two cropping years from *kharif* 2015 tosummer 2017.

Results

In rice based cropping system, significantly highest system productivity (592.88 q/ha) was recorded with treatment 100% N through recommended dose of nitrogen which was found statistically at par with system productivity recorded with treatment T_{12}, T_{16}, T_2, T_6, T_7 andT_{11} .Highest system productivity in treatment T_1 was might be due to higher yield of knolkhol-1, knolkhol-2 and green gram crop under this treatment which wholly contributes towards highest system productivity in rice-based cropping system Similar findings were also reported by Singh and Chandra (2011).

Soil bacterial, fugal and actinomycetes population did not show any significant changes with the differential substitution of nutrients through organics rice based cropping system after two crop cycles but, an increase in soil microbial population was recorded in each treatment after two crops cycle over its initial value as illustrated in Table 1. However, the highest increase in soil bacterial, fugal and actinomycetes population was recorded with treatment 100 % N through FYM followed by treatment T_5 followed by treatment T_5. The increase in microbial population was might be due to available of high organic matter in these treatments. Similar results were also reported by and Das et al., (2008) and Bisht*et al.,* (2013).

Effect of differential substitution of nutrients through organics on System productivity and soil microbial population after two crop cycles

Treatments	System Productivity (q/ha)	Bacteria $\times 10^6$ cfu	Fungi$\times 10^3$ cfu	Actinomycetes$\times 10^4$ cfu
T_1	592.88	30.56	10.94	5.41
T_2	578.00	31.79	11.29	5.58
T_3	478.30	33.37	12.25	5.88
T_4	390.92	34.29	12.95	6.18
T_5	441.86	35.77	13.45	6.35
T_6	575.87	32.64	11.44	5.63
T_7	566.64	32.96	11.59	5.71
T_8	475.60	33.69	12.46	5.93
T_9	389.27	34.64	13.12	6.22
T_{10}	439.76	35.92	13.63	6.41
T_{11}	565.43	32.98	11.82	5.77
T_{12}	587.23	30.90	11.00	5.47
T_{13}	484.19	33.11	12.13	5.82
T_{14}	394.88	33.94	12.68	6.09
T_{15}	447.17	35.35	13.24	6.26
T_{16}	583.88	31.33	11.12	5.56
SEm (+)	28.24	1.36	0.85	0.73
LSD(P=0.05)	81.55	N.S	N.S	N.S
Initial		27.79	10.44	5.17

* cfu- colony forming units, Detail of treatments were present in material methods

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Polymulch Technique: A Boon for Agriculture in Hilly Areas

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Mulching in other term means 'covering the soil'. Mulching is the practice of covering the ground and soil for making the favourable conditions for the growth and development of the plant as well as for the efficient crop production. Mulching has many beneficial effects due to which it becomes more significant practice in modern field production like reducing the crop weed competition, soil temperature, moisture conservation, certain insect pests' reduction, increase in crop yield and using the soil nutrients more efficiently (Sharma and Kathiravan, 2009; Angmo et al. 2018 and Acharya et al. 1998). It also has many interesting effects relevant with soil ecosystem, crop growth and climate. Mulching is an important breakthrough that can transform traditional agriculture into modern agriculture by helping to circumvent many of the limitations of temperature and moisture. Plastic film is used to cover the surface of the soil in order to increase the temperature, to retain moisture, and to promote the germination of seeds. In hilly areas such as Champawat where agriculture predominantly rainfed, the polymulch has greater relevancy as compared to plain areas (Das et al. 2022). Uttarakhand is a hill state situated in the North-Western Himalayas of India, blessed with naturally occurring agro-climatic regions suitable for cultivation of a wide range of vegetable crops with great potential for income generation. Cultivation of vegetables such as Capsicum, Cabbage and Cauliflower plays a major role in determining the economic development of farmers. In Champawat district the majority of small-scale farmers use traditional method of capsicum cultivation, which results in low yields and are vulnerable to drought, heat, diseases etc. Polymulch, a versatile agricultural tool, has revolutionized vegetable cultivation by significantly improving growth, yield, and overall crop quality. The benefits of the introduction of Polymulch are higher yields and farmer incomes due to the better adaptability of the crops to the environment in which they are grown and the increased resilience of cropping systems to climate-related risks (Nautiyal et al. 2017; Sharma and Kathiravan, 2009 and Choudhary et al. 2022).

Methodology

Demonstrations of Capsicum (Var. California Wonder) was conducted involving 25 farmers during two seasons i.e. 2022-23-2023-24 in 0.6 ha area in the NICRA project adopted village Tyarsoo (Latitude-29.392453; Longitude-80.021484; Altitude-1754m) Pati block of Champawat district, Uttarakhand. The plot of land to be planted is prepared first by fertilizing it with a mixture of soil, compost, or farmyard manure. The soil is gathered into parallel ridges, preferably 20 m long, 1 m wide, and 10–20 cm high; the distance between two ridges being 40–50 cm. Plastic film is used to cover the ridges and anchored into the ground. Round holes are punched in the film at regular intervals. Some soil is excavated through the holes and the seedlings are planted through the holes and thoroughly watered (Angmo et al. 2018). The holes in the plastic are sealed using soil. When the crops are harvested all residue was removed.

Result

Depending on local conditions and on whether the plastic film is still viable, the plastic-covered ridges are reused to grow another crop without replacing the film. The result showed that the production of Capsicum (Var. California Wonder) was 24.06% higher as compared to capsicum produced without using the polymulch technique, yielding around 92.50 and 74.56 q/ha, respectively. The use of black polyethylene mulch increased capsicum yield by 1.3 to 9.0-fold, depending on the variety and environmental conditions (Angmo et al. 2018).

Impact of Polymulch in Capsicum crop at NICRA village (2022-23-2023-24)

Capsicum (CW) + Polymulch			Capsicum (CW)		
Area (ha)	Productivity (q/ha)	Net return (Rs. /ha)	Area (ha)	Productivity (q/ha)	Net return (Rs. /ha)
0.6	92.50	4,47,440	3.5	74.56	3,67,411

Conclusion

As polymulch techniques has several advantages especially in hilly areas there is need for creating more awareness among farmers regarding its benefits. Thus, polymulch should be available to farmers at subsidized rates by district Horticulture Department. Polymulch has proven to be a valuable tool for sustainable vegetable production. By understanding its principles and selecting the appropriate type of mulch, farmers can optimize crop growth, improve yields, and reduce environmental impact. As agricultural technology continues to advance, polymulch remains a reliable and effective solution for enhancing vegetable cultivation.

Demonstrations of Polymulch Technique at NICRA Village

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Evaluation of Nitrogen Fractions under Diverse Farming Practices in Sandy Loam Soil of Telangana

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Soil fertility is a cornerstone of sustainable agriculture, with nitrogen playing a pivotal role in determining crop productivity. In India, where a significant portion of agriculture is rainfed, understanding the dynamics of nitrogen fractions under different farming practices is critical. Nitrogen is found in various forms in the soil, broadly inorganic and organic forms out of which organic N accounts for about 95%. But, plants can only take up the inorganic form (NH_4^+ and $N0_3^-$). The dominant form of nitrogen uptake by the plant is NO3-N, accounting for 75-85% of the total nitrogen uptake. In contrast, NH4+-N contributed 16.4% in the first season and 21.5% in the second season (Iqbal *et al.,* 2020). It is essential to measure the native plant-available nitrogen in the soil and the potential nitrogen mineralized from soil organic nitrogen during the growing season to precisely determine the additional nitrogen required. Nitrogen fractions are appreciably affected by the different crop management practices. The role of organic manures in supplying plant nutrients, particularly N is most prominent. There is built of NO_3^- -N and NH_4^+ -N under integrated and organic nutrient management practices irrespective of cropping system when compared to inorganic nutrient management practices (Vidyavathi *et al.,* 2021).This study was conducted during the *Kharif* 2023 season to evaluate the impact of various farming practices on nitrogen fractions in sandy loam soils at the Central Research Institute for Dryland Agriculture, Hyderabad, Telangana. The findings provide insights into the comparative effectiveness of natural, organic, integrated, and conventional farming systems, with a focus on their implications for soil health and sustainable agriculture.

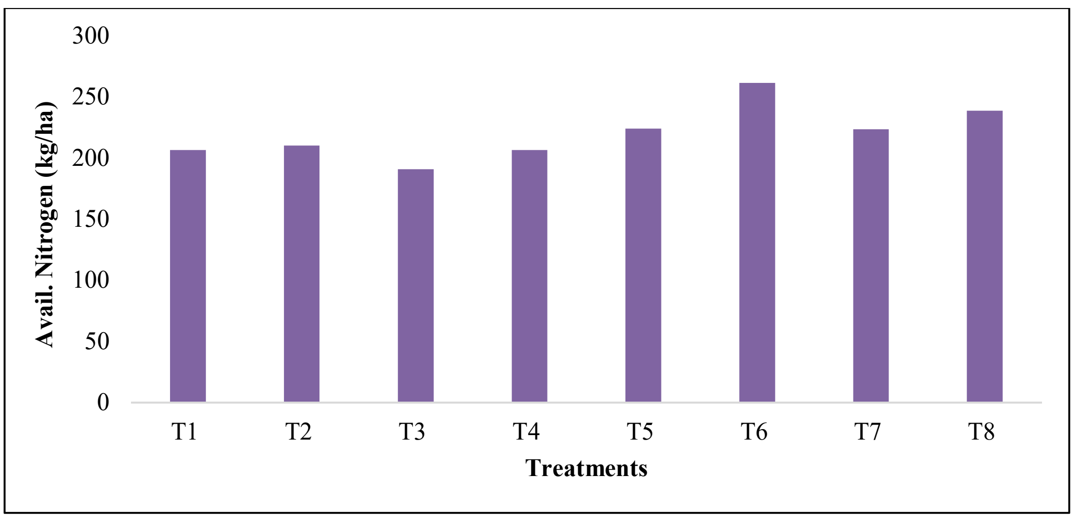
Methodology

The field experiment was conducted in *Kharif* 2023, at the Natural Farming Research Block, in the Central Research Institute for Dryland Agriculture, Hayathnagar Research Farm, Hyderabad, Telangana. The soil at the experimental plot was Sandy Loam. The experiment was laid out in a Randomized Block Design with 8 treatments and 3 replications. The treatments were i) Natural Farming (NF) ii) Organic Farming iii) Organic Farming + Ghanjeevamruth, iv) Integrated Crop Management v) Integrated Crop Management + Ghanjeevamruth vi) Conventional/Inorganic Farming vii) Conventional/Inorganic Farming + Ghanjeevamruth viii) Control. Soil samples were collected at both sowing and harvesting stages of sorghum to analyze their nitrogen fractions. Available nitrogen was determined using the alkaline permanganate method (Subbiah and Asija, 1956), while inorganic nitrogen fractions were measured using steam distillation (Black, 1965). Significant differences among treatments were identified using the Least Significant Difference (LSD) test at $p < 0.05$.

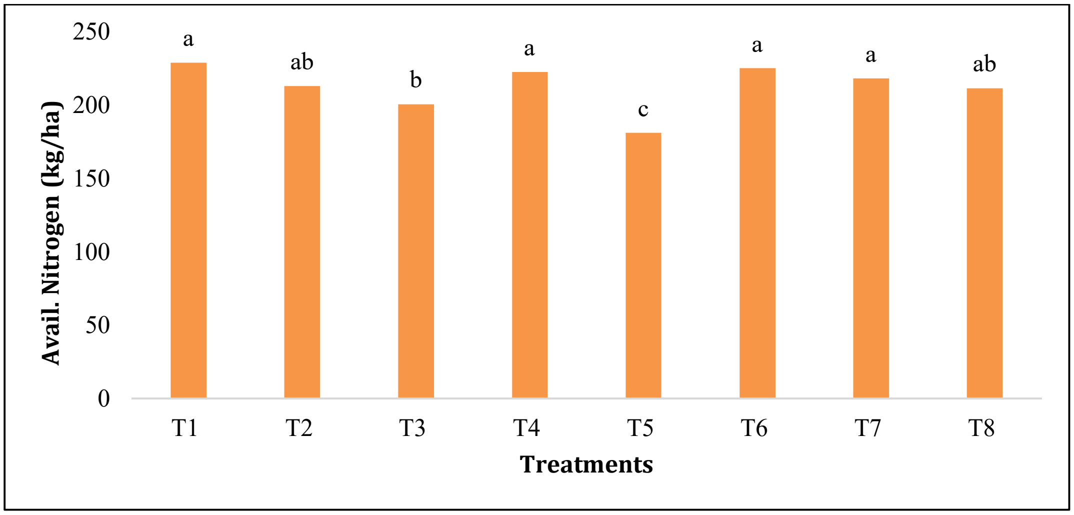
Results

The study demonstrated significant variation in available nitrogen content across the different farming practices, reflecting the influence of these practices on soil fertility and nutrient cycling. Among the initial soil samples, the highest available nitrogen was recorded in T6 (Conventional/Inorganic Farming) at 261.50 kg/ha, followed by T8 (Control) with 246.78 kg/ha, and T5 (Integrated Crop Management + Ghanjeevamruth) with 224.16 kg/ha. These differences suggest that certain farming practices, particularly those involving conventional inorganic fertilizers, may contribute to higher nitrogen availability in the short term. The use of synthetic fertilizers in T6 likely led to increased nitrogen levels in the soil, as inorganic fertilizers provide readily available forms of nitrogen, such as nitrate, which can be directly absorbed by plants (Abebe *et al.,* 2022). Although the Control treatment did not receive any added fertilizers or amendments, the soil's inherent nitrogen levels were sufficient for plant growth, possibly due to nitrogen cycling processes such as mineralization and biological fixation (Bender *et al.,* 2016). This finding highlights the importance of soil organic matter and microbial activity in maintaining nitrogen availability, even without external inputs.

The available nitrogen (N) content in the soil demonstrated significant variation among the treatments, reflecting the impact of different farming practices on nitrogen availability. In the soil samples collected after harvest, the highest nitrogen levels were observed in T1 (Natural Farming) at 229 kg/ha, T6 (Conventional/Inorganic Farming) at 225.18 kg/ha, T4 (Integrated Crop Management) at 222.66 kg/ha, and T7 (Conventional/Inorganic Farming + Ghanjeevamruth), all of which were statistically similar. In contrast, the lowest nitrogen content was recorded in T5 (Integrated Crop Management + Ghanjeevamruth) at 181.11 kg/ha, which was significantly lower than other treatments. The lower available nitrogen in T5 (Integrated Crop Management with Ghanjeevamruth) at certain stages could be because of the sorghum crop under T5 might have demonstrated vigorous growth, resulting in higher nitrogen uptake compared to other treatments. This would explain the reduction in available nitrogen in the soil at the harvest stage (Lalrintluangi *et al.,* 2019; Sarwar *et al.,* 2011).



Available Nitrogen(kg/ha) of the initial soil samples of different treatments



Available Nitrogen (kg/ha) of soil samples after harvest of different treatments.

Different small letters on top of the bar indicate significant differences among treatments performed with Least significance difference test ($p < 0.05$)

T1- Natural Farming (NF), **T2**- Organic Farming, **T3**- Organic Farming + Ghanjeevamruth, **T4**- Integrated Crop Management, **T5**- Integrated Crop Management + Ghanjeevamruth, **T6**- Conventional/Inorganic Farming, **T7**- Conventional/Inorganic Farming + Ghanjeevamruth and **T8**- Control.

Ammonium nitrogen is more likely to be rapidly converted to nitrate or leached, resulting in lower levels of ammonium after harvest, but potentially higher nitrate concentrations (Follett et *al.,* 2008). Inorganic systems often have higher risk of nutrient loss due to these processes. Ammonium in organic farming systems tends to be more stable and available over a longer period, due to slower release rates and microbial immobilization.

In organic based farming systems, nutrients are primarily derived from organic matter such as compost, manure, crop residues, and green manures. The process of decomposition is slower compared to synthetic fertilizers, leading to a gradual release of nitrogen (including nitrate) into the soil. Organic nitrogen sources are mineralized over time, so nitrate levels in the soil may be lower at harvest as nitrogen release is spread out through the growing season (Drinkwater *et al.,* 1995). In contrast, inorganic fertilizers provide readily available forms of nitrogen, leading to a more immediate increase in soil nitrate levels (Pandey *et al.,* 2017).

Conclusions

Organic based farming systems focus on enhancing soil organic matter and fostering microbial diversity may result in better long-term nitrogen retention, with ammonium being retained in organic forms or released more gradually over time. In contrast, inorganic farming systems, with their reliance on synthetic fertilizers, may experience a more "boom-and-bust" cycle of nitrogen availability, leading to higher short-term nitrogen concentrations and potential environmental risks.

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Rain Water Harvesting and Supplemental Irrigation to Groundnut + Pigeon Pea Inter-Cropping in Scarce Rainfall Zone of Andhra Pradesh

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In Andhra Pradesh, groundnut is cultivated in an area of 5.55 lakh hectares during Kharif mainly in Rayalaseema region of Andhra Pradesh. In Ananthapuramu district, though the normal rainfall is 552 mm, there is variability in amount as well as in rainfall distribution, influencing the groundnut pod yields to a greater extent. Among the abiotic stresses, drought (moisture stress) is the major factor influencing the yield of rainfed crops. Variation in crop yields is more in dry lands due to no receipt of timely rainfall and prolonged dry spells during crop periods. Added to that, the occurrence of high intense rainfall events with short duration leading to loss of rainwater through runoff are very common in the district. Hence, harvesting surplus runoff in farm ponds and recycling the same for providing supplemental irrigation to *kharif* crops is proved to be the most successful climate resilient technology for adoption in the present-day scenario due to climate change. Further studies have demonstrated that groundnut + pigeonpea (8;1) intercropping systems can reduce interspecifc competition and improve overall system productivity. Since prolonged dry spells during pod and kernel development stages can cause irrevocable loss in pod yield and one or two supplemental irrigations during these critical stages are known to increase the yield (Yellamanda Reddy *et al* ., 2020). Based on these lines, field experiment was conducted on groundnut + pigeonpea intercropping with supplemental irrigation from harvested water to increase system productivity as adaptation and mitigation strategies.

Methodology

Field experiment was conducted for five years during Kharif 2017 to 2021 on groundnut + pigeonpea (8:1) intercropping with eight treatments tested in RBD with three replications on Alfisols at AICRPDA, ARS, Ananthapuramu. The treatments consist of sole groundnut (K6) (T1), groundnut + pigeonpea (PRG-176) 8:1 (T2), groundnut + pigeonpea 15:1 (T3), Sole groundnut with two irrigations of each 20 mm at flowering and pod filling during dry spell (T4), groundnut + pigeonpea 8:1 two irrigations of each 20 mm at flowering and pod filling in groundnut and pigeonpea (furrow) (T5), groundnut + pigeonpea 8:1 two irrigations of each 20 mm at flowering & pod filling in groundnut and pigeonpea (drip) (T6), groundnut + pigeonpea 15:1 two irrigations of each 20 mm at flowering and pod filling in groundnut and pigeonpea (furrow) (T7) and groundnut + pigeonpea15:1 two irrigations of each 20 mm at flowering and pod filling in groundnut and pigeonpea (drip) (T8). Supplemental irrigation was given with harvested furrow) water as per the treatments by sprinkler to groundnut and drip and furrow irrigation to pigeonpea. During 2018-19 pigeonpea crop was failed. An amount of 480-, 226,575,504- and 379-mm rainfall in 27,11,20,39 and 25 rainy days during crop season of 2017 to 2021 respectively.

Results

The pooled data of five years (Table) indicated that, two supplemental irrigation (sprinkler) to sole groundnut (T4) of each 20 mm at flowering and pod filling stage recorded higher groundnut pod equivalent yield (1475 kg/ha), followed by intercropping of groundnut +pigeonpea (15:1) (T7) with two supplemental irrigations of each 20 mm at flowering and pod filling to groundnut (sprinkler) and pigeonpea (furrow) (1453 kg/ha) and intercropping of groundnut + pigeonpea (8:1) with two supplemental irrigations (T5) of each 20 mm at flowering and pod filling to groundnut (sprinkler) and pigeonpea (furrow) (1439 kg/ha).

Two supplemental irrigations (sprinkler) to sole groundnut (T4) of each 20 mm at flowering and pod filling stage recorded 14 percent higher groundnut pod equivalent yield compared to rainfed groundnut. Intercropping of groundnut +pigeonpea 15:1(T7) and 8:1 (T5) with two supplemental irrigations of each 20 mm at flowering and pod filling to groundnut (sprinkler) and pigeonpea (furrow) recorded 20 and 19 percent higher groundnut equivalent yield compared to respective rainfed intercropping systems. Sahadeva Reddy *et al*., (2020) reported that two supplemental irrigations each at pegging and pod development stage of 10 mm and 20 mm significantly increased the pod yields by 12% and 26%, respectively as compared to rainfed crop.

Groundnut equivalent yield (kg/ha) in groundnut + pigeonpea (8:1) inter cropping system with supplemental irrigation of harvested rain water from farm pond during 2017 to 2021

Treatments	2017	2018	2019	2020	2021	Mean
T1-Sole groundnut	2224	1023	1553	675	1005	1296
T2- Groundnut + pigeonpea (8:1)	2034	868	1613	697	852	1213
T3- Groundnut + pigeonpea (15:1)	1998	706	1716	726	904	1210
T4- Sole groundnut with two irrigations	2384	1561	1592	686	1154	1475
T5- Groundnut + pigeonpea (8:1) two irrigations in groundnut and pigeonpea (furrow)	2823	957	1551	808	1054	1439
T6- Groundnut + pigeonpea (8:1) two irrigations in groundnut and pigeonpea (drip)	2712	938	1563	794	1065	1414
T7- Groundnut + pigeonpea (15:1) two irrigations in groundnut and pigeonpea (furrow)	2646	1035	1668	822	1093	1453
T8- Groundnut + pigeonpea (15:1) two irrigations in groundnut and pigeonpea (drip)	2513	1023	1671	798	1102	1421

Conclusion

Two supplemental irrigations with harvested rain water during dry spells either to sole groundnut (sprinkler) or intercropped with pigeonpea (furrow) in 8:1 or 15:1 each 20 mm at flowering and pod filling stage recorded higher groundnut pod equivalent yield compared to rainfed .

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Biochar: Potential Ameliorant for Enhancing the Quality and Productivity of Low Ph Soils in Eastern Himalayan Region

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Hill Agriculture cropping systems of Eastern Himalayan Region (EHR) are frequently challenged by acid soil induced edaphic stresses with intermittent dry spells**.** This study examines the efficient utilization of locally available biomass and crop residues for biochar production and its subsequent effects on soil quality and carbon dynamics in a maize and upland rice-based cropping system. Biochars were produced from maize residue, weed biomass (*Lantana camara, Chromolaen aodorata, Eupatorium* sp.), and pine wood, and applied at rates of 0, 5, 10, and 20 t/ha. The biochars displayed distinct physical and chemical properties influencing their performance. Weed biochar had a pH of 9.83, total organic carbon (TOC) of 37.5%, and high potassium (6.14%), while maize biochar showed moderate potassium (1.98%) and a higher TOC (45.7%). Pine biochar had the lowest pH (5.84) but the highest TOC (55.9%) and minimal potassium (0.21%). BET surface area, total pore volume, and pore size were higher for weed biochar, enhancing soil physical interactions. These variations in surface area and porosity are expected to influence nutrient retention and water-holding capacity in soils. Maize treated with weed biochar at 20 t/ha exhibited a significant yield increase (4.58 t/ha) and longer cob length (17.7 cm) over control (4.22 t/ha). During rabi, French bean treated with 20 t/ha weed biochar produced higher pod numbers (15.8) and leaf area index (3.74). In kharif rice, maize biochar (10 t/ha) and weed biochar (20 t/ha) enhanced panicle weight (2.34–2.94 g) and grain yield (3.42–3.53 t/ha), with weed biochar promoting higher filled grains per panicle (143.8). Rapeseed grown after rice recorded higher yields with weed biochar at 20 t/ha (1537.9 kg/ha) compared to maize biochar (1295.4 kg/ha). Maize recorded the highest photosynthetic rate (56.6 μmol/m²/s) and transpiration (13 mmol/m²/s) under weed biochar at 20 t/ha, while rice showed notable improvements with weed biochar @20t/ha (30.1 μmol/m²/s) and maize biochar (28.3 μmol/m²/s). Enhanced transpiration and water uptake were linked to altered root architecture as influenced by biochar and soil moisture retention was also higher under weed biochar at 20 t/ha, supporting better crop performance in moisture-limited conditions of EHR.

Methodology

Field experiments were conducted at the ICAR Research Complex for NEH Region, Umiam, Meghalaya. Treatments included biochar application at 0, 5, 10, and 20 t/ha in maize (RCM

1-61)–French bean (Selection 9) and rice (IURON 514)–mustard (TS-46) cropping systems. Fertilizer treatments included 100% recommended doses (RDF) and combinations with farmyard manure (FYM). Soil pH, moisture retention, and nutrient availability were evaluated with standard procedures. The biochar produced from these feed stocks was characterized for physico-chemical properties, including pH, TOC, NPK, surface area (m²/g), and pore volume (cc/g). Functional groups were analyzed to understand chemical interactions using FT-IR. The external shape and dimensions of the biochar were studied using Scanning Electron Microscopy (SEM) with Energy Dispersive X-Ray Analysis (EDAX).The primary objectives of this study are to evaluate the effects of different biochar feed stocks and application rates on soil physic-chemical properties and to assess the impact on crop productivity across multiple cropping cycles.

Results

Biochar application improved soil physicochemical properties by increasing soil pH by 0.26–0.30 units and enhancing soil organic carbon (SOC) from 1.62% to 1.7–1.74%, while weed biochar showed higher available nitrogen (21.3 mg/kg), phosphorus (3.68 mg/kg), and potassium (20% increase) compared to control. It also reduced exchangeable aluminum and boosted microbial biomass carbon and enzyme activities. In terms of crop productivity, maize treated with weed biochar at 20 t/ha exhibited a significant yield increase (4.58 t/ha) and longer cob length (17.7 cm) over control (4.22 t/ha). In rice, maize biochar (10 t/ha) and weed biochar (20 t/ha) enhanced panicle weight (2.34–2.94 g) and grain yield (3.42–3.53 t/ha), with weed biochar promoting higher filled grains per panicle (143.8). Rapeseed grown after rice recorded higher yields with weed biochar at 20 t/ha (1537.9 kg/ha) compared to maize biochar (1295.4 kg/ha). Similarly, French bean treated with 20 t/ha weed biochar produced higher pod numbers (15.8) and leaf area index (3.74). Biochar application, particularly weed biochar at 20 t/ha, significantly increased photosynthetic rates and transpiration, as observed through Infra-red gas analyzer (IRGA) measurements. Maize recorded the highest photosynthetic rate (56.6 μmol/m²/s) and transpiration (13 mmol/m²/s) under weed biochar at 20 t/ha, while rice showed notable improvements with weed biochar (30.1 μmol/m²/s) and maize biochar (28.3 μmol/m²/s). Enhanced transpiration and water uptake were linked to altered root architecture influenced by biochar. Soil moisture retention was also higher under weed biochar at 20 t/ha, supporting better crop performance in moisture-limited conditions. Carbon dynamics studies revealed reduced CO_2 emissions and enhanced carbon stability through biochar application, highlighting its potential to mitigate greenhouse gas emissions and promote sustainable soil management.

Conclusion

Biochar application, particularly from weed biomass at 20 t/ha, significantly improved soil fertility, crop yields, and moisture retention. It also enhanced photosynthesis and transpiration rates, demonstrating its role in optimizing crop water use. Further future studies should evaluate long-term impacts on soil health and productivity to support widespread adoption in sustainable agriculture systems.

UID: 1612

Nutrient Uptake by Maize as Influenced by the Application of Fertilizers, FYM, and Lime in an Acid Alfisol of Himachal Pradesh

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Maize (*Zea mays* L.), globally known as the "queen of cereals", is one of the most versatile crops grown under a wide range of agro-climatic conditions. Due to its far-reaching distribution, diverse climatic adaptability and high income generation capacity, maize plays varied and vital roles in global agri-food systems and food security, especially in developing countries like India. Nationwide, maize is the third most important crop after wheat and rice and grown on 11.2 million ha with a production of 37.67 million metric tonnes, whereas in Himachal Pradesh, maize is grown in 0.25 million ha with a production of 0.61 million metric tonnes (UPAg, 2024). Amidst the pursuit of augmenting maize yield, imbalanced fertilization and intensive cropping are adversely influencing production potential leading to yield decline or stagnation. Soil acidity is also a severe constraint that has a detrimental effect on agricultural productivity and sustainability. Maize crop is highly susceptible to acidic soil due to the direct impact of low pH levels on its physiological functions. In acid soils, aluminium toxicity first affects root growth and then nutrient uptake and consequently aboveground biomass accumulation. Monitoring soil pH is crucial for achieving optimum crop productivity. The use of lime is a potential option for the sustainable management of soils to increase the productivity of maize (Bharti et al. 2021; Islam et al. 2021). Hence, achieving higher maize yield along with maintaining soil health and sustainability requires a proper soil management approach involving the judicious use of fertilizers, manures, and amendments. The study aims to investigate the combined effects of these amendments, offering insights into region-specific strategies for enhancing maize nutrient uptake in acidic soils.

Methodology

The experiment was conducted in an acid soil (pH 5.49) at Palampur, Himachal Pradesh, during *kharif* 2021 in an on-going on-going experiment which is in progress since *kharif* 2019. It was designed with eleven treatments comprising different combinations of 100% NPK, farmyard manure (FYM; 5 and 10t ha^{-1}), and lime [100% and 1/10th lime requirement (LR)], Natural Farming and control, replicated three times in a randomized block design. The details of the treatments are provided in table. After the harvest of maize, grain yield was recorded on plot basis at 15.5 per cent moisture level and then converted into quintals per hectare (q ha^{-1}). The stover yield was recorded on dry weight and expressed as q ha^{-1}. The nutrient uptake was calculated by multiplying per cent concentration of a particular nutrient with grain and stover yield.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \text{Nutrient content (\%) x yield (q ha}^{-1}\text{)}$$

The ANOVA (analysis of variance) for randomized block design was performed in R using the 'aov' function. The Fischer's Least Significant Difference test using the 'LSD test' function was performed to determine the grouping of means at 95% probability.

Results

The combined application of FYM and lime with 100% NPK resulted in significant improvement in the N, P, and K uptake by maize grain and stover over the rest of the treatments (Table). Higher nutrient uptakes were recorded by the application of 100% NPK + 10 t FYM ha^{-1} + lime incorporation @ 100% LR (T_8). When compared to 100% NPK+ 10 t FYM ha^{-1} (T_4), T_8 recorded 59, 77, and 53% higher N, P, and K uptake by maize grains, respectively, while stover uptake was increased by 61, 90, and 64%, respectively. Similarly, T_8 recorded 71, 80, and 74% higher grain N, P, and K uptake over T_5 (100% NPK+ lime incorporation @ 100% LR), respectively and 74, 106, and 83% in case of stover uptake, respectively.

Conclusion

Combining farmyard manure and lime with inorganic fertilizers in acidic soil significantly improved the nutrient uptake in maize grain and straw. Hence, an integrated approach in acid soil management is essential for optimizing the nutrient uptake without compromising soil health and sustainability in acid Alfisol of Himachal Pradesh.

Growth of maize under different treatments

Effect of fertilizers, FYM, and lime on nutrient uptake by maize

Treatment	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})	
	Grain	Stover	Grain	Stover	Grain	Stover
T_1: Control	9.7 i	4.5 h	2.3 h	0.9 f	1.1 f	5.9 g
T_2: 100% NPK	28.6 g	14.8 f	7.4 f	2.7 e	3.9 e	15.2 f
T_3: 100% NPK+ 5 t FYM ha^{-1}	40.6 f	19.2 ef	10.4 e	3.6 e	5.5 de	21.1 e
T_4: 100% NPK + 10 t FYM ha^{-1}	57.4 d	27.7 c	14.5 d	5.5 d	8.6 bc	34.8 d
T_5: 100% NPK+ lime incorporation @ 100% LR	53.2 de	25.6 cd	14.3 d	5.1 d	7.6 c	31.1 d
T_6: 100% NPK+ lime incorporation @ 1/10th LR in furrow	47.1 ef	22.3 de	12.5 de	4.6 d	4.9 d	23.3 e
T_7: 100% NPK + 5 t FYM ha^{-1} + lime incorporation @ 100% LR	72.4 bc	35.4 b	19.5 c	8.1 b	9.9 b	41.5 c
T_8: 100% NPK + 10 t FYM ha^{-1} + lime incorporation @ 100% LR	91.1 a	44.6 a	25.7 a	10.5 a	13.2 a	56.9 a
T_9: 100% NPK + 5 t FYM ha^{-1} + lime incorporation @ 1/10th LR in furrow	67.0 c	34.3 b	18.0 c	6.7 c	9.3 b	40.1 c
T_{10}: 100% NPK + 10 t FYM ha^{-1} + lime incorporation @ 1/10th LR in furrow	80.7 b	41.3 a	22.4 b	8.7 b	11.9 a	51.3 b
T_{11}: Natural Farming	19.0 h	10.1 g	4.8 g	1.4 f	2.4 f	8.1 g

Note: Same letter on the points indicates that treatments are statistically indifferent at 5% level of significance

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In-Situ Moisture Conservation Practices in Maize under Rainfed Condition

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In Perambalur district, maize is an dominant crop mainly grown under rainfed situation, it is mostly used as grain, feed, fodder, and industrial products. The average annual rainfall of the district is 861 mm and 54% of the total rainfall is received during North-West monsoon. The 13 predominant soils in the district are different variants of red and black soils ranging from very deep to moderate and very shallow. In Kurumbalur (NICRA) village, water scarcity is a major constraint for maize cultivation. Crop water requirement for maize on 500 to 600 mm of rainfall. Total rainfall received during cropping period 377 mm in Kurumbalur village (2023-24) (Table.1). Farmers in this village generally cultivate maize under rainfed conditions of available moisture for entire crop duration.

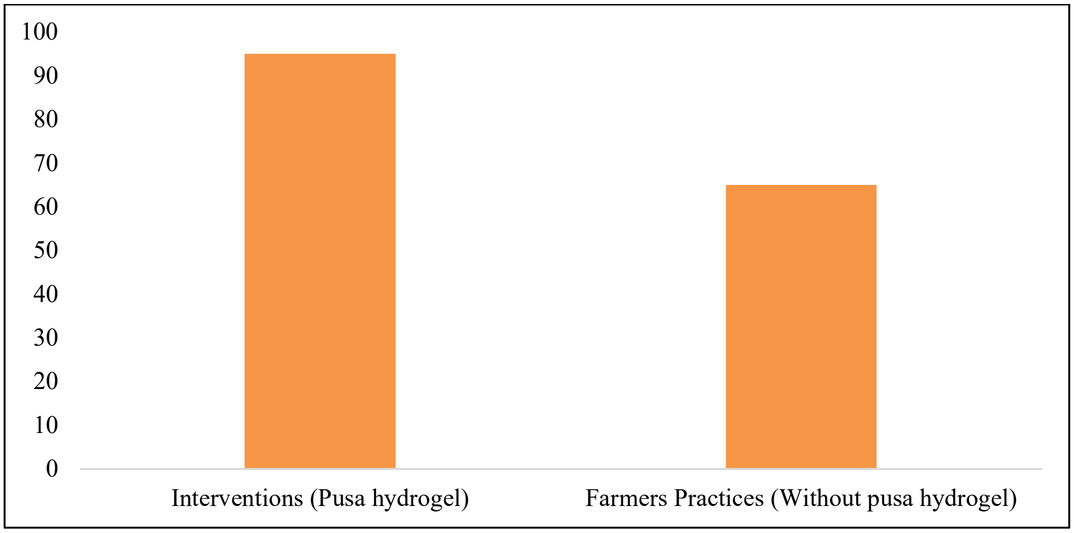
Pusa Hydrogel is a super absorbent polymer developed by Indian Agriculture Research Institute, New Delhi which has been commercialized by CUMI. Pusa Hydrogel, a cellulose based hydrogel absorbs water 300 times of its own size. During water-stress or drought conditions it helps the roots to absorb water for crop growth and development (Abedi-Koupai *et al.*, 2004).

Methodology

The present study was carried out in 10 farmers' field in Kurumbalur (NICRA) village during 2023-24 to evaluate the application of pusa hydrogel to increase root water uptake suitable for rainfed maize crop. The total area under each trial was 0.4 ha. Application of Pusa Hydrogel along with FYM to maize crop in the soil near the root zone was applied during last ploughing kharif season in Month of July 08.6.23. Dibble the seeds at a depth of 4 cm along the furrow in which fertilizers are placed and cover with soil on 10.6.23. Followed by application of pre-emergence herbicide atrazine @ 0.25 kg/ha as pre-emergence on 3-5 DAS followed by 2,4-D @ 1 kg/ha on 20-25 DAS, using Backpack sprayer fitted with a flat fan nozzle using 500 litres of water/ha on 13.06.23.During the dry spell, soil moisture is maintained up to 35 % and uniform growth of the crop and homogeneity of the maturity. Significantly higher yield obtained (46.11 q ha^{-1}) yield compared to district average yield (37.43 q ha^{-1}).

Results

Under field conditions, basal application of pusa hydrogel 2. 5 kg per ha had observed were recorded for the parameters, germination per cent, plant population, Plant hight at 30 DAS and 60 DAS, number of grains per cob and grain yield components of Maize in 2023-24. During the crop growth period, 18 day- dry spell occurred (23/06/23 to 10/07/23), 26 days dry spell occurred 14/07/23 to 09/08/23). Basal application of Pusa Hydrogel @ 2.5 kg ha^{-1}, recorded maximum seed germination (95.35%), compared to farmers' practices of 66.00 % (Fig.1). The plant population in Pusa Hydrogel was 22% higher as compared to the non-hydrogel treated plots (Shashank Tyagi *et al.*2018). Plant height was significantly influenced by moisture conservation practice. On 30 and 60 DAS the highest plant height was recorded 66.60 cm and 110.84, respectively. The shortest plant height of 54.98 cm and 92.03 was recorded with farmers' practices.



Pusa Hydrogel application on maize Germination %

Pusa Hydrogel application on maize grain yield and economics

Intervention	Yield (q ha^{-1})	Cost of cultivation (ha^{-1})	Gross return (ha^{-1})	Net return (ha^{-1})	BC ratio
Basal application of Pusa hydrogel @ 2.5 kg ha^{-1}	46.11	31502	84807	53305	2.77
Farmer's practice	31.89	28937	55291	26353	1.91

The growth and grains cob^{-1} significantly improved with application of Pusa Hydrogel, which recorded higher grains cob^{-1} of 238.19. The lowest number of grains cob^{-1} of 148.34 was recorded with farmers' practices. The grain yield increased significantly with application of Pusa Hydroge (46.11 q ha^{-1}**)** (Table.2) (Kritika *et al*.,2021). The basal application of Pusa Hydrogel increased the yield and net returns by 45 and 54% respectively (Anupama and Balraj S Parmar. 2012). This technology could be promising in terms of combating the moisture stress, productivity improvement of maize crop in drought prone areas of Perambalur district.

Conclusion

From the present study, moisture conservation practices basal application of pusa hydogel @ 2.5 kg per ha could be promising in terms of combating the moisture stress, increased yield upto 45 % and productivity improvement of maize crop in drought prone areas of Perambalur district.

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Aldor as an Alternative to Urea: Impacts on Productivity, Profitability, and Nutrient Use Efficiency in the Maize-Wheat System

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Indian agriculture faces persistent challenges in achieving high nutrient use efficiency (NUE). Nitrogen (N) use efficiency in most field crops typically remains below 40% (Upadhyay et al., 2023), while sulfur (S) efficiency ranges between 8-12%. Such low efficiencies result in suboptimal crop responses to fertilizers, excessive application rates, increased production costs, and reduced profitability for farmers. Moreover, the overuse of fertilizers often causes significant nutrient leaching, leading to soil degradation, water contamination, and broader environmental concerns. To address these issues, aligning nutrient availability with crop requirements is essential for minimizing losses and improving NUE. Over the years, various agronomic strategies have been explored, including split nutrient applications during critical growth stages, site-specific nutrient management, soil test-based fertilization, and the use of real-time decision support tools. Innovations such as monitoring crop nitrogen demand during the growing season and testing novel fertilizer formulations under field conditions have also shown promise. While these efforts have advanced the concept of balanced nutrient application, there remains an urgent need for focused research on developing new-generation fertilizers that can further enhance NUE, support soil health, and boost farm incomes.

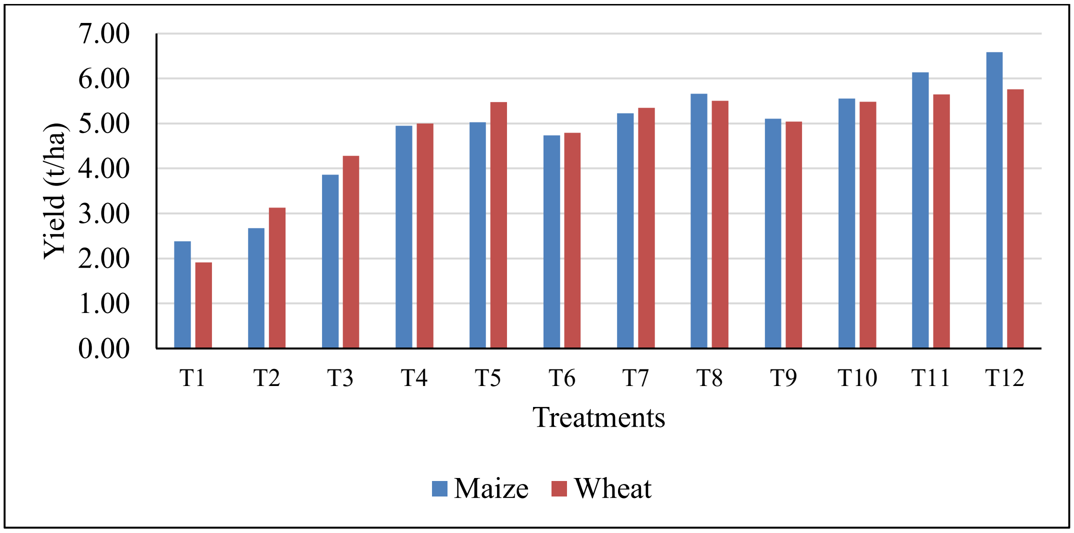
One such innovative product is Aldor fertilizer, developed by Anglo American, a UK-based company. This fertilizer contains 30% N, 5% potassium (K), and 7% S, offering a potentially superior alternative to traditional urea for meeting crop nutrient demands. Its formulation aims to optimize nutrient delivery, reduce environmental losses, and improve crop productivity. An experiment was conducted at the ICAR-Indian Agricultural Research Institute (IARI) to evaluate the effectiveness of Aldor in promoting crop growth, improving yield and quality, and enhancing nitrogen use efficiency (NUE) within a sustainable production system. The study aims to assess whether Aldor can be a practical alternative to conventional fertilizers, contributing to sustainable agriculture by increasing farm productivity and minimizing environmental impacts.

Methodology

A field study was carried out at the ICAR-Indian Agricultural Research Institute's research farm in New Delhi to assess the effectiveness of Aldor fertilizer. The trial followed a randomized block design (RBD) with 12 treatment combinations, each replicated three times. The soil at the experimental site was sandy loam in texture, slightly alkaline with a pH of 8.13, and had a non-saline electrical conductivity (EC) of 0.26 dS m^{-1}. The surface soil (0-15 cm depth) was characterized by an organic carbon content of 0.52%, an available nitrogen level of 268 kg ha^{-1}, phosphorus of 23.1 kg ha^{-1}, potassium of 302 kg ha^{-1}, and sulfur availability at 11.8 mg kg^{-1}.

Results

Data from one year of trials on maize and wheat indicated that Aldor fertilizer shows strong potential as an alternative to urea. Treatments using Aldor at rates equivalent to urea in T10 (despite a lower nitrogen application compared to urea) produced grain yields statistically comparable to the recommended dose of fertilizers (RDF) in both crops (Fig). This finding highlights that comparable yields were achieved with 18 kg less nitrogen from Aldor compared to urea. Previous research has also shown that split potassium applications can significantly improve the yields of maize and wheat (Singh et al., 2023). Since Aldor contains potassium, its application strategy may contribute to enhanced crop performance. Additionally, the slow-release nature of Aldor ensures a steady supply of nutrients during critical growth stages, supporting optimal crop development and yield potential.



Effect of treatments on yield (t/ha) of maize and wheat

T1: *Control (Only Recommended P and K – No Nitrogen)*
T2: *Control (No N through Urea, Recommended P and K through DAP and MOP)*
T3: *Nitrogen equal to applied in T9 and DAP Farmer Practice (only Urea and DAP)*
T4: *100% Nitrogen based Farmer Practice (only Urea and DAP)*
T5: *125% Nitrogen based Farmer Practice (only Urea and DAP)*
T6: *Nitrogen equal to applied in T9 + Rec. P & K (P through DAP, remaining N through Urea and K through MOP)*
T7: *100% RDN + Rec. P & K (P through DAP, remaining N through Urea and K through MOP)*
T8: *125% RDN + Rec. P & K (P through DAP, remaining N through Urea and K through MOP)*
T9: *Aldor equivalent to Urea applied in T4 and T7 + Rec. P & K (P through DAP and K through MOP)*
T10: *Aldor equivalent to to Urea applied in T5 & T8 + Rec. P & K (P through DAP and K through MOP)*
T11: *Aldor equivalent to Nitrogen applied in T4 & T7 + Rec. P & K (P through DAP and K through MOP)*
T12: *Aldor equivalent to Nitrogen applied in T5 & T8 + Rec. P & K (P through DAP and K through MOP)*

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Impact of Different Organic Nutrient Sources on Growth and Seed Yield of Soybean (*Glycine max* (L) Merrill.)

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Soybean (Glycine max L. Merrill) is an important oilseed pulse crop of the world. It became miracle crop of 20th century and designated as "Golden Bean". Soybean is the cheapest source of protein and it is called "Poor man's meat". Soybean crop was introduced in sixties as supplementary oilseed crop to overcome the edible oil shortage in the country. Among all oilseeds crops, soybean occupied third position in the edible oil scenario of India. Nutritional point of view, soybean is an excellent source of protein and oil. Proper fertilization is one of the major factors to gain higher yield but injudicious application of inorganic fertilizers without organic supplements causes environmental pollution, damaging soil physical, chemical and biological properties. Objectives of this study is organic formulations used in agricultural crop and many beneficial effect in the term of enhancement of yield and quality of have been reported (Gore and Shreenivasa, 2011).

Methodology

A field experiment was conducted during kharif season 2023-24 to study the Impact of different organic nutrient sources on growth and seed yield of Soybean (Glycine max (L) Merrill.) at OFRTC, VNMKV, Parbhani. The initial soil pH was 7.63, EC-0.28 dSm^{-1}, OC-0.54% , Calcium carbonate -3.26%, available nitrogen-186.00 kg ha^{-1} , Phosphorus -12.27 kg ha^{-1}, Potassium- 449 kg ha^{-1}. Experiment was laid in RBD with three replications. Trial was Sown on 13.07.2023 and harvested on 27.10.2023.

Results

Soybean yield and monetary returns

The effect of various organic sources on soybean yield was found to be significant. The treatment T_2 i.e. 100 % RDN through vermin-compost recorded the highest soybean yield (1769 kg/ha) but it was found to be at par with treatments T_7, T_8, T_9 and T_{10}. The lowest soybean yield was recorded in T_{11} i.e. Control.

Similar trend observed in GMR i.e. 100 % RDN through Vermi-compost (T_2) (76067 Rs/ha) which was found significantly superior over rest of the treatments except T_6, T_7, T_8 and T_9. Whereas, highest NMR was obtained with the application of 100 % RDN through Vermi-compost (T_2) (39024 Rs/ha) which was found superior over rest of the treatments and it was found at par with T_9, T_8, T_6 and T_7. In-case of RWUE study shows that the highest RWUE was recorded in treatment T_2 i.e. 100 % RDN through Vermi- compost (3.76) followed by T_{10} and lowest RWUE was recorded in treatment control (T_{11}). Whereas, application of 100 % RDN through Vermi- compost recorded highest B:C ratio (2.05) followed by treatment T_8.

Table 1. Soybean crop yield, monetary returns, B:C ratio and rain water use efficiency as influenced by different treatments

Treatments	Soybean Yield (Kg/ha)	GMR (₹/ha)	NMR (₹/ha)	B:C ratio	RWUE (kg/mm/ha)
T_1: 100 % RDN through FYM	1418	60974	27798	1.84	3.01
T_2: 100 % RDN through VC	1769	76067	39024	2.05	3.76
T_3: Jivamrut 3 applications (At 30, 45, & 60 DAS)	1053	45279	15151	1.50	2.24
T_4: Biofertilizers 2.5 lit/ha SA	1255	55126	25245	1.84	2.67
T_5: Cow Urine 3 applications (At 30, 45, & 60 DAS)	1115	47945	17751	1.59	2.37
T_6: 50 % RDN : FYM + 50 % RDN : VC	1539	66177	32401	1.96	3.27
T_7 : 50 % RDN : FYM + 50 % RDN: VC+ JA 3 applin (At 30, 45& 60 DAS)	1578	67854	32326	1.91	3.35
T_8: 50 % RDN : FYM + 50 % RDN: VC+ Biofertilizers 2.5 lit/ha SA	1612	69316	34035	1.96	3.42
T_9: 50 % RDN : FYM + 50 % RDN: VC + Cow Urine 3 applins (At 30, 45& 60 DAS)	1594	68542	32948	1.93	3.39
T_{10}: 50 % RDN : FYM + 50% RDN : VC+ JA 3 Applns (SA+FA) + Biofert 2.5 lit/ha (At 30, 45& 60DAS)	1645	70735	31884	1.82	3.49
T_{11}: Control.	845	36335	6959	1.23	1.79
SE +	69	3939	2681	0.09	-
CD at 5%	207	11817	8043	0.27	-
Mean	1466	63132	29602	1.88	3.11

Soil Nutrient status

Among various treatments higher concentration of available nitrogen, phosphorus and potassium was found in T_2 followed by T_8 of organic sources of nutrients. The differences for micronutrients were found to be non-significant. Whereas, among various treatments T_2 showed higher concentration of micronutrients.

Conclusions

Application of 100 % RDN through vermi-compost (T_2) recorded highest Soybean yield (1769 kg/ha), highest GMR (₹76067/ha) and highest NMR (₹39024/ha). Among various treatments higher concentration of available macronutrient was found in T_2 followed by T_8 of organic sources of nutrients.

Table 2. Soil nutrient status under different organic nutrient sources after harvest of soybean

Treatments	Available Major nutrients kg/ha			Micronutrients ppm			
	N	P	K	Cu	Fe	Mn	Zn
T_1: 100 % RDN through FYM	174	15.87	429	1.24	1.45	4.73	0.47
T_2: 100 % RDN through VC	208	17.61	507	1.62	5.44	5.14	0.56
T_3: Jivamrut 3 applications (At 30, 45, & 60 DAS)	159	12.79	431	0.98	1.39	4.49	0.42
T_4: Biofertilizers 2.5 lit/ha	154	13.54	429	1.08	1.48	4.31	0.41
T_5: Cow Urine 3 applications (At 30, 45, & 60 DAS)	151	14.98	428	1.6	1.42	4.28	0.44
T_6: 50 % RDN : FYM + 50 % RDN : VC	148	14.67	397	1.27	2	4.08	0.42
T_7 : 50 % RDN : FYM + 50 % RDN: VC+ JA 3 applin (At 30, 45& 60 DAS)	157	16.87	406	0.97	2.44	4.21	0.47
T_8: 50 % RDN : FYM + 50 % RDN: VC+ Biofertilizers 2.5 lit/ha	179	19.81	491	1.29	4.13	5.27	0.49
T_9: 50 % RDN : FYM + 50 % RDN: VC + Cow Urine 3 applins (At 30, 45& 60 DAS)	172	17.46	469	0.98	2.61	4.08	0.47
T_{10}: 50 % RDN : FYM + 50% RDN : VC+ JA 3 Applns (SA+FA) + Biofert 2.5 lit/ha (SA+ST) + CU 3 applns (At 30, 45& 60 DAS)	169	17.68	483	0.87	4.95	5.75	0.54
SE +	10.61	1.90	21	0.04	0.06	0.35	0.06
CD at 5%	31.31	5.57	64	0.13	0.17	1.04	NS
Mean	149.80	16.20	450	1.10	2.52	4.13	0.46
Initial soil analysis	139	11.27	393	0.61	1.33	3.94	0.4

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Long-Term Effect of Tillage and Nitrogen on Soil N Fractions under Different Cropping System in Diverse Agroecology- A Mini Review

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Nitrogen is the key element for plant growth and development. It is a major limiting factor for achieving sustainable crop yields in both rainfed and irrigated agroecology under different cropping systems. The poor availability of is due to low soil organic matter, limited soil moisture content, imbalance nutrient application, nitrate leaching and soil erosion. Nitrogen in soil mainly occurs as organic (>90%) and inorganic forms (<10%). Soil organic N is comprised of hydrolyzable N (hydrolysable NH_4^+-N, hexosamine N, amino acid N, and unidentified N), and non-hydrolyzable N (fixed NH_4^+). The inorganic forms viz., NH_4^+-N and NO_3^--N are easily available for crop uptake. Apart from many climatic factors, the management factors such as tillage practices and nitrogen levels significantly affect the N fractions in soil and its availability to the plants. Therefore, the objective of this mini-review paper was to understand the effect of tillage and nitrogen levels on soil N fractions under diverse agroecology.

Methodology

A systematic search was conducted by multiple electronic databases including Web of Science, PubMed, Google Scholar, Researchgate, Scopus as well as ICAR-CRIDA Library to ensure comprehensive coverage of pertinent studies. The search strategy utilized a combination of keywords and phrases such as "rained agro-ecology," "irrigated agro-ecology", "tillage types," "nitrogen levels," "soil N fractions," "soil aggregate associated N fractions," and "cropping systems," along with specific crops species names. This approach aimed to capture the studies relevant to the tillage and nitrogen levels in response to soil N fractions. Research studies more than five years were considered for this mini review paper.

Results

It has been found that highest concentration of N fractions viz. total hydrolysable-N, hydrolysable ammonical-N, hexose amine-N, amino acid-N, unidentified hydrolysable-N, non-hydrolysable N, inorganic N, and total N were found in no tillage or minimum tillage or reduced tillage with highest surface residue application as compared to conventional tillage.

It has been also reported that amino acid constituted the predominant organic N fraction representing 40-43% of total hydrolysable N followed by hydrolysable NH_4^+-N (19.08-31.66%), unidentified hydrolysable-N (11.81-33.53%) and hexosamine-N (9.25-11.81%) (Biradar *et al*. 2024). All the N fractions significantly increased with the increasing rates of surface residue application and fertilization, this could be because crop residues increase the organic matter content in the soil which may contribute to the N fractions during decomposition. The cropping systems significantly influenced the availability of soil N and its fractions. Inclusion of the legumes in the cropping system positively impacted on these N fractions and soil N content. Although the N fractions and soil N content are significantly influenced by the soil type, year of the experiment, climate and management practices.

Effect of tillage and cropping systems on different soil N fractions, total N, and available N in diverse agroecology

Location, duration of experiment and reference	Treatments and soil type	Salient findings
ICAR CRIDA, Hyderabad; 2005-2012; Sharma *et al.*, 2021.	Different levels of surface crop residue application under minimum tillage in sorghum-cowpea system; Typic Haplustalf	The higher exch. NH_4-N (30.7), NO_3-N (19.3), total Hydrolyzable N (545.7), Hydrolysable NH_4-N (71.7), Hexosamine N (22.3), Amino acid N (384.3) Unidentified N (67.4) and Non-Hydrolysable N (202.7 mg/kg) were recorded in 6 t ha^{-1} crop residue application as compared to the rest of the treatments. Amino acid N, hexose amine N, hydrolysable NH_4 & unidentified N constituted 52%, 8%, 13%, and 27% of total hydrolysable N respectively. The total N and available N significantly increased with added level of the crop residues.
Southern Spain; 1986-2013; Lopez-Bellido *et al.*, 2016.	Tillage, crop rotation and N fertilizer rate; Vertisols	In 0 to 90 cm depths, macro-aggregate and micro-aggregate N stock under no-tillage (NT) was greater than conventional tillage (CT). Crop rotation and N fertilization do not contribute to the C and N sequestration.
Central Texas; 1982-2002; Wright & Hons, 2005.	Tillage and cropping sequence {sorghum /wheat /soybean rotation (SWS) & soybean monoculture (CS)}; Inceptisols	Soil organic nitrogen (SON) was more in SWS than CS. At 0–5 cm soil depths, NT increased SON by an average of 122%, 92%, 0%, and 37%, in >2-mm, 250-µm- 2mm, 53-250µm, and <53 µm, respectively. At 5–15 cm, the only treatment that had greater SON under NT than CT was the SWS sequence in the >2-mm fraction.
Southeastern Nigeria; 10 years; Onweremadu *et al.,* 2007.	Tillage practices; Inceptisols	Mean SON was higher under minimum tillage (MT) than CT, and higher SON was observed in larger aggregates (4.75–2.00 mm and 2.00–1.00 mm) as compared to the smaller aggregates. Under MT large aggregates contributed more SON (22–26%) than small aggregates (14–24%) whereas the reverse trend was observed in CT.
North china plains; 2016-2021; Tang *et al.,* 2024.	Tillage and Residue return in maize-wheat system; Sandy loam	Tillage with residue return significantly increased TN storage in soil as compared to the tillage without residues return at 0–10 cm soil depths. At below soil depths (10-20 and 20-30 cm soil depths) variable results were found with respect to TN.
CSK Palampur; 1991-2008; Subehia and Dhanika, 2013.	Continuous fertilization and amendments in rice-wheat system; Typic Hapludalf	The inorganic and organic fractions of N in soil were all increased by the application of both mineral fertilizers alone or in combination with organics, except unidentified N, and were highest in 50%NPK+50%N by organic sources (FYM and dhaincha GM) as compared to the control. The organic fractions constitute 96% of TN (67.3% total hydrolysable N, and 32.7% non-hydrolysable N).

Conclusion

The significantly higher content of various N fractions was recorded in no tillage together with greatest surface residue application and in integrated use of organic and inorganic fertilizers especially N under different cropping systems.

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Optimizing Nutrient Management through Various Organic Sources in Pigeon Pea

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The long-term use of chemical fertilizers is known to degrade physico-chemical and biological properties of soil. The integrated nutrient management having organic manures, vermi compost, FYM, etc. improves the soil properties, its health and fertilizer use efficiency, mitigates short supply of micronutrients, stimulates the proliferation of diverse group of soil micro-organisms and plays an important role in the maintenance of soil fertility and improves the ecological balance of rhizosphere (Singh et al., 2017). Pigeon pea is one of the important pulse crops which is being used in daily diet is gaining popularity because of its high market value as well as low nutrient requirement and giving sustainable yields under organic farming. By using different organic sources of nutrients to this crop it was essential to evaluate their effect over seed yield, economics as well as gain in soil nutrient status. Hence, the present experimentation was conceptualized and executed by considering prior importance of integrated nutrient management through various organic sources over pigeon-pea yield.

Methodology

A field experiment was conducted during *kharif* season 2022-23 to study the impact of different organic nutrient sources on growth and seed yield of pigeon pea at field section of OFRTC, VNMKV, Parbhani. The initial soil pH was 7.61, EC-0.27 dSm^{-1}, OC- 0.56%, Calcium carbonate -3.24%, available nitrogen: 182.00 kg ha^{-1}, Phosphorus -11.57 kg ha^{-1}, Potassium- 447 kg ha^{-1}. Pigeon-pea (BDN-711) variety was used in experimentation. Experiment was executed in RBD design with three replications which was sown on 01.06.2022 and harvested on 29.12.2022. RDF applied was 25:50:25 NPK kg/ha.

Results

The data on pigeon-pea seed yield, monetary returns, B:C ratio and rain water use efficiency as influenced by different treatments is presented in table below.

a) Seed yield:

The effect of various organic sources on pigeon-pea yield was found to be significant. The treatment T_{12} i.e. RDF + FYM 5 t/ha recorded the highest Pigeon-pea yield (2064kg/ha) which was found at par with T_2 and T_3 and it was found significantly superior over rest of the treatments. Among the organic treatments, the treatment T_2 (100 % RDN through Vermi-compost) recorded significantly higher seed yield (1893 kg/ha) which was found at par with T_3. The major reason behind it was better availability and translocation of nutrients through organic sources to pigeon pea. The lowest seed yield was recorded in T_{11} i.e. control. Comparable findings were reported by Sumit Kumar et al. 2023.

b) Monetary returns:

The highest GMR was obtained with application of RDF + FYM 5 t/ha (T_{12}) which was found at par with T_2 and T_3 and it was found significantly superior over rest of the treatments. Whereas, among organic treatments, the treatment T_2 (100 % RDN through Vermi-compost) recorded significantly higher GMR (Rs 124938/- ha^{-1}) which was significantly higher than the rest of all treatments but found at par with T_3. Whereas, highest NMR was observed in case of T_{12} i.e. RDF + FYM 5 t/ha followed by T_2 i.e.100 % RDN through Vermi-compost. Whereas, among organic treatments, the treatment T_2 (100 % RDN through Vermi-compost) recorded significantly higher NMR (Rs 79557/- ha^{-1}) which was significantly higher than the rest of all treatments but found at par with T_3 and T_4. It might be due to better yield in T_2 as compared to other due to better supply of major nutrients to crop. Comparable findings were reported by Sumit Kumar et al. 2023.

c) Rain Water Use Efficiency (RWUE) & B:C ratio :

The RWUE was also differed for different treatments. It was found highest i.e. 3.71 kg/mm/ha with T_{12} treatment followed by T_2 (3.40 kg/mm/ha) and lowest RWUE was recorded in treatment T_{11} i.e. control. Whereas, highest B:C ratio was observed in treatment

T_{12} i.e. RDF + FYM 5 t/ha (3.00) followed by T_2 i.e.100 % RDN through vermi-compost (2.76). Similar results reported by Sumit Kumar et al. 2023. Those reports were mostly due to the effect of nutrient management using organic sources.

Pigeon-pea seed yield, monetary returns, BC ratio and rain water use efficiency as influenced by different treatments (2022-23)

Treatments	Seed Yield (Kg/ha)	GMR (₹/ha)	NMR (₹/ha)	BC ratio	RWUE (kg/mm/ha)
T_1: 100 % RDN through FYM	1459	96294	54653	2.31	2.62
T_2: 100 % RDN through VC	1893	124938	79597	2.76	3.40
T_3: 100 % RDN through 33% FYM + 33% VC + 33% NC	1789	118074	73700	2.66	3.21
T_4: 100 % RDN : FYM + JA 3 at 30, 45 & 60 DAS (SA & FA)	1554	102564	59171	2.36	2.79
T_5: 75 % RDN : FYM + JA 3 at 30, 45 & 60 DAS (SA & FA)	1396	92136	49743	2.17	2.51
T_6:100 % RDN through FYM + Biofertilizer 2.5 lit/ha (SA)	1678	110748	67602	2.57	3.01
T_7:75 % RDN through FYM + Biofertilizer 2.5 lit/ha (SA)	1421	93786	51640	2.23	2.55
T_8: JA 3 Appln at 30, 45 & 60 DAS (SA & FA)	1151	75966	36573	1.93	2.07
T_9: JA 4 Appln at 30, 45, 60 & 75 DAS (SA & FA)	1242	81972	43895	2.15	2.23
T_{10}: JA 5 Appln at 30, 45, 60, 75 & 90 DAS (SA & FA)	1191	77506	38545	1.99	2.14
T_{11}: Control (Without any application)	1083	71478	34582	1.94	1.95
T_{12}: RDF + 5 t FYM/ha	2064	136224	90777	3.00	3.71
SE +	115	7562	6817	-	-
CD at 5%	336	22180	21497	-	-
Mean	1493	98474	56707	2.34	2.68
CV	12.42	12.42	20.57	-	-

Conclusions

The highest seed yield, GMR as well as NMR was obtained with application of RDF + FYM 5 t/ha which was found comparable with 100 % RDN through vermi compost and 100 % RDN through 33% FYM + 33% vermi compost + 33% Neem cake. Among various treatments higher concentration of available nitrogen was found in RDF + 5 t FYM/ha followed by 100 % RDN through 33% FYM + 33% vermi compost + 33% Neem cake of organic sources of nutrient. Hence 100 % RDN through vermi compost is better alternative for nutrient management through organic sources.

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Effect of Ca-Bentonite on Soil Physical, Chemical and Biological Properties Under Rainfed Maize-Pigeonpea Crop Rotation in Alfisols

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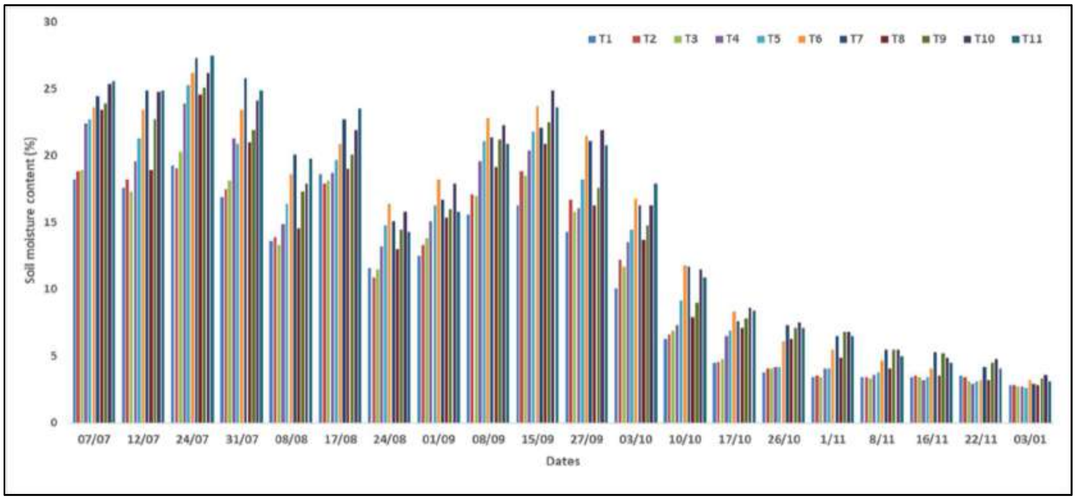
Ca-bentonite has a water absorption property due to its large surface area. Adding of the Ca-bantonite in coarse textured Alfisol soils can improve the soil moisture dynamics and other soil properties, and thus ultimately improve the major plant nutrient availability and crop productivity. Ca-Bentonite as a soil inorganic amendment can be an effective approach for solving the problems related to drought stress in crops as drought mitigation technology. In Telangana, Ca- Bentonite beds are present in Rudravaram, Tinsanpalli, Marepalli and Alipur (Adilabad) and Jadapalli and Godamaguda (Rangareddy). Keeping the view above, a field study was started during the year 2021 to evaluate the effect of Ca-bentonite on soil properties in maize-pigeonpea crop rotation under rainfed maize-pigeonpea crop rotation in Alfisols.

Methodology

During the year 2023 pigeonpea crop was sown on dated 07 July 2023 at GRF of ICAR-Central Research Institute for Dryland Agriculture, Hyderabad. Treatments include: Absolute control (T1), 75% RDF (T2), 100% RDF (T3), 5 t Ca-bentonite ha^{-1} + 75% RDF (T4), 10 t Ca-bentonite ha^{-1} + 75% RDF (T5), 15 t Ca-bentonite ha^{-1} + 75% RDF (T6), 20 t Ca-bentonite ha^{-1} + 75% RDF (T7), 5 t Ca-bentonite ha^{-1} + 100% RDF (T8), 10 t Ca-bentonite ha^{-1} + 100% RDF (T9), 15 t Ca-bentonite ha^{-1} + 100% RDF (T10) and 20 t Ca-bentonite ha^{-1} + 100% RDF (T11). For the estimation of the soil moisture content, soil pH, EC, bulk density, total porosity, soil available N, P and K, and different soil enzymes a standard methodology was adopted. Experiment was laid out in the randomized block design with three replications. The data on soil parameters were subjected to analysis of variance (ANOVA) using RBD design.

Results

The soil moisture content in soil ranged ranges to 3.1% to 27.5% during the crop growth period. Added level of the Ca-Bentonite recorded higher soil moisture content. The trend of higher soil moisture content was following the trend:15 t > 20 t >10 t >5 t.



Effect of Ca-bentonite on soil moisture content (%) at different dates.

The effect of the Ca-bentonite was more pronounced during dry-spell as compared the just after rain. The application of 15 t Ca-bentonite found the superior treatment for conserving the soil moisture (Fig. 1). It can supply the soil moisture more than 3-4 weeks extra during the dry-spell.

Results further revealed that significantly higher soil bulk density was observed with 20 t Ca-bentonite+75% RDF and 20 t Ca+-bentonite+ 100% RDF as compared to the 100% RDF. Added levels of the Ca-bentonite decreased the soil total porosity. Significantly highest soil pH was observed with 20 t Ca-bentonite+75% RDF and 20 t Ca+-bentonite+ 100% RDF as compared to the 100% RDF. Significantly highest soil ECs was observed with 20 t Ca-bentonite+75%RDF and 20 t Ca+bentonite+ 100% RDF as compared to the 100% RDF. Added levels of the Ca-bentonite slightly decreased the soil N content at both the levels of RDF (75% RDF and 100% RDF) as compared to 75% RDF o 100% RDF alone. Application of 20 t Ca-bentonite with 75 RDF% (18.2 kg/ha) or 100% RDF (21.6 kg/ha) increased the soil P content as compared to alone 75% RDF or 100% RDF. Added levels of the Ca-bentonite increased the soil K content as compared to the alone 75% RDF or 100% RDF. There is significantly higher soil K content observed in 20 t Ca-bentonite + 75% RDF as compared to the only 75% RDF. Protease enzyme activity was not affected by the application of Ca-bentonite with 75% RDF and 100% RDF as compared to the alone 75% RDF and 100% RDF. Urease enzyme activity increased with the added levels of the Ca-bentonite with

75% RDF and 100% RDF as compared to the 75% RDF or 100% RDF alone. Added levels of the Ca-bentonite significantly decreased the soil acid phosphatase activity as compared to the alone RDF. No significant effect was observed on soil alkaline phosphatase activity in Ca-bentonite+75% RDF or 100% RDF as compared to only 75% RDF or 100 RDF% alone.

Conclusion

Application of the 15 t Ca-bentonite plus 100% RDF found quite effective in improving the soil physical, chemical and biological soil quality indicators in maize-pigeonpea crop rotation under red Alfisols soil.

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UID: 1646

Rhizospheric Based Phosphorus Management in Paddy

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A field experiment was conducted on "Rhizospheric based Phosphorus Management in Paddy" in the farmers Fields at Golaghati Gram Panchayat, under KVK Sepahijala, CAU (I), Latiacherra during *Kharif* 2022 and 2023. The experiment was laid out in Randomized Complete Block Design (RCBD), where the numbers of treatments were seven viz. i. Control (No P), ii. Brodcasting of SSP, iii. Broadcsting of RP, iv. PSB, v. PSB + RP, vi. SSP Soil slurry + PSB, vii. SSP soil slurry + PSB + RP) with three replications in the farmer field at Golaghati. Results from the experiment revealed that seedlings root dip in SSP soil slurry (0.125 g P_2O_5 in 1 kg soil) + PSB (4 kg/ha) along with rock phosphate (20 kg/ha) were found better. In this experiments, the seedlings root dip in SSP slurry + phosphorus solubilizing bacteria + rock phosphate (20 kg/ha) performed better result than SSP broadcast as basal application (40 kg/ha) and control in terms of more dry matter content at 90 DAT (1142.14

g/m2), p content in grains (0.33%) and straw(0.16%) and p uptake in grains and straw (30.39 kg/ha) at the time of harvest and also increased comparable grain yield (58.25 q/ha) and straw yield (67.25 q/ha) with 50% reduction of p fertilizer input quantity. The gross return was found Rs.140610 /ha and benefit cost ratio was 1.92 which was significantly higher compared to other treatments. It was concluded that SSP soil slurry + PSB + RP is proven to be the best *kharif* paddy cultivation option by utilizing optimum phosphorus with higher productivity in the Sepahijala district of Tripura.

UID: 1673

Effect of Micronutrient Grades on Yield and Economics of Soybean (*Glycine Max* L.)

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Soybean (*Glycine max* L.), golden bean is a leguminous crop, member of Fabaceae family and Faboideae subfamily. Soybean has compelling importance in the human and livestock nutrition. It consists of about 40 % quality proteins, 20% cholesterol free oil and 23% carbohydrates. About 85% unsaturated fatty acids including 55% polyunsaturated fatty acids (PUFA). It has high caloric value releasing 446 calories from 100 gm of edible soybean. Considering its nutritional contribution, it is also known as a ‘Wonder Crop’, ‘Miracle Crop’ and ‘Golden Bean’.

The assumed nitrogen fixed by soybean is approximately 50- 450 kg ha^{-1}. So, it is also called as 'Gold of soil’. Maharashtra and Madhya Pradesh dominate the production of soybean in India, which contribute about 89% of the total India’s Production. (Anonymous, 2022). During year 2020-2021, area sown in Maharashtra was 4.36 million ha with production of 6.20 million ton and productivity of 1423 kg ha^{-1} (Anonymous, 2020).

Nutrients interaction is the core of balanced nutrition. Along with macronutrients like nitrogen, phosphorus and potassium, some micronutrients are believed to be necessary for increasing growth & seed yield of soybean. Among various plant nutrients, micronutrients play an important decisive role in improving the productivity of crop.

There is better awareness and adoption among the farmers for the use of macronutrients compared to micronutrients. As a result, it has become the great need of time to suggest most effectual and economical source of application of micronutrients to meet the hidden hunger of crop like soybean.

Methodology

The field experiment was carried out at Experimental Farm, Agronomy Section, College of Agriculture, Latur during *kharif* season of 2022-2023, located between $18^o05'$ to 18^o 75' North latitude and between 76^o 25' to 77^o 36' East latitude.

The experiment was laid out in Randomized Block Design with three replications and seven treatments. The treatments were T_1: Absolute control, T_2: RDF (30:60:30 NPK kg ha^{-1}), T_3: RDF + FYM @ 5 t ha^{-1}, T_4: RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1}, T_5: RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25 % (Foliar spray at 20 DAS), T_6: RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.5 % (Foliar spray at 40 DAS), T_7: RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25 % (Foliar spray at 20 & 40 DAS).

The micronutrient grade-I complex contains Zn- 5%, Fe- 2%, Mn- 1%, B- 1%, Cu- 0.5% and micronutrient grade-II complex contains Zn- 3%, Fe- 2.5%, Mn- 0.1 %, B- 0.5%, Cu- 1%, Mo- 0.1%.

Results

The data presented in Table 1. showed that highest seed yield (Kg ha^{-1})and harvest index were found with the application of RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25% (foliar spray at 20 and 40 DAS) (T7) followed by RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25% (foliar spray at 20 DAS) (T5). Present finding was in line with results obtained by Huger and Kurdikeri (2000), Awlad *et al.* (2003), Bhosale and Pacharne (2017) and Kumari *et al*. (2017).

The application of RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25% (foliar spray at 20 and 40 DAS) (T7) recorded maximum Gross monetary returns (₹ ha^{-1}), Net monetary returns (₹ ha^{-1}) and B:C ratio followed by the treatment RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25 % (foliar spray at 20 DAS). Similar kind of result was obtained by Bahure *et al.* (2016), Bhosale and Pacharne (2017) and Kumari *et al*. (2017).

Effect of different treatments on yield attributing characters, yield and economics of soybean

Treatments	Seed yield (Kg ha^{-1})	Harvest index (%)	GMR (₹)	NMR (₹)	B:C ratio
T_1 : Absolute Control	1571	32.14	62068	48137	2.10
T_2: RDF (30:60:30 NPK kg ha^{-1})	2048	35.19	80889	51628	2.18
T_3 : RDF + FYM @ 5 t ha^{-1}	2420	36.86	95603	53442	2.27
T_4: RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1}	2625	38.31	103689	69063	2.35
T_5: RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1}+ Micronutrient Grade-2 complex @ 0.25% (foliar spray at 20 DAS)	3116	41.60	123076	77765	2.70
T_6: RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.5% (foliar spray at 40 DAS)	2899	40.60	114541	57228	2.47
T_7: RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25% (foliar spray at 20 and 40 DAS)	3255	41.80	128591	80980	2.72
S.E. (m) ±	119	-	3914	3914	-
C.D. at 5%	352	-	11906	11906	-
General Mean	2562	38.07	101208	59427	2.40

Conclusion

The study of the experiment revealed that the application of RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25% (foliar spray at 20 and 40 DAS) (T_7) was proved to be effective for obtaining higher yield attributes and yield of soybean, closely followed by RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade-1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25% (foliar spray at 20 DAS) (T_5). The highest economic returns *viz.,* mean gross return and net return and B:C ratio were found with the application of RDF + FYM @ 5 t ha^{-1} + Micronutrient Grade- 1 complex @ 25 kg ha^{-1} + Micronutrient Grade-2 complex @ 0.25% (foliar spray at 20 and 40 DAS).

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UID: 1676

Building Resilience in Productivity of Blackgram in Rice- Blackgram Paira Cropping System Through Foliar Nutrition

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Agricultural panorama of Odisha is characterized via the widespread adoption of rainfed rice-based mono-cropping system across its assorted agro-climatic zones, in which a vast area of 12.2 lakh ha is left fallow during dry season after the rice harvest which leads to lower productivity of this cropping system. Although Kendrapara is a coastal district, but the agricultural scenario is same as the district accounts about 37,000 ha rice fallow land. Analysis of crop coverage information of last few decades reveals that the fallow areas are in increasing trend. In coastal Odisha Rice-pulse paira/relay cropping system is a potential traditional farmers' practice adopted in suitable land types. However, the productivity of such paira crops is declining due to multiple factors. Inadequate nutrition is one of the important root causes of low crop performance affecting crop growth and yield as well. Terminal drought occurs in the blackgram under residual soil moisture condition also a main factor in reducing the productivity.Keeping these factors in view, an on-farm trial was carried out by Krishi Vigyan Kendra, Kendrapara at Gajapitha village of Marshaghai block during rabi 2023-24 to investigate the effect of foliar nutrition in Blackgram under Rice-blackgram paira cropping system to mitigate the terminal drought condition experienced in second crop.

Methodology

The experiment was laid out in a randomized complete block design on PU-31 variety under rainfed condition with three treatments replicated seven times. The individual plot size was 10 m X 10 m. Soil type of the experimental site was sandy loam with pH 6.1 and EC 1.3 dS/m. The initial soil nutrient status was 126.3 kg ha^{-1} nitrogen, 16.2 kg ha^{-1} phosphorus and

217.8 kg ha^{-1} potassium. The soil was rich in organic carbon (0.62 %). As a climate resilient practice Rice-blackgram paira cropping system is demonstrated among the farmers under NICRA programme. The farmers were used to grow only long duration rice varieties keeping the fallow land during rabi season. Rice-blackgram paira cropping system was demonstrated where the long duration rice variety was replaced with a shorter one which will extend the residual soil moisture availability period for the second crop. For better utilization of the residual soil moisture Blackgram was taken in the paira system. But the second crop experienced soil moisture stress condition due to lack of irrigation. So foliar nutrition would help the second crop to grow successfully.

Results

The results of the experiment revealed that highest yield (5.89 q ha^{-1}) was obtained in the third treatment i.e., RDF + Foliar spray of 1.5% NPK (18-18-18) which was significantly higher than T2 (5.65 q ha^{-1}) and T1 (5.10 q ha^{-1}). Significantly higher stover yield was obtained in third treatment i.e., RDF + Foliar spray of 1.5% NPK (2.83 q ha^{-1}) followed by RDF + Foliar spray of 1.5% urea (2.42 q ha^{-1}) and RDF (2.15q ha^{-1}). This might be due to foliar application of nutrients helped in higher dry matter mobilization to the grain and other parts.

Table 1. Yield and economics of balckgram as affected by foliar nutrition in rice-blackgrampaira cropping system.

Treatment	Yield (q ha^{-1})	Straw yield (t ha^{-1})	Harvest Index	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C Ratio
T_1- RDF (80-40-40) kg ha^{-1}	5.10	2.15	0.43	21,000	35700	14700	1.70
T_2 – T_1 +Foliar spray of 1.5% urea	5.65	2.42	0.42	22,200	39550	17350	1.78
T_3- T_1 +Foliar spray of 1.5% NPK (18-18-18)	5.89	2.83	0.40	22,600	41230	18630	1.82
SEm	0.06	0.19	0.01				
CD	0.17	0.56	0.02				

Under rainfed condition the second crop experienced terminal drought which drastically affect the crop yield. Foliar nutrition enhances the nutrient use efficiency and acted as a lifesaving irrigation to the blackgram crop under stress condition. The T3 resulted in the highest cost of cultivation per ha (Rs. 22600/ ha) followed by T2 (Rs. 22,200/ ha) and T1 (Rs. 22,600/ha). Similar trend was followed in case of gross returns as well as net returns. A B:C ratio of 1.82 was obtained with RDF + Foliar spray of 1.5% NPK (18-18-18) followed by RDF + Foliar spray of 1.5% urea (1.78) and RDF (1.70). Highest return and B:C ratio was obtained in foliar application of 1.5% NPK (18-18-18) due to higher yield resulted higher gross return. So, application of recommended dose of fertilizer along with foliar spray of 1.5% NPK (18-18-18) at pre-flowering stage and pod development stage is good for harnessing higher yield and income from blackgram under rice-blackgram paira cropping system and improves the productivity of the system.

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The impact of mulching and micronutrient application on turmeric crop yield and quality characteristics under protected cultivation

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Turmeric (*Curcuma longa* L.) is one of the essential spices belong to the family Zingibereceae and having chromosome number 2n=3x=63. Currently more than 80 % of turmeric is produced by India. India has been occupying the most important position in world trade of turmeric from long time. Turmeric is a significant spice crop known for its diverse applications in culinary, pharmaceutical, and cosmetic industries. Enhancing its yield and quality is essential for meeting growing global demands. Recent advancements in agronomic practices, such as mulching and micronutrient application, have shown promise in improving turmeric production, particularly under protected cultivation systems. Common mulching materials include straw, coconut husks, black polyethylene sheets, and biodegradable films. Studies under protected cultivation have demonstrated that mulching can increase turmeric rhizome yield by up to 20% compared to non-mulched conditions. Micronutrients like zinc (Zn), boron (B), iron (Fe), and manganese (Mn) are vital for turmeric's physiological processes, including chlorophyll synthesis, enzyme activation, and carbohydrate metabolism. Deficiency in these nutrients can lead to poor growth and reduced rhizome quality. When mulching is combined with targeted micronutrient application, synergistic effects are observed. Mulching maintains optimal soil conditions, allowing efficient uptake of applied micronutrients. This combination leads to higher yield, improved quality and reduced input cost. Addressing these deficiencies through informed agricultural practices is crucial for ensuring food security and sustainable agriculture in the country.

Methodology

The experiment was conducted at Research Farm, Department of Horticulture, College of Agriculture, Indore, (M.P.). The experiment consisted of 10 treatments in combinations of recommended dose of biodynamics along with bio-fertilizers in Randomized Complete Block Design during *Rabi* season. The observation recorded for the different characters were statistically analysed by the methods of analysis of variance as described by Fisher (1938).

Result

The findings of the experiment revealed that the fresh weight of rhizome, dry weight of rhizome, and rhizome yield was found significantly higher in treatment T_9 (Black polythene mulch + 0.5% of foliar spray Zinc Sulphate) which was followed by T_{10} (Black polythene mulch + 0.5% of foliar spray Ferrous Sulphate) and T_6 (Black polythene mulch + 0.5% foliar spray of Zinc Sulphate. The quality parameters such as colour of turmeric powder, recovery percentage and curcumin content were studied and found significantly different for different treatments. The maximum and significantly higher recovery percentage (24.87%) and curcumin content (0.92%) were recorded best in treatment T_9 (Black polythene mulch + 0.5% of foliar spray Zinc Sulphate) followed by T_{10}Black polythene mulch + 0.5% of foliar spray Ferrous Sulphate.

Table 1: Treatment details

Sl. No.	Treatments	Symbols
1.	Only recommended dosages of NPK (control)	T_1
2.	Grass mulch + 0.5% foliar spray of Sulphur	T_2
3.	Grass mulch + 0.5% foliar spray Zinc Sulphate	T_3
4.	Grass mulch +0.5% foliar spray Ferrous Sulphate	T_4
5.	Wheat straw+ 0.5% foliar spray Sulphur	T_5
6.	Wheat straw+ 0.5% foliar spray Zinc Sulphate	T_6
7.	Wheat straw+ 0.5% foliar spray Ferrous Sulphate	T_7
8.	Black polythene mulch+0.5% foliar spray of Sulphur	T_8
9.	Black polythene mulch+0.5% foliar spray Zinc Sulphate	T_9
10.	Black polythene mulch+0.5% foliar spray Ferrous Sulphate	T_{10}

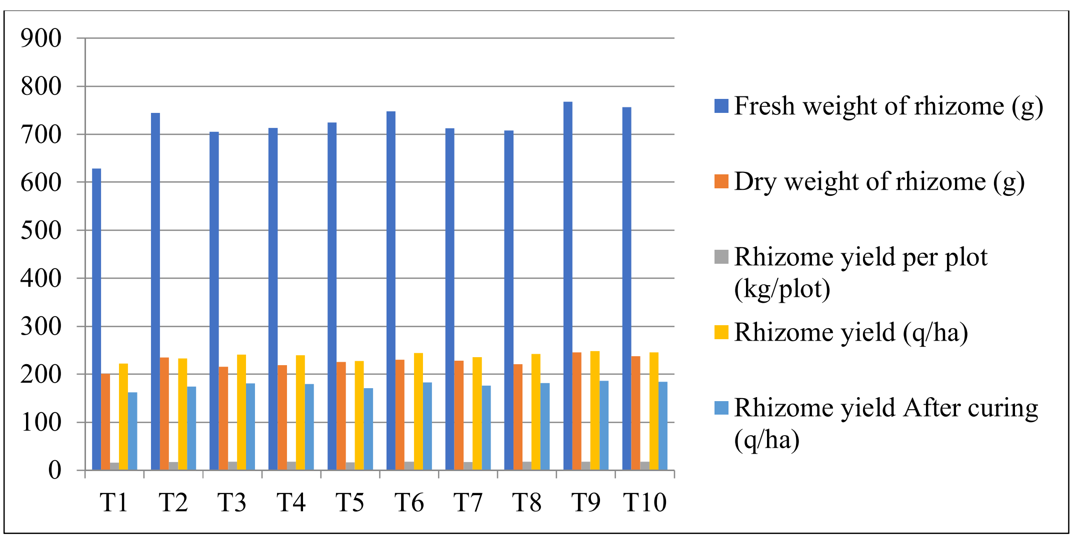

Fig 1. Effect of mulching and micronutrient on yield attributing characters of turmeric

Table 2. Effect of mulching and micronutrient on yield attributing characters of turmeric

Sl. No	Treatment	Fresh weight of rhizome (g)	Dry weight of rhizome (g)	Rhizome yield per plot (kg/plot)	Rhizome yield (q/ha)	Rhizome yield After curing (q/ha)
T_1	Only recommended dosages of NPK (control)	628.47	201.14	16.40	222.24	162.68
T_2	Grass mulch +0.5% foliar spray of Sulphur	744.06	234.62	17.20	232.77	174.57
T_3	Grass mulch +0.5% foliar spray Zinc Sulphate	704.91	215.88	17.80	240.92	180.69
T_4	Grass mulch + 0.5% foliar spray Ferrous Sulphate	712.91	218.86	17.70	239.71	179.79
T_5	Wheat straw + 0.5% foliar spray Sulphur	724.35	226.13	16.80	227.52	170.64
T_6	Wheat straw + 0.5% foliar spray Zinc Sulphate	747.97	230.22	18.04	243.85	182.89
T_7	Wheat straw + 0.5% foliar spray Ferrous Sulphate	712.18	228.40	17.40	235.50	176.62
T_8	Black polythene mulch + 0.5% foliar spray of Sulphur	707.70	220.77	17.89	241.89	181.42
T_9	Black polythene mulch + 0.5% of foliar spray Zinc Sulphate	767.75	245.74	18.30	248.27	186.21
T_{10}	Black polythene mulch + 0.5% of foliar spray Ferrous Sulphate	756.26	238.04	18.20	246.07	184.55
	SE(±m)	8.161	1.218	0.020	3.069	0.040
	CD(5%)	24.52	3.632	0.059	9.189	0.120

Table 3. Effect of mulching and micronutrient on Color of turmeric powder, Recovery % and Curcumin content (%)

S. No	Treatment	Color of turmeric powder	Recovery (%)	Curcumin content (%)
T_1	Only recommended dosages of NPK (control)	Red-Orange	17.53	0.49
T_2	Grass mulch +0.5% foliar spray of Sulphur	Orange yellow	19.43	0.53
T_3	Grass mulch +0.5% foliar spray Zinc Sulphate	Orange yellow	20.38	0.61
T_4	Grass mulch + 0.5% foliar spray Ferrous Sulphate	Orange yellow	20.78	0.57
T_5	Wheat straw + 0.5% foliar spray Sulphur	Orange yellow	18.40	0.52
T_6	Wheat straw + 0.5% foliar spray Zinc Sulphate	Yellow	23.62	0.65
T_7	Wheat straw + 0.5% foliar spray Ferrous Sulphate	Dark yellow	14.93	0.63
T_8	Black polythene mulch + 0.5% foliar spray of Sulphur	Dark yellow	21.49	0.50
T_9	Black polythene mulch + 0.5% of foliar spray Zinc Sulphate	Bright yellow	24.87	0.92
T_{10}	Black polythene mulch + 0.5% of foliar spray Ferrous Sulphate	Yellow	24.06	0.69
	SE(±m)		**1.367**	**0.016**
	CD(5%)		**4.094**	**0.049**

Conclusion

It is concluded from the result of the present investigation that among the different treatment, T_9(Black polythene mulch + 0.5% of foliar spray Zinc Sulphate) showed the maximum growth, yield and quality parameters in turmeric. The adoption of mulching and micronutrient application under protected cultivation presents a viable solution for increasing turmeric yield and quality. These practices not only address environmental sustainability but also enhance economic returns for farmers. Future research should focus on identifying the most effective combinations of mulch types and micronutrient formulations to further optimize turmeric production.

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Carbon Sequestration and Yield of Cotton as Influenced by Various Organic Sources of Nutrients under Rainfed Cotton in Vertisols

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Cotton (*Gossypium*spp.) is the most important fiber and cash crop originated in India and belongs to Malvaceae family and is said to be king of cash crops and is popularly known as "white gold". It is known as "king of fiber" because of having vast importance in global economy(Ahmed *et al.*, 2009). It is a shrub with broad and lobed leaves whose seeds are contained in a capsule called 'boll'. When fully matured, these bolls are picked and transported for processing. It provides fiber, a raw material for textile industry and plays a vital role in economy of the country. India is the largest cotton growing country in the world and occupies 41% world cotton area and produces around 26% of world cotton production.In 2022-23 area, production and productivity under cotton in India was estimated as 130 lakh ha, 52 lakh tonnes and 439 kg ha^{-1} respectively. In India, Maharashtra rank first in acreages with 42.29 lakh ha and 81.85 lakh bales production with average productivity of 329 kg lint/ha (Anonymous, 2023). The indiscriminate uses of chemical fertilizers are prone to several environmental problems like deterioration of soil heath, contamination of natural resources, loss of bio diversity, high insecticide resistance, pesticide resistance, etc. This problem can be mitigated by the use of organic manure. Soil organic carbon (SOC) is a basic building block for all life on the earth. It plays an important role in soil fertility and productivity. Soil organic carbon can be used for assessing soil quality; it indicates the level of productivity of a given soil. Agricultural soil is a potential sink for atmospheric carbon as soil organic carbon (Rudrappa *et al*., 2006; Kundu *et al*., 2007). The carbon sequestration is affected by various organic sources of nutrients. The objective of this study was to determine C sequestration after five years as influenced by various organic sources of nutrients applied to rainfed cotton in Vertisols.

Methodology

The study was carried out to determine C sequestration after five years as influenced by various organic sources of nutrients applied to rainfed cotton in Vertisols under an ongoing experiment conducted during kharif season of 2023-2024 at research farm of AICRP for Dryland Agriculture, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. This study was based on nine treatments consisting of various combinations of organic sources of nutrients along with three replications evaluated in randomized block design. Surface soil samples (0-20 cm) depth were collected for soil analysis. The treatments were **T_1**-100% RDF (60:30:30 NPK kg ha^{-1}), **T_2**-FYM 12 t ha^{-1}, **T_3**-Gliricidia 8 t ha^{-1}, **T_4**-Vermicompost 3.0 t ha^{-1}, **T_5**-50% N through FYM + 50% N through Gliricidia, **T_6**-50% N through FYM + 50% N through Vermicompost, **T_7**-50% N through Vermicompost + 50% N through Gliricidia, **T_8**-25% N through FYM + 25% N through Vermicompost + 50% N through Gliricidia, **T_9**-25% N through Gliricidia + 25% N through Vermicompost + 50% N through Gliricidia.

Results

The data presented in Table indicate that significantly highest seed cotton yield, soil organic carbon was observed in organic treatment with application of 50% N through FYM + 50% N through gliricidia (T_5)and was at par with application of 50% N through vermicompost + 50% N through Gliricidia(T_7).This may be due to mineralization and slow release of nutrients from FYM/ Gliricidia/vermicompost to cotton crop, throughout the crop growth period, favouring more utilization of nutrients by plant and enhanced the translocation of photosynthates towards sink and increase cotton yield(Solunke *et al.*,2018 ; Gabhane *et al,*2020).

SOC stock, carbon sequestration and rate of carbon sequestration was observed highest in organic treatment with application of 50% N through FYM + 50% N through gliricidia(T_5) followed by with application of 50% N through vermicompost + 50% N through Gliricidia(T_7).Similar results were also observed by Brar *et al.* (2013). The possible reason for enhanced SCS under organic farming was possibly due the increased SOC in soil and further relative increase in SOC storage depending upon crop mediated C input, large supply of organic matter and the initial organic C content of soils (Singh and Benbi, 2018).

Lowest SOC, SOC stock, carbon sequestration and rate of carbon sequestration was observed in RDF, whereas bulk density of soil was significantly reduced in all organic treatments over the (RDF).Similar kind of result were found by Surekha and Rao (2009).

Seed cotton yield, SOC stock, Cseq and soil organic carbon sequestration rate as influenced by various organic sources of nutrients under rainfed cotton

Treatments	Seed cotton (kg ha^{-1})	BD (Mg m^{-3})	SOC (g kg^{-1})	SOC stock (Mgha^{-1})	C $_{seq}$ (Mg ha^{-1})	SOCSR (Mg C ha^{-1}yr^{-1})
T_1-100% RDF (60:30:30 NPK kg ha^{-1})	900.0	1.46	5.4	15.77	0.78	0.15
T_2-FYM 12 t ha^{-1}	813.0	1.41	6.2	17.48	2.49	0.50
T_3-Gliricidia 8 t ha^{-1}	784.0	1.45	6.1	17.69	2.7	0.54
T_4-Vermicompost 3.0 t ha^{-1}	891.0	1.43	6.5	18.59	3.6	0.72
T_5-50% N through FYM + 50%Nthrough Gliricidia	1008.8	1.41	6.7	18.89	3.9	0.78
T_6-50% N through FYM + 50% N through Vermicompost	765.8	1.44	6.1	17.57	2.58	0.51
T_7-50% N through Vermicompost+ 50% N through Gliricidia	969.2	1.43	6.6	18.88	3.89	0.78
T_8-25% N through FYM + 25% N through Vermicompost + 50% N through Gliricidia	927.9	1.43	6.3	18.02	3.03	0.60
T_9-25% N through Gliricidia + 25% N through Vermicompost + 50% N through Gliricidia	639.5	1.45	6.1	17.69	2.7	0.54
SE (m) ±	52.5	0.01	0.18	-	-	-
CD at 5%	157.4	0.03	0.53	-	-	-

Initial year (2019-20) SOC stock : 14.99 Mg ha-1

Conclusion

Balanced and conjunctive use of FYM + Gliricidia/ Vermicompost resulted in increase in seed cotton yield with improvement in soil organic carbon, SOC stock, carbon sequestration and rate of carbon sequestration in Vertisols.

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Influence of Integrated Nutrient and Water Management on Crop Productivity in Summer SRI at the New Alluvial Soil of India

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Meeting the food demand of nine billion population by 2050 will be an arduous task as the ecosystem is continuously deteriorating. The emerging challenges need to be produced more food with less land, water and labour in more efficient, environmental-friendly production systems that are more sustainable and resilient to climate change. Finding solutions for this is at the heart of system intensification (SI) that deals with the biological management of crop and soil for long-term sustainability (Uphoff, 1999). SRI is amalgamation of refined and intensive management practices of rice production with advantages of production enhancement and cost reduction. In comparison to traditional transplanted rice; SRI, which is not a fixed set of things that farmers 'must' do, require no material inputs beyond what farmers already have and it is just a change in thinking and practice (Ghosh *et al.,* 2014). Considering these facts, the experiment was projected with system of rice intensification methodology to study the effect of integrated nutrient and water management on crop productivity of summer paddy.

Methodology

The field experiment was conducted following SRI methodology on summer transplanted paddy cv. IET 4786 with spacing 25 cm x 20 cm during 2014 and 2015 at Bidhan Chandra Krishi Viswavidyalaya Farm, Mohanpur, West Bengal. The experiment consists of 3 main plots (water) and 6 sub-plots (nutrient) treatment replicated thrice following split plot design. The water management levels were Farmers' practice (FP) (*i.e.,* 5 cm continuous water submergence); SRI (*i.e.,* Hair crack stage + 2 cm water submergence at active tillering, panicle initiation and grain filling) and Alternate wetting & drying (AWD) (*i.e.*, keeping field in moist condition) whereas the nutrient management levels were RDF + NC (*i.e.,* Recommended dose of fertilizer + Neem Cake @ 2 t ha^{-1}); N (25 % OR + 75 % INOR) + NC (*i.e.,* Nitrogen - 25 % through vermicompost + 75 % through urea + Neem Cake @ 2t ha^{-1}); N (50 % OR + 50 % INOR) + NC (*i.e.,* Nitrogen - 50 % through vermicompost + 50 % through urea + Neem Cake @ 2 t ha^{-1}); N (75 % OR + 25% INOR) + NC (*i.e.,* Nitrogen - 75 % through vermicompost + 25 % through urea + Neem Cake @ 2 t ha^{-1}; N (100 % OR) + NC (*i.e.,* 100% nitrogen through vermicompost + Neem Cake @ 2 t ha^{-1}) and RDF only. The RDF is 100: 50: 50 N: P_2O_5: K_2O kg ha^{-1}. Full doses of neem cake and vermicompost as per treatment were applied to the field after lay out along with full dose of P_2O_5 and 25 % K_2O in the form SSP and MOP. 25 % N in the form of urea was applied at 10 DAT and 25 % N + 25 % K_2O were applied at 25, 50 and 75 DAT.

Results

The results revealed that SRI *i.e.*, judicious use of irrigation water by submerging paddy field only at its critical physiological stages recorded higher growth attributes over the farmers' practice and AWD treatments, respectively. The increasing growth attributes helped the SRI water management treatment to increase the yield and yield traits by 21 & 49 % number of panicles $plant^{-1}$ and 15 & 31 % number of filled grains $panicle^{-1}$ over farmers' practice and AWD, respectively. The grain yield of summer SRI paddy treatment recorded 20 & 68 % more than that observed in farmers' practice and AWD, respectively.

Table 1: Impact of integrated water and nutrient management on grain yield of summer SRI

Treatments	Grain yield (t ha^{-1}) Nutrient management						
Water management	**RDF + NC**	**N (25 % OR + 75 % INOR) + NC**	**N (50 % OR + 50 % INOR) + NC**	**N (75 % OR + 25% INOR) + NC**	**N (100 % OR) + NC**	**RDF**	**Mean**
FP	3.89	4.48	4.65	4.94	4.87	3.66	4.42
SRI	4.67	5.43	5.56	5.95	5.82	4.41	5.31
AWD	2.86	3.07	3.25	3.61	3.52	2.71	3.17
Mean	3.81	4.33	4.49	4.83	4.74	3.59	
SEm (±)	WM = 0.06	NM = 0.04		WM x NM = 0.07			
CD (p=0.05)	WM = 0.20	NM = 0.12		WM x NM = 0.21			

Conclusion

Application of irrigation water through SRI method is better in comparison to farmers' practice using continuous submergence throughout the crop growing period or application of irrigation water in hair crack stage only. More addition of nutrient through organic sources by substituting inorganic sources will also help to increase the soil health by enriching microflora population and higher productivity. This will save not only the precious one third irrigation water but will also increase the productivity. SRI water management integrated with more organic nutrient treatments is better than that of the continuous submergence or application of irrigation water in hair crack stage integrated with RDF only.

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Use of Broad Bed Furrow (BBF) Method for Increasing Productivity of Soybean under Rainfed Situation

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Jalna District is in erratic rainfall zone; the average rainfall is 688mm annually and dry spell occurrence more than 15 days every year. The productivity of rainfed farming is low as compared to the irrigated crop production. The crop yield in the rainfed farming is often reduced due to the lack of soil moisture. It is necessary to adopt suitable technology to conserve the rain water in-situ to ensure adequate moisture during the various growing stages of the crop in rainfed farming. Animal drawn broad bed-furrow former is available but their efficiency is very less, therefore, it is necessary to develop suitable tractor operated BBF planter to overcome this problem. According to climate change for In Situ Moisture Conservation BBF in Soyabean Crop demonstrated in NICRA demonstration.

Table 1. Technical specification and dimensions of broad bed furrow machine

Sl. No.	Particulars	Details
1.	No. of ridgers	2
2.	Width of bed	180 cm
3.	No. of plant rows in bed	4
4.	Row to row spacing of plants	45 cm
5.	Seed and fertilizer metering mechanism	Fluted roller type
6.	Type of furrow openers	Shoe type
7	Length of bed (m)	60-80
8	Width of bed (cm)	180
9	Height of bed (cm)	20-25
10	Length of furrow (m)	60-80
11	Top width of furrow (cm)	42-45
12	Bottom width of Furrow (cm)	7-10
13	Depth of furrow (cm)	20-25

The broad bed furrow machine was provided under NICRA Project CRIDA, Hyderabad of farm mechanization and machine is purchased by KVK Jalna-I under the ICAR project National Innovations on Climate Resilient Agriculture. Before trial, trainings were conducted for farmers about use of BBF. Keeping in the view, need under rainfed farming to increase area in the district, therefore, KVK Jalna-I has taken following technologies the technical details & dimensions of broad bed furrow machine is given in Table 1. seed yield, net returns, benefit: cost ratio (B:C ratio) were recorded for soybean crop.

Methodology

The Demonstration was carried out during Kharif 2022-23, 2023-24 on Fourty farmer's field NICRA village of Pokalwadgaon of district Jalna of Maharashtra state with size of demo is one acre to determine the impact of sowing techniques on yield of soybean under farmers' conditions. The soil moisture is managed by maximizing the use of rainfall through increasing infiltration and moisture retention and reducing runoff and soil erosion.

Table 2. Analysis of broad bed furrow and flat bed method

Year	Treatment	Seed Yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross Income (Rs/ha)	Net Income (Rs/ha)	B:C ratio
2022-23	Farmer practices	1720	38900	68800	29900	1.76
	BBF technology	2274	35900	90960	55060	2.53
2023-24	Farmer practices	1900	41700	76000	34300	1.82
	BBF technology	2450	35600	98000	62400	2.75

Performance of BBF Planter Over Farmers Practice

Particular	*BBF Technology*	*Farmers Practice*	*Remark*
Sowing Method	BBF Planter	Seed Drill	-
Seed Rate (Kg/ha)	75 kg	60 kg	Saving of seed over farmer practice 25%
Time taken for sow	4hr	2hr	Saving of half of the time in BBF
Spacing line	45cm	45 cm	-
Level of Pest & Diseases	Low	High	Easy to spraying even during later crop growth stages with the help of furrow made by BBF planter
Moisture Level in Dry spell 15>Days	Available	Unavailable	In BBF 10-11 % Moisture holding capacity in Dry spell
Seed Yield kg/ha	2450 kg/ha	19.00 kg/ha	18.50% higher yield over conventional method
Cost of Cultivation	35600	41700	6000-7000 can be saving in conventional method
Gross Return	98000	76000	
Net Return	62400	34300	About 30000/-Additional return
B:C Ratio	2.75	1.82	-

Benefit cost ratio

B:C ratio was also worked out for both farmers practice and demonstration plots from sowing to harvesting as given in Table 2. The B:C ratio as observed from table has been more in BBF field as compared to conventional method of sowing of soybean. It is because of reduction in primary tillage operation BBF method as well as due to higher production.

Conclusion

Soybean is more water stress crop and at the time of germination sudden rainfall affects the crop. Thus, by this machine, the performance of high yielding improved varieties is optimized as the deep furrows created under BBF provides effective drainage during excess rains, while serves as in situ moisture conservation during dry spells, thus mitigating the detrimental effects of both extreme situations. The results of experiment indicate that for achieving maximum productivity from soybean crop in NICRA village of Jalna district of Maharashtra, the soybean crop should be sown on broad bed furrow planting system.

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Assessment of Nano Urea in Pearlmillet as Source of Nitrogen under Changing Climate Condition

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Pearlmillet [Penisetum glaucum (L.)] R. Br. Emend Stuntz] is one of the important cereal crops of arid and semi-arid regions. It has been estimated that pearl millet embodies a good productivity potential particularly in areas encountering extreme environmental stress situations on account of drought. It grows well on poor sandy soils as well as its drought escaping character has made it a popular crop of drought prone areas. It is extensively cultivated as dual purpose crop. India is the largest producer of pearl millet with an annual production of 10.28 million tonnes from an area of 7.52 million ha with a productivity of 1368 kg ha-1.

Nitrogen plays a most important role in various physiological processes (Leghari et al. 2016). Fertilizers have an axial role in enhancing the food production in developing countries especially after the introduction of high yielding and fertilizer responsive crop varieties. Urea contributes about 82% of the total Nitrogenous fertilizer consumption in India and about 55% of the total fertilizer nitrogen consumed in the world. Around 30-40% of nitrogen from urea is utilized by plants and the rest gets wasted due to quick chemical transformation as a result of leaching, volatilization, denitrification and run off, thereby low use efficiency (Shraddha et al. 2024). These transformation processes make nitrogen management very complex and quite difficult to improve the nitrogen use efficiency. In order to improve the nitrogen-use efficiency by crops, several strategies have been suggested in the past few decades. Among these, nanotechnology has the potential to revolutionize the agricultural system. Nano fertilizer technology is designed to deliver nutrients in a regulated pattern in correspondence with the crop demand thereby nutrient use efficiency can be improved without associated ill-effects (Naderi and Shahraki 2013). Nano urea has high nitrogen use efficiency and also it is environment friendly. This fertilizer is popularly known as "smart fertilizer" because it reduces the emission of nitrous oxide which is primarily responsible for contaminating soil, air and water bodies and also helps in reduction of global warming. These properties make it a promising alternative over conventional urea (Kannoj et al., 2022).

Nano fertilizers are the important tools in agriculture to improve crop growth, yield and quality parameters, reduce wastage of fertilizers and cost of cultivation. Nano urea particles are easily available to crops due to their small size and high surface area to volume ratio. It increased chlorophyll and photosynthesis in leaves, as well as an increase in root biomass and the number of effective tillers/branches, result in higher crop yields. Nano urea makes the use of bulk nitrogen fertilizers like urea more efficient. It is environment friendly, required in small quantities compared to bulky nitrogenous fertilizers like urea, it is easy to store and transport. Farmers can easily carry bottles of nano urea over bulkier urea bags, which have a substantial influence on relative logistics and warehousing costs (Meena and Verma, 2022).

In order to solve higher fertilizer requirement during crop growth, environmental issues and also taking economic aspects, the use of nitrogen nano fertilizer is essential. Therefore, keeping above facts in view an on-farm trial experiment entitled "Assessment of Nano urea in pearlmillet as source of nitrogen under changing climate condition" was conducted during Kharif season of 2022-23 and 2023-24 at Farmers field in different selected villages under Krishi vigyan Kendra Morena.

Methodology

The field experiment was carried out during Kharif season of 2023 and 2024 at Farmers field in different selected villages under Krishi vigyan Kendra Morena. Geographically, the study area is located at Chambal agro-climatic zone of Madhya Pradesh. The region's climate is classified as semi-arid with characterized by aridity of the atmosphere and extremity of temperature both in summer (47.5ºC) and winter (2ºC) with annual rainfall of 750 mm. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction.

The experiment was laid out in factorial randomized block design with five replications and consisting three treatment T1- Control (100 % RDN through Granular urea), T2- 25% RDN through Granular urea + 75% as 2 spray of nano urea at 30 & 45 DAS) and T3- 50% RDN through Granular urea + 50% as 2 Spray of nano urea at 30 & 45 DAS). The experimental area was 2000 m^2 at each farmer's field. The number of farmers was treated as replication for statistics calculations. The pearl millet variety 'GK-1301' was sown during 10-25 July 2023 and 05-20 July 2024. On the basis of gross plot size, the required quantity of fertilizer and Nano-Urea as per treatments was calculated and weighted for different plots. Full recommended dose of 40 kg P2O5 ha^{-1} was applied uniformly as basal at the time of sowing. Recommended dose of nitrogen at 90 kg ha^{-1} and was applied half as basal and half as top dressing. Liquid nano-urea was sprayed as per treatments. Standard crop production practice and methods were followed for fertilizer application and crop protection management to grow crop.

Results

Effect on yield and yield attributes

The length of earhead was recorded at the time of harvesting. Perusal of data indicated that different treatments exhibited their significant influence on length of ear head. Significantly the highest ear head length of 25.05 cm found under the treatment T3 (50% RDN through Granular urea + 50% as 2 Spray of nano urea at 30 & 45 DAS), followed by 23.22 in T2 (25% RDN through Granular urea + 75% as 2 spray of nano urea at 30 & 45 DAS) and 20.30 inT1(100 % RDN through Granular urea). This is due to foliar application of nano urea enhance protein synthesis and supply adequate nitrogen which plays an important role in accelerated the activity of enzyme, cell division and plant growth. The chief function of nitrogen is multiplication; cell elongation and tissue differentiation that ultimately enhanced vegetative growth of plant and it produce more food for storage. Similar findings have been reported by Bhargavi and Sundari (2022).

Yield attributes of pearlmillet as affected by nano urea application

Treatments	Length of ear head (cm)	Girth of ear head (cm)	Weight of ear head (g)	Grain Yield (g/plant)	Test Weight (g)
T1	20.30	11.06	40.10	27.77	18.25
T2	23.22	11.21	42.17	29.92	18.52
T3	25.05	12.25	44.15	31.79	18.56
SEm+_	0.11	0.23	0.04	0.026	0.13
CD@5%	0.34	0.75	0.12	0.84	NS

An appraisal of data revealed that different treatments caused their significant influence on ear head girth. Significantly the highest ear head girth (12.25 cm) was noted under the 50% RDN through Granular urea + 50% as 2 Spray of nano urea at 30 & 45 DAS followed by (11.21) T2 (25% RDN through Granular urea + 75% as 2 spray of nano urea at 30 & 45 DAS). Whereas, the Control (T1) recorded statistically inferior ear head girth (11.06 mm).

The data recorded on weight of ear head presented in table-1. Perusal of data indicated that weight of ear head was also affected significantly with the use of nano urea. The maximum weight of ear head was recorded in treatment T3 (44.15 g) which was followed by T2 (42.17

g) and T1 (40.10 g). All three treatments was significantly differ to each other in concern to weight of ear head.

The data regarding the test weight recorded after harvest are furnished in Table-1. A perusal of the data revealed that different treatments exercised did not show any significant influence on test weight. The increase in yield attributes due to nano fertilizer used alongside conventional fertilizer, enhance plant cells capacity for nutrient absorption. This promotes optimal growth of various plant components and vital metabolic processes like photosynthesis, leading to an accumulation of higher levels of photosynthates. Subsequently, the translocation of these photosynthates to economically vital plant parts results in a notable improvement in yield attributing character. These results are in conformity with the findings of Rajesh et al. (2021), Bhargavi and Sundari (2022), Ranjan et al. (2022).

Data presented in Table above revealed that different treatments exerted their significant influence on grain yield. Significantly the highest grain yield (3389 kg/ha) was produced with an application of 50% RDN through Granular urea + 50% as 2 Spray of nano urea at 30 & 45 DAS (T3), which was statistically at par with 25% RDN through Granular urea + 75% as 2 spray of nano urea at 30 & 45 DAS (T2) 3289 kg/ha. However, significantly lower grain yield (2806 kg/ha) was obtained under Control (T1).

Effect on economics

For calculating gross return, grain and fodder yields and their market prices were considered, which are given in Table above.The data regarding gross return was furnished in Table 2. which revealed that the maximum gross return (72876 ₹/ha) was obtained with the application of 50% RDN through Granular urea + 50% as 2 Spray of nano urea at 30 & 45 DAS (T3), followed by 70717 ₹/ha with application of 25% RDN through Granular urea + 75% as 2 spray of nano urea at 30 & 45 DAS (T2). However, the minimum gross return (60337 ₹/ha) was achieved with the treatment T1 (Control – 100 % RDN with urea grannules). The highest cultivation cost (30500 ₹/ha) was incurred with the treatment of T3, followed by the treatment T2 with mean cost of 30400 ₹/ha. However, the lowest cultivation cost (28673 ₹/ha) was observed with the treatment T1 (Control). The maximum net return (42376 ₹/ha) was accrued with the treatment of 50% RDN through Granular urea + 50% as 2 Spray of nano urea at 30 & 45 DAS (T3), followed by the treatment 25% RDN through Granular urea + 75% as 2 spray of nano urea at 30 & 45 DAS (T2) with mean net return of 40317 ₹/ha. Whereas, the lower net return (31664 ₹/ha) was recorded in T1 control. The highest B:C ratio (2.39) was obtained under the treatment T3 (50% RDN through Granular urea + 50% as 2 Spray of nano urea at 30 & 45 DAS), followed by 25% RDN through Granular urea + 75% as 2 spray of nano urea at 30 & 45 DAS (T2), with an average B:C ratio of 2.33. The Control (T1) recorded the lowest B:C ratio (2.10). These in findings are vicinity with those reported by Rajesh et al. (2021), Ranjan et al. (2022), Chinnappa et al. (2023) , Karanjikar et al. (2023) and Upadhyay et al. (2023).

Yield (kg/ha) and Economics of pearl millet as affected by nano urea application

Treatment	Grain yield (kg/ha)	Cost of cultivation (₹/ha)	Gross Return (₹/ha)	Net Return (₹/ha)	B:C Ratio
T1	2806	28673	60337	31664	2.10
T2	3289	30400	70717	40317	2.33
T3	3389	30500	73876	42376	2.39
SEm+_	36.63	NA	787.48	787.48	NA
CD@5%	119.45	NA	2568.11	2568.11	NA

Conclusion

On the basis of the results of an on-farm trial, it is concluded that application of 50% RDN through Granular urea + 50% as 2 Spray of nano urea at 30 & 45 DAS in pearl millet grown under chambal Agro-climatic zone is beneficial as it provided significantly highest yield and yield attributes e.i. ear head length and girth and grain yield along with more net returns.

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Evaluation of soil properties in rice fields under two management practices under NICRA adopted village

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The National Innovation on Climate Resilient Agriculture (NICRA), initiated by the Indian Council of Agricultural Research (ICAR) in 2011, focuses on mitigating the impacts of climate change on Indian agriculture. This initiative seeks to strengthen agricultural resilience to climate variability and extreme weather events by emphasizing strategic research, innovative technology development, and farmer capacity-building. The program prioritizes the development of climate-resilient crop varieties, advanced water management strategies, soil health conservation and the promotion of sustainable farming practices. Additionally, NICRA advocates for resource conservation measures and equips farmers with climate risk advisories, facilitating adaptation efforts and safeguarding food security amidst evolving climate challenges.

Methodology

Two rice genotypes i.e. Sahbhagi and Sabourdeep were conventionally cultivated for over five years at one location i.e. Garhi (Poriyahat, Godda district, Jharkhand). Under the T_1 treatment (Recommended Dose of Fertilizer, RDF), the rice fields received NPK @ 120:60:60 kg ha^{-1}, whereas under the T_2 treatment (RDF + Additional Fertilizer), the fields were supplemented with NPK @ 120:60:60 kg ha^{-1}, along with $ZnSO_4$ @ 20–25 kg ha^{-1}, $FeSO_4$ @ 25–50 kg ha^{-1}, and Borax @ 1–2 kg ha^{-1}, applied through both basal and foliar applications. Soil samples were collected from the experimental fields after the harvest of the two rice genotypes grown during the wet (kharif) season of 2023 under both management practices. These samples were analyzed at GVT-Krishi Vigyan Kendra, Godda, Jharkhand, India. The analysis assessed the soil's physico-chemical properties (organic carbon, pH, and electrical conductivity) and nutrient status (mineralizable nitrogen, available P_2O_5, and available K_2O) using standard procedures. The statistical analysis of the collected data was conducted using a Split plot Design for the two treatments and two cultivars to evaluate differences between the management practices and cultivar. The analysis was performed using OPI-STAT software to ensure accurate interpretation of results.

Results

A detailed analysis of the data in Table 1 reveals that T_1 (5.71) exhibits a slightly lower pH compared to T_2 (6.08). Electrical conductivity (EC) values for both T_1 (0.360 dS/m) and T_2

(0.375 dS/m) are comparable, showing no significant variation. However, T_2 (0.61%) demonstrates a higher organic carbon (OC) content than T_1 (0.52%). Among the cultivars, Sahbhagi (5.78) shows a lower pH compared to Sabourdeep (6.01). Similarly, EC values for Sahbhagi (0.370 dS/m) and Sabourdeep (0.365 dS/m) are nearly identical. In terms of organic carbon, Sabourdeep (0.59%) surpasses Sahbhagi (0.54%). Overall, Treatment T_2 and the Sabourdeep cultivar contribute positively to soil quality by enhancing organic carbon levels and moderating pH. The significant differences in organic carbon for both treatments and cultivars underscore the importance of tailored nutrient management and cultivar selection to improve soil organic carbon. Meanwhile, the negligible variation in EC suggests stable salinity conditions regardless of treatment or cultivar.

An examination of the data in Table 2 reveals that T_1 (282.93 kg ha^{-1}) and T_2 (285.44 kg ha^{-1}) exhibit similar nitrogen levels, with no significant difference. However, T_2 (18.90 kg ha^{-1}) records a higher phosphorus content compared to T_1 (15.86 kg ha^{-1}) and significantly increases potassium availability (138.17 kg ha^{-1}) compared to T_1 (123.30 kg ha^{-1}). Among the cultivars, Sabourdeep (286.94 kg ha^{-1}) demonstrates higher nitrogen levels than Sahbhagi (281.43 kg ha^{-1}). In terms of phosphorus, Sabourdeep (17.79 kg ha^{-1}) slightly outperforms Sahbhagi (16.98 kg ha^{-1}). Both cultivars exhibit nearly identical potassium levels, with Sahbhagi (130.48 kg ha^{-1}) and Sabourdeep (130.99 kg ha^{-1}). While the treatments do not significantly impact available nitrogen, the consistently higher nitrogen levels in Sabourdeep suggest cultivar-specific influences on nitrogen uptake or retention. Similarly, Sabourdeep's superior phosphorus levels indicate a possible genetic advantage in phosphorus utilization. The significant increase in potassium availability with T_2 highlights its positive impact on potassium dynamics. Overall, T_2 enhances soil fertility by significantly improving phosphorus and potassium levels compared to T_1, with minimal effects on nitrogen. Sabourdeep emerges as the better cultivar for nutrient optimization due to its advantages in nitrogen and phosphorus availability.

Table 1: Physico-chemical properties of soil in rice fields at one location in district of Jharkhand

Treatment	**Location: Garhi**		
Nutrient management	**pH**	**EC (ds/m)**	**Organic Carbon (%)**
T1	5.71	0.360	0.52
T2	6.08	0.375	0.61
CD (P=0.05)	NS	NS	0.05
Cultivar			
Sahbhagi	5.78	0.370	0.54
Sabourdeep	6.01	0.365	0.59
CD (P=0.05)	0.11	NS	0.013

T1: Recommended Dose of Fertilizers (RDF), T2: RDF + Additional Fertilizer/Amendment

Table 2: Primary nutrient status in soil in rice fields at one location in same district of Jharkhand

Treatment	Location: Garhi		
Nutrient management	Ava. N (kg ha^{-1})	Ava. P_2O_5 (kg ha^{-1})	Ava. K (kg ha^{-1})
T1	282.93	15.86	123.30
T2	285.44	18.90	138.17
CD (P=0.05)	NS	1.98	14.63
Cultivar			
Sahbhagi	281.43	16.98	130.48
Sabourdeep	286.94	17.79	130.99
CD (P=0.05)	5.26	0.36	NS

T1: Recommended Dose of Fertilizers (RDF), T2: RDF + Additional Fertilizer/Amendment

Conclusion

The analysis highlights the positive impacts of Treatment T_2 and the Sabourdeep cultivar on soil quality and nutrient availability. T_2 improves soil organic carbon, phosphorus, and potassium levels while maintaining stable pH and electrical conductivity. Sabourdeep demonstrates superior nitrogen and phosphorus availability and higher organic carbon compared to Sahbhagi. Together, T_2 and Sabourdeep enhance soil fertility and nutrient optimization, making them a promising combination for improved crop performance.

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UID: 1732

Conservational and Managerial Interventions for Natural Resource Management of Wetland Ecosystem of Kuttanad

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Rice continues to be the staple food for most of the Keralites despite the change in their lifestyle. The most important producer of rice in Kerala is Kuttanad, the rice bowl of Kerala. The wetlands in Kuttanad are geographically and climatically one of its kind and are submerged in water for most part of the year. The lowland has soil pH (3.5-5.5) and resultant problems like iron toxicity and low availability of other nutrients. These, along with change in climate has made cultivation of crops very difficult. The region is now more prone to recurrent, erratic rains and result in flood, water logging and crop loss. The region is also known for indiscriminate use of fertilizers and pesticides, further worsening the situation, polluting the soil and water bodies. Minor interventions in natural resource management along with a proper crop calendar and crop production strategies can bring resilience. In this scenario, the present intervention on conserving and managing natural resources though interventions was carried out in the NICRA village Kumarakom under the guidance of KVK Kottayam during 2022-24.

Methodology

Thekkeppallippadam *padashekaram* of NICRA village Kumarakom was chosen for the study as this area was severely affected by climate change. The prime constraint for paddy cultivation in the kumarakom fields was management of water. The existing irrigation channels were desilted and deepened in convergence with the MGNREGA. Bunds and side walls were strengthened. Sluice gates were also installed. The *padashekaram* was supplied with vertical axial flow Motor Pump in convergence with Kuttanad package project. Soil samples were collected from the paddy fields, tested and soil test-based fertilizer recommendations were provided to the farmers. The quantity of lime to be added to the soil was also recommended. On field testing of pH and EC using portable pH and EC meter were demonstrated to the farmers. Also, a proper crop calendar was given to the farmers along with trainings for scientific cultivation of paddy in the lowlands. Scientific recommendations and timely intervention on integrated pest and disease management were also adopted.

Result

Deepening and desilting of the water channels enabled better holding of the water. Installation of sluice gates improved the water regulation in the field. The vertical axial flow pump eased the pumping of excess water from the field saving the crop from flood loss.

Liming of the acidic soils had a great impact on the soil health and absorption of nutrients. Application of fertilizers according to the soil test-based requirement helped not only the plant, but also improved the soil and water health. The soil became less contaminated and its quality improved owing to a healthy microbial population. Optimum quantity of fertilizers ensured minimal wastage, hence minimal leaching of chemicals into nearby water bodies. This also helped in bringing down eutrophication. All these prevented further pollution of the environment.

Adoption of crop calendar and integrated weed, nutrient, pest and disease management under guidance together with NRM interventions resulted in early harvesting of healthy crop with enhanced yield.

Table 1: **Impact of adoption of NRM activities along with other scientific crop cultivation practices for Uma rice variety**

Intervention	NICRA village		Non- NICRA Village	
	Yield (q/ha)	Net Return (Rs/ha)	Yield (q/ha)	Net Return (Rs/ha)
NRM activities	54	66600	44	32600

Conclusion

Interventions implemented by KVK Kottayam in convergence with line departments enhanced the environmental health status, water quality and increased yield. Application of lime and soil test based application of secondary and micronutrients helps in by reducing the percentage of chaffy and partially filled grains.

UID: 1742

Impact of Mulching with Coconut Husk on Water Retention and Coconut Productivity

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Coconut palms, absolutely require water for survival and growth. Unlike some plants that store water for dry periods, coconut palms have shallow roots that can't reach deep groundwater. They rely on the moisture in the upper soil layers, which can quickly dry out during droughts, causing significant water stress. Coconut palms produce nuts year-round, so consistent water availability is crucial for their continuous growth and yield. Water stress can cause various problems, including leaf drooping, stunted growth, and premature nut fall, ultimately reducing the overall yield. In-situ mulching with coconut husks or pith can significantly enhance soil moisture retention in coconut plantations. The conservation of soil moisture through mulching is one of the important purpose due to modification of micro-climate conditions in the soil . According to Hatfield et al. (2001), crop residue mulching can effectively reduce soil water evaporation by 34-50%. Khurshid et al. (2006) and Muhammad et al. (2009) also support these findings, emphasizing that mulching improves soil ecological health and consequently reduces soil water loss. Burying fresh or dried coconut husks around the palm is beneficial, especially for improving soil moisture.(KAU,2016).These sustainable interventions effectively enhance water retention within the soil profile, significantly mitigating the impact of drought. The demonstration aimed to evaluate the effectiveness of mulching and husk burial in improving water retention and enhancing yield in the coconut plantation.

Methodology

The demonstration was carried out in Pattithara panchayath, NICRA village of Palakkad district. The demonstration involved mature West Coast Tall coconut palms planted at a spacing of 7.5 m x 7.5 m. The trees were approximately 40 years old. The experiment involved 100 mature coconut palms, with 50 receiving treatments of mulching and husk burial and the other 50 palms as control during the dry seasons of 2022-23 and 2023-24. Coconut husks with convex surface facing upwards (100 Nos) up to a height of 10 cm in the basin of 1.8 m radius around the palms was used as mulch.Soil moisture content was monitored at 40-day intervals using the gravimetric method to assess the impact of these treatments on soil moisture conservation. Data on annual nut yield were collected to assess productivity. Concurrently, yield figures were paired with water usage data from the demonstration to evaluate water use efficiency. The monthly total rainfall during dry season starting from October, 2022 to March, 2023 and October 2023 to March, 2024 are presented in table below.

Table 2: Total Rainfall Data of the Demonstration Plot

Year/Month	2022 October	2022 November	2022 December	2023 January	2023 February	2023 March
Rainfall	92.1	54.8	71.8	1.5	0	16.3
Year/Month	**2023 October**	**2023 November**	**2023 December**	**2024 January**	**2024 February**	**2024 March**
Rainfall	138.5	351.5	28	28.02	0	0

Result

This study demonstrated the significant benefits of mulching of coconut husk in improving coconut palm productivity. Treated plots exhibited significantly higher soil moisture levels, reaching 19.28% from an initial 10.8%, resulting in a notable decrease in soil temperature. This enhanced soil moisture environment led to a substantial increase in nut yield, with treated plots showing a 25% and 34% yield enhancement in the first and second years, respectively. Similar trends of result were also reported by Liyanage et.al (1993) that the mulching of coconut husk and coir dust induced a significant increase in nut yield in lateritic soil and palms gave 15-20% higher yield than the control. Concurrently, water use efficiency significantly improved in treated plots, increasing from 0.63 to 0.94, while no such enhancement was observed in the control plots. These findings highlight the effectiveness of these sustainable practices in enhancing resource utilization and improving the overall productivity of coconut plantations.

Table 3: Impact of Treatments on Soil Moisture, Water Use Efficiency, and Yield

Parameter with unit	Before demo	I year		II year	
		Demo	Control	Demo	Control
Yield (Nuts/ha)	11250	15048	12015	16935	12580
Soil moisture level (%)	10.8	16	11.21	19.28	11.90
Water use efficiency (Nuts/ m^3 of water)	0.63	0.89	0.65	0.94	0.68

Conclusion

In conclusion, this study unequivocally demonstrates the significant benefits of mulching with coconut husks and implementing husk burial practices in coconut plantations. The study observed a significant increase in yield, a substantial improvement in soil moisture levels, and a marked enhancement in water use efficiency in plots treated with these practices. These findings strongly advocate for the widespread adoption of mulching and husk burial techniques in coconut plantations as effective strategies for enhancing productivity, conserving water resources, and promoting sustainable coconut cultivation.

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UID: 21402

Effect of Broad Bed Furrow Technology on Yield Parameters of Improved Variety of Soybean Crop Under Rainfed Condition

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The major crop of Dharashiv district is soybean and it occupy about 80% of kharif cultivated area. The average rainfall of the district is 769 mm. Uneven and erratic nature of rainfall causes yield loss of soybean crop (Nagavallemma *et al*., 2005; Lomte *et al*. 2006), so the field experiment on the effect of Broad Bed Furrow (BBF) sowing method were taken with the soybean var. MAUS-612 under rainfed condition. BBF technology is highly suitable to rainfed situations prevailing in the district. Thus, by this BBF planter, the performance of high yielding improved varieties is optimized as the deep furrows created under BBF provides effective drainage during excess rains, while serves as in-situ moisture conservation during dry spells, thus mitigating the detrimental effects of both extreme situations (Singh et al., 2011). This would enable farmers to enhance their productivity.

Methodology

The 100 demonstrations were conducted by Krishi Vigyan Kendra, Tuljapur, Maharashtra in the village Bhusani and Bhuyar Chincholi Block - Omerga during the kharif season of the year 2023-24 to 2024-25 under rainfed condition. Five lines of soybean var. MAUS-612 were sown with the spacing 45 cm x 5cm on the BBF and the width of the furrow was 30 cm. 55 Kg seed was dibbled by BBF Planter on one hector of land. The BBF machine was introduced basically to serves as in-situ moisture conservation practice during dry spells.

Results

The observations on yield parameter shows that the average yield of demonstration plot was 30.0 q/ha over the local check having yield 23.50 q/ha. The average per cent increase in yield was 27.65 % over the local check. Similar observations were recorded by M.P. Jagtap *et al* (2018). According to the market price the average net profit of the trial plot was Rs. 1,09,000/- whereas the net profit of the check plot was Rs.76,500/-. The results shows that the sowing of soybean var. MAUS-612 on BBF gives B:C ratio 3.6 over the local check 2.8. The observations were similar to the findings of P G Shete *et al* (2020).

Conclusion

It is concluded that adoption of improved technology of BBF sowing method with improved variety of soybean MAUS-612 significantly increases yield ultimately increases the net returns of the farmers. Hence, there is a need to disseminate the improved technology among the farmers for getting the higher yield and net return.

Economics of the demonstration plot

Sl. No	Year	Yield (q/ha)		Gross return (Rs)		Net return (Rs)		B:C	
		Demo	Check	Demo	Check	Demo	Check	Demo	Check
1	2023-24	26.25	21.50	131250	107500	91250	67500	3.2	2.6
2	2024-25	33.75	25.50	168750	127500	126750	85500	4.0	3.0
Average		**30.00**	**23.50**	**150000**	**117500**	**109000**	**76500**	**3.6**	**2.8**

Soybean Crop (MAUS - 612) field

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Next-Gen Technologies: AI & ML, Remote Sensing, Modelling, Drones

UID: 1005

Information System for Research Management in Rainfed Agriculture

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The institute is involving number of research and outreach programes. There is an increase in need for monitoring and reporting. Quick analysis of these multiple activities will help in better focusing of activities. Compiling the existing information into a usable database can aid such an analysis. Customizing existing information and designing new specific display formats are among the important tasks for getting an accurate view of information. For that Building a digital tool is required for researchers and policymakers to facilitate the data visualization.

In Visualization, data, information and knowledge are three terms used extensively, often in an interrelated context. In many cases, they are used to indicate different levels of abstraction, understanding or truthfulness (C. Min *et al.*, 2009). As with research that supports scientific visualization, the emphasis has been on visualization as a tool for dispassionate analysis (F. B. Viégas,2007).

Due to the massive amount of information that exists and is created every day, the number of existing artifacts and the needs of all users and consumers of knowledge that exist, it is difficult to find ways to present the information in an accessible way or make sense. To address the inability of humans to deal with large amounts of data, dashboards are a typical instrument to represent business-critical information in a comprehensible manner.Dashboard, is mainly aimed at technology managers of organizations to plan, design, implement and direct applications in real time, and thus monitor the information.

So dashboards are often used for this purpose as they are a powerful tool to comprise relevant information in a single view by providing graphical overview of the current status .So Dashboard users will be able to interact with the information in the form of tables, graphs .This will allow testing an existing set of visualization data tools and techniques. Therefore, dashboard 'was developed which will be very useful for the policy makers, researchers.

Methodology

Development of Dashboard of ICAR-CRIDA was initiated with developing templates for various aspects of monitoring and reporting. The database of the app has been designed using SQL server. User Interfaces were designed. Integrated all the menus and database. This dashboard has been tested with different datasets and evaluated for its user-friendly environment.

Results

The templates for ICAR-CRIDA developed were reviewed and finalized. Key indicators were identified for the dashboard and data for each indicator was uploaded. Provisions were made for user query-based visualization and generating outputs in the form of graphs or tables. The output of the query can be downloaded as .jpeg image format or .csv file. The developed dashboard was demonstrated with real time. The user can easily navigate from one page to another and also provision made to import data into the database.

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UID: 1032

Detection of Sesame Phyllody Disease using Image Analysis and Deep Learning: A Transfer Learning Model Approach with MobileNetV2

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Sesame is a major oilseed crop in India. Among the major yield limiting factors, biotic stress plays the major role in yield reduction which leads to decrease in cultivable areas. Sesame phyllody disease is a very serious disease in most sesame growing regions and causes up to 100% yield loss and thus its management gained national importance. Phyllody caused by phytoplasmas where the entire inflorescence is replaced by a growth consisting of short, twisted leaves closely arranged on a stem with very short internodes and affected plants remain partially or completely sterile, resulting in total loss in yield. The disease spreads in nature by different leafhopper species, among them Orosius orientalis was reported as the major vector. No resistant germplasm has been identified till date and no precise integrated management approaches are available to combat the disease. In this study we are attempting to predict the disease using computer vision and deep learning models. The study presents a detailed exploration of Mobile NetV2 for addressing the disease detection problem, emphasizing the optimization of accuracy and efficiency. Transfer learning and hyperparameter tuning were employed to enhance model performance, and our findings show significant improvements in key metrics.

Data

The images were taken in experimental fields of at Ranjendra Nagar farm ICAR-Indian Institute of Oilseeds Research in Hyderabad. The photos were taken using a DLSR Nikon high-resolution (24 pixels) camera in natural daylight to obtain images uniform resolution. A total of 428 images consisting of 191 healthy and 237 diseased were collected and labelled based on the based on symptoms of Phyllody disease by Pathologist This rigorous annotation procedure guaranteed that the dataset was accurate and reliable, allowing for effective model training and evaluation.

Data Preprocessing

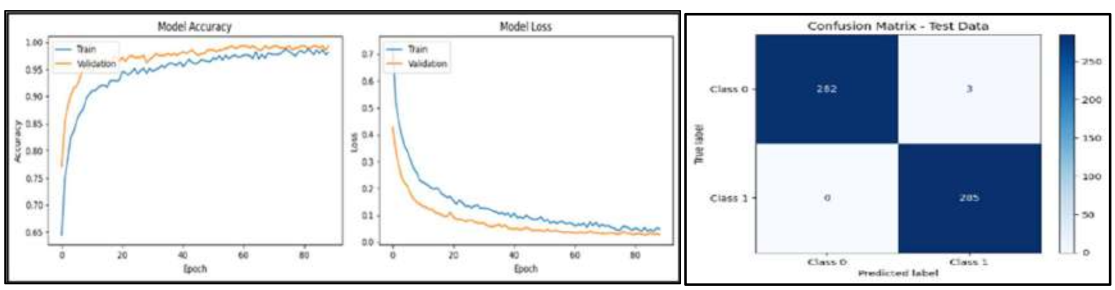
The data preprocessing phase ensures uniformity and efficiency for training the model. Initially, all images were resized to 512 x 512 pixels to meet the requirements of the neural networks. Class balancing has been done by resampling to address potential imbalances between diseased and healthy images. Further, data has been expanded by augmentation, including random rotation, horizontal flipping, brightness adjustments, and random cropping for enhanced model ability to generalise, reducing overfitting risks. Pixel normalisation, scaling values from 0–255 to 0–1, has also been done to ensure consistent treatment of images and improved convergence efficiency. The dataset was split into 70% for training, 10% for validation, and 20% for testing, ensuring an unbiased evaluation of the model. Label encoding assigned numerical values to the binary classification: 0 for healthy and 1 for diseased images.

Model Architecture

The study utilizes a pre-trained MobileNetV2 model with a transfer learning strategy to identify Phyllody disease in sesame. Detailed architectural features can be referenced from Sandler et al. (2018). To adapt MobileNet for binary classification (healthy vs diseased), we removed the top layers of the original architecture. The output from the base model was passed through a GlobalAveragePooling 2D layer to reduce the spatial dimensions. This was followed by a fully connected Dense layer with 512 units and ReLU activation, adding non-linearity. A Dropout layer with a 50% dropout rate was applied to prevent overfitting. Another Dense layer with 256 units and ReLU activation was added, followed by a second Dropout layer (50% dropout rate) for improved generalization. Finally, a Softmax-activated Dense layer with two units was used to output the probabilities for the binary classification task.The model was optimized such it suits to present sesame phyllody dataset. An approach was adopted the first 100 layers of the model were freezed such that the model preserves the overall feature representations acquired from the ImageNet dataset This enables to learn Phyllody disease-specific traits by unfreezing the remaining layers. An Adam optimizer with a learning rate of 1e-4 is used to ensure an incremental fine-tuning and preserve the integrity of the pre-trained weights. A sparse categorical cross-entropy loss function was employed to handle integer-encoded target labels in the binary classification.

Results and Conclusion

The study uses real field photos where the target object is kept with their natural context. The images captured directly from the farm environment and used in their raw form for model development, preserving the complexity and variability of real-world conditions. This causes a significant amount of noise in the images. To handle this data augmentation was to create a more robust and varied dataset as raw field photos frequently differ depending on elements like illumination, land, sky, plants other than target object. Early stopping and model checkpointing were also employed during training to avoid over fitting and to ensure the top performing model will be stored. The optimal model was loaded and assessed on the test dataset following training, yielding the final test accuracy and loss scores. This transfer learning strategy successfully made use of the MobileNet model disease detection capabilities, showcasing the potential of deep learning models in situations with a lack of large labeled datasets. Thus, Phyllody disease can be predicted accurately and computationally efficiently with a combination of MobileNet's efficiency, fine-tuning, and data augmentation techniques.



Model accuracy and loss for training and validation data and confusion matrix for Test Data

In summary, our study successfully demonstrated the potential of a MobileNet-based transfer learning strategy for precisely detecting Phyllody disease in sesame crops. We effectively tailored MobileNet for this particular agricultural application by honing a general-purpose model and adding focused modifications, resulting in excellent performance even with a little dataset. While methods such as early halting and model checkpointing prevented overfitting, data augmentation improved the model's generalization by replicating a range of image variances. With a test loss of 0.0289 and a test accuracy of 98.77%, the model's training and validation accuracy after 88 epochs were 98.44% and 99.65%, respectively. With an F1 score of 99.65%, 100% recall, 99.65% accuracy, and 99.30% precision, the final model yielded outstanding results. The model's dependability in identifying diseases is demonstrated by the confusion matrix, which displays just one misclassification. The feasibility of employing pre-trained models for agricultural disease detection is demonstrated by this study, offering a quick and precise diagnostic tool with encouraging potential for real-world application in precision agriculture.

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UID: 1075

Multivariate Statistical Analysis for Discrimination of Agricultural Crops using by Optimized Hyperspectral Bands

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Discrimination of agricultural crops plays an important role for customized fertilizer and pesticide application in precision farming that will help in the maximization of the crop yield while minimizing resource wastage. Thus, discrimination of agricultural crops is necessary, which can be carried out using spectral profiles of Hyperspectral data. Although, hyperspectral data provides continuous and narrow spectral bands but most of the bands are correlating to each other indicating the existence of multicollinearity among the spectral bands. According to Hughe's phenomena, when the number of bands are increasing, the number of samples (Ground Truth) required for the crop classification increases exponentially otherwise crop classification accuracy will be reduced. Thereby, it is difficult to get higher crop classification accuracy due to limited samples. Thus, it is necessary to reduce dimensionality of the hyperspectral bands by selecting optimum bands, which are having most discriminating power for crop classification. Statistical techniques such as Stepwise discriminant analysis (SDA) and Partial least square Regression Techniques-Discrimnanat Analysis (PLS-DA) are envisaged in this study. In this study, a comparison was made for SDA and PLSR-DA and selected best technique for selecting the most discriminative bands optimally. This study is carried out with a specific objective namely (i) Evaluation of SDA, PLS-DA statistical techniques for hyperspectral data analysis for selection of optimal bands 2) Crop classification using optimized bands

Methodology

In this study, PRISMA Hyperspectral data was acquired over part of Nizamabad district,Telanagana State on 14-Feb-2024. The crops covered were, Rice,Tur,Sunflower,Maize in the study area. The methodology includes that 1) Acquisition of PRISMA Data over Part of Nizamabad district. 2) processing of data for Atmospheric correction 3) removal of Noisy bands 4) Application of SDA on the data and selection of Optimum bands 4) Application of PLS-DA on PRISMA Data and selection of optimum bands 5) comparison of both techniques and selection of best technique based on the classification accuracy.

Results

The SDA technique was applied on the PRISMA data and the SDA technique selected total 13 optimal bands from 187 bands in 13 steps based on Wilks Lamda which ranges between 0.565 to 0.020. The Wilk's lamda range between 0 to 1.0, indicates that 0 is completely dissimilar and 1 is completely similar. The classification accuracy for discrimination of crops was 73%. Later on, PLS-DA techniques was applied on the PRISMA data and the optimum bands were selected based on the PLS-DA parameters. The no of optimum bands, selected by Loading Weights (LW-PLS) are 21 and the classification accuracy was 77.53%. Similarly, the no of bands selected by Variable Importance in Projection score (VIP-PLS) were 44 and the accuracy was 76.40% and the optimum bands selected based on Regression Coefficients (RC-PLS) were 30 and the accuracy was 79.78%. PLS-DA with all the 187 bands indicated 74.40% accuracy. Among the SDA, Variants of PLS_DA, RC-PLS was selected as the best technique with classification accuracy was 80% with only 30 bands.

Conclusions

The optimum bands were identified by different multivariate techniques and evaluated based on classification accuracies. The SDA technique indicated accuracy of 73.53% with 13 bands based on the Wilk's lamda. The PLS-DA technique indicated accuracies 77.53%,76.40%,79.78% with 21,44,30 optimum bands, which were selected based on LW-PLS, VIP-PLS, RC-PLS respectively. The RC-PLS with nearly 80% accuracy with 30 optimum bands was selected as the best technique.

UID: 1088

Design and Development of IoT Enabled Ultrasonic Sensor-based Runoff Gauging Device

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Quantitative estimation of components of hydrological processes under different climate change scenarios will be helpful for appropriate design and management of water resources (Kumar *et al.*, 2017). Hydrological models can be used for quantification of water resources in the present prevailing situations and also be used for impact of climate change on hydrological components conditions. In the recent past, many researchers used lumped, distributed and semi distributed models based on conceptual and physical theory in nature to study the water resource availability at large river basin to micro watershed level.

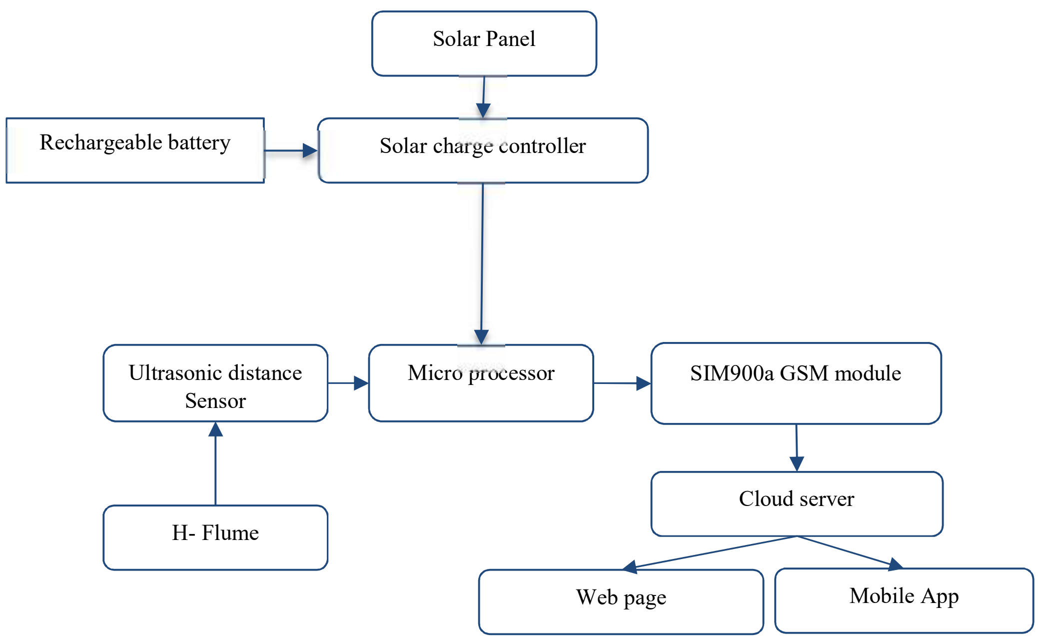
These hydrological models need be calibrated and validated with observed runoff data. The quality and quantity of observed data plays a major role in calibrating the model that support models to help in accurate prediction of flood or runoff from a given area. In India, a large number stream flow gauging stations are available particularly for flood monitoring on medium to major rivers. However, the devices used for this purpose are not economically viable and technically suitable for runoff monitoring from small or micro catchment areas. Water measuring system with based on a ultrasonic sensor and microcontroller and to measure the water level in small tanks without any contact (Mohammed et al., 2019). Wahyuni et al. (2021) designed a tool that can be used to monitor water levels automatically. The tool can monitor and control the water level in the Tandon using ultrasonic sensors, Arduino and LCD Lm0161.This control system uses Arduino Uno, GSM protector and sensors which was supported by a by a solar panel with a rechargeable battery. With this background, it is proposed to develop runoff monitoring device using water level sensors integrate with Internet of Things (IoT) to get real time runoff measurement and monitoring.

Materials and Methods

An experiment was conducted at Agricultural Research station, Anantapuramu of Acharya N. G. Ranga Agricultural University during 2024. H-flume was installed at the outlet of a micro watershed of 1.5 ha along with horizontal drum type stage level recorder to monitor runoff from the catchment. The developed IoT enabled ultrasonic sensor based runoff monitoring device also installed on the same H-flume to compare the result.

Electronic devise setup

An ultrasonic sensor JSN-SR04T (waterproof for outdoor applications), Arduino Uno and GSM module were selected for design of smart runoff device. A rechargeable battery along with solar panel and charge controller were sued to continuous power supply to the electronic device. An interfacing programme between the ultrasonic sensor, microprocessor (Ardiuno) and GSM is developed. The programme can also calculate the discharge in liter per second (lps) based on the depth of water in the H-flume. The device was tested under laboratory condition and field condition. The sensitivity of device under varied depth of flows in the channel is also studied. A computer programme is also developed to estimate the discharge in lps with the sensor data (depth) instantly. The detailed flow chart of the device is given below (Fig).



Flow chart of IoT enabled Ultrasonic sensor-based runoff measuring device

An ultrasonic distance sensor works on the principle of sound wave reflection by emitting high-frequency sound waves and measuring the time to take for the sound wave to reflect off an object and return to the sensor. This time interval is then used to calculate the distance to the object based on the speed of sound. The height from the bed surface of flume to the sensor is measured initially. When the runoff occurred from the catchment, the sensor capture the fluctuation of water levels in the flume and send to microprocessor. The speed of the sound wave travel in the air is taken as 342 m.

$$Distance = \frac{Time\ delay\ x\ spped\ of\ sound}{2}$$

Further, Depth of water level in the flume can be calculated from the deviation of water level to initial height of instrument. Based on the relationship of stage level and discharge relationship of H-flume, runoff discharge is estimated from the following formula.

$$LogQ = 0.0238 + 2.5473LogH_a + 0.254[Log(H_a)]^2$$

Where, Q is in m^3/sec and Ha is the depth water in the flume, m

A GSM (Global System for Mobile Communications) module is device which allows microcontrollers to connect mobile network to enable to communicate the server through access mobile internet. In the present system, the GSM module enables wireless communication between the sensor, microprocessor and cloud server. This GSM module is crucial for real-time data transmission, allowing users to monitor the runoff from the catchment area and used for simulation and modeling of hydrological events. It is not only a cost effective technology but also enables users to monitor and download runoff data from remote catchment area.

Results

A H-flume was installed at the outlet which was also an inlet of the farm pond with catchment of 1.5 ha. An approach channel was constructed before H flume to bring the flow into steady flow conditions. The ultrasonic sensor is installed at the certain height over the surface of the flume which sense the distance from the flume or runoff water level in the flume and sent the data to microprocessor from which is uploaded to cloud server with help of mobile internet provided by GPS module. Along with ultrasonic sensor data, voltage and percent of battery and data uploading status data also is uploaded to cloud server to monitor the health condition of the equipment.

Runoff gauging equipment installed at field & Different components of gauging equipment

The hydrographs of runoff events recorded by the conventional stage level recorder and IoT enabled ultrasonic sensor-based runoff monitoring devises were compared and found that there is no deviation observed data.

Conclusions

An ultrasonic sensor-based runoff measuring device with IoT enabled platform designed and developed with low cost components. This device is more advanced that the conventional stage level recorder for monitoring runoff from a catchment area and concluded that this devise can be used to monitor the runoff from a catchment area.

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Decision Tree-based Solutions for Adaptation to Climatic Hazards and Sustaining Farm Income in Rainfed Agriculture

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Droughts, dry spells, untimely rains and high temperatures are important climatic hazards threatening sustainability in rainfed agriculture. Identifying adaptation options to address these climatic challenges and enhancing farmers' income is key to ensuring sustainable livelihoods in rainfed regions. The government of India looks at enhancing farm income as a strategy to cope with unforeseen climatic hazards and set a target of doubling farmers income by 2022-23 (Chand, 2017). Development of state-specific strategies in different agro-ecologies involving optimum resource use is very essential for fulfilment of the goal of doubling farmers' income.

Machine learning tools such as decision tree, logistic regression, and discriminant function have the potential to identify and prioritize adaptation options to counter the major climatic hazards and explore options of managing farm inputs for enhancing farm income provided the data are available at regional scale at least on sample basis on relevant parameters. Cost of cultivation surveys are conducted every year on a sample basis by ES&ED, DA&FW in 20 major States and plot level data are collected from farmers. Though data at farm level is not available on adaptation options and associated yield and net returns, a workshop conducted involving relevant stakeholders can substitute such data requirements. The present study aims at generating such choices for informed decision-making by rainfed farmers.

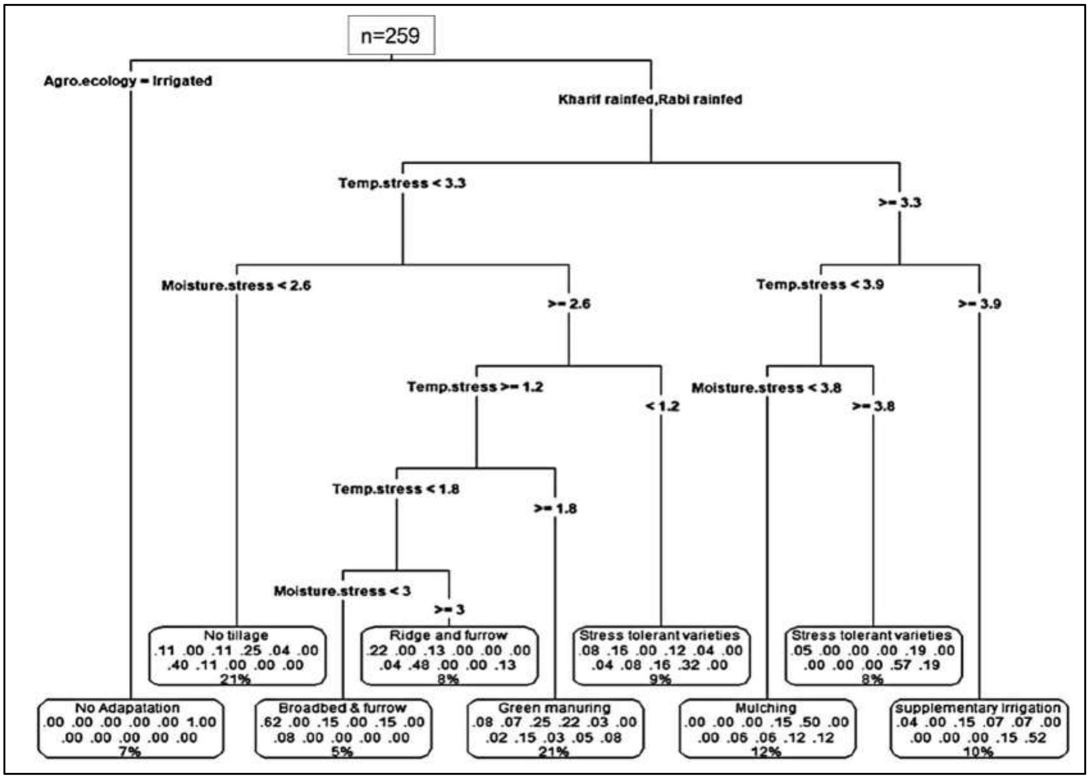
Methodology

A questionnaire was developed for the evaluation of various climate adaptation options in the sorghum production system. The responses of about 20 multi-disciplinary scientists were captured on a scale of 1-5 regarding the usefulness (1 is very low and 5 is very high) of a technology (A comprehensive list of adaptation options was prepared through a systematic review of the literature using PRISMA guidelines) to deal with the major climatic hazards faced by sorghum growing farmers in different agroecologies. CART, a nonparametric machine learning model (Timofeev, 2004) was employed for generating the tree. The dependent variable was the adaptation option, while agro-ecology, soil type, season and effectiveness against stress are taken as independent variables. In order to avoid complexity, different intensities of drought (with weightage of moderate 18% and severe 43%) and dry spells (with weightage of short 12% and long 27%) were summarised as moisture stress index. Similarly, a weightage of 38% to moderately high and 62% to very high temperature were used to generate high-temperature index.

Cost of cultivation survey data from 2011-12 to 2021-22 for about 25 important crops covering 20 major states (sample of about 3.5 lakh farmer plots) was used in order to identify optimum combination of level of various inputs for enhancing per ha farm income from a crop. The CHAID decision tree analysis was carried out. A threshold net return of Rs. 50,000 per hectare from a season was fixed and above which the case is considered as profitable and not profitable otherwise.

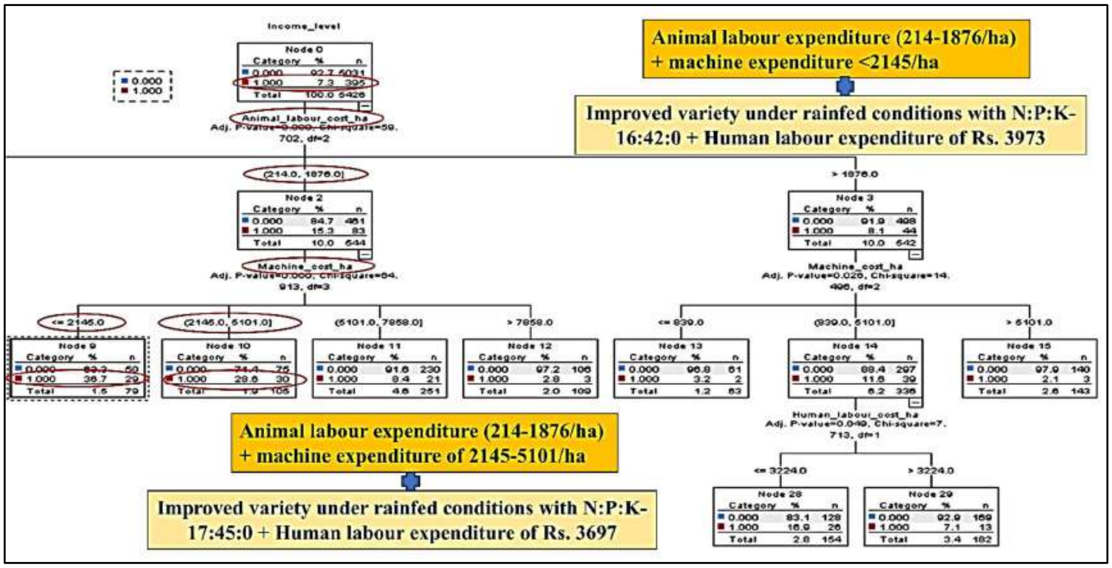
Results and Conclusions

For illustration purposes, a CART based tree trained to identify the adaptation options suitable for temperature and moisture stress conditions in sorghum is furnished in Fig. If the ecosystem is irrigated, no adaptation is required. If the ecosystem is either kharif or rabi rainfed, there are different adaptation options suitable for different moisture stress and temperature stress score combinations. Ridge & Furrow will be the suitable option when the temperature stress score ranges between 1.2 and 1.8 and the moisture stress score is greater than 3.0. Stress-tolerant varieties are suitable for the conditions when temperature stress score is less than 3.3 and the moisture stress score is less than 1.2 or temperature stress ranges between 3.3 and 3.9 and the moisture stress greater than 3.8. When temperature stress score is greater than 3.3 and the moisture stress score is less than 3.8, mulching is the suitable option and supplemental irrigation is found to be suitable when temperature stress score is greater than 3.9.



Decision tree identifying the adaptation options suitable for temperature and moisture stress conditions

Decision tree identified potential level of input combinations to achieve net returns of Rs. 50000 per ha in a season from soybean crop in Madhya Pradesh (Fig). About 7% of soybean farmers in Madhya Pradesh receive a net income of more than Rs. 50,000 per hectare. This likelihood can be increased to 36.7% if farmers manage with the animal labour expenditure of Rs. 214-1876/- and machine expenditure of Rs. 2145-5101/- per ha by adopting improved varieties under rainfed conditions with N:P:K doses of 17:45:0 and human labour expenditure of Rs. 3697/- per hectare.



Optimum input combinations identified with CHAID decision tree to achieve net returns of Rs. 50000 per ha from soybean crop in Madhya Pradesh

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UID: 1121

Digital Soil Mapping of Adgaon Village in Parbhani District for Site Specific Diagnosis of Nutrients by Using Remote Sensing and GIS Techniques

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Digital Soil Mapping (DSM) is an efficient method for mapping soil classes and properties, driven by advancements in quantitative methods and Geographic Information Systems (GIS). Traditional field surveys, though detailed, are time-consuming and costly, making them unsuitable for large-scale surveys (Behrens and Scholten, 2006). DSM integrates digital terrain modelling, remote sensing, and fuzzy logic to produce predictive soil maps (Scull *et al*., 2003). By combining field and laboratory observations with spatial inference systems, DSM enhances data accuracy and reduces costs, illustrating soil distributions while accounting for prediction uncertainty (Carré *et al*., 2007). GIS-based soil fertility maps also serve as valuable tools for nutrient management (Iftikar *et al*., 2010).In India, most soil maps operate at a 1:50,000 scale, providing regional insights, but there is a need for more detailed village-level data. GIS and remote sensing are also critical for groundwater mapping, offering insights into groundwater distribution and geological relationships. Advanced technologies help identify high-potential groundwater zones and well locations (Ali *et al.*, 2015). Studies in regions like Parbhani District have shown their effectiveness in assessing groundwater potential (Waikar *et al*., 2014).

Materials and Methodology

Adgaon village, located between 18° 57' 20.481" N to 18° 58' 32.126" N latitude and 76° 54' 13.289" E to 76° 55' 24.301" E longitude, lies at an elevation of 350-370 meters above MSL. The region features basaltic lava flows from volcanic activity during the Cretaceous-Eocene epoch, with hard basaltic Lithic or Paralithic contacts and gravelly sediments. The climate is hot and subhumid, with an annual rainfall of 1174 mm, mostly between June and September, and temperatures ranging from 30.4°C to 22.0°C. The soils have an Ustic moisture and Isohyperthermic temperature regime, with a growing season of 150-160 days.Soil samples were air-dried, ground, sieved (2 mm), and stored in polyethylene bags. Morphological properties were recorded following USDA standards. Soil colour was determined with the Munsell chart, particle density by pycnometer, bulk density by clod coating, hydraulic conductivity by the constant head method, and texture by the pipette method. Water holding capacity was measured using the brass box method.

Chemical properties were analysed electrometrically for pH and using titration for calcium carbonate. Organic carbon was measured by the Walkley and Black method, and available nitrogen, phosphorus, potassium, and sulphur by standard methods. Micronutrients (Fe, Mn, Zn, Cu) were extracted with DTPA and analysed via Atomic Absorption Spectrophotometry, while exchangeable cations (Ca, Mg, Na) were measured by titration and flame photometry. Water samples from bore wells were tested for pH, EC, sodium, potassium, calcium, and magnesium. Carbonates and bicarbonates were analysed using titrimetric methods, and SAR and RSC were calculated to evaluate irrigation suitability.

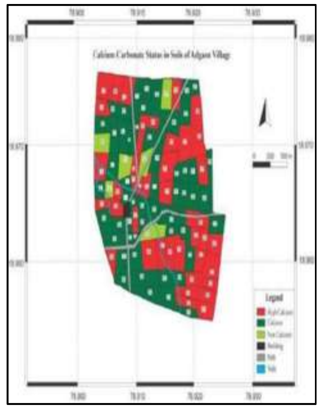
Results and Discussion

The study highlights significant variability in soil physico-chemical properties across the Adgaon region, emphasizing the need for tailored soil management practices to improve agricultural productivity. The table below summarizes the key soil parameters analysed in this study.

Summary of Physico-Chemical Properties and Nutrient Composition of Soils in Adgaon Region

Parameter	Range	Interpretation
Soil Depth	Shallow (<30 cm) to Moderately Deep (30-60 cm)	Varies with topography, affecting water retention, root development, and agricultural viability.
Soil Structure	Granular, Crumbly to Blocky, Prismatic	Upper horizons: Good aeration and drainage; Deeper horizons: Affects permeability and stability.
Soil Consistency	Loose, Friable to Sticky, Plastic	Influences workability and suitability for agriculture depending on moisture content.
Particle Density (Mg/m^3)	2.41 to 2.72	Lower density indicates lighter components; higher density suggests denser minerals or compaction.
Bulk Density (Mg/m^3)	1.21 to 1.46	Lower values indicate organic-rich soils; higher values suggest compaction and clay-rich layers.
Hydraulic Conductivity (cm/hr)	1.54 to 18.58	Lower values indicate limited water movement; higher values associated with coarser textures.
Soil Colour (Munsell Notation)	Very Dark Gray (10YR 3/1) to Brown (10YR 5/2)	Reflects physical and chemical composition, with variations indicating different soil health conditions.
pH	6.0 to 9.23	Alkaline conditions dominate; pH impacts nutrient availability and microbial activity.
Electrical Conductivity (dS/m)	0.11 to 0.99	Low to moderate salinity; high values may cause salinity stress, affecting plant growth.
Organic Carbon (OC %)	0.01% to 0.99%	Higher values enhance fertility; lower values may hinder soil fertility.
Calcium Carbonate ($CaCO_3$ %)	3.25% to 20.25%	High levels increase alkalinity; lower levels promote broader plant species range.
Exchangeable Calcium (meq/100g)	20 to 41	High levels favour plant growth, but excessive levels may disrupt nutrient balance.
Exchangeable Magnesium (meq/100g)	8 to 20.2	Adequate levels are crucial; levels below 10 may require supplementation.
Nitrogen (N kg/ha)	129.18 to 298.63	Moderate availability; excessive or insufficient levels impact plant growth.
Phosphorus (P kg/ha)	12.14 to 37.01	Higher levels support root development; lower levels may require supplementation.
Potassium (K kg/ha)	167.5 to 572.65	Adequate levels vital for plant functions; low levels can stunt growth.
Iron (Fe mg/kg)	1.823 to 5.955	Essential for photosynthesis; levels around 1.8 mg/kg may indicate deficiency.
Manganese (Mn mg/kg)	4.75 to 13.46	Important for enzyme activation; levels below 5 mg/kg may require supplementation.
Zinc (Zn mg/kg)	0.115 to 0.894	Vital for enzyme function; levels below 0.2 mg/kg indicate deficiency.
Copper (Cu mg/kg)	0.108 to 2.128	Crucial for photosynthesis; levels below 0.5 mg/kg may require supplementation.

pH Status in Soils of Adgaon Village



CaCO3 Status in Soils of Adgaon Village

Iron Status in Soils of Adgaon Village

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Biochemical Indices and Haematological Parameters of Barbari Goat feed Moringa (*moringa oleifera*) Leaves

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Goat in considered as poor man's cow in Indian condition which is the main occupation for rural people in village condition (Devendra, 2013). Goat meat is consumed by people to fulfill their protein demand and their milk is full of nutrition and easily digestible proteins. But the condition of goat is not good in India due to low productivity which is due to poor quality and inadequacy of available feeds (Qwele*et al.*, 2013).The changing climatic conditions in the past years have resulted in persistent droughts, heat waves and shortages in animal feed. This has severely affected ruminant animal production leading to a dire need to address feed shortages particularly in small scale farming systems. Usually, farmers tried to feed their animals through crop residues and poor quality hay that are little in nitrogen, high in lingo-cellulose (Sultana *et al*.,2014) and poor in vitamin and mineral contents, which leads to low digestibility and reduced voluntary intake (Gerbregiorgis*et al*., 2012).*Moringa oleifera* is a rich source for crude protein (Crude protein varies between 25 and 30% in the leaves) and vitamins (Ferreira *et al*., 2008; Foidl*et al*., 2001), and possesses significant anti-oxidative potential (Verma *et al.,* 2009), attributed to poly-phenols, tocopherols and carotenoids in the foliage.These nutritional traits along with high production of leaf mass, adaptability to grow in all types of soils and tolerance of extreme temperatures, have turned Moringa a potential high quality feed source for livestock (Foidl*et al*., 2001; Sanchez and Ledin, 2006).Recently, focus has been given to the use of moringa leaf meal as a protein source and feed components in animal production especially in goats (Sarwatt*et al*., 2002; Asaolu*et al*., 2012; Moyo *et al*., 2012; Sultana *et al*., 2015). Various studies conducted shown that feeding of moringa leaves in diet of goats, sheep and cattle influenced blood metabolites (Khalel *et al.,* 2014; Kholif*et al*., 2015; 2016; Azzaz*et al.,* 2016). Moreover, effect of moringa leaves feeding on blood mineral profile in livestock has not been investigated yet.Keeping in view of the above mentioned facts, the present study therefore was carried out to determine the effect of replacing concentrate mixture with *Moringa oleifera* leaves on biochemical indices and haematological parameters in diet of growing barbari goat kids.

Materials and Methods

The study was carried out at the Barbari Goat Unit, KVK Jhabua. Total 24barbarigoat kids (average age 3-4 months) were randomly divided into three treatment groups using completely randomized design, so that each group had eight animals per treatment. The three experimental treatments were T_1 = 100% concentrate mixture; T_2 = 50% concentrate mixture + 50 % Moringa leaves and T_3 = 100 % Moringa leaves. All the kids were treated with albendazole deworming medicine before the commencement of the experiment to ensure the kids were free of intestinal worm. The kids were kept in individual pens and provided individual feeders and waterbuckets. The kids were allowed 15 days of adjustment period during which they were gradually introduced to the experimental diets. Conventional concentrate mixture was gradually replaced at 0, 50 and 100% with dried moringa leaves and mixed thoroughly and supplied to animals. *Moringa oleifera* leaves were collected from the locally available moringa plots of the KVK Farm. The collected moringa leaves were dried in shed on thick plastic sheets. Kids were allowed 6 hours daily grazing. In addition to grazing, kids were supplemented with above mentioned diet at the 1% of live body weight. The duration of the feeding trial was of 90 days. The chemical composition of concentrate mixture and moringa leaves was analyzed according to standard procedures of the AOAC (2000).On day 90th, blood samples were collected from each kid in the morning (before feeding and watering) under aseptic conditions through jugular vein puncture. Immediately after blood collection the vials were kept in slant position without disturbing. After 1 hr and centrifuged at 700xg for 15 min to separate the serum, which was analyzed for serum biochemical constituents. The concentrations of aspartate aminotransferase (SGOT), alanine transaminase (SGPT), glucose, total protein, albumin, cholesterol, calcium and phosphorus were determined by using respective ready to use kits (procured from Agappe Diagnostics Ltd., Kerala, India) by employing Clinical Analyzer-635 (Systronics India Ltd., India). The micro-minerals were analyzed by digestion of 0.2 ml blood serum sample with 1.8 ml of triple acid mixture (Nitric acid: Sulphuric acid: Perchloric acid @ 4 : 2 : 1) till it becomes colourless. After digestion the final volume was made up to 10 ml with triple glass distilled water. Copper, zinc, iron, and manganese concentration from digested samples were estimated by atomic absorption spectrophotometer (Model AAS 4141, Electronic Corporation of India Ltd.).

Statistical Analysis

One-way ANOVA procedures by using SPSS (Version 11.0, SPSS Inc, Chicago, USA) were adopted to analyse the data of blood biochemical and minerals. The difference between treatments were analyzed by using students'' test andanalysis of variance and the significance was declared at $P<0.05$.

Results and Discussion

Chemical and mineral composition of feeds

The chemical and mineral composition of the *Moringa oleifera* leaves and concentrate mixture used in this study are presented in Table 1.

Table 1. Chemical and mineral composition of Moringa leaves and concentrate mixture (on % DM basis) fed to experimental BARBARI goat kids

Chemical composition	Moringa leaves	Concentrate mixture
Dry matter (%)	74.41	94.00
Crude protein (%)	23.12	16.45
Crude fibre (%)	8.05	5.42
Ether extract (%)	5.46	2.41
Total ash (%)	14.12	8.98
Calcium (%)	1.15	0.94
Phosphorus (%)	0.12	0.65
Copper (ppm)	9.47	22.56
Manganese (ppm)	88.21	47.53
Zinc (ppm)	26.77	36.51
Iron (ppm)	324.56	201.26

The analyses revealed that the content of crude protein (23.12 vs. 16.45 %), crude fibre (8.05 vs. 5.42 %), ether extract (5.46 vs. 2.41%), total ash (14.12 vs. 8.98 %) and calcium (1.15 vs. 0.94 %) werehigher in Moringa leaves as compared to the concentrate mixture. But, the levels of dry matter (74.41 vs. 94.00 %) and phosphorus (0.12 vs. 0.65%) were lower in Moringa leaves than concentrate mixture.

The crude protein content of moringa foliage used in the study was comparable with the values (29.7, 25.95 and 22.6%) obtained by Fadiyimu*et al.* (2010), Manh *et al.* (2005) and Sánchez *et al.* (2006), respectively, but higher than the values (19.5 and 19.3% in DM) reported by Kakengi et al. (2005) and Aregheore (2002), respectively. The variations in nutritive value of moringa foliage could be due to the age of harvest, soil type and fertility, proportion of leaf and stem and agro-ecological zone where trees are growing.

Blood Biochemical Profile

The effect of replacement of conventional concentrate with Moringa leaves on blood biochemical profile in Barbarigoat kids is presented in ***Table 2***.

Table 2. Blood biochemical profile in Barbari goat kids fed experimental diets (n = 24)

Parameters	Treatments			Significance
	T_1	T_2	T_3	
Glucose (mg/dl)	68.33±1.15	72.50±2.70	70.22±5.19	NS
Total Protein (g/dl)	6.86^a±0.25	7.35^b± 0.13	7.58^b±0.14	*
Albumin (g/dl)	3.78^a±0.17	4.56^b±0.29	4.71^b±0.28	*
Cholesterol (mg/dl)	124.65^a±1.59	124.41^a±1.68	110.60^b±1.86	***
SGPT (U/L)	9.60±1.08	9.02±1.23	12.51±1.05	NS
SGOT (U/L)	16.30^a±1.16	17.46^a±1.28	22.99^b±2.76	*

*[ab]Means in a row with different superscripts differ significantly (*P<0.05; ***P<0.001; NS: non-significant).*

All the measured blood biochemicals were within the reference ranges (Boyd, 2011).The blood glucose level (mg/dl) observed in different treatment groups were 68.33±1.15, 72.50±2.70 and 70.22±5.19 in T_1, T_2 and T_3 groups, respectively.Result showed that there was comparable effect observed on all over the different treatment groups.The concentration of glucose found in the present study was in agreement with the values reported byKholif*et al*. (2015). They reportedthat feeding moringa leaves diets to goats had no significant effects (P > 0.05) on glucose concentrations.In contrarily to our findings Kholif*et al*. (2016), Khalel *et al.* (2014) and Azzaz*et al.*(2016) observed that feeding moringa leaves to goat kids had significant effects (P<0.05) on glucose concentrations. The serum total protein level (g/dl) found to be significantly (P<0.05) higher T_2 (7.35±0.13) and T_3 (7.58±0.14) groups as compared to T_1 (6.86±0.25) group. Similarly, albumin concentrations were significantly higher group T_2 and T_3 than group T_1. The concentration of total protein and albumin found in the present study were in agreement with the values reported byKhalel*et al*. (2014) and Babeker and Abdalbagi(2015). They reported that feeding moringa leavesdiets to goats significantlyincreased total protein and albuminconcentrations. However, contrarily to our findings Kholif*et al*. (2015) reported that feeding moringa leaves did not affected serum protein and albumin levels. The higher serum protein and albumin levels observed in the present study may be due to higher protein content of Moringa leaves than the concentrate mixture.

The cholesterol concentration was significantly lower in T_3 group as compared to T_1 and T_2 groups andrespective values for groups T_1, T_2 and T_3were 124.65±1.59, 124.41±1.68 and 110.60±1.86 (mg/dl). Similar to the present findings, Kholif*et al*. (2015; 2016) recorded lower serum cholesterol concentrations in goats fed Moringa leaves in their diets.The enzyme SGPT concentrations were found to be 9.60±1.08, 9.02±1.23and 12.51±1.05U/L in T_1, T_2 and T_3, respectively, which were similar (P>0.05) among the treatment groups. In line with the present findings, Azzaz*et al.* (2016) reported that feeding of Moringa dried leaves to diets of Rhamani lactating ewes had no significant effect on serum level of SGPT. Similarly, Khalel *et al*. (2014) observed no significant difference in SGPT concentrations in lactating cows fed Moringa leaves, respectively. In contrast, Kholif*et al*. (2015) recorded that feeding of Moringa leaf meal as a protein source min lactating Anglo-Nubian goat's diets significantlyincreased (P<0.05) SGPT concentration. The SGOT concentration was significantly higher in T_3 group than the groups T_1 and T_2. The respective values for groups T_1, T_2 and T_3were 16.30±1.16, 17.46±1.28and 22.99±2.76 U/L. In agreement with the present results, Kholif*et al*. (2016) reported that feeding of*Moringa oleifera* leaf meal as a protein source in diets of lactating goats had significantly higher serum SGOT levels. The observed SGOT levels in present study were within normal physiological ranges are important indicators of liver activity and function suggesting there were no pathological lesions in the liver (Pettersson *et al.,* 2008) to feeding of Moringa leaves.

Blood mineral profile

The blood mineral profile in Barbarigoat kids fed experimental diets is presented in ***Table 3.***

Table 3. Blood mineral profile in BARBARI goat kids fed experimental diets (n = 18)

Parameters	Treatments			Significance
	T_1	T_2	T_3	
Calcium (mg/dl)	8.56±0.35	10.51^b±0.44	11.09 ^{b}±0.39	*
Phosphorus (mg/dl)	5.07±0.24	4.87±0.30	5.15±0.27	NS
Copper (ppm)	0.46± 0.02	0.48± 0.02	0.47±0.02	NS
Iron (ppm)	1.54± 0.01	1.51± 0.01	1.50± 0.05	NS
Zinc (ppm)	0.79± 0.01	0.79±0.01	0.80±0.02	NS
Manganese (ppm)	1.03± 0.20	1.23± 0.25	1.12± 0.29	NS

^{ab}*Means in a row with different superscripts differ significantly (*P<0.05; NS: non-significant).*

The level of calcium (mg/dl) was significantly higher in groups T_2 (10.51±0.44) and T_3 (11.09±0.39) as compared to the group T_1 (8.56 ±0.35).As the chemical composition (Table 1) revealed that the content of calcium was higher in Moringa leaves than the concentrate mixture and same is reflected in blood calcium level in the present study. The blood phosphorus level (mg/dl) observed in different treatment groups were5.07±0.24, 4.87±0.30 and 5.15±0.27 in T_1, T_2 and T_3 groups, respectively. Result showed that the phosphorus levels were statistically similar (P>0.05) among the different treatment groups.There was no significant difference among different treatment groups for blood concentrations of copper, zinc, iron and manganese content. There are no reports of effect of feeding Moringa leaves in diets of goats, sheep and cattle till date. So, this study is first to report the values of blood micro-minerals such as copper, zinc, iron and manganese in goats fed Moringa leaves as replacement of concentrate mixture.

Conclusion

Based on the results, it was concluded that moringa (*Moringa oleifera*) leaves are rich in protein and minerals. Replacing the concentrate mixture with moringa leaves in diet of growing Barbarigoat kids increased concentrations of blood total protein, albumin, SGOT and calcium while decreased level of blood cholesterol. Feeding of moringa leaves did not affect blood micro-mineral profile in BARBARI goat kids.

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UID: 1138

Use of UAVs for Spraying in Pigeon pea

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The adoption of unmanned aerial vehicles (UAVs) in agriculture has revolutionized pesticide and nutrient applications, particularly for field crops like pigeon pea (Cajanus cajan L.). Conventional methods such as manual and tractor-mounted sprayers often result in inconsistent pesticide deposition and crop damage due to their limitations in reaching higher crop canopies. Drone-based spraying technology offers a precise and efficient alternative by utilizing a powerful downwash airflow generated by rotors to ensure uniform pesticide deposition across all layers of the crop canopy. This study emphasizes the potential of UAVs equipped with flat-fan nozzles for targeted pesticide application in pigeon pea fields. Key operational parameters such as flight height, speed and nozzle configuration significantly influence droplet size, deposition density and drift. Hypothetical field simulations demonstrated UAVs achieving a droplet deposition rate of 3.2 µL/cm² on the upper canopy, 1.8 µL/cm² on the middle canopy, and 0.6 µL/cm² on the lower canopy. With a droplet density of 55 droplets/cm² and a consistent droplet size of Dv0.5 at 140 µm, the technology reduced pesticide use by 30% and spray drift by 20% compared to conventional methods. Operating at a flight speed of 4 m/s and a spray height of 2.5 m, UAVs covered 5 hectares per hour with a swath width of 4 m, optimizing labor and operational efficiency. Results demonstrated improved pesticide penetrability, reduced wastage and enhanced crop protection due to the uniform distribution of fine droplets. Additionally, UAVs enable timely and large-scale coverage with minimal environmental impact, addressing key challenges in traditional practices. This paper underscores the importance of optimizing UAV operational parameters for efficient spraying in pigeon pea could be transformative.

UID: 1180

Estimation of Drought Frequency through SPI-1 Month Time Scale over Andhra Pradesh

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Meteorological drought is a natural catastrophe that occurs and changes abnormally due to less or no rainfall over a period of time. It occurs at a slow rate although causes significant human and financial damage (Shah and Iqbal, 2016). Quantification of meteorological droughts is a very complex phenomenon due to its slow pace and variation in onset, end and spatial extent. Availability of groundwater, soil moisture and stream flow are some of the water resources where deficits occur due to drought at certain periods (Biswajit *et al*., 2021). Urbanization and industrial growth have led to improved living standards of people, which enhanced water demand throughout the world (Vijaya Kumar *et al*., 2018).

The Standardised Precipitation Index (SPI) can provide information on drought exposure, which can describe the characteristics of drought events by characterizing their frequency, duration, magnitude and intensity for the study area in a particular period. The present study mainly emphasizes the implementation of SPI-1 month time scale in Andhra Pradesh, India for the assessment of drought frequency.

Materials and Methods

An experiment was conducted was conducted during 2022-23 in S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University in the Southern Agro-Climatic Zone of Andhra Pradesh. Daily rainfall were collected from India Meteorological Department (IMD), Pune for the stations located across the Andhra Pradesh.

Drought Frequency (FD)

Drought frequency is used to assess drought liability during a study period (Gopal, 2019). The number of drought years during the study period was calculated for SPI for one month time scale. The drought frequency in the experiment was classified based on SPI values for the above study period in 19 locations of Andhra Pradesh.

Results

The results indicate variations in rainfall patterns and the occurrence of drought events at different locations in Andhra Pradesh. Among the 19 meteorological stations, Ananthapuramu and Nandigama recorded the highest number of extreme drought events, with 7 and 6 months, respectively. Other locations such as Kavali, Kurnool, Tirupati and Ongole also experienced significant periods of extreme drought (Table). The years 1993, 2002, 2004, 2011, 2013, 2016 and 2017 were particularly notable for their high occurrence of extreme drought months.

Severe drought conditions were observed in Waltair, Arogyavaram, Ananthapuramu and Gannavaram, with varying durations. Moderate drought events were relatively more frequent in Tirupati and Machalipatnam, while Bapatla, Narsapur and Visakhapatnam also experienced considerable periods of moderate drought. Ananthapuramu and Waltair had a higher number of mild drought events compared to other stations, indicating a relatively higher occurrence of drier conditions. Gannavaram had the highest number of normal months, while Ananthapuramu had the lowest number of normal months. Ananthapuramu and Waltair had a higher number of mild drought events compared to other stations, indicating a relatively higher occurrence of drier conditions. Gannavaram had the highest number of normal months, while Ananthapuramu had the lowest number of normal months.

Conclusions

Ananthapuramu, Arogyavaram, Gannavaram and Waltair locations in Andhra Pradesh are more prone to drought events. These areas experienced inadequate precipitation, leading to water shortages during the study period.

Drought frequency at SPI-1 month time scale during 1991-2020 over Andhra Pradesh

S. No.	Station	Drought frequency (months)				
		Normal	Mild	Moderate	Severe	Extreme
1.	Ananthapuramu	191	131	18	13	7
2.	Arogyavaram	227	101	17	13	2
3.	Bapatla	219	105	23	10	3
4.	Kadapa	248	80	22	6	4
5.	Gannavaram	250	77	17	12	4
6.	Kakinada	220	112	21	6	1
7.	Kalingapatnam	212	114	22	10	2
8.	Kavali	184	101	16	6	5
9.	Kurnool	244	81	22	8	5
10.	Machilipatnam	211	109	29	9	2
11.	Nandigama	232	94	19	9	6
12.	Nandyal	242	88	20	9	1
13.	Narasapur	220	106	23	7	4
14.	Nellore	214	116	18	9	3
15.	Ongole	221	106	20	8	5
16.	Tirupati	214	105	29	7	5
17.	Tuni	193	82	16	8	1
18.	Visakhapatnam	226	104	23	5	2
19.	Waltair	202	131	9	14	4
	Mean	219.5	102.3	20.2	8.9	3.5

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Advanced LULC Classification for Water Resource Management in the Narmada Basin using Water Accounting Plus (WA+) Model

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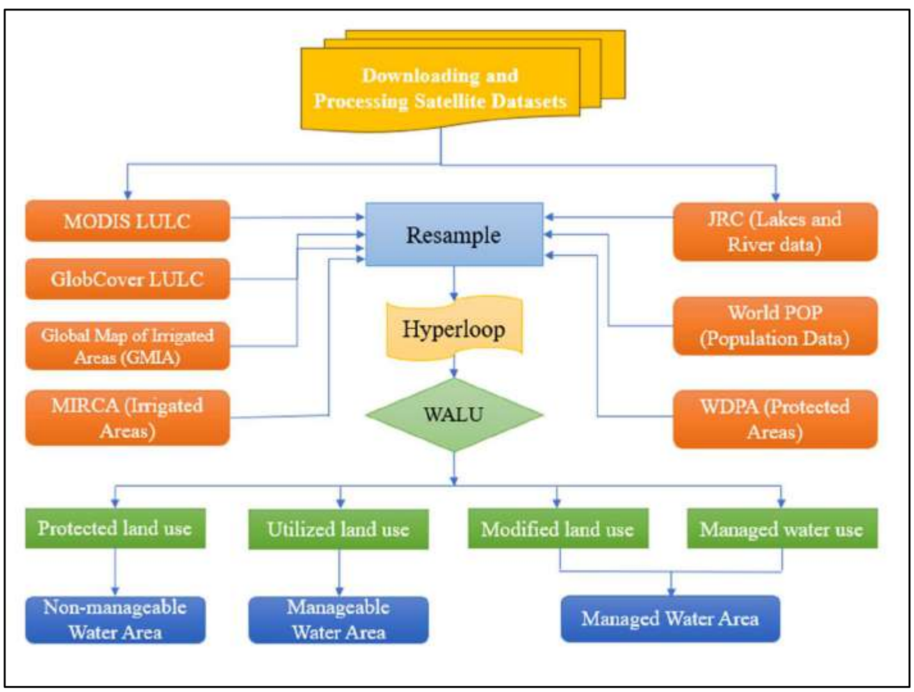
Water management typically focuses on controllable water resources, while addressing water distribution through land use changes is less common but crucial for tackling future water scarcity (Karimi et al., 2013). The Water Accounting Plus (WA+) model is an essential tool for water resource management as it links LULC patterns with hydrological processes (Mishra et al., 2021). LULC significantly influences the hydrological cycle and ecosystem services, necessitating spatially detailed data for comprehensive analysis. The WA+ framework categorizes LULC into 80 classes grouped under four Water Management Classes (WMC) based on human intervention levels (Karimi et al., 2013; Singh et al., 2022). Managed Water Use (MWU) includes areas with significant human control, like irrigation systems, while Modified Land Use (MLU) involves regions altered for agriculture or urban development, affecting processes such as evapotranspiration. Utilized land use (ULU) covers minimally impacted areas, such as forests and grazing lands, providing ecosystem services, and protected land use (PLU) represents untouched ecosystems, like national parks, that maintain natural hydrological functions. This classification provides valuable insights into human-environment interactions, supporting sustainable water management (Singh et al., 2022; Kumar et al., 2022).

This study aims to classify the Narmada River Basin (NRB) into four distinct land use categories, focusing on their potential for managing land and water resources, to better understand the impact of land use changes and planning on water management using the WA+ framework. This classification aims to provide critical insights into water resource dynamics and inform sustainable water management strategies for the Narmada Basin.

Methodology

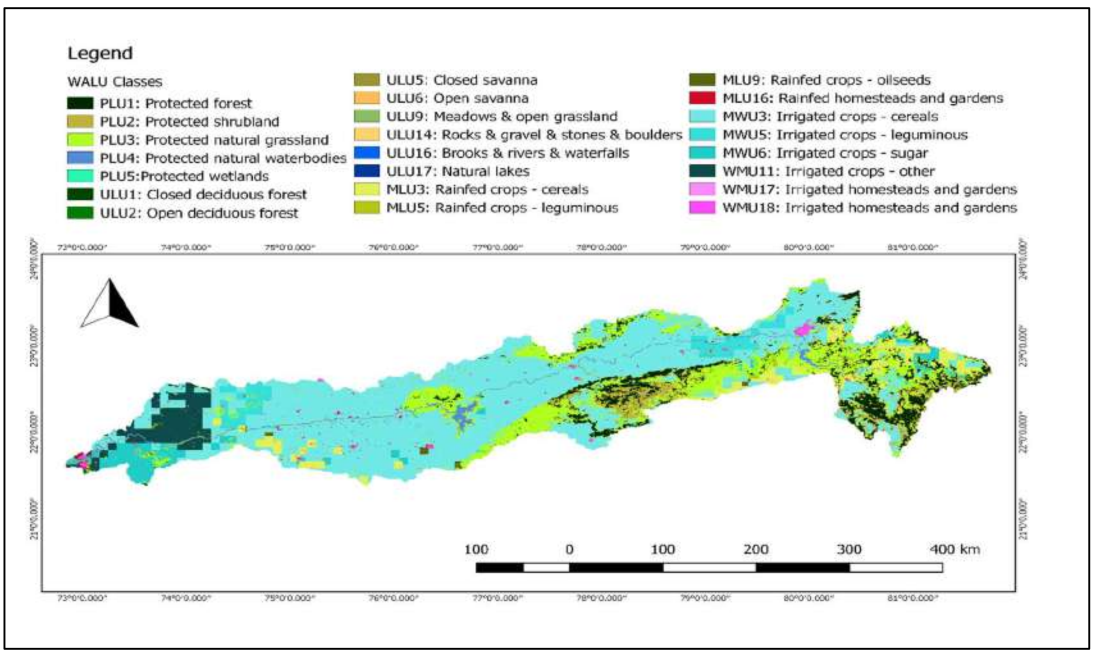
The study focuses on classifying LULC in the NRB using the WA+ framework. The NRB spans the states of Madhya Pradesh, Gujarat, and Maharashtra, covering an area of 98,796 km^2. The preparation of WALU relies on nine key open-access satellite datasets, which are essential for detailed analysis (Kumar et al., 2022; Singh et al., 2021). These include MODIS-based LULC, GlobCover LC, Monthly irrigated and rainfed crop areas (MIRCA), Global Map of Irrigated Areas (GMIA), JRC lakes and river data, WorldPOP population data, and World Database on Protected Areas (WDPA). Each dataset is systematically downloaded, processed, and resampled to ensure consistency and compatibility for further analysis. The processing and resampling of datasets were performed using QGIS software. Subsequently, the data were classified into four WMC, as depicted in Fig.



Flowchart showing the workflow of the methodology for WALU preparation

Results

The LULC map prepared using the WA+ framework for the Narmada Basin reveals the distribution of 23 LULC types across the region. Fig illustrates this water accounting-based land use map. Protected Land Use (PLU) covers 30.35% of the basin, with Protected Natural Grasslands (15.27%) and Protected Shrubland (6.6%) as the dominant types. Utilized Land Use (ULU) accounts for 0.13% of the area and includes natural forests and grasslands. Modified Land Use (MLU), covering 5.2% of the basin, is dominated by rainfed crops—cereals (4.39%) and rainfed homesteads and gardens (0.48%). Managed Water Use (MWU) occupies the largest share, 64.32%, primarily due to Irrigated Crops—Cereals (52.04%), followed by Irrigated Crops—Sugar (3.8%) and Leguminous Crops (3.4%). These findings highlight the dominance of agriculture, particularly irrigated and rainfed cereals, and the region's heavy reliance on irrigation infrastructure for agricultural productivity. The LULC analysis of the Narmada Basin provides critical insights for sustainable land and water management. The dominance of MWU, driven by irrigated cereals, underscores the region's reliance on irrigation infrastructure, emphasizing the need for efficient water resource planning to ensure long-term agricultural productivity. The substantial share of PLU highlights opportunities for conservation efforts, particularly in natural grasslands and shrublands, to preserve biodiversity.



The Water Accounting Land Use (WALU) Map based on the four water management classes

Conclusion

The LULC assessment of the Narmada Basin highlights the critical interplay between land use and water resource management. The dominance of Managed Water Use (64.32%)

indicates the basin's heavy dependence on irrigation, particularly for cereal cultivation, underscoring the necessity for efficient irrigation systems and sustainable water management strategies to ensure food security. The significant coverage of Protected Land Use (30.35%) emphasizes the importance of conserving natural grasslands and shrublands to maintain biodiversity and ecological balance. These findings provide a robust foundation for developing targeted policies aimed at balancing agricultural productivity with conservation and sustainable resource utilization.

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An IoT Based Smart Irrigation System for Nagpur Mandarin

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Nagpur mandarin (*Citrus reticulata Blanco*) is one of the important fruit crops grown in Vidarbha region of Maharashtra and adjoining states. It is one of the best mandarins in the world because of its good flavour, special taste and abundant nutrient values. Nagpur mandarin is locally called orange or Santra. It is rich in vitamin C, A, B and phosphorus. One orange actually has all the vitamin C that one needs for the day. It contains no fat or sodium. Water plays a crucial role in photosynthesis and plant nutrition. Agriculture is the major user of fresh water, consumes 70% of the fresh water i.e., 1,500 billion m^3 out of the 2,500 billion m3 of water is being used each year (Shah et al., 2012). The problem of agricultural water management is today widely recognized as a major challenge that is often linked with development issues. Many freshwater resources have been degraded by agricultural activity, through over-exploitation, contamination with nutrients and salinisation (Thompson et al., 2007). Therefore, a new approach of collecting real time data from the field by using soil moisture sensor offers real potential for reliably monitoring soil water status in agriculture fields. The relatively low cost of the sensor nodes allows for installation of a dense population of soil moisture sensors that can adequately represent the inherent soil moisture variability present in any field (Dias et al., 2013; Dursun et al., 2014; Vellidis et al., 2008; Xiao et al., 2013). The objectives of this study are to assess the soil moisture status in Nagpur mandarin with IoT based sensors and to find suitable irrigation and fertilizer level for yield and quality of Nagpur mandarin.

Methodology

A field experiment was conducted in Vidarbha region for 6 to 9 year old bearing Nagpur mandarin plants of nearly uniform growth for Ambia Bahar (flush) during 2023-2024 and 2024-2025 at progressive farmer's field of Narkhed, Katol and Kalmeshwar taluka of Nagpur district in Maharashtra. The experiment was laid out in a split-plot design with four treatments of Irrigation levels with fertigation level with five nutrient levels in 18 split at 15 days interval replicated five times in mandarin.

Results

It was observed that the class of soil of experimental plot is clay, having sand 16.06 per cent, silt 29.74 per cent and clay 53.86 per cent. It was observed that the field capacity of the soil was 34.54 per cent and the permanent wilting point was found to be 18.10 per cent. Thus, available moisture content was 16.34 per cent. The bulk density of soil was observed as 1.36 g/cm^3. The hydraulic conductivity was 1.47 cm hr-1. The data pertaining to fruit juice percentage are reported in Table.

Fruit quality of Nagpur mandarin as influenced by nutrient levels

Treatments		Juice (%)	TSS (°Brix)	Acidity (%)	Brix: Acid ratio	Ascorbic acid (mg 100 ml-1)
A. Main plot: Nutrient levels						
NL1:	175 N + 87 P2O5 + 175 K2O	48.65	10.01	0.93	10.75	35.36
NL2:	210 N + 100 P2O5 + 210 K2O	49.32	10.14	0.90	11.23	35.40
NL3:	250 N + 125 P2O5 + 250 K2O	49.74	10.28	0.88	11.51	35.42
NL4:	290 N + 145 P2O5 + 290 K2O	50.41	10.59	0.85	12.59	35.44
NL5:	325 N + 160 P2O5 + 325 K2O	50.98	11.03	0.85	13.08	35.82
F Test		Sig.	Sig.	Sig.	Sig.	Sig.
SE (m) ±		0.04	0.07	0.004	0.11	0.06
CD at 5%		0.11	0.20	0.011	0.32	0.17

The increase in water use efficiency was due to the application of the right amount of water at the right place at the right time and attainment of higher yield. The results pertaining to number of fruit was significantly influenced by increasing nutrient levels with low depletion level. Number of fruits per plant varied from 524.6 to 642.0 fruits per tree. It is revealed that the B:C ratio of Soil Moisture sensor based irrigation system with irrigation at 40% depletion of AWC is more than 50%, 60% and 70% depletion of AWC. However, the net income of manual irrigation system is also minimum than the Soil Moisture sensor based irrigation system with irrigation at 40% depletion of AWC.

Conclusion

From the investigation it can be concluded that treatment combination of T1- Irrigation at 40% depletion of AWC with nutrient levels of 325 N + 160 P_2O_5 + 325 K_2O + 30 S + 24 Mg

+ 9 Zn + 12.5 Fe + 1.5 B kg ha-1 with 18 splits at 15 days interval recorded highest fruit yield (41.11 t ha-1) and improved fruit quality (Juice per cent, TSS and acidity) of Nagpur mandarin. Soil Moisture sensor based irrigation system with 40% depletion of AWC was found superior in terms of attaining maximum yield and water use efficiency. The IoT based irrigation system having the facility to view the present available soil moisture content. The system automatically supplies water to the field, constantly forwarding field data to the mobile so that the farmer can gain insight into the field's agricultural data and water supply. It has the facility to receive details of ON and OFF through SMS to mobile phone. It has the facility to store soil moisture data and can be downloaded.

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Comparative Performance of UAV-Based Post Emergence Herbicide Spray in Transplanted Rice using Different Nozzles in Comparison to Knapsack Sprayer

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In the current scenario of high labour costs, non-availability of labour for manual weeding use of herbicides is inevitable. Agricultural labour considerably shifting towards non-agricultural sector (Srivastava et al., 2020) and agricultural labour workforce is reduced by 30.7 million labours (12% reduction) which cause hike in labour wages by 9.3% (Vaishnavi and Manisankar, 2022). To address these challenges, advanced technology is inevitable in agriculture in order to save time and energy. Unmanned Aerial Vehicles (UAVs), popularly known as drones being a modern technology can be one of the solutions for farmers. Agricultural drones provide relief for the modern-day farmer to reduce drudgery and to act timely for crop needs. The Government of India has approved only one herbicide specifically suitable for application using drones. Development of Standard Operating Protocols (SOPs) for herbicide application is essential standardising the herbicide application practices using drone and minimizing herbicide related injury. Nozzles are the critical components of drone based herbicide application systems, significantly influencing the droplet size, droplet density, drift losses and consequently the bio-efficacy of the herbicide. Current experiment aims to identify best suited nozzle for a widely used post-emergence herbicide in rice.

Methodology

Experimental details

Location	Military Farm, ARI, PJTAU, Rajendranagar, Hyderabad.
Season	*Kharif*, 2023
Crop	Rice
Variety	RNR 15048
Design	RBD
Treatments	8
Replications	3
Spacing	15 cm × 15 cm
Gross plot size	50 m × 8 m
Soil type	Clay loam
Fertilizer	120-60-40 N-P_2O_5-K_2O kg ha^{-1}
Spray fluid	40 l ha^{-1}
Swath	4 m
Spray height	1.5 m above canopy
Pre-emergence herbicide	Uniform application of pretilachlor 6% +bensulfuron methyl 0.6% GR 660 g a.i. ha^{-1} at 3 DAT.

Details of the nozzles used in the experiment

SL. No.	Tip number	Nozzle type	Spray pattern
1	XR11002VP	Extended range flat spray	Tapered edge flat spray
2	AIXR110015VS	Air induction XR flat spray	Tapered edge flat spray
3	DG110015VS	Drift guard flat spray	Tapered edge flat spray
4	DG95015EVS	Drift guard even flat spray	Non-tapered flat spray
5	SJ7A-015VP	SJ7A Multiple solid stream	Solid stream pattern

Results

Weed density (no. m^{-2}), weed dry matter (g m^{-2}), weed control efficiency (%) at 30 DAT and grain yield (kg ha^{-1}) as influenced by herbicide application with drones using different nozzles in transplanted rice.

	Treatments	Weed density	weed dry matter	WCE	Grain yield
T_1	Triafamone 20%+ ethoxysulfron 10%WG 44+22.5 g ha^{-1} PoE using drones with extended range flat spray (XR11002VP) nozzle.	5.53 (29.6)	4.77 (21.8)	65.9	5763
T_2	Triafamone 20%+ ethoxysulfron 10%WG 44+22.5 g ha^{-1} PoE using drones with air induction extended range flat spray (AIXR110015VS) nozzle.	4.65 (20.6)	4.06 (15.5)	75.7	6190
T_3	Triafamone 20%+ ethoxysulfron 10%WG 44+22.5 g ha^{-1} PoE using drones with drift guard flat spray (DG 110015VS) nozzle.	5.26 (26.7)	4.64 (20.6)	67.8	5850
T_4	Triafamone 20%+ ethoxysulfron 10%WG 44+22.5 g ha^{-1} PoE using drones with drift guard even flat spray (DG95015EVS) nozzle.	4.72 (21.3)	4.14 (16.2)	74.6	6137
T_5	Triafamone 20%+ ethoxysulfron 10%WG 44+22.5 g ha^{-1} PoE using drones with multiple solid stream (SJ7A015VP) nozzle.	4.46 (19.0)	4.02 (15.1)	76.3	6564
T_6	Triafamone 20%+ ethoxysulfron 10%WG 44+22.5 g ha^{-1} PoE using knapsack sprayer with nozzle (flat fan nozzle).	4.24 (17.0)	3.88 (14.0)	78.0	6597
T_7	Hand weeding (20 and 40 DAT).	3.04 (8.3)	3.27 (9.7)	84.7	6834
T_8	Unweeded check.	7.90 (61.3)	8.06 (64.0)	-	2955
	SE(m) ±	0.16	0.10	-	230
	CD (P=0.05)	0.47	0.29	-	6999

Conclusion

- The effect of application of post emergence herbicide using knapsack sprayer or drone sprayer with multiple solid stream (SJ7A015VP) nozzle, drones with air induction extended range flat spray (AIXR110015VS) nozzle and drones with drift guard even flat spray (DG95015EVS) nozzle recorded statistically on par weed density and weed dry matter. This suggests drones can be deployed for PoE herbicide spraying using these nozzles.
- The highest grain yield was recorded in T7 (Hand Weeding at 20 and 40 DAT), it was comparable to post-emergence herbicide using knapsack sprayer or drone sprayer with multiple solid stream (SJ7A015VP) nozzle, drones with air induction extended

range flat spray (AIXR110015VS) nozzle and drones with drift guard even flat spray (DG95015EVS) nozzle.

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Data-Driven Irrigation Solutions for Dryland Vegetable Crops

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The burgeoning demand for polyhouse vegetable production stems from its capacity to boost yields, reduce pest and disease incidence and improve produce quality, even under adverse climatic conditions (Neelam *et al.,* 2023). Meanwhile, rainfed agriculture, dominating India's agricultural landscape, grapples with water scarcity, resulting in compromised yields and limited crop choices.

Leveraging cutting-edge technologies such as rainwater harvesting, protective cultivation and smart irrigation is necessary in rainfed agriculture to overcome its inherent challenges. Harvesting rainwater from polyhouse rooftops ensures water availability even in the dry spell, Thus, makes it more reliable water source in rainfed agriculture. Recent research underscores the potential of rainwater harvesting to Enhance cultivated land utilization boost crop water productivity, increase gross returns by 60-100% (Piemontese *et al.,* 2020 and Panwar *et al.,* 2023).

Sensor-based irrigation systems, play a pivotal role in modern agriculture. By leveraging IoT technology, these systems enable real-time monitoring of crucial parameters such as soil moisture levels continuously this data-driven approach facilitates precise irrigation scheduling, leading to increased crop yield and effective water conservation (Padma *et al*., 2023). Building upon this theme, the present study aims to examine the yield advantage and water saving potential of sensor-driven irrigation for vegetables under reduced runoff farming.

Materials and Methods

A polyhouse experiment was conducted at AICRP on Dryland Agriculture, UAS, GKVK, Bangalore (930 m MSL), during 2021-22 and 2022-23, India. The soil at the experimental station is red sandy loam, with low in organic carbon content (0.48%) and available nitrogen (252.86 kg ha^{-1}), medium available phosphorus (49.31 kg ha^{-1}) and potassium (166.04 kg ha^{-1}) with a slightly acidic pH (5.26) and EC of 0.14 dS m^{-1}.

The irrigation optimization experiment for broccoli, capsicum, pole bean and cherry tomato were laid out separately in a randomized block design with six replications. The crops and varieties used in the study are listed in Table.

Crop and variety details

Crop	Sowing date		Variety	Spacing	RDF (kg ha^{-1})
	Season-1	Season-2			
Broccoli	13-8-2021	8-8-2022	Saaki	30 cm x 30 cm	120:80:60
Capsicum			Indira	45 cm x 45 cm	160: 60: 30

The experiment harvested rainwater from the polyhouse rooftop and stored it in a tank. During 2021-22 and 2022-23, the water harvested was 1992.6 and 2216.0 cm^3, respectively. Cultyvate Hydro Sense moisture sensors were used to monitor soil moisture levels in real-time. The sensors trigger the irrigation system when soil moisture falls below preset thresholds (Table), ensuring timely watering until the desired moisture level is achieved.

Field capacity and irrigation frequency for each irrigation regimes

Irrigation regimes	Field capacity	
	FC (Vol %)	ASM (Vol%)
I_1: 75 % ASM	27.5 %	24.5 %
I_2: 50 % ASM	27.5 %	21.5 %
I_3: 25 % ASM	27.5 %	18.5 %
I_4: Surface irrigation	-	-

Yield data were collected from five randomly selected plants on each treatment. Mean curd weight for broccoli; mean fruit weight (g) for capsicum; mean pod weight for pole bean; and mean no. of fruit cluster for cherry tomato was recoded with standard protocol. Fruit yield per plant (g $plant^{-1}$) is calculated based on the total fruit weight harvested from selected plant in each treatment. Fruit yield (t ha^{-1}) was computed by multiplying the number of fruits per plant by the average fruit weight. The water use efficiency of crops was calculated according to equation given by (Zotarelli *et al.,* 2011).

WUE (kg/ha-mm) = Total fruit yield (kg)/Total water used (ha-mm)

Statistical analysis

The experimental data was analyzed using ANOVA. The differences between the mean values of irrigation treatments were compared using the F and t tests. Letters (a, b, c) were assigned to the mean values to represent the significance of the differences between them.

Two letters in common indicate that the difference is not significant or weakly significant (Gomez and Gomez, 1984).

Results and Discussion

Irrigation regimes significantly ($P < 0.05$) impacted broccoli and capsicum yield and yield per plant. Scheduling irrigation at 75% ASM maximized both overall yield (26.05 and 48.59 t ha^{-1}, respectively) and yield per plant (1444 and 1424 g, respectively), surpassing all other treatments.

Impact of different irrigation levels on broccoli yield and water use efficiency

Treatment	Average quantity of water applied (mm)			Mean curd yield (t ha^{-1})		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
			Broccoli			
75 % ASM	329.23	319.94	324.59	25.80±0.84^{a}	26.30±1.37^{a}	26.05±1.90^{a}
50 % ASM	380.12	388.04	384.08	23.41±1.05^{b}	24.52±1.27^{b}	23.96±0.90^{b}
25 % ASM	426.31	405.42	415.87	18.45±0.96^{c}	18.96±1.02^{c}	18.71±0.80^{c}
Surface irrigation	635.67	643.93	639.80	23.52±1.39^{b}	23.43±1.65^{b}	23.47±0.86^{b}
	Mean yield per plant (g)			**WUE (kg/ha-mm)**		
75 % ASM	1372±58.42^{a}	1515±56.42^{a}	1444±149.60^{a}	78.36^{a}	91.60^{a}	84.98^{a}
50 % ASM	1204±62.93^{b}	1442±66.62^{a}	1323±151.09^{b}	61.59^{b}	63.20^{b}	62.40^{b}
25 % ASM	990±22.87^{c}	1003±41.45^{c}	996±171.55^{d}	43.28^{c}	46.80^{c}	45.04^{c}
Surface irrigation	1129±46.64^{b}	1332±52.56^{b}	1230±197.80^{c}	37.00^{d}	31.70^{d}	34.35^{d}
			Capsicum			
	Average quantity of water applied (mm)			**Average fruit yield (t ha^{-1})**		
75 % ASM	499.12	453.20	476.16	49.06±2.03^{a}	48.11±2.25^{a}	48.59±1.22^{a}
50 % ASM	552.63	552.63	552.63	45.60±1.71^{b}	44.98±1.97^{ab}	45.29±1.29^{ab}
25 % ASM	603.21	573.66	588.44	41.70±1.78^{c}	39.92±2.29^{c}	40.81±1.39^{c}
Surface irrigation	907.89	919.70	913.80	43.43b±1.49^{c}	44.16±1.84^{b}	43.80±2.14^{c}
	Mean yield per plant (g)			**WUE (kg/ha-mm)**		
75 % ASM	1467±48.86^{a}	1380±^{a}	1424±153.66^{a}	98.29^{a}	106.20^{a}	102.25^{a}
50 % ASM	1355±55.72^{b}	1268±^{b}	1312±154.29^{b}	82.51^{b}	81.40^{b}	81.96b
25 % ASM	1110±58.02^{d}	1224±^{b}	1067±190.66^{d}	69.13^{c}	69.60^{c}	69.37c
Surface irrigation	1226±28.32^{c}	1202±^{b}	1214±181.37^{c}	47.84^{d}	48.00^{d}	47.92d

While 50% ASM produced comparable yield (23.96 and 45.29 t ha^{-1}) to surface irrigation (23.47 and 43.80 t ha^{-1}, respectively) and both significantly outperformed the 25% ASM treatment (18.71 and 40.81 t ha^{-1}, respectively). Correspondingly, yield per plant followed a similar trend, with 50% ASM and surface irrigation closely trailing the 75% ASM, while 25% ASM exhibited the lower yield per plant (996 and 1067 g, respectively).

Water use efficiency was higher for plot receiving 75% ASM irrigation treatment both in broccoli and capsicum (84.98 and 102.25 kg/ha-mm, respectively) than all other treatments, with significant water savings (48.95%) compared to surface irrigation. Although both 50% ASM (39.59 and 81.96 %, respectively) and 25% ASM (34.59 and 18.64%, respectively) (Table) Despite moderate water savings, treatment showed significant yield loss. Many factors both externally and internally influence the crop growth and productivity. Yield is a series of integrated interactions biochemical, physiological and morphological changes which take place during its development in accordance with the supply of light, water, temperature and nutrients (Donald, 1962) and its scarcity influence crop growth and productivity through its interaction on nutrition, translocation and assimilation in the plant, in turn regulating many physiological functions *viz.,* cell division & differentiation, nutrient mobility in soil & plant, photosynthesis, respiration, flowering, maturity *etc.* Assured supply of water at 75% ASM by harvesting roof water under protected cultivation ensure the optimum soil moisture throughout the growing season which led to higher yield, yield attributes and WUE under dryland situation.

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Monthly Streamflow Prediction using Machine Learning Algorithms in Eastern Indian River Basin

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The streamflow is considered a vital component of the complex hydrological cycle and is difficult to predict accurately (Sharma and Machiwa, 2021). It is invariably affected by precipitation, temperature, evapotranspiration, snow cover area, land use pattern, and drainage basin (Adnan et al. 2019). The accurate and reliable forecast of streamflow processes is critical in the design, planning, optimisation, utilisation, and management of water resources. Streamflow prediction models, also known as hydrological models or runoff models, are used to anticipate how much water will flow in rivers and streams over time. Streamflow prediction models are classified into physically based model and data-driven model. Physically based models require large data and also computationally intensive (Teutschbein et al. 2018). In contrast, a mathematical relationship (linear or nonlinear) is established between streamflow and its constraints (Rainfall, Temperature, etc) in data driven model (Zhang et al., 2021). Therefore, to overcome the shortcomings of traditional models, researchers have concentrated on building machine learning (ML) based models (Adnan et al. 2019).

The present study focuses on the lower catchment in the Mahanadi River Basin, which is characterized by a forest-dominated, hilly topography with moderate streamflow variation. Given the region's susceptibility to climatic fluctuations, accurate streamflow prediction is crucial for effective water resource management. By leveraging ML models, this study aims to overcome the limitations of traditional hydrological approaches and improve prediction accuracy. Hence the objective of the study is to predict the streamflow using machine learning approach and identify the most accurate and reliable machine learning model for streamflow prediction for the study area.

Materials and Methods

The study was carried out in the Kantamal catchment, which is located in the middle reach of Mahanadi river basin. The basin lies in the western part of Odisha state between 82° 02 ′ 11″ to 84° 18′ 56″ E longitude and 19° 16′ 07″ to 20° 44′ 12″ N latitude, spreading over an area of about 20,097 Km^2. Most of the catchment receives more than 70% of the annual rainfall during four months from June to September. However, water is generally scarce during the remainder of the year due to low rainfall. Water levels in surface water bodies like reservoirs, ponds, rivers, streams start to decline and residual moisture in crop fields starts depleting just after the withdrawal of monsoon and dependency on groundwater resources increases during this period.

Dataset

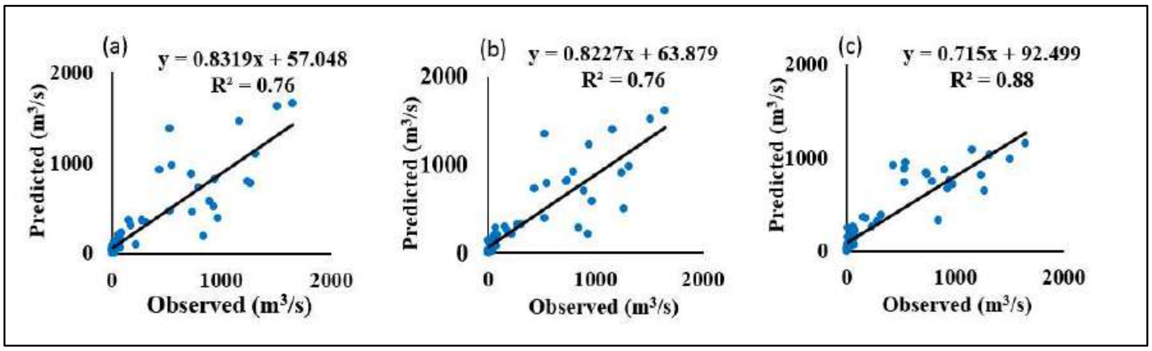
The basic input data for this study includes meteorological and hydrological data. Climatic data such as rainfall, maximum and minimum temperature were collected from Indian Meteorological Department (IMD) at 1° × 1° scale for 30 years from 1990 to 2019 in daily time step. The daily streamflow data for Kantamal gauging station was collected from Central Water Commission (CWC) for the same period. Three different models such as Artificial Neural Network (ANN), Support Vector Machine (SVM) and Random Forest (RF) were used for streamflow forecasting. For convenient purposes, 80% the data was divided into training and the rest was for testing. The autocorrelation function (ACF) with high confidence levels are employed to determine the order of the autoregressive process and to select suitable model inputs. Since the streamflow has high correlation with precipitation, therefore only the lag value of precipitation and streamflow was taken along with the maximum and minimum temperature.

Results and Discussion

The performance of ANN, SVM, and RF models for streamflow prediction at the Kantamal station was evaluated using Coefficient of determination (R^2), Root mean square error (RMSE), and Mean absolute error (MAE). The RF model outperformed the other two, achieving the highest R^2 value of 0.88, compared to 0.76 for both ANN and SVM (Table.1). This indicates that RF has a stronger predictive capability and can better capture the variance in streamflow data. Similarly, the RF model had the lowest RMSE (0.11) and MAE (0.05), indicating its superior ability to minimize prediction errors. In contrast, SVM and ANN exhibited higher error metrics, with RMSE values of 0.125 and 0.13 and MAE values of 0.08 and 0.09, respectively. Similarly, scatter plots of observed and predicted streamflow values in Fig revealed that the RF model showed the best alignment along the 1:1 line, reflecting high prediction accuracy. In comparison, ANN and SVM demonstrated a more dispersed pattern, indicating less accurate predictions and a tendency to deviate from observed values, especially for extreme streamflow events. These results emphasize that the RF model, with its ensemble learning approach, is more effective in capturing the complex, nonlinear dynamics of streamflow in the Kantamal catchment.

Performance of ML models

Statistical indicators	ANN	SVM	RF
R^2	0.76	0.76	**0.88**
RMSE	0.13	0.125	**0.11**
MAE	0.09	0.08	**0.05**



Comparison of Models (a) ANN (b) SVM and (c) RF

Conclusion

This study evaluated the performance of ANN, SVM, and RF models for streamflow prediction at the Kantamal station in the Mahanadi Basin. Among the three models, RF demonstrated the best performance. The results indicate that RF's ensemble learning approach effectively captures the complex, nonlinear relationships in streamflow data. In comparison, ANN and SVM models showed moderate performance, highlighting their limitations in handling such complexities. These findings suggest that RF is a robust and reliable tool for streamflow prediction, offering valuable insights for hydrological forecasting and water resource management.

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Dynamic Interactions between Drought Indices and Agricultural Productivity using Wavelet Analysis

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Drought is often considered as the most complex natural hazards affecting ecosystems (e.g. wildfire), agriculture (e.g. crop losses), and socioeconomic sectors (e.g. water supply, industry) (Heim 2002). Agriculture poses the most significant losses; drought-induced crop yield loss is considered a major loss among agricultural sub-sectors. Crop-drought-related studies have been conducted in local (Quiring and Papakryiakou 2003) and global scale (Li et al 2009,). Few studies compared drought index development (i.e.SPI) using several global precipitation datasets, such as Golian et al (2019).

The primary objective of this research is to develop the meteorological drought indices, namely the Standardized Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI), across various timescales and study their temporal coherence with standardize crop yield anomaly using Wavelet transform coherence analysis.

Materials and Methods

Study Area

Bastar district, located in the southern part of Chhattisgarh, India, serves as a significant region for studying the impacts of drought due to its diverse agro-climatic characteristics and socio-economic reliance on agriculture. Covering an area of approximately 10,000 square kilometers, Bastar is geographically situated between 18°44'N to 19°55'N latitude and 81°15'E to 82°15'E longitude. It is predominantly characterized by undulating terrain, plateaus, and dense forests, with agriculture forming the backbone of the local economy.

Dataset

The daily data ($0.5*0.5^0$ gridded) of precipitation and temperature (maximum and minimum) were obtained from the Indian Meteorological Department (IMD), Pune for 32 years from

1986 to 2018.These data were converted to monthly scale as input of drought indices (SPI and SPEI). For calculation of standardize crop yield anomaly, the rice yield data were observed from ICRISAT Crop database website.

Methodology

Drought Index Calculation

The SPI and SPEI were employed to characterize meteorological drought. In this study, we used R 4.2.3 to construct time series of SPI and SPEI of 3, 6 and 9 month timescale. The SPI approach generally follows the method given by McKee et al., 1993. Once original precipitation data fitted to gamma or Pearson-III distribution, they frequently convert to a normal distribution. The SPI values are utilised to determine the standard deviations from the historical mean of observed anomaly. The Standardised Precipitation Evapotranspiration Index (SPEI) is calculated using an approach similar to that of SPI, but it differs significantly in that it incorporates potential evapotranspiration. Both monthly potential evapotranspiration (PET) and total monthly precipitation (P) serve as indications for this measure. Vicente-Serrano et al. (2010) provided a more systematic overview of the SPEI estimation's features. However, PET values must be derived indirectly from other observed meteorological data. During this stage, PET must be estimated using an appropriate technique (such as Thornthwaite, Hargreaves, and Penman-Monteith). The Hargreaves approach was used to determine the ET0 for the current study.

Standardized Crop Yield Anomaly

The Standardized Crop Yield Anomaly (SCYA) is a metric used to assess deviations in crop yield from long-term averages, enabling the evaluation of agricultural productivity in relation to climatic and environmental stressors. To calculate SCYA, historical crop yield data of rice over a baseline period are first collected and analysed to determine the mean ($\bar{y}$) and standard deviation (σ_Y) of yields for the target crop within the specified region. The anomaly for each year i is computed as the difference between the observed yield Y_i and the long-term mean:

$$A_i = y_i - \bar{y}$$

The anomaly is then standardized by dividing it by the standard deviation of historical yields:

$$\text{SCYA}_i = \frac{Ai}{\sigma_y} = \frac{y_i - \bar{y}}{\sigma_y}$$

This process yields a dimensionless index, where positive SCYA values indicate above-average yields, while negative values reflect below-average yields.

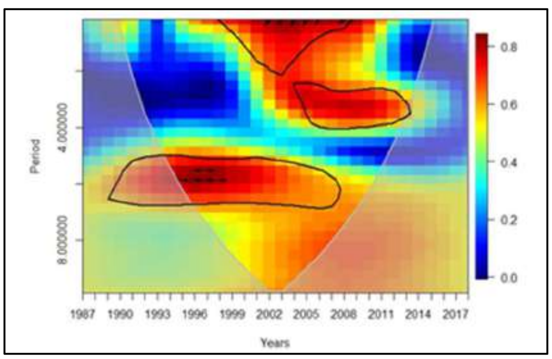
Wavelet Transform Coherence (WTC) Analysis

Wavelet Transform Coherence (WTC) analysis is a powerful tool used to examine the localized, time-frequency relationship between two time series. It identifies both the strength and phase of correlations across different scales and time periods. In drought studies, WTC helps uncover the dynamic interactions between variables, such as drought indices (e.g., SPI, SPEI) and crop yield anomalies, providing insights into their temporal and frequency-specific coherence.

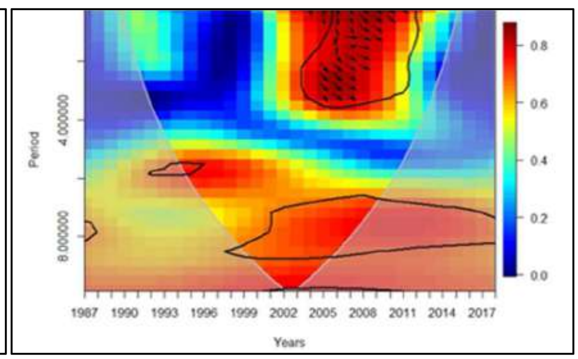
Results

Comparison of SPI and SPEI with SCYA

We compared the resulting SPI and SPEI index of different timescales with SCYA value (Fig). The WTC (Wavelet transform coherence) plot between SPEI-3 and SCYA shows the Maximum coherence during the year 2003 to 2009 for 4 years period (Fig). The WTC plot between SPI-6 and SCYA indicates maximum coherence and in phase relationship during the year 1995 to 2006 for 5 to 7 years period (Fig).



WTC plot between SPEI-3 and SCYA



WTC plot between SPI-6 and SCYA

Conclusion

The WTC analysis between SPEI-3 and SCYA in Bastar district indicates maximum coherence during 2003 to 2009 at a 4-year period, highlighting the strong influence of short-term drought conditions on crop yield anomalies during this time. Conversely, the WTC analysis between SPI-6 and SCYA shows maximum coherence and an in-phase relationship during 1995 to 2006 at a 5 to 7-year period, reflecting the impact of medium-term rainfall variability on crop yields. These findings suggest temporal variability in drought-yield interactions, emphasizing the importance of scale-specific indices for understanding and managing agricultural drought impacts.

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Quantifying the Influence of El Nino-Southern Oscillation on Rainfall Anomalies in different region of India

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Precipitation is a complex phenomenon in India that is influenced by many different factors that interact in intricate ways. Particularly the southwest monsoon is the primary driver of the precipitation in India which brings the majority of the annual rainfall. The El Nino-Southern Oscillation (ENSO) is a critical climate phenomenon that significantly influences global weather patterns, particularly the Indian monsoon (Zhang et al., 2021). The relationship between ENSO and Indian rainfall anomalies has been a subject of extensive research due to its implications for agriculture, water resources, and disaster management in India. El Nino events, characterized by warmer sea surface temperatures in the central and eastern Pacific Ocean, are often associated with reduced monsoon rainfall and increased drought conditions across various regions of India. Conversely, La Nina events tend to enhance monsoon rainfall, leading to flooding in some areas (Mohan and Pandey, 2022).

Recent studies have shown that the ENSO-Indian rainfall relationship is complex and varies regionally and temporally (Chowdary and Mohan, 2021). For instance, while northern India exhibits a strong correlation with ENSO events, central India shows a declining relationship, and southern India maintains a consistent interaction with these climatic phenomena (Mishra et al., 2020). This variability necessitates a detailed examination of how different ENSO phases impact rainfall anomalies across India's diverse climatic zones. Furthermore, changes in global climate patterns may alter the traditional ENSO-rainfall dynamics, making it essential to quantify and understand these influences for better predictive modeling and climate adaptation strategies. This study aims to quantify the influence of ENSO on rainfall anomalies in different regions of India by employing advanced statistical methods and analyzing historical rainfall data alongside ENSO indices.

Materials and Methods

Study area

India is currently composed of 28 states and 8 union territories. In this research work whole India is divided into five regions: North, comprising the Himalayan mountains and Indo-Gangetic plains; South, encompassing the Peninsular Plateau and coastal plains along the Arabian Sea and Bay of Bengal; West, including the Thar Desert and coastal areas of Gujarat and Maharashtra; East, covering the eastern coastal plains and hilly terrains of states like West Bengal and Odisha; and Central, consisting of Madhya Pradesh and Chhattisgarh, located at the geographical center of India.

Data set

Daily meteorological data (rainfall) of India was collected by India meteorological department, Pune. At a resolution of 0.25*0.25, the rainfall gridded data was downloaded in grd format for the years 1951–2023. Nino 3.4 index data were obtained from National Oceanic and Atmospheric Administration (NOAA) for the period of 1951 to 2023 (http://ncdc.noaa.gov).

Pearson Correlation Coefficient (PCC)

PCC is a statistical measure that quantifies the strength and direction of the linear relationship between two continuous variables. Ranging from -1 to +1, a positive value indicates a direct relationship, while a negative value signifies an inverse relationship. Widely used in research, it provides insight into variable interdependencies and patterns.

Nino 3.4 index

The Nino 3.4 Index measures sea surface temperature anomalies in the central Pacific (5°N-5°S, 170°W-120°W) and is a key indicator of El Nino and La Nina events. El Nino events occur when the sea surface temperature anomalies of +0.5°C or higher for at least three consecutive months. Conversely, La Nina events are identified when the index records anomalies of -0.5°C or lower for the same duration.

Results and Discussion

The analysis has been carried out to assess the correlation between rainfall and ENSO events (El Nino and La Nina) for five region of India.

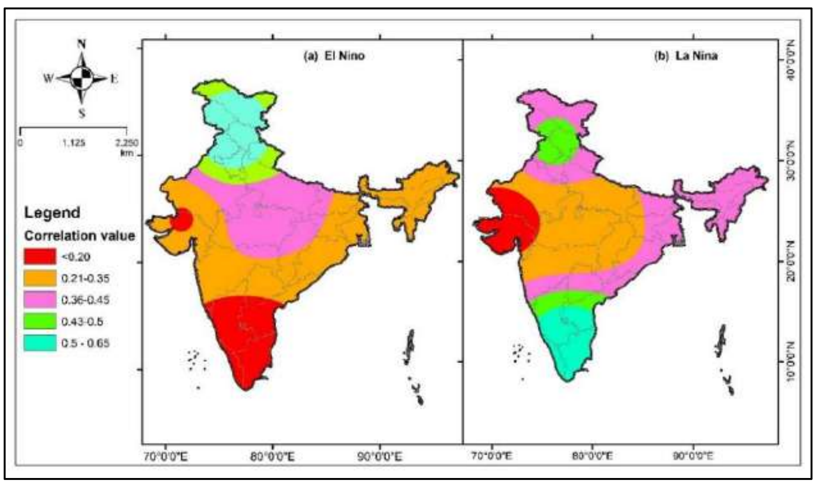
El Nino events

El Nino events are showing a deficiency of rainfall over India. The correlation coefficient for all five part of India is shown in Table.

Correlation Coefficients Between ENSO Indices and Rainfall Anomalies

S. No.	Region	El Nino	La Nina
1	North	-0.65	0.45
2	South	-0.1	0.55
3	Central	-0.35	0.3
4	East	-0.25	0.4
5	West	-0.2	0.25

Table shows that highest negative correlation -0.65 for North India, because the northern region of India is farthest from the ocean and the monsoon winds get there last. It is more vulnerable to El Nino episodes. The lowest negative correlation (R=-0.1) was for South that during El Nino events, there is a tendency for below-average rainfall. The spatial map of PCC between rainfall and El Nino event have been shown in the Fig.



Spatial map of PCC of El Nino and (b) for La Nina with rainfall

La Nina events

La Nina episodes often increase monsoon rainfall, therefore India had either normal or above-average rainfall this year. South India has a greatest positive correlation of 0.55 as it is the closest location to the ocean and is where monsoon winds primarily arrive, and minimum correlation found for West part of India which 0.3 which shown in Table. The spatial map of PCC between rainfall and La Nina event have been shown in the Fig.

Conclusion

The correlation analysis of rainfall anomalies in India reveals significant regional variability in response to El Nino and La Nina events. North India shows a strong negative correlation with El Nino (-0.65), indicating reduced rainfall during these events, while South India demonstrates a positive correlation with La Nina (0.55), leading to increased monsoon rainfall. Central India exhibits a moderate negative correlation, suggesting variability influenced by local climatic factors. East and West India present mixed responses, highlighting the complexity of ENSO impacts across the country. These findings underscore the importance of tailored climate adaptation strategies and improved forecasting models to manage agricultural and water resources effectively in the face of changing climatic conditions.

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Revolutionizing Dryland Agriculture with AI: Advancing Research-Extension-Farmer (R-E-F) Collaboration through Social Media

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Global agriculture has undergone a paradigm shift, and extension services must evolve to address the unique challenges of dryland agriculture. Dryland regions, characterized by limited rainfall, low soil fertility, and vulnerability to climate change, require extension mechanisms that emphasize resource-efficient and resilient farming practices. Extension efforts should focus on enhancing farmers' decision-making and management skills, promoting leadership, and encouraging participation in cooperative credit societies and support organizations. However, the scarcity of extension workers remains a significant bottleneck. With only one extension worker available for every 1,162 farmers in India (Doubling Farmer Income Report, 2017) and only 41% of farm households receiving any assistance (Bera, 2014), dryland farmers often lack critical access to advisory services. Globalization and the growing demands of the global economy necessitate rapid adaptation in agriculture. However, infrastructure deficits, low productivity, poor extension coverage, and a lack of skilled personnel continue to hinder progress. Public extension systems are overburdened, with many positions vacant (Mukherjee and Maity, 2015), leaving personnel stretched thin across multiple development tasks and reducing their efficiency.

Information and Communication Technologies (ICTs) and social media offer scalable solutions to these challenges. These tools enable the dissemination of precise, timely, and localized information to a large audience, addressing the specific needs of dryland farmers. Mobile penetration in rural India—77% unique mobile user penetration as of 2022-23—and the increasing role of smartphones (which account for 79% of web traffic) have significantly expanded the reach of extension services. Among 759 million internet users in India in 2022, 399 million are from rural areas, highlighting the opportunity for social media in rural development (TRAI, 2022).

Social Media Platforms and Their Role in Dryland Agriculture

1. **Facebook**: Farmers and agricultural organizations use Facebook to form communities, share drought-resilient practices, and organize training on resource-efficient cropping systems.
2. **Twitter**: Ideal for real-time updates on weather alerts, market prices, and policy changes impacting dryland agriculture.
3. **WhatsApp**: Widely adopted by dryland farmers to form groups that discuss efficient water use, crop diversification, and pest management. Quick, targeted messaging allows for rapid knowledge sharing.
4. **YouTube**: Educational videos on micro-irrigation, rainwater harvesting, and organic farming techniques in arid regions are widely shared and accessed by dryland farmers.
5. **Instagram**: Used for visually engaging posts to promote drought-tolerant crop varieties, showcase successful adaptation strategies, and foster agri-tourism in dry regions.
6. **Telegram**: Enables the formation of large groups and channels for dryland agriculture topics, including climate-smart farming and soil conservation techniques.
7. **Krishi Jagran**: Provides a comprehensive platform for updates on drought-mitigation technologies, market information, and success stories from dryland regions.
8. **eKisaan**: Offers weather forecasts and advisory services tailored to the needs of dryland farmers, facilitating better planning and decision-making.

The Way Forward

Social media platforms, complemented by AI-driven tools, hold immense potential to transform extension services for dryland agriculture. AI-enabled models can provide predictive insights into rainfall patterns, soil health, and market trends, which can be disseminated through social media for quick and widespread adoption. Furthermore, these platforms enable peer-to-peer learning, fostering collaboration among farmers and reducing dependence on overburdened extension workers. By leveraging the power of social media and ICTs, extension services can address the persistent challenges of dryland agriculture, ensuring that farmers receive timely, actionable information to build resilience and improve productivity in these vulnerable regions. This approach not only complements traditional extension mechanisms but also bridges the critical gap between research, extension agents, and the farming community.

Why use social media in Agriculture?

"Social media platforms are transforming traditional extension services into dynamic, interactive spaces where farmers can access real-time insights, connect with experts, and share experiences with peers."

The special features of participation, openness, conversation, community, and connectedness make social media a unique user experience (Mayfield, 2008). Facebook has 385.7 million active users in India, YouTube gets more than 450 million unique users each month, X (Twitter) has 27.3 million users, WhatsApp has 487 million users in India and the highest number of monthly active users in the world (statista.com, 2023). All these statistics prove the huge potential that social media can have for extension practitioners to reach out to the people. India is a huge market for social media that is constantly expanding into the rural areas and that improves the scope of reaching not only the farmers but the farm families and youth altogether for a higher impact.

Social media can be advantageously used in agricultural extension, as discussed below (Saravanan *et al.,* 2015):

- Highly cost-effective
- Simultaneously reaches large numbers of clients
- Location and client-specific, problem-oriented
- User-generated content and discussion among the community members
- Easily accessed from mobile phones
- Increases internet presence of extension organizations and their client reach
- Democratization of information by making it accessible to all
- Brings all stakeholders into a single platform

- Can measure reach and success by tracking the number of visitors, friends, followers, mentions, Facebook 'likes', conversation index, and number of shares

These potentials make social media a highly relevant and beneficial platform for extension personnel to engage with their clients and peers. Lack of connectedness with farmers has long been cited as a serious lacunae of extension services and social media gives ample opportunities to solve this issue. There are shortcomings at the personal (lack of interest in social media, negative attitude, or organizational restrictions), infrastructural (lack of internet connectivity for target clients or the extension personnel), and policy level (organizational policies that restrict the use of social media for official purposes) that hinder the use of social media. With the challenges like limited availability of ICTs and internet facilities in rural areas, their suitability to only educated and online clientele, lack of awareness and readiness to accept social media by some farmers and extension professionals, breach of individual privacy, piracy of the materials and irrelevant information, the success of social media depends on commitment level of extension workers and community members in using social media for extension. (Saravanan *et al*., 2015). But despite these problems, social media are becoming popular among rural people.

How to integrate social media in Agricultural Extension?

"The fusion of agriculture and social media is not just a trend; it's a revolutionary leap that democratizes information, empowering farmers and researchers alike to co-create sustainable solutions."

Internet-based services are increasingly restructuring the daily lives of people, instead of dividing them into online and offline experiences. Rural people are using social media to connect with friends and family, read contemporary news, to get information from peers. Connecting that to agriculture and leveraging it to bridge the research-farmer gap can prove to be a boon to the agriculture sector and the farm families. A few pointers for engaging with the farming community through social media are given below:

1. Strategic Planning*:*

- A thorough planning is needed before engaging online through social media, specifically about objectives, target audience, channels, and approaches.
- Focusing on specific platforms based on clients' preferences and engaging them continuously rather than engaging in several platforms but failing to engage properly.
- Social media use in extension should aim for steady growth that requires time, budget, patience, the right subject matter, and commitment from extension professionals.

2. Timely Posting and Real-time Interaction:

- Posting information at times when target audiences are most probably active online.

- Interacting in real-time to keep the interest of the involved clients alive.

3. Content Relevance and Personalization:

- Sharing only relevant posts or information.
- Keeping a holistic view in mind while sharing information rather than focusing on a single enterprise as most smallholders have multiple enterprises on their farm.
- Tagging individual clients to whom the information might be specifically useful and share for all so that the intended audience receives it personally while others can also benefit.

4. Accessibility and Communication:

- Encouraging peer-to-peer communication as much as possible, so that information related to local context can be brought out more efficiently.
- To tackle literacy issues, using more pictures and videos, even audio if possible, is easier through Facebook, Instagram YouTube channels (Digital green), and WhatsApp.
- Bandwidth and pricing are hurdles to sustainable use of social media and so, strategic planning like low-resolution videos and pictures, short audio files, fixing specific times for group chats, etc., can be taken up to ensure judicious consumption of data.

5. Community Engagement and Evaluation:

- Connecting farmers and consumers on the same platform for increased interaction. Also, that would increase the market for the producers.
- Making the most out of messenger apps as their popularity has risen substantially in recent years, especially among the rural youth.
- Regular monitoring and evaluation of information shared, participating clients' preference of information, etc., needs to be done meticulously to most effectively record, synthesize, and interpret the information consumption habits and preferences of clients.

Implications of social media on Agricultural extension:

1. Social media provides tools to extension professionals for sharing information and to be a part of discussions and debates on extension. It also helps them to be aware of the ongoing developments in the agriculture sector and stay updated.
2. With increasing awareness among urban consumers about the farm-to-plate journey that food makes in today's world, agricultural practitioners and professionals can use social media to build informed communities and thus increase the visibility of farmers

(increase information access to consumers about farm conditions, mechanism of food production, plights of farmers, etc.)

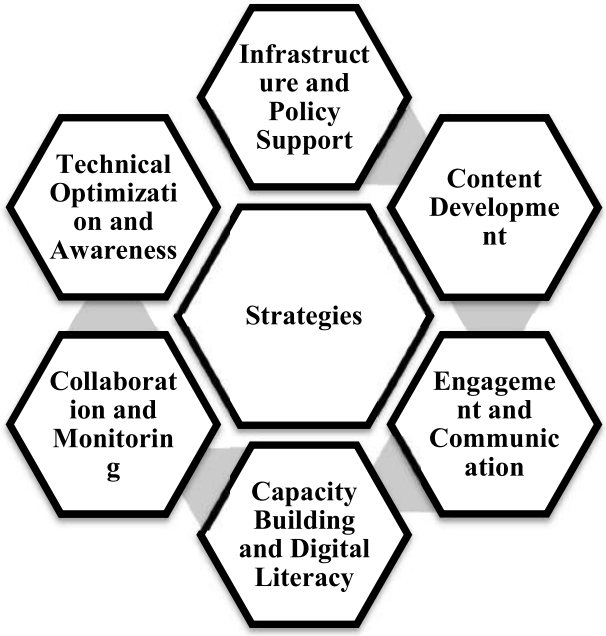
3. The reach of extension personnel in rural areas (which is estimated to be around 1200-1500 farmers per extension personnel currently) can increase manifolds with the use of platforms like Facebook, WhatsApp, and YouTube.
4. The professional development of extensionists is an important aspect, which social media can help with. Networking, sharing ideas and opinions, and even conducting research can ultimately help in the career advancement of extension professionals and they become competent to serve the clients better.
5. Projects and initiatives for agricultural development that suffer from a lack of funds can take the help of crowdfunding platforms like *www.gofundme.com* to reach a sustainable stage. Active use of social media to highlight development projects in critical areas can attract huge funds through crowdfunding if promoted strategically through Twitter, Facebook, and Instagram.
6. With the increasing visibility of agriculture-related issues faced today, many youths from non-agricultural and urban backgrounds are getting interested in agripreneurship and creating employment opportunities for others in the rural sector. Extension professionals can take advantage of this and effectively reach out to them through social media and collaboration. Also, a large number of farm youth who are moving out of the sector can be influenced to return to better agricultural practices through social media.
7. Social media provides insights and evidence required to influence policy and policymakers. It has long been established that social media can create and shape public opinion. When used efficiently in agriculture, social media can bring out the plights of farmers for developing immediate and effective interventions.
8. Capacity development is another issue that can be conveniently addressed through social media for field functionaries, rural youth, and farmers. With technological advancement, platforms like YouTube, WhatsApp, and Facebook can be easily integrated into delivering content in different formats for self-learning of the target groups.

1. Infrastructure and Policy Support:

1. *Digital Agriculture Infrastructure Fund (DAIF):* Creating a specialized DAIF fund to offer long-term financial assistance for building digital agriculture infrastructure facilities will solve the issues & challenges faced in the agriculture sector. This will enable inclusive, farmer-centric solutions through relevant digital information services for crop planning and health, digital solutions for pest and disease

managemen15t, improved access to farm inputs, credit, and insurance, help for crop yield estimation, market intelligence, weather forecast and support for growth of Agri Techs industry and start-ups.

Strategies to enhance the use of social media in agriculture extension:



Source: Author Compilation

2. *Internet governance and digital policy:* The shared principles, norms, rules, decision-making procedures, and programs that shape the evolution and use of the Internet. Governments, the private sector, and civil society contribute to developing these guided principles, and favourable digital policies for making the availability of low-cost internet for agricultural purposes.

2. Content Development:

1. *Create Engaging Content:* Develop and share informative, visually appealing, and engaging content on various social media platforms. This content can include videos, infographics, articles, and live demonstrations. Tailor the content to the specific needs and preferences of the target audience.
2. *Multi-lingual Content:* India is a diverse country with multiple languages spoken. Ensure that content is available in multiple languages to cater to farmers across regions.
3. *Storytelling:* Share success stories of farmers who have adopted innovative practices or technologies successfully. Personal narratives can inspire others and make the information applicable.

4. *Promote User-Generated Content*: Encourage farmers to share their own experiences, success stories, and challenges related to agriculture. Sharing user-generated content can create a sense of community and authenticity.
5. *Content Creation and Curation*: Develop high-quality and relevant content, including videos, infographics, articles, and live sessions. Ensure that content is easy to understand and applicable to local agricultural practices. Curate content from credible sources as well.
6. *User-Generated Content:* Encourage farmers to share their experiences, questions, and innovations on your social media platforms. User-generated content can enrich the knowledge-sharing ecosystem.

3. Engagement and Communication:

1. *Social Media Groups and Forums:* Create or support online farmer communities and forums on platforms like Facebook, WhatsApp, and Telegram. Encourage discussions, Q&A sessions, and the sharing of success stories and challenges. These groups can serve as valuable support networks for farmers.
2. *Live Webinars and Virtual Workshops*: Conduct live webinars and virtual workshops on topics of interest to farmers. Experts and researchers can share their knowledge and interact with farmers in real time. These events can be recorded for future reference.
3. *Agricultural Chatbots:* Develop AI-powered chatbots that can answer basic questions and provide the latest agricultural information. These chatbots can be integrated into social media platforms to provide instant assistance.
4. *Collaboration with Influencers*: Partner with agricultural influencers or well-known farmers who have a significant following on social media. They can help disseminate information and promote best practices.
5. *Engagement and Interactivity:* Foster two-way communication with your audience. Respond promptly to comments, questions, and feedback. Conduct live Q&A sessions, surveys, and polls to encourage engagement.
6. *Promote Offline-Online Integration:* Use traditional extension methods, such as radio and community meetings, to promote your social media presence. Create synergy between offline and online extension services.

4. Capacity Building and Digital Literacy:

1. *Capacity Building:* Offer training programs to enhance digital literacy among farmers, enabling them to navigate and benefit from social media and online resources.

2. *Training and Digital Literacy:* Provide training and resources to improve digital literacy among farmers. Teach them how to use social media effectively and safely.

5. Collaboration and Monitoring:

1. *Collaboration with Agricultural Institutions:* Partner with agricultural research institutions and universities to bring their expertise to the digital extension efforts. Researchers can participate in webinars, write articles, and engage with the farming community.
2. *Collaborate with Experts:* Collaborate with agricultural experts, researchers, and extension workers to provide credible information and insights. Expert-driven content can establish trust and authority.
3. *Collaboration and Partnerships*: Collaborate with government agencies, NGOs, and private sector organizations to amplify your outreach and provide a comprehensive set of services.
4. *Monitoring and Evaluation:* Regularly assess the impact of your digital extension efforts. Gather feedback, track engagement metrics, and make adjustments based on the data.

6. Technical Optimization and Awareness:

1. *Real-time Updates:* Ensure regular and real-time updates on important topics, such as weather forecasts, market prices, pest and disease alerts, and government schemes. Farmers should be able to rely on social media presence for the latest information.
2. *Interactive Mobile Apps:* Develop mobile apps that farmers can use to access information, receive personalized recommendations, and report issues. Integrate social sharing features to encourage knowledge dissemination.
3. *Feedback Mechanisms:* Create channels for feedback and communication between farmers and extension services. Allow farmers to ask questions, provide feedback on the effectiveness of the information, and request specific content.
4. *Localized Content:* Tailor content to local conditions, crops, and farming practices. Recognize that agricultural practices vary across regions, and provide context-specific guidance.
5. *Data Security and Privacy:* Ensure that the privacy and data security of farmers are respected. Educate them on safe online practices.

By adopting these strategies, agricultural extension service providers can effectively harness the power of social media and digital technologies to bridge the gap between farmers and the research system, ultimately leading to the adoption of improved agricultural practices and outcomes.

Conclusion

The integration of social media into agriculture is revolutionizing knowledge sharing and collaboration. Platforms like Facebook, WhatsApp, Twitter, and YouTube enable real-time, 24/7 access to research insights, bridging the gap between researchers and farmers. This digital shift empowers farmers to actively participate in co-creating solutions, enhancing decision-making, and addressing shared challenges. By democratizing knowledge and fostering a collaborative environment, social media transcends traditional extension barriers, offering scalable, inclusive, and efficient solutions. It empowers farmers to adapt to global challenges, improve sustainability, and strengthen community ties. Social media's role in agriculture underscores its potential as a transformative force, ensuring a resilient, informed, and connected farming ecosystem. The future of agriculture lies not only in the fields but also in these virtual spaces where innovation and collaboration thrive.

Proposed Next-Gen extension strategies to bridge the gap between research and farmers

Individual level

- User-Generated Localized Content
- Identify target audiences
- Create Engaging & Multilingual Content
- Consortium of Social Media Groups and Forums
- Live Webinars and Virtual Workshops
- Content Creation and Curation
- Choose the Right Platforms
- Consistency
- Real time updates
- Collaboration with Influencers
- Use hashtags
- Feedback Mechanisms

Organizational level

- Promote Offline-Online Integration
- Training and Digital Literacy
- Measurement and Analytics
- Data Usage Awareness
- Mobile Optimization
- Collaborate with Experts
- Agricultural Chat bots
- Capacity Building
- Collaborate with Experts
- Interactive Mobile Apps
- Promote User-Generated Content
- Monitoring and Evaluation
- Real time updates
- Feedback Mechanisms

Government level

- Digital Agriculture Infrastructure Fund (DAIF)
- Digital Agriculture Research Institute
- MoU with International institutes
- Data Security and Privacy
- Sustainability and Scaling
- Internet governance and favorable digital policy

Source: Author Compilation

"In the era of social agriculture, hashtags plow the fields of collaboration, tweets sow the seeds of innovation, and posts harvest a bounty of shared knowledge – a testament to the transformative potential of next-gen extension strategies."

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Development and Validation of Stoichiometric Model in Groundnut (*Arachis Hypogaea* L.)

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Indian agriculture, a cornerstone of the nation's economy, is heavily reliant on weather conditions. Climate variability significantly impacts crop yields, making it crucial to develop tools that can predict and mitigate these impacts. Crop weather models, which simulate the growth and development of crops in response to meteorological factors, offer a valuable solution (Baier, 1979). By understanding the complex interplay between weather and crop phenology, these models can help farmers make informed decisions, optimize resource use, and improve overall agricultural productivity (Thimmegowda *et al*., 2023).

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops of India. It is a leguminous plant and widely cultivated in the tropics and subtropics (Thimmegowda *et al*., 2007). The information on growth models for groundnut crop is meager (Rajegowda *et al*., 2010); here an attempt was made to develop a Stoichiometric crop weather model for groundnut crop. It is a crop weather model used to predict the dry matter accumulation at the end of each stage and pod yield well before the harvest of the crop. The influence of actual evapotranspiration (AET), growing degree days (thermal unit i.e., GDD) and solar radiation (SR) prevailing during each stage of the crop and finally on the pod yield have been studied.

Materials and Methods

The research work was conducted in GKVK, Bangalore which is situated in the Karnataka state with the latitude of 13^0 05' N, longitude of 77^0 34' East with altitude of 930 m msl. The district comes under Agro Climatic Zone-V: Eastern Dry Zone with normal annual rainfall of 941.5 mm and the normal maximum and minimum temperature of 29.2 ^{o} C and 17.9 ^{o} C, respectively. The mean bright sunshine hour is 7.1 hr. day^{-1}. The major land use cover includes groundnut, finger millet, pigeon pea etc.

Treatment details

The phenological growth stage of the groundnut crop has been grouped into 5 stages.

T_1: Sowing to 30 days after sowing (30DAS)

T_2: 30 DAS to 50% flowering

T_3: 50% flowering to pod initiation stage

T_4: Pod initiation to pod filling stage

T_5: pod filling stage to harvest stage

Varietal details:

Variety: TMV-2

Duration: 125 days

Development of Stoichiometric Model

The field experiment data of 2001,2003-2014 (i.e., two sets of data in each year) were used to formulate multiple linear regression equations relating to the GDD, SR and AET with the accumulated dry matter at each phenological growth stage as well as the ultimate pod yield.

The coefficients of determinant indicate the climatic parameters considered and the initial TDM (total dry matter) used to estimate the final TDM in each stage.

Crop weather relationships have been generated to know the influence of weather parameter on accumulation of the dry matter. The initial TDM (Total Dry Matter) of the crop being exposed to the environment has been considered as one of the independent parameters along with the GDD, SR, and AET to know the bio-mass accumulated at the end of each stage.

The multiple linear regression equations (noted below) by considering parameters such as GDD, SR, and AET as well as the initial TDM as independent parameters and the Total Dry Matter accumulated at the end of each stage as a dependent parameter for all the stages have been generated in order to understand the influence of these crucial parameters on the growth of crops in each stage.

$$T_1 = (A_1X_1+B_1Y_1+C_1Z_1) \quad \ldots (1)$$

$$T_2 = T_1S_2 + (A_2X_2+B_2Y_2+C_2Z_2) \ldots (2)$$

$$T_3 = T_2S_3 + (A_3X_3+B_1Y_3+C_3Z_3) \ldots (2)$$

$$T_4 = T_3S_4 + (A_4X_4+B_4Y_4+C_4Z_4) \ldots (4)$$

$$T_5 = T_4S_5 + (A_5X_5+B_5Y_5+C_5Z_5) \ldots (5)$$

Where,

Subscript indicates the respective stages,

T_1, T_2, T_3, T_4, and T_5 = dry matter accumulated at the end of each stage

A, B and C = Coefficient of determinants of the variables i.e., GDD, SR, AET

X (GDD), Y (SR), Z (AET), = coefficients of determinants of input accumulated.

S_2, S_3, S_4, S_5 = coefficients of initial TDM for respective stage of the crop

The pod yield as influenced by the dry matter accumulated at the end of each stage is related in the multiple linear regression equation,

$$Yg = IT_1\,(O) + JT_2\,(O) + KT_3\,(O) + LT_4\,(O) + MT_5\,(P)$$

Where,

T_1 (O), T_2 (O), T_3 (O) and T_4 (O) = observed TDM at the end of first four stages

T_5 (P) = predicted total dry-matter for 5th stage.

I, J, K, L, M and N = coefficients of TDM for respective stages

Model calibration and validation

Calibration is the process of adjusting the model parameters to improve the agreement between model simulations and observed data. The model was calibrated with the data (that included phenology, biomass and yield components) collected from AICRP on Agro-Meteorology, GKVK, Bengaluru.

Validation involves the comparison of model output with independent field observation or experimental data that were not included during model development. The developed stoichiometric model was validated for the year 2023.

Results and Discussion

Development of the stoichiometric crop weather model

The observed total dry matter at end of first four stages i.e., 30 DAS, 50% flowering, pod initiation, pod filling stage and predicted dry matter at harvest stage was used as independent variable (initial biomass) along with the derived weather parameters and pod yield was used as dependent variable for the development of regression equation. The multiple regression equations emerged between weather parameters, TDM and pod yield is presented in Table.

Multiple regression equations between the derived weather parameters and total dry matter production and pod yield

Stages	Regression Equations	R^2
30 DAS (T_1)	$y=5.07-0.04(X_1)+0.16(Y_1)-0.02(Z_1)$	0.08
50% flowering (T_2)	$y=26.76+1.16(T_1)-0.08(X_2)+0.05(Y_2)+0.52(Z_2)$	0.33
Pod initiation (T_3)	$y=-271.05+1.59(T_2)+1.19(X_3)-0.66(Y_3)+3.34(Z_3)$	0.44
Pod filling (T_4)	$y=-181.54+0.81(T_3)-0.11(X_4)+0.3(Y_4)+3.76(Z_4)$	0.77
Harvesting (T_5)	$y=-815.52+2.96(T_4)+0.48(X_5)+0.13(Y_5)-1.09(Z_5)$	0.67
Pod yield (Yg)	$y=315.03-0.38T_1(O)+0.002T_2(O)-0.11T_3(O)-0.61T_4(O)+0.24T_5(P)$	0.38

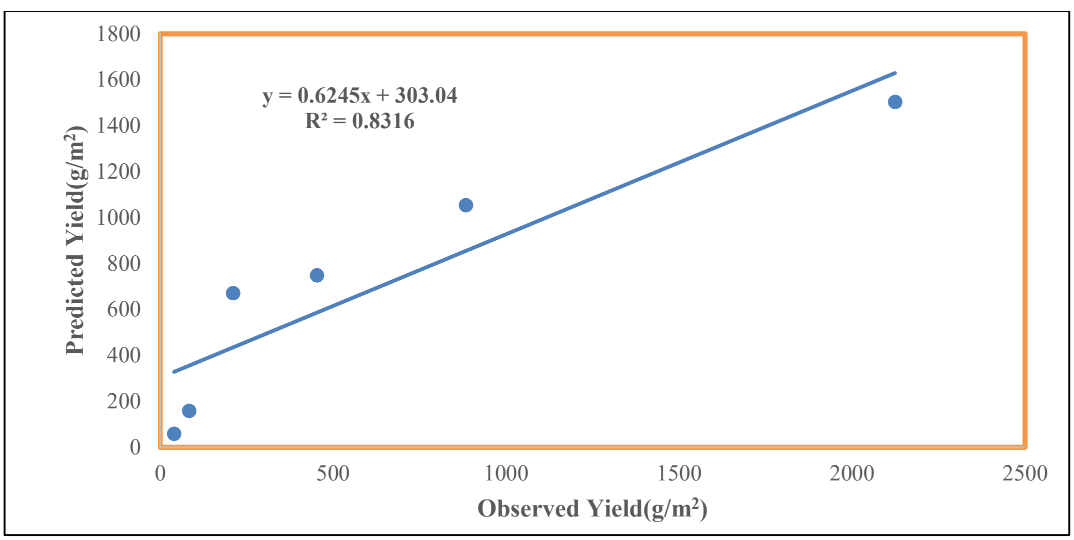
Note: For development of regression equations crop and weather datasets from 2001-2014 were exploited. X= Growing degree days (degree days), Y=Solar radiation ($MJ/m^2/day$), Z= Actual evapotranspiration (mm/day), T_1, T_2, T_3, T_4, T_5 = Total dry matter at the end of each stage (g/m^2), (O) = Observed dry matter (g/m^2), (P) = predicted dry matter (g/m^2).

Equations (Table) were fitted to know the influence of GDD, SR, AET and initial dry matter on accumulation of dry matter at the end of each stage. The model showed lower and higher coefficient of determination (R^2 value) of 8 and 77 per cent for the prediction of dry matter accumulation at the end of 30 DAS, pod filling stage, respectively. This might be due to the greater variability of environmental conditions. Moderate variability was observed at 50% flowering, pod initiation and harvesting stage with the coefficient of determination value of 33, 44, and 67 per cent, respectively. The developed regression equation indicated a moderate fit of the model and showed statistical significance at 0.05 levels for the prediction of pod yield with R^2 value of 38 per cent. These findings align with the earlier research conducted by Muralidhara and Rajegowda (2002).

Validation of the stoichiometric crop weather model for the year 2023

Stages	Initial TDM	GDD	SR	AET	Observed DM(g/m²)	Predicted DM (g/m²)
T_1		402.10	465.70	36.50	39.70	57.69
T_2	39.70	123.85	467.20	91.28	83.45	157.72
T_3	83.46	267.80	400.40	84.20	210.06	669.65
T_4	210.07	143.40	409.10	72.70	452.73	747.02
T_5	452.73	637.60	472.30	50.32	883.24	1052.68
Pod yield	TDM 1 TDM 2	TDM 3	TDM 4	TDM 5(P)	Yg (O)	Yg (P)
	39.70 83.46	210.07	452.73	1052.68	2124	1502.21

The results of the model validation for the year 2023 at first date of sowing are presented in Table. The model overestimated the dry matter accumulation at 30 DAS (T_1), 50% flowering (T_2), pod initiation (T_3), pod filling (T_4), harvesting (T_5) and Pod yield (Yg). However, the model was within the acceptable range, indicated good agreement between the observed and predicted yield. In this model, a good agreement has been realized between the predicted and observed yield of groundnut with coefficient of determination 83.16 per cent as indicated in Fig. This level of agreement suggests that the model can effectively capture the underlying relationships between weather variables and groundnut yield, despite some overestimation in specific growth stages. These findings align with the work of Rajegowda *et al.* (2014), who also reported discrepancies between predicted and observed values in their groundnut crop model.



Coefficient of determination between observed and predicted yield for the year 2023

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Influence of Automated Sensors Based Drip Irrigation Methods on Physiological Responses of Chilli (*Capsicum Annuum* L.)

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Chilli (*Capsicum annuum* L.) is considered as one of the most significant commercial spice crops. Due to its unique dual role as both a vegetable cum spice crop, it is often referred to as the ‘wonder spice’. In arid and semiarid regions, the yield and quality of chilli crop are primarily influenced by irrigation, among other management factors (Demir *et al*., 2022). Globally, Water scarcity and drought, driven by unpredictable weather patterns and climatic changes, are major constraints on agricultural production in these areas (Aziz, 2016). As a result, precise irrigation scheduling is essential to optimize productivity and water use. India, being an agrarian economy based on irrigation, there is a growing demand for novel and efficient irrigation methods. Micro irrigation methods, a modern approach, have been rapidly developed and adopted in recent years. In the current water scarce scenario, irrigation at right time and right amount is a significant challenge for the farmers. Advanced AI-based IoT technology is emerging as a transformative solution, enabling devices and objects to connect and communicate with each other, transmitting information to servers or clouds *via* a core network to determine the optimal timing and quantity of water application to the field.

Material and Methods

A two year field experiment was conducted during the *rabi* seasons of 2022-23 and 2023-24, at College Farm, College of Agriculture, PJTAU, Rajendranagar. The experiment was laid out in split plot design, with main plots representing drip irrigation methods (I) and sub plots as irrigation scheduling approaches (S). The drip irrigation methods studied were I_1- Surface drip irrigation and I_2- Subsurface drip irrigation and the irrigation scheduling approaches tested were S_1- Soil moisture sensor based irrigation triggering, S_2- Plant water stress sensor based irrigation triggering, S_3- ET sensor based irrigation triggering and S_4- Irrigation scheduling at 1.0 Epan by manual (control). The data collected during the experimental period for the various parameters was analysed statistically using the split-plot design analysis of variance (ANOVA) technique as suggested by Gomez and Gomez (1984).

Results and Discussion

a) Leaf chlorophyll content (SPAD) and Canopy temperature depression (CTD) (^{0}C)

At 30 DAT, the mean leaf chlorophyll content and CTD was found to be non-significantly influenced by both the drip irrigation methods and irrigation scheduling approaches (Table). Whereas at 60, 90, 120 DAT and at harvest, between drip irrigation methods, subsurface drip registered significantly higher mean leaf chlorophyll content and CTD. Among irrigation scheduling approaches, significantly higher mean leaf chlorophyll content and CTD was recorded under ET sensor based irrigation triggering and was comparable with irrigation scheduling at 1.0 Epan by manual.

b) Stomatal conductance (µmol m^{-2} s^{-1}) and Intercepted PAR (%)

Significant influence on stomatal conductance and intercepted PAR was observed by drip irrigation methods and irrigation scheduling approaches at all the crop growth stages except at 30 DAT (Table). Between drip irrigation methods, significantly higher mean stomatal conductance and intercepted PAR was recorded under subsurface drip and among irrigation scheduling approaches, ET sensor based irrigation triggering noticed significantly higher mean stomatal conductance and intercepted PAR and was found to be on par with irrigation scheduling at 1.0 Epan by manual at 60, 90, 120 DAT and at harvest respectively. The reason for higher intercepted PAR could be due to the uniform plant growth and denser canopy development under subsurface drip enhanced the ability of crops to intercept and utilize more sunlight for energy conversion which directly increased intercepted PAR.

Effect of drip irrigation methods and irrigation scheduling approaches on leaf chlorophyll content (SPAD) and canopy temperature depression (^{0}C) of chilli (mean of two years data)

Treatments	Leaf chlorophyll content (SPAD)					Canopy temperature depression (^{0}C)				
	30 DAT	60 DAT	90 DAT	120 DAT	At harvest	30 DAT	60 DAT	90 DAT	120 DAT	At harvest
Main Plot-Drip irrigation methods (I)										
I_1- Surface drip irrigation	50.57	53.31	58.06	58.22	49.65	-0.69	-0.69	-0.90	-1.06	-0.35
I_2- Subsurface drip irrigation	52.12	56.76	61.94	62.08	52.47	-0.81	-0.98	-1.19	-1.39	-0.60
S.Em±	0.73	0.41	0.40	0.60	0.41	0.04	0.05	0.03	0.04	0.04
CD (p=0.05)	NS	2.49	2.43	3.65	2.49	NS	0.28	0.18	0.23	0.22
Sub plot-Irrigation scheduling approaches (S)										
S_1- Soil moisture sensor based irrigation triggering	49.68	51.03	55.20	54.38	46.11	-0.63	-0.51	-0.66	-0.73	0.46
S_2- Plant water stress sensor based irrigation triggering	50.19	53.28	58.05	56.93	48.32	-0.70	-0.78	-0.85	-1.02	0.12
S_3- ET sensor based irrigation triggering	53.17	58.49	63.99	65.29	55.55	-0.86	-1.05	-1.37	-1.63	-1.29
S_4- Irrigation scheduling at 1.0 Epan by manual (control)	52.35	57.33	62.75	64.01	54.26	-0.81	-1.00	-1.32	-1.51	-1.19
S.Em±	0.98	0.70	0.66	0.77	0.65	0.08	0.04	0.07	0.08	0.06
CD (P=0.05)	NS	2.16	2.04	2.37	2.00	NS	0.14	0.21	0.25	0.18
Interaction (M x S)										
S.Em±	1.40	0.95	0.91	1.12	0.90	0.10	0.07	0.09	0.10	0.08
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (S x M)										
S.Em±	1.39	0.99	0.94	1.09	0.92	0.11	0.06	0.10	0.11	0.08
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Effect of drip irrigation methods and irrigation scheduling approaches on stomatal conductance (µmol m-2 s-1) and Intercepted PAR (%) of chilli (mean of two years data)

Treatments	Stomatal conductance (µmol m^{-2} s^{-1})					Intercepted PAR (%)				
	30 DAT	60 DAT	90 DAT	120 DAT	At harvest	30 DAT	60 DAT	90 DAT	120 DAT	At harvest
Main Plot-Drip irrigation methods (I)										
I_1- Surface drip irrigation	326.3	336.5	405.9	568.9	464.1	14.29	35.35	56.27	64.28	57.70
I_2- Subsurface drip irrigation	329.4	348.4	443.6	609.5	509.8	15.52	38.55	61.93	68.75	62.33
S.Em±	1.8	1.8	3.1	5.9	5.9	0.57	0.41	0.90	0.66	0.73
CD (p=0.05)	NS	10.8	18.9	36.0	36.1	NS	2.49	5.48	4.02	4.44
Sub plot-Irrigation scheduling approaches (S)										
S_1- Soil moisture sensor based irrigation triggering	325.1	329.7	371.2	510.2	405.1	13.84	33.72	52.29	57.06	50.62
S_2- Plant water stress sensor based irrigation triggering	326.8	337.0	385.5	554.5	457.0	14.67	35.78	56.55	63.16	56.93
S_3- ET sensor based irrigation triggering	330.3	353.4	476.4	651.3	549.7	15.88	39.96	64.48	73.46	66.86
S_4- Irrigation scheduling at 1.0 Epan by manual (control)	329.2	349.8	465.8	640.9	536.0	15.24	38.34	63.07	72.40	65.65
S.Em±	2.4	2.2	4.5	7.4	8.5	0.67	0.63	1.15	1.15	1.43
CD (P=0.05)	NS	6.8	13.9	22.9	26.1	NS	1.94	3.54	3.54	4.41
Interaction (M x S)										
S.Em±	3.4	3.2	6.3	10.9	12.0	1.00	0.87	1.67	1.56	1.90
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (S x M)										
S.Em±	3.3	3.1	6.4	10.5	12.0	0.95	0.89	1.63	1.63	2.02
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusions

The study conducted during *rabi* seasons of 2022-23 and 2023-24 clearly indicated that subsurface drip irrigation, between drip irrigation methods and ET sensor based irrigation triggering, among irrigation scheduling approaches proved to be effective for irrigation water and labour saving under the present scenario of scarce resources.

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Modeling and forecasting of Soyabean Production in Rewa District, Madhya Pradesh: A Comparative Study using ARIMA and ARIMAX

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Madhya Pradesh is the leading soybean-producing state in India, accounting for a substantial share of the nation's overall production. The conducive climate and good soil of Madhya Pradesh render it an optimal site for soybean growing. The root nodules of soybeans contain organisms that fix atmospheric nitrogen, resulting in a yield of 40–45 kg of nitrogen per hectare at harvest.

Material and Methods

This research aims to analyze the soybean production trends in Rewa district, Madhya Pradesh, utilizing two distinct models: ARIMAX and Autoregressive Integrated Moving Average (ARIMA).

Results and Discussion

Following a comparison investigation, the ARIMAX model demonstrated superior performance relative to the ARIMA model, exhibiting reduced RMSE, MAPE, MPE, and MAE values, and elevated R2 values. The findings indicate that the ARIMAX model (2,1,2) had the highest accuracy in forecasting soybean production in the Rewa district, achieving a 95% prediction accuracy. This study's crucial component is its potential to elucidate the future interaction between soybean output and demand, hence addressing any discrepancies. This study offers valuable insights into the future dynamics of soybean production in the Rewa district. To meet the increasing demand for soybean and address supply deficiencies for the forthcoming year, policymakers, researchers, and agricultural stakeholders should utilise advanced forecasting models like ARIMAX.

Conclusion

The findings of the prior analysis about soybean output from 2022 to 2028 suggest an increase in production; nevertheless, the point forecasts for all weather parameters have diminished with time. ARIMA and ARIMAX models were employed to assess and forecast soybean production in the Rewa district. Metrics utilized for evaluating the models included RMSE, MAPE, MAE, MPE, and R^2 values. The ARIMAX model was developed to serve as the most precise predictive model for soybean production in the Rewa district, contingent upon fertilizer usage. Key elements such as price support programs, agricultural financing, and improved management approaches will be essential for sustaining this expansion.

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Comparative Evaluation of Herbicides Application through Drone and Power Sprayer in Soybean

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Spraying with a power sprayer is more efficient than a knapsack sprayer, according to Mairghany *et al*. (2018). The results show that the power sprayer has the ideal specifications when compared to the knapsack sprayer, which had no losses in the field, but the knapsack sprayer did have losses in the field. However, the use of drones in crop protection is gaining popularity in agriculture. Growers have recently begun to use drones to spray pesticides on their fields, which are said to be more reliable, faster, and use less energy. Drone application in crop fields is a critical measure to take in order to improve and increase crop productivity. Therefore, in this study, the number of droplet density on target areas, droplet deposition on crop canopy, droplet losses to the ground, and droplet drift from the sprayed area resulting from drone in crop field were compared with those from motorized knapsack sprayer to optimize UAVs application techniques.

Methodology

A field experiment was conducted at AICRP on Weed Management, Dr. PDKV, Akola on vertisol during *kharif* 2023 in clay soil having low in available nitrogen, medium in available phosphorous and high in available potassium. The pH of the soil was 6.6. The trial was laid out in randomized block design with four replications under gross plot size of 12 x 50 m. Soybean (cv PDKV Amba) was sown on 15th July 2024 at 45 x 10 cm, fertilized with 30:60:30 kg NPK/ha and harvested on 20th October 2024. The treatment comprises of two pre-emergence (Diclosulam84% WDG and Sulfentrazone 28%+ Clomazone 30% WP) and one post-emergence herbicides (Propaquizafop 2.5%+ imazethapyr 3.75% ME), farmers practice (2 Hoeing and 1 hand weeding) and weedy check. The volume of water used 25 liter/ha for drone and 250 lit/ha for power sprayer. The height of the drone was 3 m above the top of the crop. The experiment was conducted at two places AICRP-Weed Management and second at Krishi Vigyan Kendra, Wardha, Dr.Panjabrao Deshmukh krishi Vidyapeeth, Akola.

Results

Weed dry weight, weed control efficiency, weed index and grain yield of soybean as influenced by different treatments

SN	Treatment	Total weed density (no./m^2) at 40 DAS		Weed control efficiency (%) at 40 DAS		Yield (kg/ha)		Weed index (%)	
		Akola	Wardha	Akola	Wardha	Akola	Wardha	Akola	Wardha
T1	Diclosulam 84% WDG 22 g/ha as PE (0-3 DAS) through drone	3.71 (13.27)	6.23 (38.36)	80.3	53.0	5.01	5.22	13.69	7.92
T2	Diclosulam 84% WDG 22 g/ha as PE (0-3 DAS) through power sprayer	3.93 (14.93)	6.39 (40.32)	78.6	48.6	4.85	5.11	17.51	11.31
T3	Sulfentrazone 28% +clomazone 30% WP 725 g /ha as PE (0-3 DAS) through drone	3.87 (14.51)	6.37 (40.14)	78.7	42.5	4.85	5.07	15.44	7.66
T4	Sulfentrazone 28%+ Clomazone 30% WP 725 g /ha as PE (0-3 DAS) through power sprayer	4.03 (15.75)	6.48 (41.49)	77.5	39.4	4.52	4.77	20.19	15.66
T5	Propaquizafop 2.5%+ imazethapyr 3.75% ME @ 125 g/ha as POE (15-20 DAS) through drone	4.93 (23.77)	6.24 (38.40)	85.4	60.5	4.24	4.74	18.35	12.67
T6	Propaquizafop 2.5%+ imazethapyr 3.75% @ 125 g/ha as POE (15-20 DAS) through power sprayer	5.08 (25.31)	6.39 (40.32)	82.6	67.6	4.42	4.65	21.28	15.51
T7	Farmers practice (2 Hoeing and 1 HW)	1.42 (1.50)	3.71 (13.30)	97.8	84.0	4.76	5.26	0.02	-4.23
T8	Weedy check	8.43 (70.60)	8.25 (67.64)	0.0	0.0	3.37	3.60	34.49	24.55
	S.E(m+)	**0.14**	**0.19**	**--**	**--**	**0.10**	**0.08**	**--**	**--**
	C.D. at 5%	**0.41**	**0.59**	**--**	**--**	**0.31**	**0.23**	**--**	**--**

Data presented in Table indicated that the total weed dry matter was lower with the application of both pre-emergence and post-emergence herbicides through drone over power sprayer. However, application of pre-emergence herbicides diclosulam 84% WDG and sulfentrazone 28% + clomazone 30% WP through drone recorded higher weed control efficiency, lower weed dry weight, lower weed index and higher seed yield over power sprayer and similar result was recorded with application of post-emergence herbicides.

Conclusion

It can be concluded that efficacy of herbicides with drone was similar or greater than that of power sprayer.

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Assessing Rainfall Variability and Agricultural Drought in Sub Catchment of Halia Basin and Comparison with NDDI Drought Indices

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Rainfall plays a significant role inagriculture, insufficient or inconsistent rainfall can affect crops, resulting in lower yields and losses due to drought. Rainfall analysis of meteorological variables (Rainfall, Temperature, humidity etc.) helps in understanding the climate change of any region. Among all the variables, rainfall received in an area is one of the key variables to study climatic variability and further for planning socio economic development strategies accordingly. Since the rainfall performs crucial role in agriculture, water resource, hydroelectric power generation and consequently economy of the region hence along with annual and seasonal variation monthly rainfall variation also plays an important role in planning purpose.Though the mean of annual and seasonal rainfall remain normal, prolonged drought during the crop growing period effecting the agricultural productivity.

The present study was taken up in part of Halia river basin located in Nalgonda district of Telangana which lies in semi arid region.Long term rainfall analysis, agricultural drought during crop season and comparision with remote sensing indicesNormal Difference Drought Index (NDDI) during the drought year and normal year is taken up.

Materials and Methods

The study area lies between north latitude 16^{o}60'12" - 17^{o}60'52" and east latitude 78^{o}50'21" - 79^{o}59'57" is part of Halia basin. Rainfall data of past 73 (1951-2023) is used for rainfall analysis which was collected from IMD. The Weather Cock software developed by CRIDA, Hyderabad is used for the analysis of annual, seasonal, monthly, weekly rainfall, mean, standard deviation, coefficient of variation of rainfall and agricultural drought during the study period. Agricultural drought are two types, *kharif* drought means at least four consecutive weeks receiving less than half of the normal rainfall during *kharif* season and *rabi* drought means six consecutive weeks during *rabi* season receives less than half of the normal rainfall (Nandeesha, 2015). To monitor the agricultural drought, remote sensing data (Landsat 8) is used to analyze NDDI during drought year and normal year. The Normalized Difference Drought Index (NDDI) was created by Gu *et al*, 2007 in 2007 to study the behavior and intensity of the drought by combining more than one index to study the phenomenon. For this purpose, the NDVI and NDWI indices were selected.

Generally, Landsat data are used for classification. Landsat data having several bands based on their wavelength (blue band, green band, red band, infrared band, thermal band, panchromatic) used to assess Normal Difference Vegetation Index NDVI and Normal Difference Water Index NDWI. Then, NDDI calculation is performed by combining the NDVI and NDWI values using following equation

NDDI= (NDVI-NDWI)/ (NDVI+NDWI)

Using the landsat images first NDVI and NDWI were assessed and then the information generated was transformed into TIFF format and NDDI is calculated.

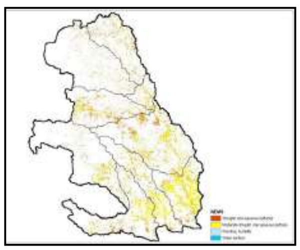
Results and Discussions

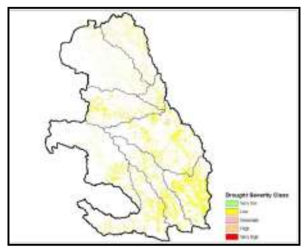
Monthly, Seasonal and Annual rainfall over Halia basin during 1951-2023

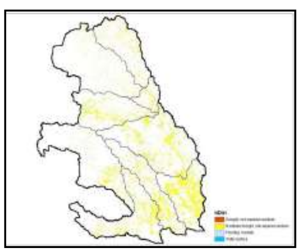
Month	Mean RF (mm)	SD	CV	% Contribution in rainfall
January	9	21	235	1.1
February	5	13	240	0.7
March	12	21	183	1.5
April	16	18	114	2.0
May	33	43	129	4.2
June	97	63	64	12.3
July	153	89	58	19.3
August	152	72	47	19.3
September	165	99	60	20.8
October	115	100	87	14.6
Novenber	28	43	153	3.5
December	6	15	235	0.8
Northeast monsoon	149	111	74	18.8
Southwest monsoon	566	183	32	71.6
Summer	60	52	87	7.6
Winter	14	25	178	1.8
Annual	791	216	27	100

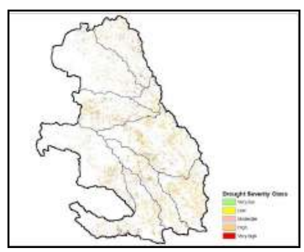
The annual mean precipitation over Halia is 791 mm with SD of 216 mm and CV of 27% indicate that annual precipitation was inconsistent. Monsoon contributes 71.6% of the annual precipitation. The contributions of winter, pre-monsoon and post-monsoon to annual precipitation were 1.8%, 7.6% and 18.8% respectively. CV in case of winter was highest (178%) indicating inconsistency followed by 87, 74 and 32% for pre-monsoon, post monsoon and monsoon respectively.

Dry spells or drought days for 4 or more consecutive weeks were identified by using the weather cock. In 73 years of study period 34 years have faced the agricultural drought in *kharif* season and 8 years during *rabi* season. During the year 2002 and 2014, drought has aroused from 22nd week to 25th week then from 31st week to 34th week and 39th to 42nd week, the prior one was early drought (effecting major activities viz., land preparation and sowing of the crops) thenlater one will be mid drought (affects the shoot length or physiological process) and then late season drought (effecting maturity stage).


NDWI


NDDI 2014


NDDI 2018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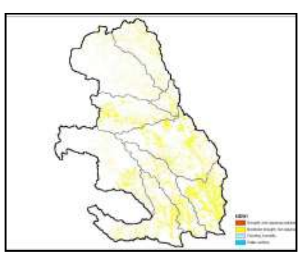
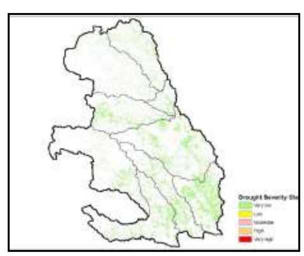

NDWI


NDDI 2023

Comparison of agricultural drought week during 2014 and 2018 with year 2023 (normal year) using NDWI and NDDI during 1st week of October

The year 2014 and 2018 indices data is downloaded, anlysed and compared with normal year 2023 to show the variability during drought period and normal rainfall period using NDDI for the month of October in Halia basin.

Conclusion

The highest annual (1541mm) and south west monsoon (1233mm) rainfall during the entire study period was recorded in the year 1988 in 60 rainy days. Out of 73 years 34 years experienced agricultural drought ranging from 6 to 12 weeks during *kharif* season. During the year 2014 Halia basin showed 12 weeks of agricultural drought during *kharif* season. Halia's annual mean precipitation was 791 mm, with a CV of 27%, indicating inconsistency. Monsoon contributes 71.6%, while winter, pre-monsoon, and post-monsoon contribute 1.8%, 7.6%, and 18.8%, with winter showing the highest CV (178%). NDDI shows a more significant drought patches in the year 2014 and 2018 compared to 2023.

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UID: 1478

Studying the Performance of Maize in North Bihar under Future Climate Scenarios and evaluating Climate Resilient Agricultural Interventions using Crop Simulation Modeling

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The growing challenges of climate variability in rainfed agriculture necessitate the development of robust tools to predict and recommend effective interventions for future scenarios. This study integrates the Decision Support System for Agrotechnology Transfer (DSSAT) with experimental data from the Climate Resilient Agriculture (CRA) program to assess maize performance under future climate scenarios and evaluate the impacts of various climate-resilient practices. By simulating crop growth, yield, and resource use under different scenarios, the research provides a decision-making framework for selecting interventions, such as zero tillage, raised bed planting, and nutrient management, to ensure enhanced productivity and sustainability. Climate change and variability significantly affect agricultural productivity, particularly in rainfed systems, making it crucial to adopt innovative interventions. CRA practices like zero tillage, raised bed planting, and nutrient management have shown potential for building resilience, but their performance under future climate scenarios requires advanced tools. DSSAT, a crop simulation model, offers a comprehensive framework for simulating maize growth and evaluating interventions under varying environmental and management conditions. This study aims to evaluate the best-performing CMIP6 models for the study region, simulate future crop performance, and assess the impacts of several climate-resilient interventions.

Methodology

1. **Data Preparation:** Historical data from 10,361 CRA demonstrations covering 6,572 acres were collected. Input variables included soil properties, crop management practices, weather data, and outcomes of various interventions.
2. **DSSAT Calibration and Validation:** The crop models were calibrated and validated using observed yield and resource efficiency data from field experiments conducted under the Climate Resilient Agriculture (CRA) Program.
3. **Scenario Development:** Future climate scenarios were developed using downscaled climate projections from CMIP6 datasets, considering varying levels of temperature, rainfall, and CO_2 concentration.
4. **Simulation:** DSSAT simulated maize performance under conventional practices and various interventions (e.g., zero tillage, nutrient management) under both baseline and future climate scenarios, integrating biophysical and socio-economic factors.
5. **Optimization and Ranking:** Simulated results were analyzed to identify the optimal interventions based on yield, water use efficiency, and economic viability.

Results

1. **Future Yield Predictions:**
   - Zero tillage maize showed a 12–18% yield advantage under future climate scenarios, with reduced water and labor requirements.
   - Raised bed planting in maize demonstrated consistent yields even under reduced rainfall scenarios due to enhanced water use efficiency.
2. **Climate Resilience:**
   - Nutrient management outperformed conventional methods under high-temperature scenarios, maintaining yield and resource efficiency.

3. **Optimal Interventions:**
   - Simulations identified combinations of practices, such as raised bed planting with precision nutrient management, as the most effective under future climate conditions.

Discussion

The results validate the ability of DSSAT to predict the performance of CRA interventions under various climate scenarios. For instance, integrating zero tillage and nutrient management proved to be highly effective in water-scarce conditions. This approach not only supports evidence-based decision-making but also aligns with sustainable development goals by promoting resource-efficient practices in agriculture.

Conclusion

This study demonstrates the utility of DSSAT in predicting the future performance of maize and evaluating the most effective CRA interventions for future climate scenarios. By providing actionable insights into the performance of practices like zero tillage and nutrient management, the study supports policy-makers and practitioners in scaling up climate-resilient agricultural systems. Future research will focus on integrating real-time weather data and AI-based decision support tools to improve predictive accuracy and enhance usability.

UID: 1511

Impact of Future Climate on Cowpea using Crop Simulation Model

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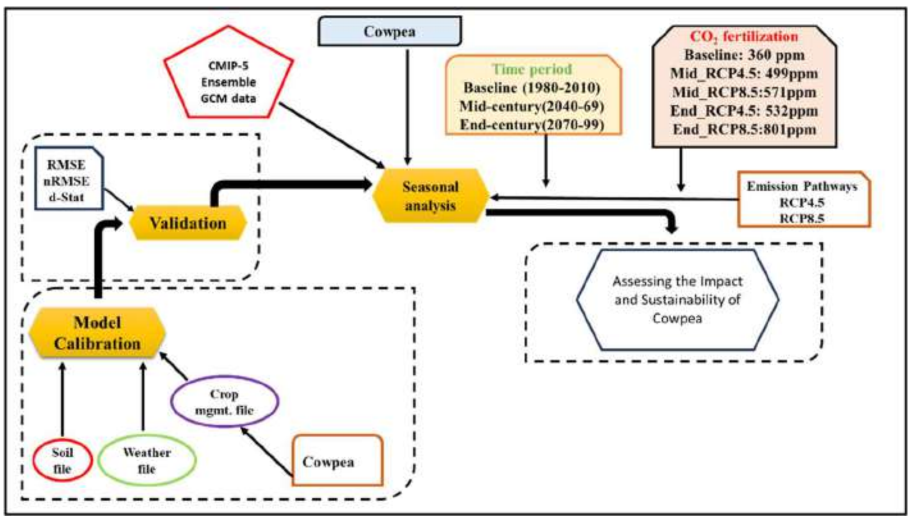
The impact of climate change on crop production has been a topic of increasing concern in recent years. The substantial variability in the climate impacts the production of crops across all the crops and agricultural systems (Thornton et al., 2010). This effect of changing climate will largely affect the dryland and rainfed areas. The challenge for agricultural researchers is to increase food production while using less land, water, and nutrients in order to meet the demands of a growing population. We must simultaneously lessen our carbon footprint. Furthermore, the crops are subject to altered rainfall patterns and rising temperatures. There is always a trade-off between the negative consequences of these potential challenges and the positive impacts of CO_2 fertilization. Selection of an appropriate cropping system and crop cultivar, especially in precipitation-limited areas could be one strategy for adaptation to changing climatic conditions (O'Brien et al., 2000; Thomas et al., 2007). Crop simulation modelling offers a research tool for evaluating trade-offs of these potential changes (Mathews et al., 2013). This can form the basis of decision support system for the farmers, and tool for education and training.

Methodology

The field experiment was conducted at the Gungal Research Farm of ICAR- Central Research Institute for Dryland Agriculture (17°05' N, 78°39'E) between 2022-2023 and 2024-2025.

Calibration of DSSAT – For calibration, daily weather data was collected from the meteorological observatory located at Gungal Research Farm. Agronomic and soil data was collected by carrying out field study. Calibration involved the parameterization of crop models, i.e., estimation of genetic coefficients. The sequence of calibration was crop phenology, leaf area index, final above ground biomass and grain yield.

Validation of DSSAT – The validation of calibrated models will be done using RMSE and d-index of agreement.



$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(S_i - M_i)^2}{n}}$$

$$d = 1 - \frac{\sum_{i=1}^{n}(S_i - M_i)^2}{\sum_{i=1}^{n}(|S_i - \bar{M}| + |M_i - \bar{M}|)^2}$$

Where Si is the simulated value, Mi is the measured value, n is the number of values, $\bar{M}$ is the average of the measured values. Index of agreement (d) is a measure of the degree of deviation between observed and predicated. A combination of lower RMSE value and a higher 'd-index' value indicates good performance of the model.

Assessing the impact of future climate on Cowpea in semi-arid region of Telangana - IPCC AR5 scenarios (Representative concentration pathways) 4.5 and 8.5 is used for mid (2040-2069) and late (2070-2099) century periods. After preparing the future climate files, long term simulations were done.

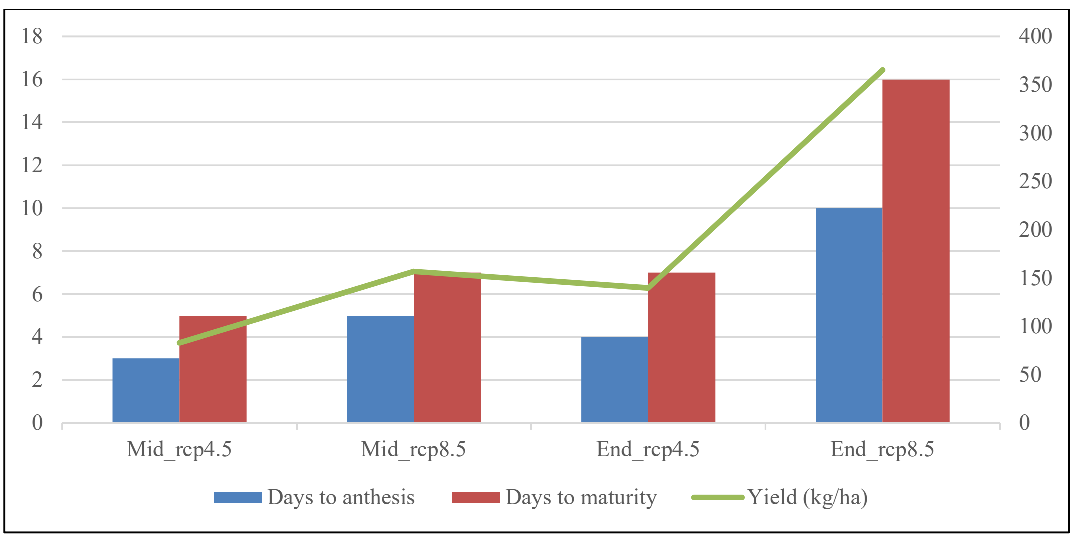
Results

Calibration provided a set of genetic coefficients for cowpea cultivar "TPTC29". The average days taken to anthesis and maturity and, yield is given in Table.

Model evaluation metrics for Cowpea

Variable	Obs	Sim	RMSE	d-Stat	r-Square
Days to anthesis	39	39	0.577	0.923	0.964
Days to maturity	82	84	2	0.743	0.981
Yield(kg/ha)	1257	1273	10.47	0.991	0.967

Effect of projected climate on crop phenology and yield: There was a substantial increase in crop duration in days to anthesis and days to maturity under all four future scenarios. The days to anthesis increased by 3, 5, 4, and 10 days during mid-century-RCP4.5, mid-century-RCP8.5, end-century-RCP4.5 and end-century-RCP8.5, respectively. In the case of days to maturity increased by 5, 7, 7, and 16 days during mid-century-RCP4.5, mid-century-RCP8.5, end-century-RCP4.5 and end-century-RCP8.5, respectively. And grain yield increased by 82.9, 156.9, 139.7, and 365.4 kg/ha from baseline during mid-century-RCP4.5, mid-century-RCP8.5, end-century-RCP4.5 and end-century-RCP8.5, respectively



Change in days to anthesis, maturity and Yield from the baseline

Conclusion

There was increase in days to anthesis, days to maturity and grain yield also increased in all mid and end-century scenarios.

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UID: 1516

Characterizing Preferential Flow in Semi-arid Soils Using GIS and Image Analysis Techniques

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Semi-arid ecosystems cover approximately 6 billion hectares and support about 33% of the global population (Hassan *et al.*, 2005). In such regions, understanding soil hydrodynamics is critical for efficient water use, as these areas are often subject to water scarcity (Reynolds et al., 2002). Preferential flow (PF) significantly influences infiltration, runoff, and soil moisture distribution, which are crucial for managing water resources effectively (Beven & Germann, 2013; Van Schaik et al., 2014). This study focuses on PF assessment in different land uses and elevations within the Hayathnagar micro-watershed, emphasizing the importance of PF for sustainable water management in semi-arid ecosystems (Wu et al., 2022).

Materials and Methods

The study was conducted in the 154-hectare Hayathnagar micro-watershed located in Hyderabad, Telangana, which was divided into three reaches based on elevation: upper (54 ha), middle (60 ha), and lower (40 ha). The dominant land uses in the region include forests, horticulture, and field crops such as sorghum, castor, pigeon peas, and maize. To study preferential flow (PF) dynamics, 18 soil profiles were selected, with six profiles per elevation and two profiles per land use type (forest, fallow, and cropped land) at each elevation.

Brilliant Blue dye at a concentration of 4 g/L was applied (Fig) to visualize PF pathways. After 24 hours, the stained vertical profiles were excavated and photographed. Digital images of these profiles were analysed using ArcGIS 10.3 (Fig) and ImageJ software to quantify key parameters such as dye coverage, total stained area, uniform infiltration depth (UID), preferential flow fraction (PFF), and stained path width (SPW) (Pushpanjali et al., 2024). This methodology provided insights into the influence of land use and elevation on preferential flow patterns in the semi-arid watershed.

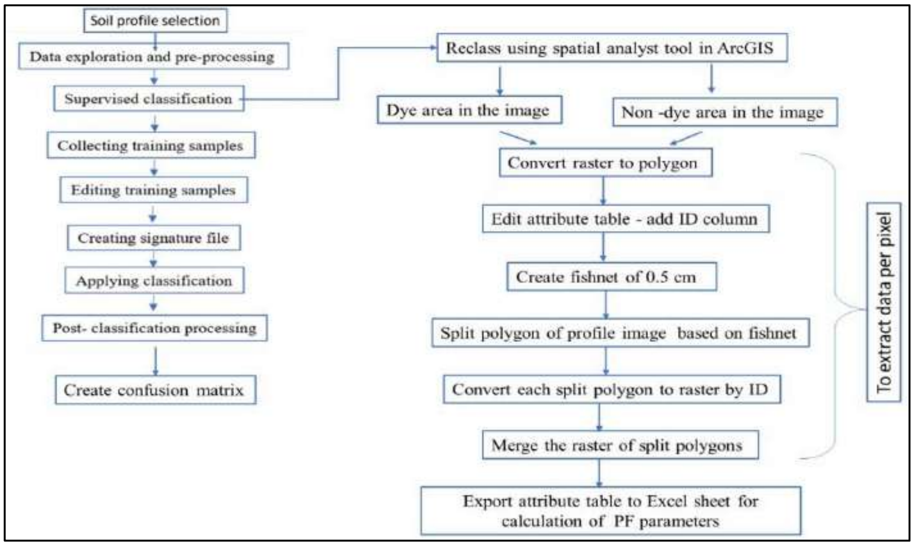
Application of Dye- water with power sprayer

Results and Discussion

The soils in the Hayathnagar micro-watershed are derived from granite gneiss and exhibit varying textures across different reaches, with sandy clay loam in the upper and lower reaches, and loamy sand in the middle reach. Moderate erosion was observed in 67% of the area. Preferential Flow (PF) patterns showed that dye coverage was highest in the top 0–10 cm of soil but decreased significantly below 30 cm (Beven & Germann, 2013). Among the land uses, cropped land exhibited more uniform dye coverage compared to forest and fallow land (Yan et al., 2016). The Uniform Infiltration Depth (UID) was highest in the lower reach, while the middle reach displayed the highest PF fraction, indicating more pronounced preferential flow patterns in this area (Bai et al., 2020).

The Stained Path Width (SPW) analysis revealed different PF characteristics based on elevation: the upper reach was dominated by fine flow paths (SPW <20 µm and 20–200 µm), the middle reach showed significant macropore flow (SPW >200 µm), and the lower reach exhibited macropore flow (SPW >200 µm) up to a depth of 15 cm (Zhang et al., 2024).

The flow types observed included heterogeneous matrix flow and fingering at the soil surface (Fig), while subsurface soils exhibited macropore flow with mixed interactions between the macropores and the soil matrix (Dai et al., 2019). Funneling was notably observed in cropped land, contributing to concentrated flow pathways (Wu et al., 2022).



Flow chart for data extraction using GIS software. (Source: Pushpanjali et al., 2024)

Profile study for Dye movement

These results highlight the variability of PF dynamics influenced by land use and elevation within the micro-watershed. The study's multi-index evaluation highlighted that dye coverage and preferential flow (PF) fraction were the most critical indices for assessing PF dynamics. The middle reach exhibited the highest PF evaluation index, indicating its susceptibility to PF due to its soil structure and elevation characteristics (Yan et al., 2016). Macropore flow paths were significantly influenced by land use and soil structure, with skeletonized images revealing that the connectivity of macropores played a key role in determining PF behavior (Beven & Germann, 2013). Areas with poor macropore connectivity showed more pronounced PF, as water bypassed the soil matrix and rapidly moved through preferential pathways. Flow stability also varied across different reaches; the middle and lower reaches displayed more lateral water movement due to subsurface heterogeneity and macropore interactions, while the upper reach exhibited flow instability, likely caused by the coarse surface texture and reduced water retention, leading to fragmented and less predictable flow patterns (Wu et al., 2022). These findings underscore the importance of considering both soil structure and land use when evaluating PF dynamics in semi-arid regions (Zhang et al., 2024).

Conclusion

The study concludes that soils in the middle and lower reaches of the micro-watershed exhibit significant PF, with implications for nutrient distribution and water management. PF patterns vary by elevation and land use, with the middle reach showing the highest PF potential. Effective water management in semi-arid regions requires understanding these PF dynamics to optimize infiltration and reduce runoff.

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UID: 1522

Drone-Driven Assessment of Maize Crop Water Productivity

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Escalating climate change and variability, compounded by rapid population growth, urbanization, and socio-economic development, have intensified competition for limited freshwater resources. Agriculture, as the largest global consumer of freshwater (around 70%) is increasingly under scrutiny. In this context, the need to reassess traditional water management practices has never been more urgent, both for the scientific community and policymakers. A key concept in this regard is Crop Water Productivity (CWP)—the crop yield produced per unit of water consumed (Y/ET) (Bastiaanssen and Steduto, 2017), serves as a vital metric, for evaluating the overall efficiency of water utilization in agricultural systems (Ma et al., 2024). Thus, mapping and assessment of CWP assumes critical importance for the optimal utilization of water resources in agriculture. While conventional techniques for measuring water productivity have been widely used, achieving precise evaluations over large-scale areas remains elusive. Unmanned Aerial Vehicles (UAVs) offer a promising solution, serving as cost-effective platforms for scientific data collection. With their capacity to conduct on-demand flights, capture high-resolution data, and provide rapid insights, UAVs are increasingly recognized for their potential in agricultural research. This study aimed to map crop water productivity of maize crop under varying irrigation levels using UAV based multispectral and thermal imagery.

Methodology

The field experiment was conducted with the maize crop (Hybrid: DHM-117) during *rabi* season at the Maize Research Centre, Rajendranagar, Professor Jayashankar Telangana Agricultural University (PJTAU), Hyderabad. Maize was sown along the sides of ridges, with spacing of 60 cm × 20 cm and seed rate of 25 kg ha^{-1}, adhering to the package of practices prescribed by the university. The crop was subjected to two distinct irrigation treatments: scheduling irrigation at 20% Depletion of Available Soil Moisture (DASM) (I_{20}) and 40% DASM (I_{40}). To collect the data regarding reflectance and emittance, an UAV, equipped with integrated multispectral and thermal sensors (ALTUM-PT), was deployed over the experimental field at 16-day intervals. The UAV enabled near real-time data acquisition, which was subsequently processed using Pix4D Mapper. Crop water productivity was then computed in three steps and compared against ground-based measurements.

1. **Estimation of Crop Yield:** The Enhanced Vegetation Index (EVI2) (Jiang et al., 2008) was derived using the Red and Near-Infrared (NIR) bands, which was then correlated with ground-based biomass measurements. A regression model was developed to spatially estimate biomass, which was subsequently multiplied by the harvest index to derive crop yield. The formula for EVI2 is as follows

$$EVI2 = 2.5(NIR – Red) (NIR+2.4 Red +1)$$

2. **Estimation of ETc:** Evapotranspiration, a pivotal component of the hydrological cycle, was estimated using the METRIC model (Mapping Evapotranspiration at high Resolution with Internalized Calibration) (Allen et al., 2007a), which is based on the principles of surface energy balance:

$$\lambda ET = Rn - G – H$$

Where, λET is the latent heat flux, Rn is net radiation, G is soil heat flux, and H is sensible heat flux. All these fluxes are expressed as W m^{-2} or MJ m^{-2} day^{-1}

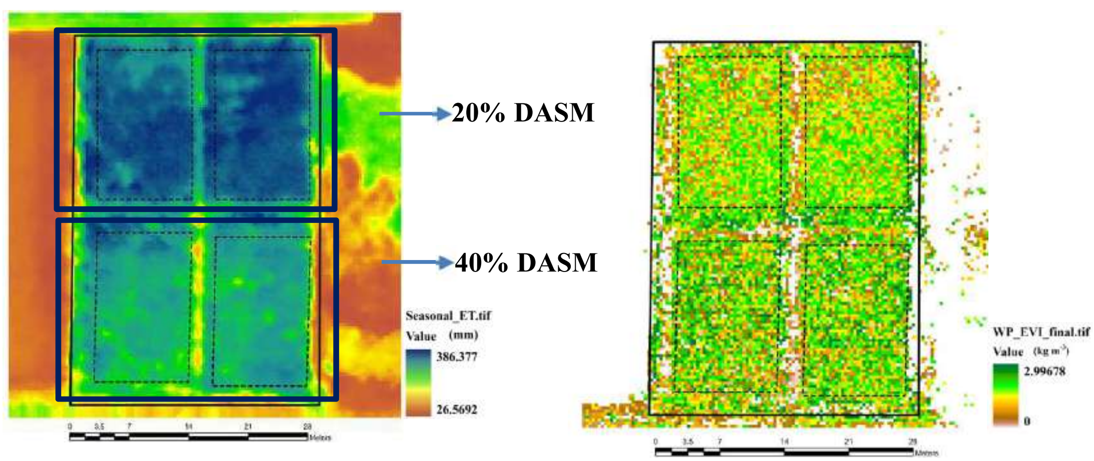
Initial daily ETc values for the date of flight were computed and then interpolated between flights to derive daily ETc for the entire crop growth period. The seasonal ETc was subsequently calculated by summing the daily ETc values.

3. **Computation of CWP:** Crop Water Productivity was determined by dividing the spatial map of crop yield by the ETc

$$\text{CWP (kg m}^{-3}\text{)} = \text{Crop yield (Y, kg)/Evapotranspiration (ETc, m}^{3}\text{)}$$

Results

In the process of mapping crop water productivity, a series of parameters including net radiation, soil heat flux, sensible heat flux, latent heat flux, EVI2, biomass, and yield were derived. Upon examining crop yield estimates using the EVI2-based linear model (R^2 = 0.90), the I_{20} treatment exhibited 8.2% higher yield (527 kg ha^{-1}) compared to the I_{40} treatment (487 kg ha^{-1}), with an average underestimation of 13% relative to the observed yields. Furthermore, when examining the ETc, as shown in Fig., substantial spatial and temporal variability was observed in both treatments, ranging from 1.46 to 2.98 mm day^{-1}. However, when considering the average seasonal ETc, the I_{20} treatment displayed a 20% higher ETc (318 mm) compared to the I_{40} treatment (265 mm). UAV measurements of ETc showed a 6% underestimation compared to ground-based observations.



(a) (b)

UAV captured spatial variation of (a) seasonal crop evapotranspiration and (b) crop water productivity of maize crop as influenced by irrigation treatments

In contrast, when assessing CWP, although distinct spatial variations were evident irrespective of treatment, the irrigation-induced differences in water productivity were more pronounced. The I_{40} treatment (1.79 kg m^{-3}) reported 8.5% higher CWP than I_{20} (1.65 kg m^{-3}), compared to the actual values of 1.92 kg m^{-3} and 1.85 kg m^{-3} for I_{20} and I_{40}, respectively (Fig). UAV-based CWP measurements displayed an underestimation of approximately 8% relative to ground-based values (I_{40}: 1.95 kg m^{-3} and I_{20}: 1.89 kg m^{-3}). The relatively lower CWP under 20% DASM could potentially be attributed to higher water loss through ETc. Additionally, it is plausible that despite the increased irrigation, plants under 20% DASM conditions were unable to increase yields at the same rate.

Conclusions

In conclusion, crop water productivity was approximately 5% higher when irrigation was scheduled at 40% DASM compared to 20% DASM, suggesting that the 40% DASM treatment may be more suitable for optimizing irrigation water usage under water-limited conditions. Furthermore, UAV-based sensors proved to be highly effective, demonstrating the potential for accurate estimation of evapotranspiration (ET), yield, and water productivity (WP) with an accuracy of approximately 90%. These capabilities, combined with fine spatial resolution, position UAVs as a promising tool for near real-time monitoring of agricultural water requirements, offering substantial benefits for precision irrigation and sustainable water management.

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Integrating Soil Moisture Sensors and LSTM Models for Sustainable Irrigation Practices in Southeast Asia and India

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With climate change, plant water demand has increased, leading to drier soils over the past three decades (Vicente-Serrano et al., 2024). A growing number of crops, including vegetables from peri-urban farming and large-scale crops, now require irrigation (FAO et al., 2022), while water resources are simultaneously declining. In this context, farmers can no longer rely solely on their experience, which rarely ensures optimal water use (Inthakesone and Syphoxay, 2021, McPhee et al., 2022). Smart agriculture technologies are essential for effective water management and yield maintenance. Similarly, researchers must adapt by integrating artificial intelligence (AI) into their practices to enable faster and more widespread application of research outcomes.

Barriers exist on both sides: farmers and researchers. Farmers face challenges in adopting innovative technologies, while researchers encounter obstacles in implementing AI-based approaches. To address these issues, we established LoCSAI (Low-Cost Soil Sensors & Artificial Intelligence), an international, multidisciplinary network of experts (froml soil science and agronomy to electronics and artificial intelligence). The project, launched in North Africa in 2022 (https://intel-irris.eu/) expanded to Southeast Asia (Lao PDR) in 2024 and is set to begin in India next year (ICRISAT and ICAR Hyderabad). LoCSAI's goal is to collect soil moisture data from various agro-socio-economic and climatic contexts, both in experimental stations (for controlled testing) and on smallholder farms (to assess real-world practices). By identifying irrigation typologies and training farmers with the most efficient practices, the project aims to improve water use efficiency and disseminate these practices among other farmers.

Our presentation will highlight (i) soil moisture data collected in Laos and (ii) the initial steps of AI integration et draw some perspective for developing this project in India.

Materials and Methods

Site selection: The study was conducted in Thaxang village, 30 km north of Vientiane. The monsoonal tropical climate features 1,600 mm of annual rainfall, with a dry season (November–April) characterized by significant water deficits (evapotranspiration exceeds rainfall). The village, with 1,000 residents across 150 households (100 h getting their income from farming), practices organic vegetable farming with limited or no use of chemical fertilizers and pesticides. Irrigation methods include sprinklers, hoses, and occasionally flooding, with water sourced from an irrigation system or private wells.

Plot selection: Ten farmers using similar irrigation methods (sprinklers or manual watering) and crop cycles were selected. During the rainy season, plots are fallowed, allowing weeds to grow freely. In the dry season, plots are cleared for short-cycle crops such as lettuce (harvested within a month).

Soil water sensors: Watermark® tensiometers (0 to -250 hPa range) were chosen for their global reliability and lack of calibration requirements. Two sensors were installed per plot: one at 10 cm depth (root zone) and another at 30 cm (below root zone). Data were recorded hourly and transmitted via LoRa to a gateway, which forwarded data via GSM to a server in CSV format.

AI model: A Long Short-Term Memory (LSTM) model was chosen for its ability to analyze time-series data. The model considers temporal variations within and between the two sensor depths.

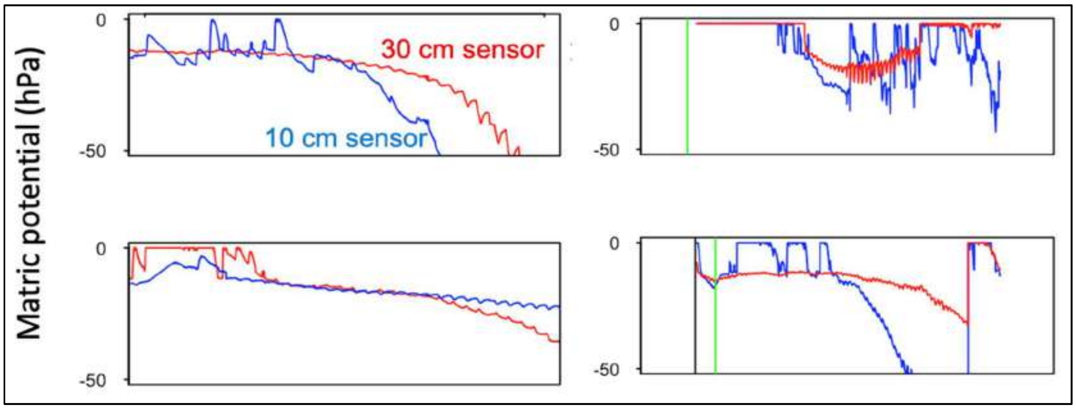
AI learning process: In the context of time-series data learning, our process involves three key stages: preprocessing, training, and evaluation. Raw sensor data are cleaned, refined, and relevant features are extracted to ensure high-quality input. A neural model, such as Long Short-Term Memory (LSTM), is then trained to capture complex temporal dependencies and deliver accurate diagnostics or classifications. Finally, evaluation using test data validates the model's robustness and generalization, ensuring its effectiveness for applications like irrigation management. (Hochreiter & Schmidhuber, 1997; Goodfellow et al., 2016).

Results and Discussion

1. Measurements from cultivated plots (dry season)

Soil matric potential rarely dropped below -50 hPa (Fig), indicating irrigation occurs before plants fully utilize available water. This not only wastes water but also risks creating unfavorable conditions for soil organisms and encouraging pathogen growth on wet leaves. Excessive irrigation likely limits root development depth, increasing vulnerability to water scarcity. Identifying a farmer practicing efficient irrigation for future monitoring is a priority.

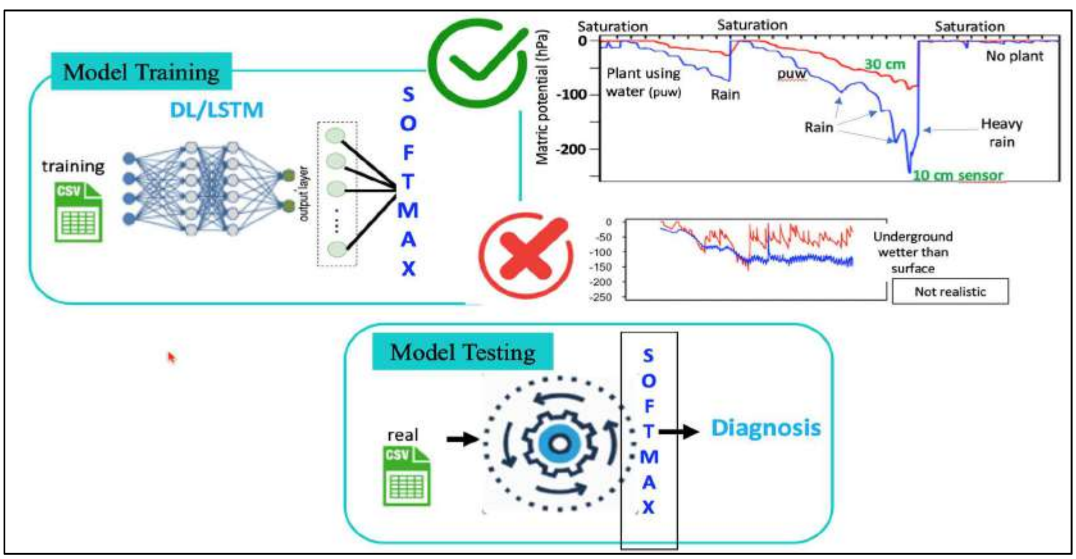
Moreover our data have several iconsisten results that need to check both the famers practices et the way the sensors where installed and their position.



Water content monitoring

2. Measurements from Fallow Plots (Rainy Season)

Weed growth significantly impacted soil water dynamics, with continuous water uptake during the plant development and rewetting during rainfall events, depending on precipitation intensity. Some of the rain events resulted in rewetting only the soil surface without water infiltration to the bottom sensor, while bigger rain event resulted in deeper infiltration and even on rewetting of both layers and some times resulted in surface of whole profile saturation. The different record we got on the fallow field provided valuable data to train our model. Some apparently wrong data were also obtained, allowing to teach also data for which warning signals must be sent.



Top left: conceptual model showing the training process, top right: examples of data that we used for this training process. Bottom: conceptual model of the next step of testing of our algorithms

Conclusion and Perspectives

We confirmed the existence of unsustainable irrigation practices in Laos, emphasizing the potential benefits farmers could gain from daily soil moisture data transmission to support decision-making and optimize irrigation management. Observations from fallowed plots during the rainy season provided clear, low-noise signals that were highly valuable for AI training. To further validate the model, data from plots managed under efficient irrigation practices are now essential. We hypothesize that monitoring soil water content in Indian villages with a long-standing tradition of irrigation, or at research stations operated by ICAR and ICRISAT, will be crucial for evaluating the diagnostic capabilities of our model.

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UID: 1552

Spatio-Temporal Variability in Pearl Millet Yield under Future Climates in India

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Pearl millet is a key dryland cereal grain crop highly adaptable to extreme weather events, especially drought. It is a resilient crop that thrives in arid and semi-arid regions, providing a vital source of food and nutrition in water-scarce environments. Its ability to withstand drought and grow in poor soils makes it a key staple for ensuring food security and supporting livelihoods in drylands. With its spatial and temporal variability, climate is a major influencing factor in crop production. Thus, any change in climatic elements is bound to have either positive or negative impacts on crop production. While an increase in temperature during crop growing season reduces the yield, the CO_2 fertilization effect to an extent can reduce its negative impact. Very few literatures are available in the Indian context regarding the response of pearl millet to projected climate using crop modelling. The study was undertaken with the following objectives:

- To calibrate and validate the DSSAT-CERES-Millet model for major growing districts of India
- To quantify the impact of projected climate on growth and yield of pearl millet in major growing districts of India

Methods

The major pearl millet growing districts of India were identified as cultivated area and productivity. Calibration and validation was undertaken using district level productivity and crop phenology of major cultivar (state-wise). Future climate was derived from an ensemble of 30 general circulation models (GCMs). The simulation was conducted for the mid-century (2040-69) under emission pathways of RCP4.5 and RCP8.5. The mean change in yield during the future time periods compared to that of baseline (1980-2009) was estimated.

Results

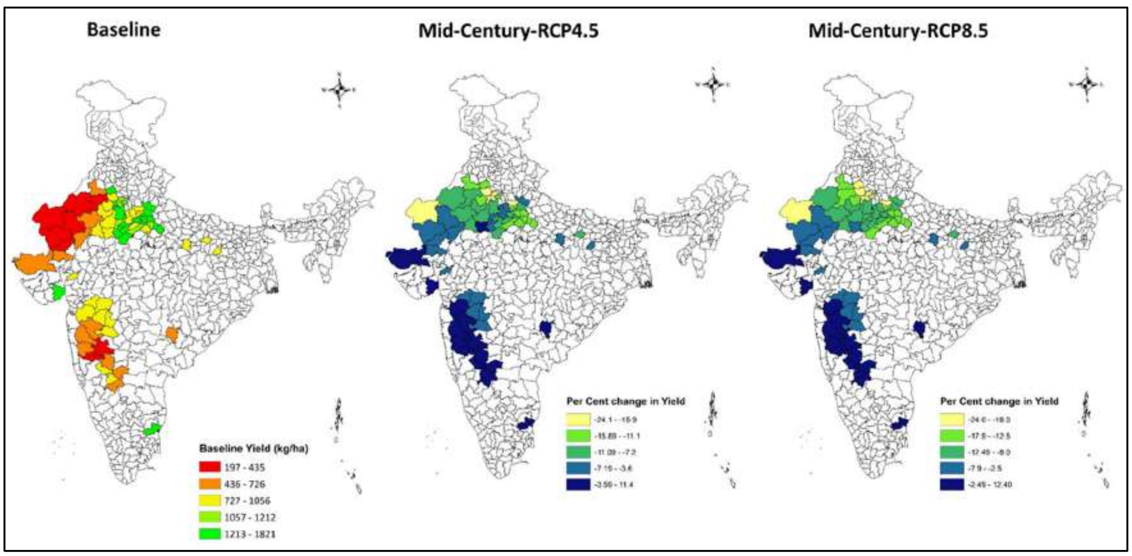
Changes in projected climate compared to baseline

The mean seasonal rainfall during baseline period ranged 300 mm (districts of Western Rajasthan) to 1000 mm (Districts of Maharashtra). The mean seasonal rainfall is projected to change by -10% to +20 during mid-century under both RCP4.5 and RCP8.5. The mean baseline maximum temperature (Tmax) during crop growing period was 29 °C (Southern

India) to 35 °C (Western Rajasthan). It is projected to increase by 0.75 - 2 °C during mid-century-RCP4.5 and by 1.2 – 2.5 °C during RCP8.5, respectively. Similarly, Tmin is projected to increase by 1.2-2 °C during mid-century-RCP4.5 and by 1.7 -2.7 °C under RCP8.5.

Projected changes in grain yield

The baseline district-level yield of pearl millet ranged 200 - 1800 kg ha^{-1}. The yield is projected to decrease during the future scenarios. During mid-century under RCP4.5, pearl millet growing districts of Western Rajasthan will have highest yield reduction to the tune of 16-24%, if no adaptation options are undertaken (Fig). The yield will remain more or less same in Maharashtra and Karnataka when compared to that of the baseline. Similar results were obtained under RCP8.5 also, however, the magnitude of yield reduction was higher (18-24%).



Yield of Pearl millet during baseline and two future scenarios (RCP4.5 and RCP8.5) during mid-century

Conclusion

The DSSAT-CERES-Millet model calibrated and validated for major growing districts of India for climate change impact assessment. Rising temperatures (both Tmax and Tmin) caused a reduction in yield. The results of the study highlight the necessity to develop adaptation strategies for overcoming the negative impact of projected climate on pearl millet cultivation.

UID: 1558

Digital Monitoring of Soil Organic Carbon under Varying Slopes of Eastern Himalayas, India

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The northeast Indian Himalayas have historically high soil organic carbon (SOC) content because of the C favouring climatic conditions and age-old traditional farming practicing monoculture. SOC is the foremost determinant of soil health and agricultural production potential. However, estimation for SOC in hilly terrains are seldom studied due to physical and monetary constraints. Northeast India being a part of the great Himalayan range, is one of the mega biodiversity hotspots. Rice is the dominant crop in the region. In this region, crop productivity in such fragile land with traditional farming depends upon the natural enrichment of the soil. Land use management and environmental conditions exert a persistent influence on SOC dynamics (Meetei *et al.,* 2020). Slope creates microclimate by modifying soil temperature, soil moisture and vegetation communities at small scale (Zhu *et al.,* 2019). SOC estimation by conventional method is laboratory based with the oxidation of organic matter. This approach generates discrete, point-specific surface data and does not capture continuous surface variability. However, it is crucial to evaluate SOC in hilly regions due to the pressing issues of soil erosion and degradation (Li *et al.,* 2015) as SOC controls over a wide range of soil properties (Van Huynh *et al.,* 2022). The limitations of such methods are overcome with indirect SOC estimation using remote sensing-based spectral indices and GIS applications (Vohland *et al.,* 2022). Therefore, this study aims to quantify the changes of SOC under different slope class gradient using geoinformatics technique.

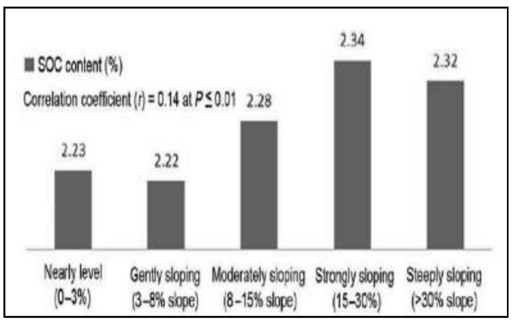
Methodology

The study was carried out in Bhoirymbong, Ri Bhoi district, Meghalaya. Composite sampling was adopted for soil sample collection from the rainfed lowland rice field of Bhoirymbong block representing lowland of Eastern Himalayan region at 0 – 15 cm depth. The collected samples were analysed for the soil properties following standard protocols. The Landsat data of 2019 and 30 m Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) were accessed from the USGS earth explorer website and 15 different predefined remote sensing (RS) indices then generated. Various auxiliary variables like climate (temperature and rainfall) and land use (pine forest and rice–fallow system) were considered, while soil attributes, elevation and slope were taken as variable factors. A total of 15 different RS indices as a predictor (independent) variable in model construction were derived.

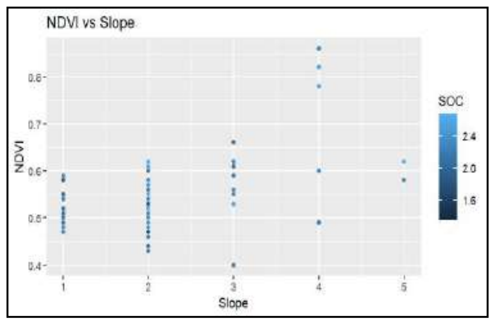
Pearson's correlation coefficient between SOC and RS indices was calculated to evaluate the impact of slope on SOC content. Multiple linear regression-stepwise was used for final SOC prediction.

Results

The effect of slope on SOC was studied using Gabriel's post hoc test and found to be statistically insignificant due to low SOC variability (CV < 15%) but with positive correlation. This is due to the presence of pine trees at the higher slope. A high SOC value 2.85% at the steep slope (15–30%) was observed compared to that at the lower slope (0–8%) i.e. 1.24% due to slow decomposition of needle shaped pine leaves which contain waxy-coated which was conferred by the higher value of NDVI at higher slope. Among the selected statistical approaches, the performance of MLR-stepwise (R^2 = 0.87 and RMSE = 0.026) was found to be the best compared to PLSR (R^2 = 0.71 and RMSE = 0.05) and PCA-R (R^2 = 0.27 and RMSE = 0.11). The best predictive model also indicated a non-significant change of SOC content under varying slope classes under traditional rice-fallow.



Laboratory analysis-based data of soil organic carbon (SOC; %) content at varying slope.



NDVI across slope with respect to SOC value

Note: MLR-stepwise, Multiple linear regression-stepwise

Mathematical equation derived using MLR-stepwise

Model	Mathematical equation	R^2	RMSE
MLR-stepwise	SOC (%) = 1.47 + 0.131 * SOCI + 0.801 * NDVI	0.87	0.026

Conclusions

This study highlights the potential of geoinformatics techniques for evaluating soil organic carbon (SOC) dynamics in the fragile and undulating terrain of the northeastern Indian Himalayas. Using remote sensing indices and GIS applications, SOC changes over varying slopes in the Bhoirymbong block of Meghalaya were quantified. The study found that slope had an insignificant effect on SOC variability due to low variability coefficients. Among the statistical models tested, the MLR-stepwise model performed best (R^2 = 0.87, RMSE = 0.026), allowing reliable SOC prediction and change detection. These findings indicate that traditional rice-fallow systems, despite minimal chemical input, have maintained SOC stability in the region. This study underscores the utility of remote sensing for long-term SOC monitoring, aiding sustainable land management in sensitive hilly ecosystems.

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Spatial variability of Start of Season and End of Season Using Operational Remote Sensing Data

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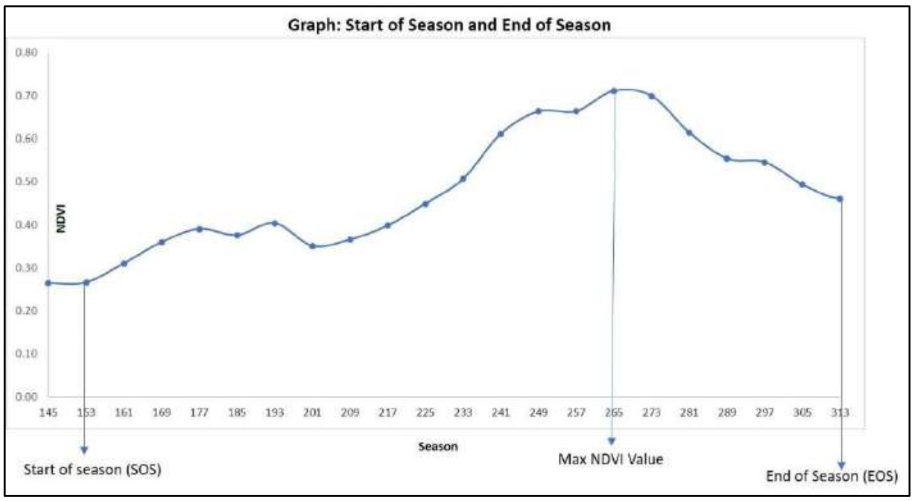
Rainfed agriculture in India largely relies on the arrival and performance of the southwest monsoon, which spans from June to September and aligns with the Kharif cropping season. The impact of variability in Start of Season (SOS) and End of Season (EOS) on agriculture results in delay in sowing of crops and shorten the crop growing period, which can lead to lower yields. The onset dates are the most critical and reliable prediction of SOS and will greatly assist on-time preparation of farmlands, mobilisation of seeds/crops, manpower and equipment and will also reduce the risks involved in planting/sowing too early or too late. Because of the critical impact of SOS and EOS on agriculture, it serves as a crucial early indicator for inclusion in early warning systems. Besides ground based information, remotely sensed data is also a potent source to estimate SOS and EOS for this reason present study aims at estimating SOS and EOS using Moderate Resolution Imaging Spectroradiometer (MODIS) data for Nalgonda district with the approach developed by Reed et al. (1994). A comprehensive overview of crop-growing conditions and rainfall patterns during the Kharif season is also studied by comparing SOS, EOS and maximum dry spell duration at 10 mm threshold.

Methodology

Normalized difference vegetation index (NDVI) derived from MODIS MOD09A1 surface reflectance was used to estimate SOS and EOS. To determine SOS and EOS, the approach developed by Reed et al. (1994) was utilized.

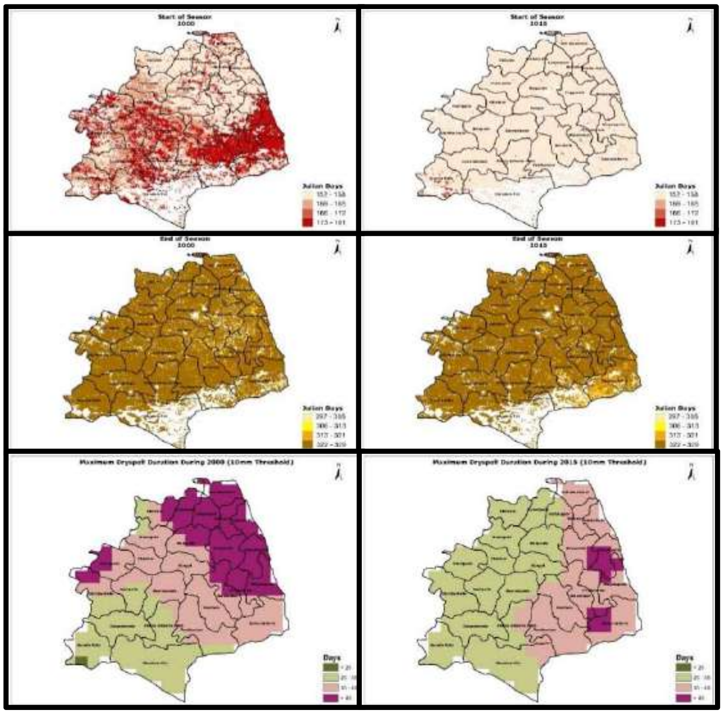


Monotonically increasing and decreasing NDVI signal (SOS and EOS)

The point at which the delayed moving average (MA) intercepts a monotonically increasing and decreasing smoothed NDVI signal is defined as SOS and EOS (Verdin et al., 2000) (Fig). The length of the MA window is adjustable, and generally depends upon the length of the non-growing season. SOS and EOS were computed in this way for images for the years 2000 and 2015 growing seasons. Maximum dryspell duration at 10 mm threshold was calculated using India Meteorological department (IMD) gridded rainfall data of 0.25mm resolution.

Results

During 2000 the SOS ranges from Julian Days 152–181 (early June to late June). The southern and eastern mandals have a delayed start (173–181 days). The northern and scattered western areas experience an earlier start in the range of 152–165 days (Fig).



SOS, EOS and Maximum dry spell duration during the years 2000 and 2015

The end of the season occurs between Julian Days 297–329 (mid-October to late November). The majority of the study area, especially in the southern and eastern mandals, shows EOS occurring later (322–329 Julian Days), indicating prolonged cropping duration. Small scattered patches, primarily in the northern regions, have earlier EOS (297–313 Julian Days) (Fig). The maximum dry spell duration varies significantly across the region, with the threshold set at 10 mm of rainfall. Northern and north-eastern mandals face >45 days of dry spells (Fig). Central and southern mandals experience shorter dry spells, typically between 26–35 days. Mandals with longer dry spells align with areas where SOS is delayed and EOS is later, suggesting prolonged vulnerability to drought stress during the season. During 2015, expect few scattered parcels in south-western region the entire district experienced an early SOS i.e. in the first week of June. The majority of the study area, except north-eastern region, shows EOS occurring later (322–329 Julian Days). The maximum dry spell in northern and north-eastern mandals face >45 days of dry spells (Fig). Central and southern mandals experience medium to shorter dry spells, typically between > 25 and 26–35 days.

Conclusions

The cropping season in 2000 exhibits significant spatial variability in SOS, EOS and as well as dry spell duration. Whereas during the year 2015, SOS remained same through the study area. The relationship between long dry spells and delayed SOS highlights the challenge of drought stress in rainfed agriculture. Northern and north-eastern districts face higher risks due to extended dry spells. Late EOS in most regions indicates prolonged cropping, which could compensate for early-season drought stress but may also expose crops to moisture deficits later. This analysis highlights the need for better rainfall management and crop planning in the context of variable seasonal conditions.

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Improved Process Representation for Hydrological Modelling Across Spatio-Temporal Scales using Satellite-Derived Land Surface Information

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Assessing hydrological dynamics is essential for sustainable water management and ensuring food and water security amidst environmental and climatic changes. Especially, in arid and semi-arid regions, the agricultural systems play a vital role in altering the regional hydrology through crop growth processes, management strategies, and irrigation practices. The spatial and temporal variability in the rainfall distribution over the region and years, highly influence the crop selection, cropping intensity, and management practices. This inter annual changes in the cropping practices and crop calendar highly influence the regional hydrological fluxes such as runoff, evapotranspiration (ET), and soil moisture by facilitating the exchange of water and energy between the land surface and atmosphere. However, many regional hydrological studies often overlook or oversimplify crop-related factors due to a lack of detailed crop data. Therefore, obtaining precise information on crop types, cropping intensity, and crop-specific phenology particularly sowing and harvesting dates, along with growth periods is critical for improving the accuracy of hydrological models and enhancing the resilience of agricultural systems.

Despite limited field-level data, remote sensing offers valuable qualitative and quantitative insights for mapping croplands and understanding land cover dynamics. This study employs an advanced semi-automated algorithm to derive cropping intensity, crop types, and cropping calendars over a 19-year period (2003-04 to 2021-22) using MODIS-derived Normalized Difference Vegetation Index (NDVI) time series at 250m spatial resolution. The algorithm utilizes Fast Fourier Transform (FFT) and a Lagrangian 3-point derivative-based approach to extract phenological metrics from the NDVI data. These metrics are then integrated into a

hybrid crop classification algorithm, combining a rule-based decision tree and a random forest classifier, to generate classified crop maps at the river basin scale for multiple seasons and years. Additionally, the algorithm provides detailed crop management information, including sowing, harvesting, and growth periods. Information on irrigation sources for each land use class is also obtained from command area maps.

This detailed crop and irrigation data serves as input for the SWAT hydrological model, enabling more accurate simulations of hydrological fluxes. By incorporating a dynamic process representation of crop management over 19 years, the model's ability to estimate streamflow (observed) and ET (MODIS) at the regional scale improved by 40% and 52%, respectively, compared to static simulations. This approach significantly reduced uncertainty in streamflow simulation, with a 24% improvement during wet years and 42% during drought years. The Nash-Sutcliffe Efficiency (NSE) and Percent Bias (PBIAS) of ET estimation improved from 0–0.4 to 0.35–0.65 and from -55%–64% to -15%–25%, respectively. These results emphasize the importance of integrating detailed crop data into hydrological modelling, which enhances the accuracy of simulated hydrological processes and deepens our understanding of regional water dynamics, for better water resource management.

UID: 1669

Modeling Soybean Yield Response to Climate Variability and Sowing Windows

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A long-term study was conducted during the *Kharif* seasons from 2018 to 2023 at the AICRP on Agrometeorology, VNMKV, Parbhani, to investigate the crop-weather relationship of soybean (Glycine max) grown under four distinct sowing windows (D1: 25th SMW, D2: 26th SMW, D3: 27th SMW, and D4: 28th SMW) with three soybean varieties (MAUS-158, MAUS-71, and JS-335). The results indicated that early sowing (D1) produced the highest yield of 2011.2 kg ha^{-1}, with the variety MAUS-158 showing superior productivity. The early-sown crop recorded the highest values for growing degree days (1812.4°C days), heat use efficiency (1.11 kg/ha/°C day), and radiation use efficiency (1.90 kg/ha/MJ). MAUS-158 exhibited a better heat use efficiency (1.06 kg/ha/°C day) and radiation use efficiency (1.67 kg/ha/MJ) compared to other varieties. Rainfall showed a positive correlation with seed yield from sowing to flower initiation and from grain formation to physiological maturity, while a negative correlation was observed during the flower initiation to pod formation phase. The maximum temperature, minimum temperature, and bright sunshine hours (BSS) were negatively correlated with seed yield throughout the crop's growth, although BSS positively correlated with yield during the flower initiation to pod formation phase. Soil moisture, along with morning (RH-I) and afternoon (RH-II) relative humidity, had a positive correlation with seed yield from sowing to flower initiation and from grain formation to physiological maturity. Multiple linear regression models were developed to predict soybean grain yield based on weather parameters during different growth stages. The models explained 69%, 50%, 41%, and 82% of the variation in grain yield during the stages of sowing to flower initiation, flower initiation to pod formation, pod formation to grain formation, and grain formation to maturity, respectively. The relationships derived from this study can assist in predicting soybean yield under specific weather conditions, particularly useful for drought management strategies. The results revealed that soybean yield at 25% PASM (Precipitation Availability) was only 200-405 kg/ha, while yields at PASM >75% ranged from 1800-2100 kg/ha. This research provides valuable insights into optimizing soybean cultivation practices by understanding the impact of environmental factors such as temperature, soil moisture, and humidity on yield, ultimately enhancing productivity under varying climatic conditions.

UID: 1686

Use of Deep Tech for Productivity Enhancement, Climate Resilient Agriculture and Input Management of Farms

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Climate change, driven by human activities including industrialization and deforestation, has fundamentally altered global temperature and weather patterns [1]. This transformation particularly challenges India, where agriculture underpins the rural economy. Farmers face mounting climate-related pressures, from unpredictable rainfall to increased pest infestations and extreme weather events [2]. With projections indicating a potential temperature rise of 2.8°C by 2050, developing climate-resilient agriculture (CRA) strategies across India's diverse agro-climatic zones has become imperative [3].

Deep technology in agriculture presents a promising solution to these challenges [4]. Unlike traditional business innovations, deep tech represents a fundamental shift driven by scientific breakthroughs. This technological evolution encompasses advanced solutions including robotics, plant wearables, field-based IoT sensors, aerial imaging, blockchain, artificial intelligence, and sophisticated remote sensing systems. These innovations enhance food production, optimize farming systems, and improve crop quality across varying climate conditions.

Deep tech's capacity for comprehensive data acquisition enables precise optimization of agricultural resources and the development of data-driven agro-advisories throughout the crop growth cycle. In response, Vassar Labs has developed an advanced cloud-based processing and analytical platform called fieldWISE that delivers tailored agro-advisories through comprehensive analysis and near-real-time monitoring of agricultural resources, encompassing crop mapping, soil wetness assessment, irrigation management, and tracking of weather and climate parameters.

Methodology

Data-driven agriculture advisories can help farmers navigate climate change uncertainties through a systematic methodology focused on individual farms. This methodology encompasses the stages of data acquisition, analysis, advisory generation, and implementation, ensuring that farmers receive relevant, timely, and actionable recommendations tailored to their farms.

Farm Data Collection: The process begins with comprehensive soil and water quality assessments to gather baseline data on nutrient levels, pH, electrical conductivity, and moisture content and the equip the farm with IoT sensors for real-time monitoring of variables like soil moisture, temperature, humidity, and atmospheric conditions.

Data Integration, Storage and Analysis: FieldWISE aggregates data from various sources, including sensors and satellite imagery, to create a cohesive view of farm conditions. Utilizing integrated processing engines such as Satellite, GIS, AI/ML, and weather engine, the platform performs predictive analytics to forecast climatic conditions, pest outbreaks, and optimal planting and harvesting times based on historical and emerging trends.

Agriculture Monitoring: The platform uses advanced deep learning algorithms such as U-Net for individual farm boundary delineation, Long Short-Term Memory (LSTM) neural network for crop identification and classification to map crop type in each field and near-real time advanced crop health monitoring techniques.

Advisory Generation: Using the platforms' comprehensive data analysis and monitoring capabilities, we have generated the following specialized advisories that guide farmers through critical agricultural decisions

Agro-Climatic Zone (ACZ) wise Crop Suitability Advisory: The methodology typically includes comprehensive assessments of ACZ local conditions such as temperature, rainfall, humidity, and historical weather patterns over the past 30 years. This analysis evaluates water requirements and identifies available water sources like canals, ponds, and rivers.

Additionally, soil fertility, texture, pH levels, and nutrient content are assessed to ensure that chosen crops align with soil characteristics, promoting healthy plant growth.

Crop Sowing Advisory: The crop sowing advisory methodology aims to provide accurate and timely recommendations to farmers regarding optimal sowing periods based on a comprehensive analysis of historical weather patterns, short, medium and long-range weather forecasts to compute crop water stress during its critical periods, soil moisture, and crop-specific requirements. It generates farm wise soil moisture values for different farms in the village using rainfall data from weather stations, and computed ET data using dynamic daily rainfall, temperature, humidity etc. This soil moisture value has been used to assess germination success of sowing.

Soil Moisture based Water Stress Advisory: It aims to deliver actionable insights for irrigation management by forecasting crop water demand and identifying critical water stress periods. Daily calculations consider soil moisture levels, evapotranspiration rates, crop type, growth stage, rainfall, temperature, and crop-specific water requirements using an integrated soil water balance model. This model estimates daily water needs and projects overall season requirements, providing data on cumulative water requirements so farmers can manage irrigation effectively. These advisories are communicated to farmers weekly.

Soil Health Card based Fertilizer Management: The platform utilize data from the soil health card (SHC) and current fertilizer consumption for the analysis. The SHC contains the status of farmer's farm soil with respect to 12 parameters, namely N, P, K (Macro-nutrients); S (Secondary- nutrient); Zn, Fe, Cu, Mn, Bo (Micro - nutrients); and pH, EC, OC (Physical parameters). Based on SHC parameters value, cropping pattern in different seasons and crop specific nutrient requirement platform indicate fertilizer recommendations and soil amendment required for the farm.

Pest & Disease Forewarning: Pest & disease alerts provide crop-specific advisories to the cultivators about the specific fields that are likely to be Pest or Disease-infested in advance of 1 to 2 weeks of time. It considers current weather patterns (Rainfall, temperature, humidity), weather forecasts, crop stages, epidemiology of pest/disease and various critical stages of the crop to generate probability of occurrence of where a pest or disease could infect the crop depending upon the favourable conditions for pest or disease to thrive.

Results & Discussion

The following results were observed from advisories generated through our system in Andhra Pradesh:

Crop Suitability Advisory Use Case:

The platform analyzes weather conditions, soil characteristics, and land quality to recommend cropping patterns. In low-productivity regions like Rayalaseema, farmers transitioned from groundnut to horticultural crops, and similar shifts were made in cotton and paddy areas, improving yields.

Crop Sowing Advisory:

Sowing advisories impacted 12,000 villages and over 10 major crops. By analyzing weather patterns and forecasts, farmers optimized sowing schedules, reducing water stress. In Anantapur, groundnut farmers shifted sowing from late June to early July, resulting in improved yields through better alignment with favorable weather.

Soil Moisture-based Water Stress Advisory:

Real-time soil moisture data, combined with crop and rainfall forecasts, enabled tailored irrigation schedules for over 100,000 hectares under moisture stress. Weekly advisories benefited 4,540 farmers, improving water management and crop productivity.

Soil Health Card-based Fertilizer Management:

Using SHC data, farmers received crop-specific fertilizer recommendations. This initiative, covering 18,000 villages and 670 mandals, reduced fertilizer usage by 7.5% compared to 2017-18, enhancing cost-efficiency and sustainability.

Pest & Disease Forewarning:

Alerts issued 1-2 weeks in advance allowed farmers to apply targeted pest control measures, reducing crop loss. Forewarnings across 800,000 hectares prevented losses from Pink Bollworm in cotton and Fall Armyworm in maize and jowar.

Conclusion

The Integration of Deep-tech solutions in agriculture mark a shift toward smarter, resilient farming. Tailored advisories and data-driven insights boost productivity, ensure food security, and promote sustainable practices. Expanding these innovations can serve as a global model for climate-resilient agriculture.

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UID: 1728

Application of AI & ML for Rainfed Agriculture: Building Pathways for Resilience & Sustainable Livelihoods

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Rainfed agriculture, completely dependent on rain, is the backbone of agricultural economies in developing countries. Most of these constraints still face smallholder farmers today: uncertain weather, poor soil quality, and lack of access to modern farming technology. Climate change adds new elements to these problems, including increasing variability in rainfall patterns, extended periods of drought, and extreme events affecting agricultural productivity. AI and machine learning are innovative approaches to bringing solutions and building resilience and sustainability in rain-fed farm systems at an interdisciplinary level. AI and ML are advanced subsets of data science that can process big data, predict patterns, and automate decision-making. Such technologies may transform rainfed agriculture from reactive to proactive to enhance productivity, resource efficiency, and farmer livelihoods.

Challenges in rainfed agriculture

It also faces many challenges, such as vulnerability to unpredictable weather patterns and, remarkably, variability in rainfall distribution and intensity. Poor soil health, inadequate irrigation, and excessive dependence on traditional farming practices contribute to low productivity. The lack of timely information is a formidable challenge in dealing with pests and diseases that cause crop losses. Smallholder producers face other barriers, including a lack of access to markets and prices and frequent fluctuations in price. Ecological imbalances have further been aggravated through overexploitation of soil and water resources, undermining agricultural systems' sustainability.

Role of AI and ML in rainfed agriculture

AI technologies are changing rainfed agriculture by enhancing productivity and sustainability in various applications. Such models use satellite data, historical weather patterns, and real-time monitoring to provide accurate weather forecasts and early warnings for extreme events, allowing farmers to adjust their sowing schedules and irrigation practices. IoT devices and sensors monitor soil moisture, nutrients, and crop health; precise fertilizer application prescriptions for pest control and irrigation through machine learning algorithms in precision farming. The crop choice and planting time optimization would also depend on AI-driven decision support systems using the location-based data and help manage the water resource efficiently as AI-based models predict water demand and irrigate appropriately (Ashoka, P et al 2024). AI is also essential in water management to enhance irrigation efficiency and ensure quality, responding to increased agricultural productivity due to climate change and finite water resources. However, while AI has significant potential for enhancing water management and agricultural output, it faces barriers such as adapting to different agricultural environments, data privacy, and small-scale farmers' lack of willingness to adopt AI technology. Moreover, research should continue to integrate AI with socio-economic data and the ability to cope with variable climates. Policy recommendations suggest standardization, more significant funding, and training for adopting AI. Also, new farm technologies such as machine learning, cloud computing, IoT, sensors, and IT platforms are changing agriculture around the globe, giving more yield with less water consumption and making farming sustainable. In combination with remote sensing, drones, and data harvesting tools, farmers' practices can become optimized. Satellite data projects like FATIMA and OpenET demonstrate this role in enriching crop forecasts and water resource management (Samuel and Surendran 2024). AI-operated agrobots and IoT systems are opening roads to self-managed precision agriculture, which depicts the future vision for agriculture.

Case studies and real-world applications

Several AI-driven initiatives significantly impact rainfed agriculture by enhancing productivity and resource management. Developed by Microsoft, Farm Beats integrates IoT devices, machine learning models, and cloud computing to gather and analyze farm data, predicting soil moisture and weather to help farmers make better decisions. Based on such innovations, Kheyti and CropIn have developed AI-based smart irrigation systems in India, which work on climatic data and soil health to give tailored irrigation schedules for specific crops and regions, thus promoting judicious water use. Using AI, Digital Green has promoted good farming practices through video-based training of smallholder farmers in rainfed areas, localized by machine learning, helping to determine specific solutions. Field Look is an AI-powered mobile app that provides satellite-based insights on crop health and growth stages, thereby significantly improving productivity levels in rainfed areas of Africa and South Asia. These AI-driven platforms are helping optimize farming practices, conserve resources, and improve farmers' livelihoods in vulnerable regions.

Socio-economic impacts

Adopting AI and machine learning in rainfed agriculture extends beyond technical benefits to significantly contribute to socio-economic development. AI-driven insights allow farmers to optimize resource use, leading to higher yields and reduced input costs, directly boosting their income levels. Technology-driven platforms bridge the knowledge gap, empowering marginalized communities, particularly women and smallholder farmers, by providing access to real-time information and training. In addition, AI applications increase the profitability and sustainability of farming and reduce rural-urban migration by alleviating economic push factors that push rural populations into urban areas. Predictive models also help farmers prepare for and adapt to climate variability, enhance resilience, reduce vulnerability, and ensure food security (Wani, S.P., 2023).

Challenges in implementation

The potential of AI and machine learning in rainfed agriculture is massive, but many barriers must be overcome before its adoption succeeds. There is the issue of the digital divide- that is, few smartphones and limited internet access, as well as a lack of digital literacy in rural areas- which deter technology uptake. High initial costs for investment in AI tools and IoT devices may also pose a challenge for smallholder farmers. Data privacy and security concerns arise as farm-level data is collected and shared, raising questions about misuse and ownership. Furthermore, AI models must be localized to regional conditions to ensure their relevance and effectiveness, as a one-size-fits-all approach may not yield the desired results (Pancholi, R. et al., 2023).

Conclusion

Public-private partnerships, capacity building through digital literacy training, policy support for investment in digital infrastructure, and continuous research for customised AI models are some of the key steps to maximize the benefits of AI and machine learning in rainfed agriculture. AI can potentially transform rainfed agriculture, address the challenges, enhance resilience, and support sustainable livelihoods depending on how success is delivered through inclusive approaches that prioritize smallholder farmers, develop digital infrastructure, and create a sustainable agricultural future through cooperation across sectors.

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Enabling Technology & Knowledge Dissemination for Scaling Impacts

UID: 1020

Unleashing Resilience: Mitigating Climate Change's Devastating Impact on Agriculture

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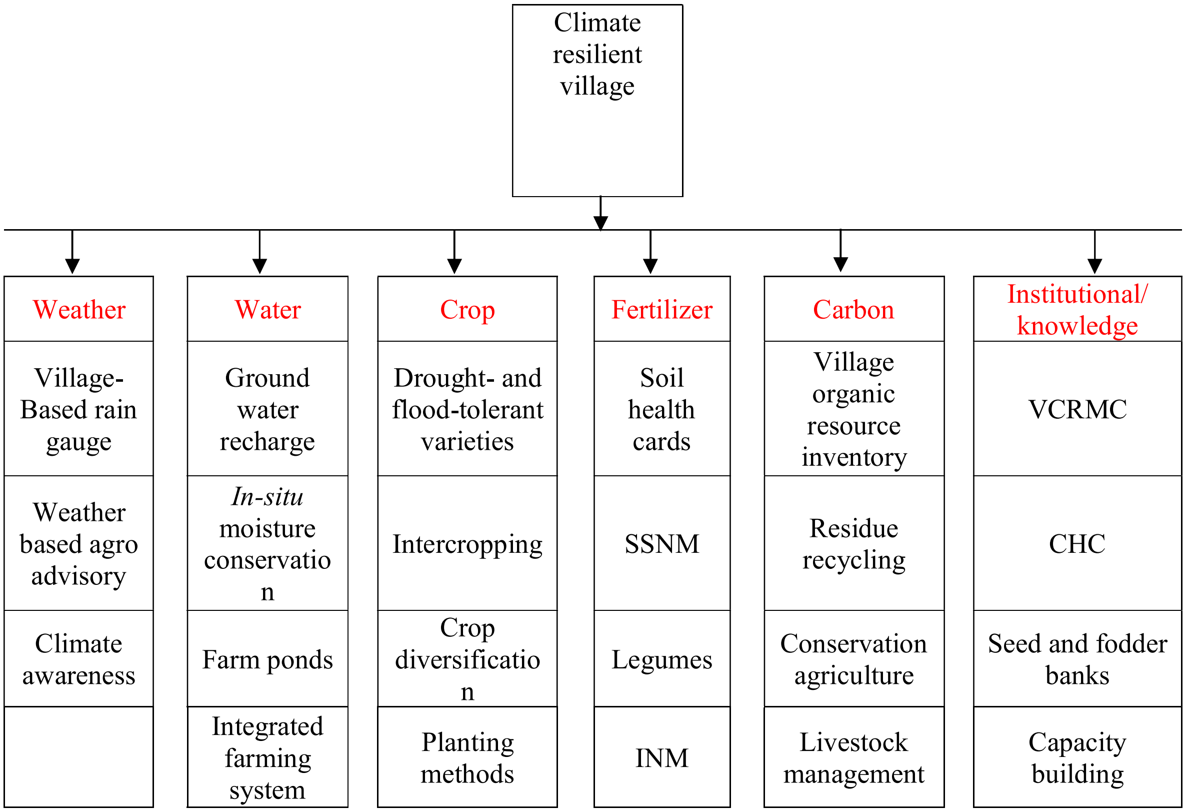
Climate change represents a significant challenge to global agriculture, threatening food security, ecosystems, and rural livelihoods. Rising temperatures, erratic rainfall patterns, and the increasing frequency of extreme weather events are intensifying the vulnerability of agricultural systems. Resilience in agriculture encompasses strategies, practices, and innovations that enhance the capacity of farming systems to adapt to, recover from, and thrive amid climatic variability. This study, conducted in the rainfed village of Alwar, Rajasthan, aims to investigate the role of resilience interventions in mitigating the adverse effects of climate change, focusing on innovative practices, institutional support, and case studies to offer scalable solutions.

Methodology

The study employed a multi-disciplinary approach combining field demonstrations, participatory research, and socio-economic analyses. Key methodologies included:

1. **Demonstrations of improved varieties:** Demonstrations of improved varieties such as mustard RH-725, barley DWRB-137, pearl millet Dhanshakti, and wheat DBW-187 were conducted in NICRA villages. The resilient mustard variety DRMR 2017-15 was implemented, with comparisons made on parameters like yield, disease resistance, and economic gains against local varieties.
2. **Capacity Building:** Conducting training programs under the National Innovations on Climate Resilient Agriculture (NICRA) project to enhance farmers' knowledge of climate-smart agricultural practices.
3. **Water Management Techniques:** Use of farm ponds, mulching, and micro-irrigation systems to optimize water use efficiency in drought-prone areas.
4. **Weather Advisory Services:** Dissemination of real-time weather forecasts and agricultural advisories to help farmers make informed decisions.
5. **Socio-Economic Surveys:** Surveys and focus group discussions to assess the impact of resilience interventions on farmer incomes and community well-being.



(Source: Srinivasa Rao *et al*., 2016)

Fig 1: Components and technology framework of climate resilient villages (CRV). CHC, Custom hiring center; INM, integrated nutrient management; SSNM, Site-specific nutrient management; VCRMC, Village Climate Risk Management Committee.

Results and Discussion

Weather-Based Agro-advisories

Weather-based agro-advisories have helped farmers strategize based on forecasts, improving awareness and adoption of modern practices like irrigation and pest management. In Gurjarpur Khurd (NICRA village), farmers benefited from reduced crop and post-harvest losses by 7–9%, with increased yields and cost savings, as reported by Maini and Rathore (2011).

1. Improved Yield and Economic Gains

The application of wettable sulphur at 0.2% has been shown to significantly enhance both seed and stover yields in mustard. This improvement is attributed to better absorption and efficient translocation of sulphur within the plant, promoting optimal growth and development. The findings align with previous studies by Raut et al. (2000) and Piri et al. (2012), which also reported increased yields and improved sulphur utilization in mustard crops. These results highlight the importance of sulphur as a critical nutrient in mustard cultivation and its potential to improve productivity when applied in appropriate formulations and concentrations. The field demonstrations of DRMR 2017-15 revealed significant improvements in productivity and profitability. The yield of DRMR 2017-15 was recorded at 21.5 q per ha, compared to 16.65 q per ha in local varieties, representing a 22.57% increase. The economic analysis indicated gross income and net returns of ₹107,500 and ₹71,000 per hectare, respectively, for DRMR 2017-15, compared to ₹83,250 and ₹47,850 for local varieties. These results underscore the potential of resilient crop varieties to enhance agricultural output and farmer incomes.

2. Biotic and Abiotic Stress tolerance

DRMR 2017-15 exhibited superior tolerance to biotic stresses such as white rust, alternaria blight, and powdery mildew. This adaptability to climatic extremes significantly reduces crop losses, ensuring stable productivity even under adverse conditions.

Midseason drought mitigation through foliar nutrient sprays

Foliar nutrition at critical growth stages helps plants overcome stress and boosts yields. Applications such as 2% KCl in mustard or KNO3 in pearl millet significantly enhance productivity by 14% in NICRA villages.

3. Water Management and Resource Optimization

The adoption of farm ponds and mulching, in conjunction with micro-irrigation technologies demonstrated in NICRA villages, led to a marked improvement in water use efficiency. These practices helped mitigate the effects of drought, reduced irrigation water requirements, and improved soil moisture retention, which is critical in rainfed regions like Alwar. During this period, farmers applied life-saving irrigation to their crops, mitigating drought stress and increasing yields by up to 14%.

4. Capacity Building and Knowledge Sharing

Training programs under NICRA emphasized climate-smart farming practices such as crop diversification, intercropping, and the use of organic inputs. Farmers reported improved decision-making capabilities, with over 80% indicating that the weather advisories helped them plan planting schedules and resource allocation effectively.

Enhanced fodder yields with advanced cultivars

Livestock farmers adopted fodder sorghum and pearl millet during the rainy season, and oats (Kent) and berseem (BL-10) postrainy. This increased quality fodder availability, boosting milk production by 15%.

5. Socio-Economic Impact

The resilience interventions contributed to enhanced livelihoods by reducing vulnerability to climate-induced risks. Surveys revealed a 30% increase in household incomes among farmers adopting these practices. Community-led initiatives, supported by institutional frameworks, played a pivotal role in knowledge dissemination and scaling up best practices.

Fig 2: Farm pond NICRA village (KVK-Alwar-I)

Conclusion

The study highlights the effectiveness of climate-resilient practices in improving agricultural sustainability and productivity in Alwar, Rajasthan. Key interventions, including improved crop varieties, water management techniques, and capacity building, significantly boosted yields, farmer incomes, and resilience to climatic stresses. The results emphasize the importance of integrating modern agricultural practices, weather advisories, and community support to enhance long-term agricultural viability in vulnerable regions.

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UID: 1022

Impact of Interventions Made through FLDS on Cobalt Chloride & Salt Tolerant Wheat Variety in NICRA Adopted Villages of Fatehabad District in Haryana

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The study was carried out in two villages adopted under the NICRA project, Bodiwali and Banmandori, of Block Bhattu District, Fatehabad (Haryana), during 2023-24. The farming system typology was irrigated (cotton + wheat). Wheat (Triticum aestivum), commonly known as gehun, is the most important cereal crop in the world. India is the second-largest producer of wheat in the world, accounting for about 14 percent of the total production. While cotton is also an important fiber and cash crop of the country. Parawilt is a serious physiological disorder of cotton. Frontline demonstrations on salt tolerant wheat variety and use of cobalt chloride on cotton crop were conducted by Krishi Vigyan Kendra Fatehabad in these villages in a 28 hectare area (40 farmers) with the main objective of boosting the production and productivity of wheat in salt-affected soil using variety (KRL-210) and management of parawilt in cotton using cobalt chloride.

The findings of the study revealed that mean yield of salt tolerant wheat variety (KRL-210) was found 3000 kg/ha, as compared to farmer practice (HD-2967) which was 2600 kg/ha and found 15.38 percent higher than that of non NICRA farmers. A higher net income of Rs. 39250/- per hectare was obtained in comparison to non NICRA farmers (Rs. 32550/ha). The B:C ratio of demonstration was 2.50 as compared to 2.35 in farmer practice. Further, it was observed that the mean yield of cobalt chloride sprayed cotton was 1050 kg/ha as compared to farmer practice with no spray in cotton was 900 kg/ha, which was 16.66 percent higher than that of non NICRA farmers. A higher net income of Rs. 21700/- per hectare was obtained in comparison to non NICRA farmers (Rs. 10000/ha). The B:C ratio of demonstration was 1.41 as compared to 1.18 in farmer practice.

UID: 1023

Enhanced Farmers Livelihood through NICRA Interventions

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The present study carried out by Krishi Vigyan Kendra, Bhilwara in adopted NICRA village Dolikhera of Suwana block under sub humid southern and plain Aravalli hills IVA agro climatic zone with their climate vulnerability *i.e.,* drought, heat wave and water stress during from 2021-22 to 2022-23.The result indicated that *In-situ* moisture conservation in maize Farmers earned a net return of Rs 46840/ ha with B:C ratio of 2.52 over the local cultivar (Rs 33340/ha with 1.48 B:C ratio) increase the productivity. 10 Foliar sprays of 1% KNO_3 in maize during drought period will results mitigate the drought effect in maize and gave 25.30% higher grain yield as compared to farmer practices. Improved variety of Black gram PU-01 was demonstrated at 10 farmers field in 8 ha area, which resulted in 29.23% higher yield as compared to local variety. Maize (*Zea mays* L.), the queen of cereals, is planted with wide row spacing and it offers the scope of intercropping system. Considering the benefits of cereal-legume association, 25 demonstrations were conducted on intervention of intercropping system of Maize + Blackgram (2:2), variety of maize DHM-121 and PU-01 of Blackgram were laid out in an area of 0.4 hectare each at NICRA village Dholi Kheda. Demonstration yield was recorded as 24.55 q/ha (maize equivalent yield), which was 24 per cent higher yield as compared to sole maize (18.65 q/ha), higher net return of Rs. 41,854 and BC ratio of 2.88 was recorded as compared to sole maize (Rs. 26,630 and 2.0, respectively) and additional yield of intercrop also obtained in intercropping system of maize and blackgram (2:2) was quite satisfactory that indicated beneficial intercropping system.

UID: 1024

Impact of Interventions Made Through FLDS on Summer Moong & Biofortified Bajra in NICRA Adopted Villages of Fatehabad District in Haryana

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The field demonstrations were carried out in two adopted villages, Bodiwali and Banmandori, of Block Bhattu, District, Fatehabad (Haryana), under the NICRA project during year 2023-24. The farming system typology was irrigated (moong + bajra). The green gram (*Vigna radiata*) commonly known as moong. Moong is an important pulse crop in India, and more than 70 percent of the world's green gram production comes from India. Bajra, also known as pearl millet, holds significant importance in the agricultural sector. Its cultivation plays a crucial role in ensuring food security. It is a significant source of iron and zinc, so bio-fortified bajra will help to reduce malnutrition in women and children. Frontline demonstrations on summer moong and bio-fortified bajra were conducted by Krishi Vigyan Kendra Fatehabad in these villages in a 20-hectare area (50 farmers). The main objective was to boost the production and productivity of green gram and bajra and also to improve the fertility status of the soil through nitrogen fixation.

The findings of the study stated that the mean yield of summer moong (MH-421) was found to be 1180 kg/ha, as compared to farmer practice (SML-668) which was 1050 kg/ha and found to be 12.38 percent higher than that of non-NICRA farmers. A higher net income of Rs. 57400/- per hectare was obtained in comparison to non-NICRA farmers (Rs. 48000/ha). The B:C ratio of demonstration was 3.27 as compared to 2.94 in farmer practice. Further, it was observed that the mean yield of bio-fortified bajra (HHB-299) was 2350 kg/ha as compared to farmer practice was 2300 kg/ha, which was 2.17 percent higher than that of non-NICRA farmers. A higher net income of Rs. 43750/- per hectare was obtained in comparison to non-NICRA farmers (Rs. 42000/ha). The B:C ratio of demonstration was 3.92 as compared to 3.71 in farmer practice.

UID: 1026

Impact and Performance of NICRA Interventions taken up During Summer, Kharif & Rabi in NICRA Adopted Villages

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The National Innovation on Climate Resilient Agriculture (NICRA) is an initiative by the Indian Council of Agricultural Research (ICAR) launched in 2011 to address the challenges posed by climate change to Indian agriculture. The program aims to enhance the resilience of Indian agriculture to climate variability and extreme weather events through strategic research, technology development, and capacity-building among farmers. Key focus areas include developing climate-resilient crop varieties, efficient water management techniques, conservation of soil health, and adoption of climate-resilient farming practices. NICRA also promotes resource conservation practices and provides farmers with advisories on climate risks, supporting their adaptation and ensuring food security in the face of climate challenges.

Methodology

For this study, the Godda district was purposefully selected, with two villages, Garhi and Gouripur, chosen for inclusion in the project. Under the NICRA Project, GVT-KVK, Godda adopted these villages and introduced three specific farming typologies: FST-1 (rainfed without animals), FST-2 (rainfed with animals), and FST-4 (irrigated with animals). These typologies were designed to build resilience against climate variability by enhancing crop and livestock practices. GVT-KVK, Godda, provided high-yielding crop varieties and improved animal breeds suited to the local agro-climatic conditions. The new crop varieties included paddy (Sahbhagi, Sabour Deep), pigeonpea (IPA-203), finger millet (A-404), horse gram (IK-1), elephant foot yam (Gajendra), mustard (PM-28), wheat (Sabour Nirjal), black gram (PU-31), brinjal (Swarna Pratibha), and tomato (Swarna Kanchan) were demonstrated. To boost livestock productivity, Napier grass and Urea Mineral Molasses Blocks (UMMB) were introduced as animal feed, along with PPR vaccinations for goats. Additionally, high-yielding livestock breeds such as Jharsuk pigs and Khaki Campbell ducks were provided to farmers. To ensure effective adoption of these practices, training programs and demonstrations were conducted, emphasizing sustainable practices and climate resilience. This initiative has ultimately proven to be a profitable venture, bringing economic benefits and enhancing the livelihoods of poor farmers in Garhi and Gouripur.

Results

A review of the data in Table highlights that NICRA farmers consistently achieved higher productivity and gross returns (GR) compared to non-NICRA farmers across all crop types and farming systems.

Table 1. Performance of different drought tolerant varieties at NICRA Adapted villages

NICRA Farmers							Non-NICRA Farmers				
FST type	**Crop / season (name)**	**Technology demonstrated**	**Area (ha)**	**Productivity (q/ha)**	**CoC (Rs/ha)**	**GR (Rs/ha)**	**Non-NICRA farmers practice**	**Area (ha)**	**Productivity (q/ha)**	**CoC (Rs/ha)**	**GR (Rs/ha)**
FST1 (Rainfed without animal)	Paddy (Kharif)	Sahbhagi	6.0	32.0	34040	54400	Saurabh	70	27.6	36120	46920
	Pigeon Pea (Kharif)	IPA 203	2.0	9.0	30082	44100	Local	10.0	7.7	28330	37730
	Finger Millet (Kharif)	A404	2.0	11.7	29360	46800	NA	--	--	--	--
	Horse gram (Kharif)	IK1	2.0	6.4	18507	23040	Local	13.0	5.8	18055	20800
	Elephant foot yam (Kharif)	Gajendra	0.5	201.5	197170	403000	NA	--	--	--	--
FST2 (Rainfed with animal)	Paddy (Kharif)	Sahbhagi	8.6	32.3	34040	54910	Saurabh	70	27.9	36120	47430
	Pigeon Pea (Kharif)	IPA 203	2.0	9.2	30082	45080	Local	10.0	7.8	28330	38220
	Finger Millet (Kharif)	A404	3.0	11.9	29360	47600	NA	--	--	--	--
	Horse gram (Kharif)	IK1	2.0	6.5	18507	23400	Local	13.0	5.9	18055	21240
	Elephant foot yam (Kharif)	Gajendra	0.5	198.6	197170	397200	NA	--	--	--	--
FST4 (Irrigated with animal)	Paddy (Kharif)	Sabour Deep	5.0	33.8	34040	57460	MTU7029	28.0	27.9	36120	47600
	Pigeon Pea (Kharif)	IPA 203	1.5	9.4	30082	46060	Local	7.5	7.7	28330	37730
	Black gram (Kharif)	PU-31	2.0	9.7	22000	48500	Local	15.0	8.5	21517	42500
	Wheat (Rabi)	Sabour Nirjal	17	36.5	36670	73000	20	30.4	36610	60800	17
	Mustard (Rabi)	PM-28	4.0	10.8	23540	54000	Local	16.0	9.0	22225	45000
	Tomato (Rabi)	Swarna Kanchan	1.0	230	66525	322000	Pvt. Company	2.5	182	63945	254800
	Brinjal (Rabi)	Swarna Pratibha	1.0	260	68595	338000	Local	2.0	190	63175	247000

For instance, under FST-1, NICRA farmers using *Sahbhagi* paddy achieved 32 q/ha with a GR of ₹54,400/ha, while non-NICRA farmers using *Saurabh* reached 27.6 q/ha with a GR of ₹46,920/ha.

In pigeon pea and horse gram, NICRA farmers outperformed non-NICRA farmers in both yield and GR. Exclusive crops for NICRA farmers, such as finger millet (*A404*) and elephant foot yam (*Gajendra*), also demonstrated high productivity, with GRs reaching ₹46,800/ha and ₹403,000/ha, respectively. Under FST-4, NICRA farmers growing *Sabour Deep* paddy, wheat, and mustard also showed higher yields and GRs than their non-NICRA counterparts. In high-value crops, NICRA farmers achieved substantial yields and returns, with 230 q/ha in tomato and 260 q/ha in brinjal, compared to non-NICRA farmers' 182 q/ha and 190 q/ha, respectively. In Table 2, under FST2 (Rainfed with animals), NICRA farmers feeding cows a mineral mixture achieve 1155 liters of milk annually with a GR of ₹46,200 per animal, compared to non-NICRA farmers' 966 liters and ₹38,640. For goats, NICRA farmers using PPR vaccination yield 7.2 kg per animal with only 2% mortality and a GR of ₹4320, while non-NICRA farmers have 6.5 kg production, 35% mortality, and a GR of ₹3900. In FST4 (Irrigated with animals), NICRA farmers raising Khaki Campbell ducks produce 212 eggs per duck and a GR of ₹1272, compared to 120 eggs and ₹720 for non-NICRA farmers with Indian Runner ducks. NICRA farmers with Jharsuk pigs reach 80 kg and ₹14,400 GR, while non-NICRA pigs yield 45 kg and ₹8100. NICRA farmers feeding cows Napier grass produce 1190 liters annually and a GR of ₹47,600, outperforming non-NICRA cows at 950 liters and ₹38,000.

Table 2. Performance of livestock demonstration in NICRA adopted villages

FST type	NICRA Farmers						Non-NICRA Farmers					
	Animal	No	Technology demonstrated	Production / year	CoC (Rs / animal)	GR (Rs / animal)	Animal	No	Technology demonstrated	Production / year	CoC (Rs / animal)	GR (Rs / animal)
FST2 (Rainfed with animal)	Cow	15	Mineral Mixture	1155 litre	15330	46200	Cow	10	Paddy straw + seasonal grass	966 litre	15080	38640
	Goat	30	PPR Vaccination	7.2 Kg (2% mortality)	30	4320	Goat	20	No Vaccination	6.5 Kg (35% mortality)	1300	3900
FST4 (Irrigated with animal)	Duck	100	Khaki Campbell	212 eggs	780	1272	Duck	05	Indian runner	120 eggs	590	720
	Pig	30	Jharsuk	80 kg	5125	14400	Pig	02	Non descriptive	45 kg	4825	8100
	Cow	05	Napier grass	1190 litre	15500	47600	Cow	1	Paddy straw + seasonal grass	950 litre	15080	38000

Conclusion

Across all FST types, NICRA farmers consistently achieved higher yields and returns than non-NICRA farmers due to the introduction of improved crop varieties and climate-resilient technologies. The productivity gains were particularly more in irrigated systems with animal integration, where crops such as wheat, mustard, tomato, and brinjal showed substantial economic benefits. The adoption of NICRA practices has evidently enhanced farm resilience, profitability, crop productivity and livestock management.

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Demonstration of Leaf Curl Virus-Resistant Chilli Variety 'Arka Meghna' in Sirohi District, Rajasthan

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Chilli, *Capsicum annuum* L. is one of the major vegetable spices grown all over the world except in colder regions. It is also known as red pepper or hot pepper. A demonstration was conducted on chilli variety 'Arka Meghna' during *rabi*, 2023-24 and studies on its resistance to leaf curl virus and high yield potential. Ten farmers of Sirohi of Rajasthan participated, cultivating the variety on 1 ha area, yielding 800 kg/ha, significantly outperforming local farmers. 'Arka Meghna' thrived in adverse climate conditions, requiring minimal care and management, ensuring high net returns. This demonstration aimed to evaluated leaf curl virus resistance, assess yield and climate tolerance and enhance farmers' income. Results revealed exceptional performance, combining high yields with virus resistance, reduced production costs and increased incomes. Recommendations include large-scale adoption, capacity building and expansion to additional villages.

UID: 1052

Women Empowerment Through Climate Resilient Micro Integrated Farming System: A Case Study

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Ri-Bhoi district in Meghalaya, India, covers an area of 2,448 sq. km and has a population of 258,840, with 88.89% being Schedule Tribe. The district is bordered by Kamrup district to

the north, Jaintia Hills and Karbi Anglong in the east, and West Khasi Hills to the west. It features diverse climates, ranging from tropical in the Assam foothills to temperate in the East Khasi Hills, with temperatures between 2°C and 36°C. The average annual rainfall is 1,636.46 mm, concentrated mainly in June and July. The district consists of 589 villages across four blocks: Bhoirymbong, Umsning, Umling, and Jirang. The predominant soil types are derived from gneissic materials, supporting major crops such as Paddy, Maize, Ginger, and *Khasi Mandarin*. Common cropping systems include paddy-pea and maize-vegetables. However, the region is vulnerable to climate change, experiencing erratic rainfall, frost, and drought, which adversely affect agriculture and food security; Gill et al. (2009). To mitigate these impacts, an assessment of *jalkund*-based micro-irrigated farming systems was undertaken with 20 women farmers from Kyrdem, Sohriewblei, and Thadnongiaw villages, as part of the National Innovations on Climate Resilient Agriculture (NICRA) – Technology Demonstration Component (TDC) project by the Indian Council of Agricultural Research (ICAR).

Methodology

Twenty progressive women farmers from NICRA villages have established a Micro-Integrated Farming System to enhance resilience against climate change and geographic challenges. This model utilizes a *jalkund*, a water harvesting unit, alongside a poultry unit and a high-tech polyhouse. The *jalkund*, measuring 5x4x2 m^3 and with a capacity of 40,000 liters, is lined with High-Density Polyethylene (HDPE) for effective rainwater storage during the *kharif* season. It houses 100 fingerlings of Indian Major Carp (Rohu, Catla, and Mrigal). Nearby, a poultry shed accommodates 40 dual-purpose Vanaraja birds, whose biomass provides nutrients for the fish and supports the growth of phytoplankton and zooplankton while generating additional income through meat and eggs. A low-cost polyhouse has also been set up to cultivate cut gerbera flowers and high-value vegetables like tomatoes, capsicum, and cucumbers, particularly during the off-season to maximize market returns. Statistical analysis was conducted based on the data recorded for the period of 2021 to 2024 as necessary (Snedecor and Cochran, 1994).

Results

The average outputs for poultry, fish, and vegetable production are summarized in Table 1. The mean weight of the poultry is 4.5 kg, yielding a net income of 16,400 rupees and a benefit-cost ratio (BCR) of 2.7. Each bird produces approximately 108 eggs per year, contributing an additional net income of 17,300 rupees, with a BCR of 6.2. The average fish yield from the *jalkund* is 30 kg, generating a net income of 4,870 rupees. In vegetable production, the average yield is 48.5 quintals per 0.1 hectares, resulting in a net income of 44,000 rupees. In total, the combined gross income from these enterprises amounts to 180,400 rupees, with a net income of 82,570 rupees and a robust BCR of 3.2. This integrated multi-enterprise approach enhances resource efficiency and significantly boosts farmers' incomes, improving their resilience against climate-related challenges (Kumar et al., 2012).

Table 1. Output of poultry-fish and vegetable production (n=20)

Interventions (n)	Output (Mean)	Gross Income (Mean Rs.)	Net Income (Mean Rs.)	B Ratio (Mean)	Standard Deviation (Output)	Standard Deviation (Gross Income Rs.)	Standard Deviation (Net Income Rs.)	Standard Deviation (B Ratio)
Average weight Poultry	4.5 kg	28,400	16,400	2.7:1	±0.5 kg	±2,000	±1,200	±0.1
Poultry eggs	108 nos/yr/bird	22,000	17,300	6.2:1	±5 nos	±1,500	±800	±0.3
Fish	30 kg/jalkund	6,000	4,870	5.3:1	±3 kg	±500	±300	±0.2
Vegetables	48.5 q/0.1	124,000	44,000	1.6:1	±10 q	±15,000	±5,000	±0.4
Total		180,400	82,570	3.2:1				

The crop-wise production data in Table 2 provides insights into the economic viability of four key crops: Capsicum, Cabbage, Coriander, and Broccoli. Capsicum requires 4,500 liters of water weekly, yielding 5 quintals per 0.1 hectare, with a net return of Rs. 12,540 and a benefit-cost ratio (BCR) of 2.00. Cabbage, also using 4,500 liters, excels with a yield of 25 quintals, offering a net return of Rs. 27,250 and a high BCR of 3.65. In contrast, Coriander needs less water (3,500 liters) but yields only 0.5 quintals, resulting in a net return of Rs. 4,600 and a BCR of 2.59. Broccoli matches the water usage of Capsicum and Cabbage, achieving a yield of 18 quintals and a notable net return of Rs. 39,750 with a BCR of 3.78. Overall, Cabbage and Broccoli emerge as the most economically viable options, highlighting the importance of crop selection based on water efficiency, yield, and profitability.

Table 2. Crop wise production data and economics (n=20)

Crop	Water Requirement (L/week/0.1 ha)	Yield (q/0.1 ha)	Water Utilization Efficiency (q/l)	Gross Cost (Rs/0.1 ha)	Net Return (Rs/0.1 ha)	BCR	Mean Water Requirement (L/week)	Mean Yield (q/0.1 ha)	Mean WUE (q/l)	Mean Gross Cost (Rs/0.1 ha)	Mean Net Return (Rs/0.1 ha)	Mean BCR	SD (Water Requirement)	SD (Yield)	SD (WUE)	SD (Gross Cost)	SD (Net Return)	SD (BCR)
Capsicum	4500	5	0.11	12460	12540	2.00	4400	5.5	0.12	12300	13000	2.10	±300	±1.0	±0.02	±500	±1500	±0.15
Cabbage	4500	25	0.55	10250	27250	3.65	4450	23.0	0.53	10100	26000	3.50	±250	±2.5	±0.03	±400	±1200	±0.12
Coriander	3500	0.5	0.14	2900	4600	2.59	3600	0.6	0.15	3000	4800	2.60	±200	±0.1	±0.01	±300	±800	±0.10
Broccoli	4500	18	0.40	14250	39750	3.78	4550	17.5	0.38	14000	39000	3.70	±200	±1.5	±0.02	±500	±1500	±0.15

Conclusion

The implementation of micro-irrigation via *jalkund* has transformed agricultural practices for hill farmers facing climatic vulnerabilities. By integrating water harvesting with fish farming and poultry rearing, this multi-enterprise system maximizes resource efficiency and diversifies income sources. The notable economic returns from crops, poultry, and fish indicate significant potential for enhanced financial stability, with an overall net income of 82,570 rupees and a strong benefit-cost ratio of 3.2. This model not only boosts agricultural productivity but also fortifies the resilience of farming communities against climate-related challenges, promoting a sustainable and secure future.

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Multi-dimensional analysis of constraints on Occupational Diversification among Agricultural Households in Odisha

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Growing uncertainties in farm-related endeavours have prompted concerns about the sustainability of farming communities, leading occupational diversification. Farmers were quite perceptive about the advantages of diversification yet they still fail to derive the benefits of it at the optimum extent in the form of the addition to the existing earning levels. That is why, this context pre-requisites of assessing the existing levels of occupational diversification and to determine the issues that ceasing the progress of farmers in the ventures of diversification.

Methods

The investigation took place in the Khordha district of Odisha, India, selected for its diverse agricultural practices influenced by the proximity of Bhubaneswar, the state capital. The area's growing demand for specific products and services is linked to an increasing demographic in nearby cities. The research utilized a multistage sampling method, focusing on two subdivisions, Khordha and Bhubaneswar, and included the purposive selection of blocks and villages based on varying soil types and farmer occupations. Farmers were identified as respondents, and data collection occurred from July 2022 to September 2023 through personal interviews with the use of pre-tested semi-structured questionnaires. Simpson's index of diversification for assessing occupational diversification along with Henry Garrett's ranking for grading the constraints faced by farmers were employed in the study.

Results and Discussion

The top ranked constraints under each dimension found to be- shortage of storage facilities (74.77) and marketing facilities (71.34) under infrastructural; absence of innovative technologies (73.55) and lack of market forecasting (70.11) under promotional; lack of proper education (72.23) and less experience on new ventures (70.79) under social; shortage of own resources (69.33) and rising fuel prices (65.33) under economic; erratic rainfall (70.77) and natural disturbances like floods, cyclones, etc. (64.46) under miscellaneous dimension. Therefore, the investigation recommends that the focusing on the solution-oriented approach towards the above-mentioned constraints for augmenting occupational diversification. Farmers encounter several challenges due to the perishable nature of their products, including limited storage facilities that hinder product availability and potential profits. The lack of marketing routes amplifies the divide between production and consumption, weakening farmers' bargaining power in price negotiations. Furthermore, the absence of custom hiring centers complicates access to machinery, particularly for those with constrained finances or fragmented landholdings. Addressing these issues promptly is essential for enabling effective occupational diversification among farmers. Moreover, the lack of advanced farming technologies prevents them from exploring new on-farm occupations, despite their interest. Limited access to real-time market information discourages sales predictions, even when opportunities are profitable. While digital advancements benefit non-agricultural sectors, agriculture remains underdeveloped, restricting farmers' access to new markets. Many farmers have low levels of education, which limits their exposure to innovative practices. Traditional beliefs and joint family systems further inhibit the adoption of new occupations.

Financial limitations and rising fuel costs strain farm budgets, while difficulty accessing institutional credit prevents investment in new ventures. Environmental factors, including global warming and disrupted monsoon patterns, also affect crop cycles. Together, addressing these challenges is vital for encouraging farmers to diversify their occupations and enhance their livelihoods.

Distribution of farmers according to their extent of occupational diversification

Sl. No.	Category	Criteria	Farmers	
			No.	%
1.	Low	<0.29	53	22.08
2.	Medium	0.29-0.63	114	47.50
3.	High	>0.63	73	30.42

List of top two constraints as opined by farmers under different dimensions

Sl. no.	Infrastructural dimension	Mean Score	Rank
1.	Lack of storage facilities	74.77	I
2.	Lack of marketing channels and facilities	71.34	II
	Promotional dimension		
1.	Lack of innovative technologies	73.55	I
2.	Lack of market predictions and forecasting	70.11	II
	Social dimension		
1.	Lack of proper education	72.23	I
2.	Less experience on new ventures	70.79	II
	Economic dimension		
1.	Lack of own resources like assets, capital, manpower, etc	69.93	I
2.	Rising prices of fuels (petrol and diesel)	65.33	II
	Miscellaneous dimension		
1.	Uneven distribution of rainfall	70.77	I
2.	Natural disasters like floods, cyclones, etc	64.46	II

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Innovative Transfer of Technology Approaches in Rainfed Tobacco crop Adopted by ICAR-CTRI-KVK, Kandukur

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Krishi Vigyan Kendra, Kandukur has been engaging in frontline extension under the administrative control of ICAR-CTRI, Rajahmundry for the last 12 years. Tobacco crop is being grown in an area of 75,000 ha under rainfed condition in rabi season in SLS & SBS regions of the Prakasam district which is more vulnerable to climatic vagaries. In order to safeguard the tobacco farmers in these regions vis-à-vis updated information and knowledge KVK took many innovative technology diffusion initiatives like Digital Farm School which consists of various ICT enabled technology delivery tools viz mobile apps, STCR platforms, multi-location audio & video conferences, YouTube live programmes, WhatsApp groups, zoom conferences, need based short message services through Kisan Sarathi portal, digital e-literature, social media platforms, Farmers Field Schools (FFS) and Research Extension Farmer Interface (REFI) linkages. ICAR-CTRI has developed two mobile apps named FCV Tobacco (https://play.google.com/store/apps/details?id=com.icar.ctri) and Crop Suraksha (https://play.google.com/store/apps/details?id=com.companyname.cropsuraksha). FCV tobacco app provides technological support to stake holders for improving the yield and quality of FCV tobacco. Crop Suraksha app designed for farmers and agricultural professionals, this app provides detailed information on various crop diseases, precautionary steps to prevent them, and effective medication options to ensure healthy and productive crop. Soil Test Based Fertilizer Recommendation System (https://stcr-fcvtobacco.com/nls/index.php) was developed for a Targeted Yield in FCV Tobacco in enhance the yield in tobacco farmers. Further in order to reach the farmers during climate vagaries like cyclones, floods, droughts, dryspells etc. KVK has been using ICT platforms like multilocation audio & video conferences to provide real time crop management practices to avoid the crops loss and ensure the good yields to the farmers. In addition to this during the crop growth period to convey the latest scientific knowledge to farmers KVK is using digital platforms like YouTube live programmes, zoom conferences, WhatsApp groups, social media platforms, digital e-literature, FFS, REFI linkages and thereby connecting directly more than 30,000 farmers on average in a year. As result of this efforts tobacco yield has been enhanced from 1450 kg/ha in 20213-14 to 1901 kg/ha in 2022-23 with 31.10% enhanced yield and net income of the farmer has been enhanced from Rs.51000/ha in 2013-14 to Rs.100250/ha.

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Coarse Cereals for Rainfed Agriculture in India: An Assessment of Production Growth and Projections

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Coarse cereals are suitable for rainfed agriculture and are engrained with a lot of nutritive benefits. With the increasing income and consumer demand, it is important to analyze the status of coarse cereals production in the country, its trends and instability, and also make projections so that policy shift towards intensifying or rationalising its future production can be taken up. This study was therefore taken up to analyse the performance of production, variability and instability of coarse cereals production in the country. The Compound Annual Growth Rate (CAGR) and Coefficient of variation and Cuddy and Della Valle Index (CDVI) were used respectively for analyzing the historical data from 2000-01 to 2021-22. The study also aimed at making future projections, segregating trend, seasonality and irregular components employing time series multiplicative modeling. The study revealed that coarse cereals production registered fairly a good growth rate of 2.32 per annum particularly the maize with an impressive growth of nearly 5 percent per annum. Higher variability in the production of coarse cereals (15.88%) overall is witnessed, which is even higher specifically for maize (29.80 %), sorghum (22.55%) and pearl millet (17.55 %). The instability indices seem to be also higher for overall coarse cereals (8.42), maize (7.32), sorghum (10.98). Of the major coarse cereals grown in the country, instability was found to be highest for pearl millet (16.46). The study forecasted that coarse cereals production would be 52.79 MT for 2024-25, 52.59 MT for 2025-26, and 54.49 MT for 2026-27. Specifically crop wise, it was found that even though a slight increase in production can be expected in case of maize and pearl millet, there would be a decrease in sorghum production in the country in next three years. Hence, considering the nutritional value it provides and its drought resistance, it is important to pay more emphasis in coarse cereals for rainfed agriculture by improving its production growth.

Coarse cereals are group of crops that consists of all cereals except rice and wheat mainly maize, sorghum, pearl millet, barley, finger millet and small millets. These crops are grown in different parts of the world for different purposes mainly in the developing countries of Africa and Asia, which contribute more of area but less of production due to low productivity and these countries are also home for the majority of poor and malnourished. Grown in marginal land with minimum input, coarse cereals gained popularity and acceptability by millions of subsistence farmers. They also have the potential to improve the food and nutritional security of the world poor since they are more nutritious than the superior cereals.

They are rich in nutrients, minerals and vitamins and hence a boon for the health-conscious people. These cereals are helpful in reducing several kinds of chronic diseases and disorders (Kaur *et al*., 2014). Despite its benefits, Green Revolution technologies have not adequately benefited coarse cereals, which are grown extensively under marginal and dry land environments (Ramasamy, et al. 2002).

Coarse cereals are also used for different industrial uses and hence has shown an increasing demand. But there has been mismatch between demand and supply of coarse cereals in the country. The production performance of coarse cereals in the country seems to be low, which might have been due to lack of adequate technology and policy focus. Low productivity combined with lack of assured market mechanisms and remunerative price may be the reasons for the neglect of these crops and not being taken seriously by Indian farmers. But this should be reversed considering its health benefits and increasing demand among urban consumers. A study by Joshi et al. (2004) argued that the coarse cereals are substituted by high value crops as a result of agricultural diversification. Irrigation infrastructure in the country has favoured cereals like rice and wheat and not coarse cereals.

With this backdrop, this study was undertaken with an aim to understand the status of coarse cereals production in the country by assessing its growth performances and variability and making projections for future so that the planners and policy makers can derive insights on making policy shifts if necessary and accordingly more emphasis in relation to coarse cereals production can be given for reaping more economic surplus in the country.

Data and Methods

The study was based on secondary data for the time period (2000-01 to 2021-22), which was collected from various published sources. Data on production of total coarse cereals and individually for major coarse cereals such as maize, sorghum, and pearl millet were collected from the publications of Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. Analytical tools like growth rates, ratios and indices of instability were employed to analyze the data set of coarse cereals production. The growth rates (r) of production of these crops were estimated using the formula:

$Y_t = AB^t e$

where:

Yt = the variable for which growth is calculated at tth period: t = the time variable

A = constant; B = (1+r); 'r' is compound growth rate; 'e' is error term

Transforming this to logarithmic form

$$\ln Yt = \ln A + (\ln B)t + \varepsilon$$

Then CAGR is calculated as:

CAGR (per cent) = [antilog (ln B) - 1] x 100

In this study, the instability in coarse cereals production was estimated using Cuddy-Della Valle Index (CDVI). Any measure of instability needs to exclude the deviation in the data series that may arise due to secular trend or growth. CDVI was originally developed by John Cuddy and Della Valle for measuring the instability in time series data that is characterized by trend (Cuddy and Della Valle, 1978). The estimable form of the equation is as follows:

$$I = CV \times \sqrt{(1-\overline{R}^2)}$$

where: I is the instability index in percent; CV is the coefficient of variation in percent;

$\overline{R}^2$ is the coefficient of determination from time trend regression adjusted by the number of degree of freedom..

Forecasting the production of coarse cereals as a commodity group and for individual major coarse cereals was done using multiplicative time series model which includes seasonal, trend, and irregular components. The series of steps undertaken for forecasting are as follows: The step number one is first visualization of data using the scatter plot. The second step is smoothing out the data and for this moving average method was used to flatten out and determine the seasonal component (St) and to segregate and get rid of the irregular component (It). This irregular component cannot be explained by any means as it does not follow any discernible pattern. To get the trend values, least square estimation method was used. The linear form fitted to this time series data is as follows: y=a+bx where, b is the slope of the line; a is the vertical intercept, i.e. the value of y where the line intersects with the y-axis; y represents deseasonalised production data in the model; x represents time code from 2001-02 to 2021-22. The regression line passes through the point ($\bar{x}$, $\bar{y}$) and has the equation

$$y - \overline{y} = b(x - \overline{x})$$

where the slope (b) is

$$b = \text{cov}(x, y) / \text{var}(x)$$

$$b = \sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y}) / \sum_{i=1}^{n}(x_i - \overline{x})^2$$

and the y-intercept (a) is

$$a = \bar{y} - b\bar{x}$$

Having estimated the trend component, the forecasted values were derived using the multiplicative model.

$$F_t = S_t * I_t * T_t$$

Where, Ft represents forecast value at time period 't' and St, It, Tt represent seasonal component, irregular component, and trend components at time period 't'. Then, these values were extrapolated to obtain the forecast for the years 2024-25, 2025-26 and 2026-27.

Results and Discussion

The growth performance and the variability of coarse cereals production have been assessed over the last two decades and the trends values have been estimated. This is done distinctly for two periods (period 1: 2001-02 to 2010-11; period 2: 2011-12 to 2021-22) and also for the entire period from 2001-02 to 2021-22 and the results are presented in the table 1. Using the trend values, forecasting has been done for the aggregate group of coarse cereals as well as individual specific commodities of maize, pearl millet, and sorghum.

Coarse cereals are a sub-set of cereals and are mainly grown as dryland crops under water deficient environments. These are grown more for human consumption, animal feed and fodder purposes and not extensively grown for sales as its marketable surplus is low despite possessing nutritionally superior benefits. A wide range of coarse grains such as sorghum, pear millet, maize, finger millets, and small millets etc. are grown across the country. India currently holds the fourth position in the world in coarse cereal production after USA, China, and Brazil. In India, the largest coarse cereal producer states are Rajasthan, Karnataka and Madhya Pradesh. Growth performance analysis and forecasting of its production gives the current status and which direction it poises towards. Coarse cereals have shown a significant and steady growth rate throughout the study period around 2.5 per cent per annum. However, it was observed that sorghum production registered negative growth rates in both periods and the overall growth rate as well. Hence, the production of sorghum should be reversed to benefit the health-conscious consumers, which would require shifts and focus towards sorghum crop. As far as pearl millet is concerned, the growth performance during the first period (3 per cent) is far better than the second period (1.42 per cent) as shown in table 1. Care must be taken to maintain a stable growth rate in production of pearl millet as possesses health benefits.

Table 1. Growth rate and Instability of coarse cereals production in India

Commodity	CAGR			CV			Instability Index		
	Period I	Period II	Overall	Period I	Period II	Overall	Period I	Period II	Overall
Coarse cereals	3.13	2.27	2.32	14.03	9.39	15.88	11.39	5.89	8.42
Maize	6.01	4.28	4.99	20.19	14.89	29.80	10.24	4.92	7.32
Sorghum	-0.24	-2.98	-3.33	5.56	14.66	22.55	5.85	11.61	10.98
Pearl millet	2.15	0.81	1.30	24.25	8.74	17.55	24.93	8.76	16.46

Source: Authors' calculation based on the historical data of DOS, GOI
Note: Period 1 denotes 2001-02 to 2010-11; Period 2 denotes 2011-12 to 2021-22
CAGR denotes compound annual growth rate and C.V denotes coefficient of variation

The forecasting model estimated that coarse cereals production would be around 52 MT for next three years starting from 2023-24 and the estimated production in 2026-27 would be 54.49 MT shows a marginal increase of 2.5 MT (Table 2) after three years. Targeted efforts therefore should be made to enhance coarse cereals production through creating a derived demand as it has multiple nutritional benefits. This can be done by campaigning and educating the consumers so that farmers would tend to allocate more area for coarse cereals and also getting remunerative price for their produce. Proper price support with adequate buying mechanism will also interest the farmers to go for more cereals production. Equally important is technology, coming up with high yielding drought tolerant and climate resilient newer varieties. On one side, providing all sorts of support for increasing the production and duly backed with the market support for getting remunerative price for their produce should be the right approach to enhance the coarse cereals production in the country.

Table 2. Forecast of coarse cereals production in India (MT)

Crops	2023-24	2024-25	2025-26	2026-27
Coarse cereals	52.13	52.79	52.59	54.49
Maize	33.82	35.46	35.45	36.96
Sorghum	3.58	3.31	3.28	2.89
Pearl millet	11.02	10.46	9.69	10.98

Source: Authors' estimation based on the historical base data of DOS, GOI

Among coarse cereals, maize is one of the most versatile crops having wider adaptability under varied agro-climatic conditions. It is predominantly a Kharif crop and the third most important cereal crop in India after rice and wheat. It accounts for around 10 percent of total food grain production in the country. Besides being used for human consumption and quality feed for animals, maize serves as a basic raw material as an ingredient in several industrial products. Hence its significance of sustaining with its production cannot be undermined. As presented in table 1, the production performance of maize has shown not only positive in both the study periods but also registered an impressive overall growth rate of CAGR 5.08 per cent implying that there would have been a continuously greater demand for maize from consumers both for food and feed purposes. While understanding its growth performance, forecasting its production also become vital possibly to take future course of action. The forecasting model estimated that maize production would be 35.46 MT, 35.45 MT, and 36.96 MT during 2024-25, 2025-26, and 2026-27 respectively. As it is presented in the table 2 that there is not much significant increase in the forecasted value in the near future and hence efforts are required for enhancing its production in the years to come keeping in view of its multiple benefits and demand. Area expansion can be given a push in largely grown states like Karnataka, Madhya Pradesh, Bihar, Tamil Nadu, Telangana, Maharashtra and Andhra Pradesh.

Sorghum is another important coarse cereal, a rainfed crop which can withstand drought conditions. Maharashtra, Karnataka, Tamil Nadu, Rajasthan, and Andhra Pradesh are major sorghum producing states in India. Among these states, Maharashtra & Karnataka account for 57.2% of sorghum produced in the country. It was observed that sorghum production growth performance has not been encouraging over the years. For instance, sorghum production in 2002-03 was 7.01 MT and it went up to the all-time high figure of 7.93 MT in 2007-08 meaning only a meagre 0.9 MT over a span of five years. Ever since sorghum production has been on a declining trend. India produced 4.23 MT of sorghum in the year 2021-22. Although the contribution of sorghum in the total food grain production has been minimal, it is a crucial cereal as it is known for its resilience in challenging environments. The model forecasted that sorghum production would be 3.31 MT, 3.28 MT, and 2.89 MT in 2024-25, 2025-26, and 2026-27 respectively, which clearly shows a declining trend. But the positive side is that net returns seem to be positive particularly in states like Tamil Nadu, Andhra Pradesh and Madhya Pradesh. Therefore, in such states, production can be possibly further enhanced through area expansion and adoption of high yielding varieties.

Another important coarse cereal crop is pearl millet grown as rainfed crop in India. Rajasthan is the top producer of pearl millet contributing around 44% to the national pool followed by Uttar Pradesh (15%), Haryana (11%), Maharashtra (10.8%), and Gujarat (10.5%). Over the years there has been a decline in area of pearl millet but the production has gone up implying the influence of technology factor. However, the increase has not been significantly higher. For instance, in 2004-05, the production was 7.93 MT and in 2021-22, its production still stood at 9.62 MT meaning 1.69 MT increase over a span of 15 years. The forecast model also estimated that there would not be much increase in pearl millet production in the coming years also. As given in the table 2, the estimated production of pearl millet would be 10.46 MT in 2024-25, followed by 9.69 MT and 10.98 MT in 2025-26 and 2026-27 respectively. In the year 2023, several promotional efforts were taken up for enhancing the production of millets and in particular pearl millet, the key millet. The year 2023 was also named after the international year of millets and its production might go up and hence there could be a deviation from the model estimations. As the model accounts for the effect of seasonal, and trend components and does not capture the effect of sudden structural shifts in promotional efforts and policy changes, the forecasted value of pearl millet could be a variation from the actuals in the future. However, efforts for further intensifying and pushing up the production by expanding its area and yield are required considering its nutritional benefits and values.

Conclusion

The study on the growth performance of coarse cereals production and the projections have provided some interesting insights. It was found that overall production growth of coarse cereals has been good in the past two decades particularly in the first decade of this century which could have been due to a higher growth rate of maize production in the country. However, sorghum production has not shown an encouraging trend as it registered a negative growth rate. The variability in overall coarse cereals production is higher particularly maize and sorghum. Although maize production growth was higher, nearly 5 per cent and the variability is also higher, which needs special focus to minimize the variability in maize production in the country. With higher instability indices of coarse cereal crops, more thrust needs to be accorded to minimize the instability. Deceleration in growth rate of sorghum production in the country also needs special attention. The forecast estimations of coarse cereals have not shown significant increase either in the near future. Policy support and technology back up for climate resilient coarse cereals for coping up with drought resistance can be given more importance. Creating awareness about nutritive benefits for creating consumer demand and a host of new opportunities for new entrepreneurship in post-production can also enthuse farmers to go for more allocation under coarse cereals. Hence, increasing efforts for enhancing awareness and demand creation along with technology and policy support in favour of coarse cereals are required to boost up coarse cereal production in the country.

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Impact Assessment of CRIDA Horse Gram Varieties

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Horse gram is a drought-tolerant legume, well-suited for cultivation in dry and arid regions. It can thrive in areas with low rainfall, poor soil and high temperatures making it an important crop for drylands. As it is a leguminous crop it can fix nitrogen and help improve soil fertility and the sustainability of farming. Horse gram is also rich in proteins, iron and dietary fiber making it a valuable food source for populations in rural and underdeveloped areas. It helps in crop diversification which allows for risk mitigation in dryland systems and is also an economically viable crop, requiring minimal inputs. For smallholder farmers, it offers a cost-effective and reliable crop option, especially in drought-prone areas. ICAR-Central Research institute for Dryland Agriculture (ICAR-CRIDA) developed four varieties of horse gram viz., CRIDA-18R, CRHG-4, CRHG-19. CRHG-22**.** Which are notable for its improved traits like high yielding, drought tolerant, non-shattering and disease resistance making it an important crop for enhancing food and nutritional security. Keeping this in view the impact of CRIDA Horse gram varieties was studied.

Methodology

The area covered under the CRIDA horse gram varieties in a State in a given year was estimated on the basis of seed sold from CRIDA to the State for the last 3 years including the current year, seed rate of 20 kg /ha, yield of 700 kg/ha and farmer keeps a reserve of 20% of production in previous 2 years for seed purpose. Let the seed sold to a State in current year be Q_0 and previous 2 years be Q_{-1} and Q_{-2} the expected area in the state in current year

$$= (Q_0/20) + (Q_{-1}/20) *700*0.2 + \{[(Q_{-2}/20) *700*0.2]/20\}*700*0.2$$

The benefits of adoption of horse gram was also obtained from primary data collected from an important Horse gram growing district, Anantapur, Andhra Pradesh. Primary data was collected from a sample of 30 horse gram growing farmers of Krishnareddypalli, Niluvarai and Atmakur villages of Anantapur. The benefits of horse gram were calculated from the difference in the net returns of local variety and CRIDA variety

Results

CRIDA horse gram varieties were released for south Indian states of Karnataka, Kerala, Telangana, Andhra Pradesh and Tamil Nadu. The seed sold from ICAR-CRIDA was used to estimate the state wise area under CRIDA varieties. The results are provided in figure 1.

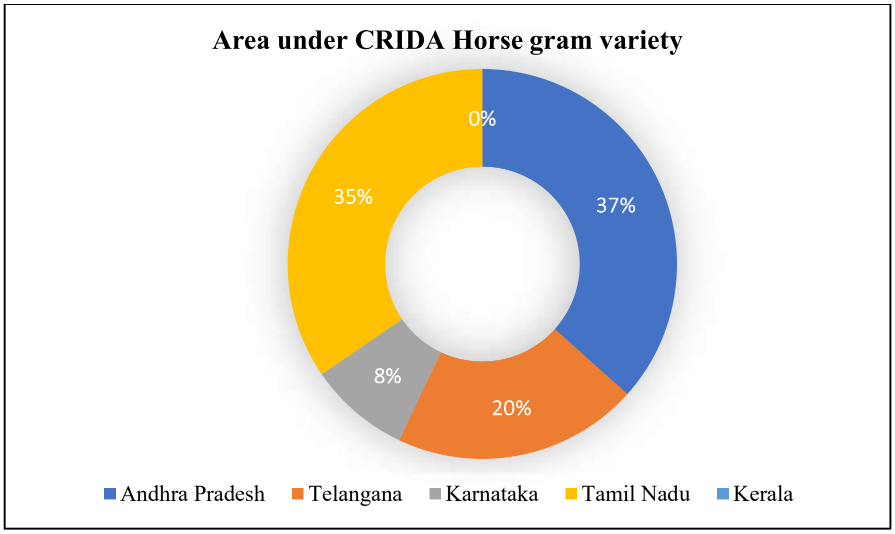

Fig 1. Area under horse gram TE2022 (Average of three years 2020, 2021 and 2022)

Estimated area under CRIDA horse gram varieties in South India during TE 2021-22 was 2,552 ha and the share of CRIDA horse gram varieties in total horse gram area in south India is 0.92%.

Table 1. Economics of CRIDA horse gram varieties based on primary data (sample in AP state)

Details	Local Variety	CRIDA Variety	Change	Change (%)
Cost of Cultivation (Rs/ha)	24,589	25,945	1,356	5.51
Yield (Kg/ha)	794	1297	503	63.35
Gross Returns (Rs/ha)	40,494	69,169	28,675	70.81
Net Returns (Rs/ha)	15,905	43,224	27,319	171.76
BCR	1.65	2.67		

The additional net returns of growing CRIDA horse gram variety over local variety was estimated as Rs. 27,319/ha. The additional benefits expected at farmer level for a year was estimated as Rs. 6.97 Crore (27319x2552) and cumulative additional benefits from CRIDA horse gram variety at farmer level for last 15 years was estimated as 85.26 crore.

Conclusion

With increasing climate change pressures leading to unpredictable rainfall patterns, the CRIDA horse gram variety serves as an important adaptation strategy for climate resilience.

Innate climate resilience of these varieties suggests their scope as a suitable alternative in the present climate change scenario. The farmers stand to gain substantially by cultivating this drought tolerant, dual purpose, medium duration, high yielding, highly nutritious, disease and pest tolerant, non-shattering podded variety as compared to the local varieties under changing climatic conditions also. Resilience to changing climatic conditions, and adaptability to poor soil conditions made it a popular variety in north and eastern states also. These varieties are having untapped potential to support poor and marginal farming communities of drylands by providing income, food, feed and nutritional security in the present and future changing climatic scenario.

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Agriculture Contingency Crop Plan for Managing Extreme Weather Events in Dry Areas

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Climatic variability is likely to affect spatial and temporal dynamics of agricultural production systems. Strategic and anticipated research to understand the significant role of climate variability on rainfed agriculture is being pursued at a greater depth. There is an immediate need to demonstrate suitable technologies to make rainfed agriculture economically viable and environmentally sustainable. The Government of India has prioritized R&D to address the climate change in the agriculture sector, and the Prime Minister's National Action Plan on Climate Change has identified agriculture as one of itseight National Missions. Several national initiatives were launched in India for climate change research, and a significant among themis the National Initiative on Climate Resilient Agriculture (NICRA) by the Indian Council of Agricultural Research (ICAR). The different strategic research needs to make rainfed agriculture resilient, economically viable, and environmentally sustainable. Real-time contingency interventions included crops, varieties, rainwater conservation, efficient utilization, and various crop management practices have proven beneficial. Real-Time Contingency Planning (RTCP)implementation timely and effectively during the delayed onset of monsoon, seasonal droughts and floods resulted in better crop performance, higher agricultural production, increased incomes and greater stability in household livelihoods (Srinivasarao *et al.,* 2013). At the All India Coordinated Research Project for Dryland Agriculture (AICRPDA)- Vijayapura center, the RTCP was implemented through two approaches, i.e., preparedness and real-time contingency measures to cope with extreme events, aiming enhance productivity and income. This paper highlights the experiences of AICRPDA-Vijayapura with RTCP implementation in NICRA adopted villages (Kavalagi and Honnutagi). It discusses initial preparedness, the role of village institutions, the establishment of a custom hiring centre and a summary of the outcomes of these interventions.

Methodology

The NICRA sites are located at the Kavalagi and Honnutagi villages of Vijayapura district. Since 2011-12, interventions involving various dryland technologies have been implemented in these NICRA villages. Vijayapura is situated in the Karnataka plateau (AESR3) and has a semi-arid climate, with an average annual rainfall of 594 mm and potential evaporation of 622 mm. The growing season lasts 90-120 days, and drought occurs approximately once every five years. The soils are shallow to deep loamy and clayey, comprising a mix of red and black soils. The dominant rainfed crops are pigeonpea and green gram during Kharif, and sorghum and chickpea during rabi. Since the project's inception at the AICRPDA-Vijayapura centre, NICRA villages have experience various weather aberrations, including delayed onset of monsoon, mid-season drought, terminal drought and extreme events such as untimely excess rainfall. To overcome these situations and reduce crop losses, various RTCPs and preparedness were implemented. These included crop and varieties change, soil, rainwater conservation and utilization, and different agronomic practices, which were demonstrated in a contiguous area in the village. The details of the RTCPs implemented in response to different weather aberrations are presented in Table 1.

Results

The priority was to have establish a good crop stand in the field and manage it effectively to achieve better yield and income, preventing potential total losses for farmers if timely responses were not implemented. The salient achievements of these technology interventions are discussed below.

NICRA villages have experienced the delayed onset of monsoon in certain years since the project'sinception. Under this situation, we implemented the RTCPs,such as changing crops and varieties. In 2023-24, while the onset of the monsoon was normal, only318.6 mm of rainfall was received, compared to the average of 594.4 mm for Vijayapura, with several dry spells. Improved pigeonpea varieties (TS-3R, GRG-811) were introduced in farmers' fields, replacing local varieties.

Table 1. Contingent planning for weather aberrations implemented in NICRA villages

Particulars	Contingent planning implemented
Weather aberrations	
Delayed onset of monsoon	Change of crop/variety depends on the farming situations, soil, rainfall and cropping patterns
Early season drought	Resowing, thinning, removal of an alternate row, weeding, inter cultivations and opening of conservation furrow
Mid-season drought	Repeated inter cultivations, foliar spray, supplemental irrigation
Terminal drought	Harvest pearl millet for fodder, protective irrigation, prepare for *rabi* crops
Preparedness	
Rainwater management	Deep ploughing, compartment bunding, ridges and furrows, recharge of defunct open and bore wells, rainwater harvesting in a farm pond
Crops and cropping systems	Drought-tolerant varieties of rainfed rabi crops, risk-resilient intercropping systems
Energy management and integrated farming systems	Energy management in compartment bunding and IFS module

The improved pigeonpea varieties noticed a yield increase of 10.23– 25.26% compared to the local variety and recorded maximum RWUE, net returns, and B:C ratio. In an early-season drought situation, interventions such as thinning, weeding, inter cultivation, and opening of conservation furrows were implemented in the various crops. Yield increase were observed due to inter cultivation during dry spells in various crops.As a mid-season correction to mitigate dry spells, interventions such as repeated inter cultivation, supplemental irrigation and foliar spray were implemented. Foliar application of KNO_3 @ 0.5% observed higher pigeonpea yields, with an increase 18.32% in2023-24 and 14.71% in2024-25 (Fig. 1). Similarly, foliar sprays during dry spells boosted yields in green gram, chickpea and sorghum. In a terminal drought situation, protective irrigation from a farm pond or other irrigation source saves crop life and stabilizes yield. The impact of RTCP on coping with aberrant weather situations was also studied in various AICRPDA centres (Srinivasarao *et al.,* 2013). Preparedness practices, similar to RTCPs, also showed yield improvements over farmers' conventional practices across different crops. Compartment bunding resulted in higher chickpea and sorghum yields, with average increases of 22.45% and 22.80%, respectively, compared to farmers' practices in medium black soils. Effective drought preparedness and management involve planning and response processes to predict drought and implement timely, appropriate actions that minimize its negative impacts. In the NICRA village, we demonstrated simple, readily adoptable preparedness practices such as in situ rainwater harvesting, climate-resilient intercropping systems, integrated farming systems, energy management, and other agronomic techniques. These practices help communities adapt to weather anomalies and improve yields. Village-level institutions, including the Village Climate Risk Management Committee (VCRMC) and the custom hiring centre (CHC) established in the NICRA village, play a crucial role in fostering community participation, enhancing the successful implementation of NICRA activities.

Conclusion

Dryland agriculture technology development must address weather aberrations to enhance climate resilience. The various RTCPs and preparedness measures implemented in NICRA villages have led to improved crop yields, RWUE, and economic outcomes under different weather scenarios. Strategic interventions, such as crop variety selection, in situ rainwater harvesting, and intercropping, have proven effective in mitigating climate-induced challenges. Community-led institutions, including the VCRMC and CHC, play a pivotal role in implementing these practices. This collaborative approach strengthens resilience, promoting sustainable agriculture and improving farmers' livelihoods in the face of climate variability.

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Gap Analysis in Mustard Crop through Frontline Demonstration for Resilience and Sustainable livelihood in Gumla District of Jharkhand

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The oilseed contributes second largest agricultural commodity in India after cereals sharing 14% of gross cropping area which accounts for nearly 3% of the gross national production and 10 % of value of all agricultural products. These crops are grown under a wide range of agro-climatic condition as best suited for scare water areas. Among the edible oilseed crops, Rapeseed and Mustard occupies an important position in Gumla as well as in India. In Gumla Rapeseed and Mustard is cultivated in approx. 16000 ha area while in earlier its area was near about 8000 ha. The 100% jumped in area is achieved only by rigorous efforts of KVK and ATMA. Nearly 40-80% area is under rainfed farming. Mostly crop Mustard is being promoted in the district in Rice-Fallow System through FLD and CFLD. As the crop has potential to ensure the sustainable income, nutritional security and contribute to livelihood security. Mustard is an important oilseed crop of the district and has been considered as productively potential region of Mustard crop in Rice-Fallow area due to assured irrigation facilities in potential areas.

Technology gap is a major problem in increasing mustard production in the region. So far not much systematic effort was made to study the technological gap existing in various components of Mustard cultivation. With the available improved latest technologies, it is possible to bridge the yield gap and increase the existing productivity to certain extent. Keeping this view Front Line Demonstration were organised under DRMR project in participatory mode with the objective to analyse the yield gap in Mustard cultivation on recommended package of practices.

Materials and Methods

The present study was carried out by Krishi Vigyan Kendra Gumla, Vikas Bharti Bishunpur, Jharkhand during Rabi season from 2019-20 to 2020-21 (Two consecutive years) on the farmer's field of two adopted villages Bahar serka and Dumbo of Bishunpur and Bharno block. During this two year of study 40.0 ha area was covered with plot size 0.4 ha under

Front Line Demonstration with active participation of 100 farmers. Before conducting FLDs selection of plots and farmers was enlisted by organizing group meetings in respective villages and specific 02 days skill training was given to the selected farmer's regarding package of practices of Mustard crop. The difference between demonstration package and existing farmers practices as given in Table-1.

Table 1. Comparison between demonstration package and existing practices under Mustard Crop

Sl. No.	Particulars	Recommended Practice	Farmer's Practice
1	Farming situation	Irrigated	Irrigated
2	Variety	PM-30	Local
3	Time of sowing	Early November	Late November
4	Method of sowing	Line sowing	Broadcasting
5	Seed treatment	Seed treatment	Without seed treatment
6	Seed rate	06 kg/ha	7-8 kg/ha
7	Thining	15-20 DAS	Not necessarily
8	Fertilizer dose	NPKS (60:40:20:15)	NPK (64:46:0:0)
9	Irrigation	03 no.	01 no.
10	Weed management	2 hand weeding at 25 and 40 DAS	No weeding
11	Plant Protection measures	Applied	Not applied
12	Harvesting and Threshing	Harvested as soon as pods turned yellowish	Harvested of over matured crop causes shattering of grains

The Improved technology included High yielding variety, Seed treatment, Timely sowing, Line sowing, Maintenance of optimum plant population, Recommended dose of fertilizer, Plant protection and Timely harvesting and threshing. The sowing was done in early November. The spacing was 45 x 20 cm apart and the seed rate of 6 kg/ha was applied. The fertilizers were given as per soil testing value, however the recommended dose of fertilizer applied in demo plots was 60 kg N, 40 kg P_2O_5, 20 kg K_2O and 15 kg S per hectare. The Nitrogen, Phosphorus, Potash and Sulphur fertilizers were applied through Urea, Dap, MOP and elemental S respectively. Thining and first-hand weeding within line was done at 15-20 DAS. The crop was harvested at proper maturity. The data was collected from both FLD as well as control plot and finally the extension gap, Technology gap, Technology index along with Benefit-Cost ratio were calculated as suggested by Samui *et al* (2000).

Results and Discussion

The data showed in Table 2 that the yield of Mustard crop fluctuated successively over the years in demonstrated plot. The maximum yield was observed (17.15 q/ha) during the year 2020-21 while in the year 2019-20 the yield was (17.05 q/ha) and the average yield of two year was recorded (17.10 q/ha) over farmer's practices (10.19 q/ha). During two years of study the percent increase over farmer's practice was between 67.69 percent and 67.97

percent on an average there was 67.05 percent increase in yield under FLD plot over farmer's practices. The similar results were also reported by verma *et al* (2012), Tomer *et al* (2003).

Table 2. Grain yield and gap analysis of Front-line demonstration on Mustard at farmer's field

Year	Area (ha)	No. of farmers	Seed yield (kg/ha)		Increase (%)	Technology Gap (q/ha)	Extension gap (q/ha)	Technology Index (%)
			Demo	Control				
2019-20	20.0	40	17.05	10.17	67.64	5.33	6.88	23.81
2020-21	20.0	60	17.15	10.21	67.97	5.23	6.94	23.36
Total / Average	40.0	100	17.10	10.19	67.80	5.28	6.91	23.58

The data indicated that the positive effect of Frontline demonstration over the existing practices towards increasing the yield of Mustard in Gumla district of Jharkhand. During the period of study emphasis, the need to educate the farmers through various techniques for adoption of improved agricultural production reverse the trend of wide extension gap. Extension gap between demonstrated technology and farmer's practice ranges from 6.88 to 6.94 q/ha during two years and on average basis, the extension gap was 6.91 q/ha. This gap might be attributed to adoption of Improved technology in demonstrations which resulted in higher grain yield than the farmer's practices. The similar results were also reported earlier by Goswami *et al* (1996) and Hiremath and Nagaraju (2010). Higher technology index reflected the inadequate proven technology for transferring to farmer's and insufficient extension services for transfer of technology. The technology index shows the feasibility of the technology. The similar results were also reported earlier by Jeengar *et al* (2006) and Mitra and Samajdar (2010). The probable reason that could be attributed to the high feasibility of Mustard production technology was that the participant farmers were given opportunity to interact with the scientist and they were made to adopt recommended practices and skills during the process of demonstration.

The higher additional returns and effective grain obtained under demonstration could be due to improved technology, non-monetary factors, timely operations of crop cultivation and scientific monitoring. The highest Benefit: Cost ratio (BCR) was 2.97 during 2019 might be due to higher MSP. It depends on grain yield and MSP. The results confirm the findings of Frontline Demonstrations on Oilseeds and Pulses crops by Verma et al (2012) : Yadav et al (2004) and Lathwal (2010).

It was thus concluded that the use of scientific method of Mustard cultivation can reduce the technological gap to a considerable extent thus leading to increase productivity of Mustard in Gumla district of Jharkhand.

Table 3. Gross return (Rs/ha), Cost of cultivation (Rs/ha), Net return (Rs/ha) and B:C ratio as affected by improved and traditional technology

Year	Gross Return		Cost of Cultivation		Net Return		B:C ratio	
	RP	FP	RP	FP	RP	FP	RP	FP
2019-20	61380	36612	24357	19269	37023	17343	2.52	1.90
2020-21	79747	47476	26887	19756	52860	27720	2.97	2.40
Average	70563.50	42044.00	25622.00	19512.50	44941.50	22531.50	2.71	2.15

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Augmenting Farmer's Income Through Climate Resilient Interventions in Villupuram District of Tamil Nadu, India

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Indian agricultural system mainly depends on rainfed agriculture only. Net cultivated area in India is nearly 140 million ha, out of this 50% area under rainfed conditions (70 million ha.). In this condition, there is a need to popularize the drought tolerant new variety with good climate resilient practices to meet the challenges in rice cultivation under rainfed conditions. The cultivation of newly released drought tolerant resistant rice variety (TKM 15) has the potential to increase productivity and needs to be promoted and popularized. Demonstrations on direct seeding rice cultivation with improved production practices for climate resilient could significantly increase the farmer's income. The demonstration Results emphasizing relative yield advantages, cropping intensity, weed control, and plant protection measures compared to current farmer practices. Keeping in this regard, the present study was conducted at farmer's field by field demonstrations of short duration drought tolerant rice variety TKM 15 with climate resilient technologies.

Methodology

The drought tolerant rice variety TKM 15 seeds were distributed to selected farmers at no cost basis for one acre along with critical inputs. The critical inputs include post emergency herbicide, bio-fertilizers and water soluble fertilizers (KNO_3). The farmers are advised to raise the crop by direct sowing method by drum seeder after seed treatment with bio-fertilizers along with ruling rice variety as a check. The selected farmers were trained for improved production technologies through training programmes funded by NICRA Project, and organized by ICAR, Krishi Vigyan Kendra, Villupuram (TN), during *Kharif* 2023. On 15-20th day after sowing, the post emergency herbicides (Bispyribac sodium) @ 400 ml/ha was sprayed. All the agronomic practices and need based plant protection measures were followed in all the demonstrations and control plots uniformly by monitoring the frequent visits by KVK scientists. The data pertaining to the cost of cultivation were collected and statistically analyzed by statistical methods.

Results

The economic analysis of field demonstrations and farmers practices was presented in Table 1. The cost of cultivation for demonstrations is Rs. 48,500/ $ha^{-1}$and gross income was Rs. 98,500/ha^{-1}. The farmers are getting additional revenue of Rs. 10,100 ha^{-1} by cultivating the new drought tolerant rice variety TKM 15 with resilient practices (demonstrations). These findings are aligning with those of Subbalakshmi *et al*. (2021); Ganapathy *et al.* (2024) and Vikram Gaur *et al*. (2024). The additional yield and net income (Rs. 50,000) was due to cultivating drought tolerant rice variety along with improved climate resilient technologies and timely supply of critical inputs. Similar kinds of front line demonstrations in rice have already been reported by Hasim *et al.,* (2022) and Ayyadurai *et al.* (2024). The TKM 15 rice variety produced a higher yield over the check variety in all the demonstrations, clearly indicating that, showing constant performance in Villupuram district / different locations, the TKM 15 was easily adopted to new environments and had high stability over the locations in the northern district of Tamil Nadu. The Front-Line Demonstration program effectively influenced the attitudes, skills, and knowledge related to improved or recommended practices in paddy cultivation, fostering adoption. It also enhanced the relationship between farmers and scientists, fostering mutual confidence. During the demonstrations, farmers emerged as primary sources of information on drought resilient cultivation practices and served as new suppliers of high-quality pure seeds in their locality and neighbouring areas for subsequent crops. The new drought tolerant short duration variety (TMK 15) along with climate resilient demonstrations, contributed to an average increase in grain yield of 7.75 % compared to the existing practices of farmers. The cost of this yield increment was a nominal of Rs. 7100 per hectare; an amount was affordable even by small and marginal farmers.

Yield and Economics comparison of demonstrations and farmer's practice

Treatments/ Intervention	Seed Yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio	Additional Income (Rs.)
Improved Variety- (TKM 15+ Improved Production Technologies)	4925	48,500	98,500	50,000	2.03	10,100
Farmer's practice (Check variety)	4570	51,500	91,400	39,900	1.77	-

Conclusion

Tamil Nadu is an important rice growing state in the country that faces several abiotic and biotic stresses, and this necessitates location specific drought tolerant rice variety for the zone. In rice cultivation, drought is an important abiotic stress in this crop that can lead to considerable economic losses. The cultivation of drought tolerant varieties like TKM 15, along with suitable drought resilient technological interventions can be an important step in this direction. This type of climate resilient demonstration on short duration drought tolerant rice variety (TKM 15) with its excellent performance in the demonstrations at Villupuram district will play a significant role in improving the productivity, profitability and sustainability in rice cultivation, leading to augmenting the farmer's income.

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Demonstration of Climate Resilient Technologies to Rahutanakatti Farmers for Sustainable Income

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Climate and agriculture are intricately associated. High variation in environmental factors such as temperature, rainfall, humidity and others may distress crop growth tremendously. Climate is one of the offender of production constraints. Hence, change in climatic variables affects agricultural productivity and food security situations in the economy (Greg *et al*. 2011). In this context, climate resilient technologies are promising tools to guard a farming system from climate variations and impact studies of these technologies are prerequisites for formulating adaptive research for better customisation for upscaling (Jasna 2017) and to disseminate the suitable to the farming community. Looking into the concerns, Indian Council of Agricultural Research (ICAR) initiated the National Innovations on Climate Resilient Agriculture (NICRA) in February, 2011 with an objective to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. ICAR-Krishi Vigyan Kendra, Haveri has been implementing NICRA project in Rahutanakatti village of Ranebennur Block since 2022 to establish climate resilient agriculture in the village and mitigate the vagaries of weather along with enhancing the farm income through implementing various interventions. The current study is an attempt to assess the impact of the interventions undertaken and a comparison of the economic condition of the farm families.

Methodology

Rahutanakatti village of Ranebennur taluk of Haveri district is having undulated topography with major climatic vulnerabilities like late monsoon, dry spell, intense and erratic rains, which affect the crop health. Majority of the farmers of the village are small and marginal farmers. Hence, the village has been selected to implement NICRA programme. Based on participatory rural appraisal, it was aware that maize monocropping coupled with poor soil health and changing climate variables are the production constraints. To mitigate the issue, climate resilient agriculture had been disseminated in the village namely, Maize + redgram intercropping system, popularization of SPV-2217 variety in *rabi* sorghum and promotion of greengram variety DGGV-2 (Table 1) with slight modification in agricultural operations as and when required depending upon the changing climate. To unveil the impact of interventions, crop yield parameters and economics of the cultivation were taken in to account in comparison with non-adopted farmers.

Table 1. List of interventions taken up

Sl. No	Interventions	Details of the intervention	Season	Farmers covered	Area covered (ha)
1	Maize + redgram intercropping system	Introduction of variety GRG-152, pulse magic, 19:19:19, potassium nitrate, seed treatment with *Trichoderma*, PSB and *Rhizobium*	*Kharif*	25	10
2	Promotion of greengram variety DGGV-2	Non-shattering and high yielding variety DGGV-2, seed treatment with *Trichoderma*, PSB and *Rhizobium*, pulse magic	*Kharif*	20	08
3	Popularization of SPV 2217 variety in *rabi* sorghum	High yielding and charcoal stem rot resistant variety SPV-2217, Seed priming with $CaCl_2$, KNO_3 and 19:19:19 spray	*Rabi*	20	08

Results

Impact of all the interventions were presented in table 2 and Results revealed that an average crop equivalent yield of 42.45 q/ha was registered in Maize + redgram intercropping system (Demo), with 23.97 per cent higher than the local practice (maize sole crop). Demo farmers remunerated high net return of 54,893.00 Rs/ha with BC ratio 2.83 compared to non-adopted farmers. High return in the demo might be attributed to the adoption of redgram as an intercrop. As redgram is consistent with the deep early-season taproot development and slow initial shoot growth and escapes moisture stress as sufficient rains coincides with grand growth, flowering and pod formation period (Renwick *et al*., 2020). The low maize yield in non-adopted farmers is due to monocropping and moisture stress during early vegetative period *i.e.* June month (31.5 mm actual rainfall as against normal rainfall of 74.0 mm).

Demonstration on greengram variety DGGV-2 resulted in a higher yield of 11.93 q/ha (32.45 % higher than the local) with net returns of 29,529.00 Rs/ha and BC ratio of 1.62 per cent. DGGV-2, a seed shattering resistant variety proven to offer higher yield and net returns than the existing varieties as documented by Hemanth *et al*., 2023. Local varieties of greengram experienced seed shattering that were exposed to water surplus conditions during maturity and harvesting, i.e. August month (291.0 mm actual rainfall as against normal rainfall of 73.4 mm).

SPV 2217 variety of *rabi* sorghum had performed better and recorded higher grain yield of 15.11 q/ha (34.13 % higher than the local), net returns (10,746.00 Rs/ha) and BC ratio (1.48) compared to local variety. Decline in grain yields of existing practice was due to moisture stress occurred during November – December (Actual rainfall - 14.5 mm and Normal rainfall

– 43.6 mm). However, earlier research proved potentiality of drought tolerance of SPV 2217 with high SPAD readings of chlorophyll content during physiological maturity (Teggelli *et al*., 2022).

Conclusion

It can be concluded from the above study that higher drought tolerant capacity of crop varieties combined with improved crop production practices may help farming community to get higher productivity compared to local practice. These climate resilient technologies at Rahutanakatti village proved to escalate income to a great extent during climate vulnerabilities.

Table 2. Impact of interventions

Intervention	Crop equivalent yield (q/ha)		Increase in yield (%)	Net return (Rs/ha)		BC ratio (%)	
	Demo	Local		Demo	Local	Demo	Local
Maize + redgram intercropping system with ICM practices	42.45	34.24	23.97	54,893	35,977	2.83	2.11
Promotion of new greengram variety DGGV-2	11.93	9.01	32.45	29,529	13,533	1.62	1.30
Introduction of SPV 2217 variety in *rabi* sorghum	15.11	11.27	34.13	10,746	3,987	1.48	1.19
	SPV 2217 provided 3.12 t/ha green fodder at the time of harvesting and there is increase in milk yield 1,950 liter/animal/year with 23.97 per cent higher than the non-adoptive farmers.						

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Effect of Climate Resilience Technologies and Convergence with Line Department in NICRA Village

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Nicra village Majha in Basti district faced severe water logging, impacting nearly 50 hectares of farmland. These conditions made agriculture unviable, seasonal migration, and social distress. However, a collaborative effort by KVK Basti and the Irrigation Department led to a remarkable transformation through scientific, technical, and livelihood-based interventions. Previously, the village struggled with persistent water logging that lasted 20–30 days post-monsoon, rendering cultivation impossible in both the kharif (due to floods) and rabi (due to excessive moisture) seasons. Economically, households depended more on manual labor or migration, with less crop-based income.

Methodology

The transformation of Nicra village was achieved through a combination of hydrological improvements, climate-resilient agriculture, and livelihood diversification. The initial step involved conducting a topographical survey to identify drainage blockages and low-lying areas prone to water logging. Collaborating with the Irrigation Department, the drainage system was renovated through desilting and regrading of channels, reducing water retention time from 20–30 days to 12–15 days. Simultaneously, KVK Basti introduced submergence-tolerant crop varieties, including Swarna Sub1 and Sambha Sub1 for rice and DBW 187 and DBW 303 for wheat. These were showcased through frontline demonstrations, and farmers were trained in scientific farming techniques. Chronically waterlogged fields were converted into fish ponds to integrate aquaculture. Farmers were guided in pond design, species selection, and sustainable practices, with high-yield fish species like Rohu, Catla, and Grass Carp being introduced. Capacity-building workshops empowered farmers to adopt these modern agricultural and aquacultural methods.

Fig 1. Survey of NICRA village

Fig 2. Construction of drainage channel with convergence irrigation department

Results

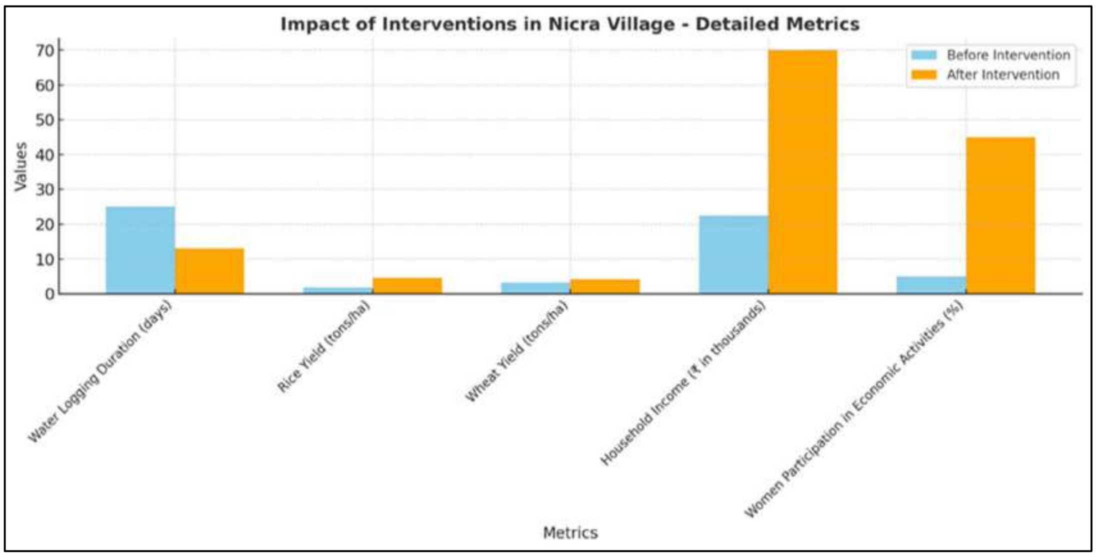

Fig 3. Impact of interventions in NICRA Village details metrics

Conclusion

The collaborative efforts of KVK Basti and the Irrigation Department successfully transformed Nicra village from a flood-prone, barren area into a productive and economically vibrant community. By addressing hydrological challenges, promoting climate-resilient agriculture, and integrating aquaculture, the interventions not only restored agricultural viability but also enhanced livelihoods and social cohesion. This case demonstrates the potential of scientific interventions and capacity-building in tackling climate-induced challenges and fostering sustainable development. The model is replicable in other regions facing similar issues of waterlogging and socioeconomic distress.

UID: 1241

NICRA Initiatives for Sustainable Agriculture in Rainfed Saline-Affected Coastal Rice Belt of Jagatsinghpur District of Odisha

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Coastal rice belts, particularly in rainfed saline-affected regions, face significant challenges due to climate change and increasing soil salinity. In these areas, rising salinity, frequent seawater intrusion and limited freshwater availability threaten traditional agricultural practices. This study evaluates sustainable agricultural practices tailored to enhance the productivity and resilience of rainfed saline-affected coastal rice belts. The interventions aim to improve soil health, crop yields, and economic returns for smallholder farmers. Coastal regions are increasingly vulnerable to the impacts of climate change which is exacerbating the challenges faced by agricultural ecosystems (Aggarwal et al., 2019, ICAR-CSSRI, 2018). The district of Jagatsinghpur, located along the Odisha coastline, is experiencing rising soil salinity due to frequent saline water flooding during high tides and the intrusion of seawater into inland aquifers. This has led to an increase in the capillary rise of saline groundwater which is increasing soil salinity and threatening agricultural productivity (Bhattacharyya et al., 2015, Das et al., 2018). The traditional rice-based farming system in this region is facing significant stress with the declining yield and less economic return. The National Innovations in Climate Resilient Agriculture (NICRA) Project, operational under the Krishi Vigyan Kendra (KVK) in Jagatsinghpur, has initiated targeted interventions to address these challenges and promote sustainable agriculture. This study was conducted in a saline-affected village namely Achyutdaspur in Erasama Block of Jagatsinghpur district under the NICRA-TDC project with an aim to evaluate the effectiveness of revised agricultural practices for enhancing rice yield and economic returns in comparison to the traditional practice.

Methodology

The study was conducted in saline-affected areas with rainfed conditions, where traditional practices struggle to cope with high salinity and erratic rainfall. Revised practices included deep ploughing to improve soil permeability, cultivation of salt-tolerant rice varieties, and implementation of integrated water management strategies such as rainwater harvesting. The use of green manure crops like Sesbania was introduced to enhance soil organic matter and reduce salinity through natural processes. Yield comparisons were made between these revised practices and conventional methods.

Results

The study implemented a series of interventions designed to counter the adverse effects of soil salinity and enhance the resilience of the coastal rice-based ecosystem. The revised practice included deep ploughing to break the hard pan layer formed due to the shallow tillage and heavy machinery operation which restricts the natural percolation of fresh rainwater. This was followed by the cultivation of *Dhanicha* (*Sesbania rostrata*) as a green manure crop before rice planting. *Dhanicha* cultivation not only improved the soil health by adding organic matter but also reduced the soil salinity through leaching salt by rupturing the hard pan layer through its deep root system. The revised practice also incorporated the use of salt-tolerant rice variety Luna Suvarna (*CR LC2096-71-2*) which has a high tolerance to saline soil conditions. Furthermore, rainwater harvesting was emphasized through construction of farm ponds for supplemental irrigation during the dry spells and also helped to dilute soil salinity. In contrast, the traditional practice in the region involved the use of local rice varieties with low tolerance to salinity, minimal land preparation and reliance on natural rainfall to meet the crop water requirement. This approach often resulted in poor crop performance and low economic returns due to the high soil salinity and rainfall variability.

The revised practices demonstrated substantial improvements in crop yield, net profit, and the benefit-cost ratio compared to traditional methods. Salt-tolerant rice varieties and supplemental irrigation from farm ponds played a pivotal role in mitigating the impact of soil salinity. Green manuring significantly improved soil structure and fertility. These findings underscore the potential of sustainable agricultural interventions in enhancing resilience and productivity in rainfed saline-affected areas.

The comparative analysis between the traditional and revised practices revealed significant improvements in agricultural outcomes under the revised interventions. The adoption of deep ploughing, green manuring and the use of Luna Suvarna rice variety coupled with supplemental irrigation from farm pond has led to substantial increases in crop yield, net profit and the benefit-cost benefit (B:C) ratio. The findings are summarized in the table below.

Comparison of farmers' practice and revised practice

Treatment	Yield (q/ha)	Net Profit (Rs/ha)	B:C Ratio
Farmers' Practice (FP	32.5	19500	1.37
Revised Practice (RP)	42.7	32400	1.54
CD at 5%	8.6		

The revised practices significantly outperformed the traditional methods, demonstrating a higher yield and better economic returns. The implementation of these practices under the NICRA-TDC project highlights the potential for improving the sustainability and resilience of coastal agricultural system in the face of climate change and increasing soil salinity.

Conclusion

This study highlights the importance of adopting sustainable agricultural practices in rainfed saline-affected coastal rice belts. Revised practices, including salt-tolerant rice varieties, green manuring, and integrated water management, can significantly enhance productivity and livelihoods. Scaling up these interventions could ensure food security, improve resource use efficiency, and strengthen the resilience of coastal agricultural systems against the impacts of climate change. The study underscores the critical importance of adopting climate-resilient agricultural practices to combat the growing threat of soil salinity in coastal regions. The interventions implemented under the NICRA-TDC project in Achyutdaspur village have shown promising results, offering a viable pathway to enhance the productivity and sustainability of coastal rice-based ecosystems. As climate change continues to intensify, it is imperative to scale up these practices and support the broader adoption of resilient agricultural strategies across similar vulnerable regions.

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UID: 1242

Agricultural Extension Services: A Effective Tool for Timely Management of Biotic and Abiotic Stresses in Rainfed Areas

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Timely and proper adoption of agricultural technologies needs to be accelerated for harvesting positive impacts on farmers field in terms of economics. Various technologies are developed and recommended for management of biotic and abiotic stress in rainfed areas. Among various crop production factors management of insect pests and plant diseases are the crucial factors determining the crop yields on farmers field. The impact of climate change and weather variabilities, created enormous difficulties at farmers level to harvest crop yields with their full potential, mainly in agronomical crops of the region like soybean, redgram, gram while to some extend horticultural crops like papaya, banana and chilli. Dryspell of more than 15 days and heavy rainfall coupled with high humidity and low solar radiation increased the infestation of stem borer in soybean, fusarium and phytopthora wilt in redgram. Soybean followed by gram is the major cropping system of the region which created the problem of wilting in gram. Undernutrition of micronutrients and low organic carbon content of the soil created unhealthy and virus infected growth of papaya, banana, and chilli. Extension functionaries needs to be work efficiently to disseminate recommended technologies effectively, timely and in simplest way at farmers level. Hence, it necessary to quantify the role of the extension agronomist of the RAEEC and subject matter specialist for strengthening the agricultural extension work in rainfed areas.

Methodology

The major crops of the Marathwada region of Maharashtra are soybean, redgram, cotton, gram while to some extend horticultural crops like papaya, banana, tomato and chilli ect. For harvesting good yield with low cost of production, various technologies viz., nutrient management, weed management, pest management water management, mechanization have been recommended by the Vasantrao Naik Marathwada Agricultural University, Parbhani, other SAUs and ICAR centres at regional and national levels. These technologies must reach farmers level in right time and in right way. In this regard, agricultural extension services are run by the Vasantrao Naik Marathwada Agricultural University, Parbhani, other SAUs with the formation of Regional Agricultural Extension Education Centres (RAEEC) and KVKs. Regional Agricultural Extension Education Centres (RAEEC) under Directorate of Extension Education, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani are established at Ambajogai, Latur, Aurangabad and Parbhani to disseminate the agricultural technology among the farmers of Marathwada region comprising eight district. RAEEC Ambajogai is working for Beed and Osmanabad, RAEEC Latur for Latur and Nanded, RAEEC Parbhani for Parbhani and Hingoli while RAEEC Aurangabad for Aurangabad and Jalana districts. These extension centres are actively involved in disseminating the technologies at farmers level. RAEEC developed system to approach 60,000 farmers in each district with collaborative work with Agriculture department. The situation needs a message that is going to pass up to the farmers level through the system channel i.e. from scientists – SMS /extension agronomist – DSAO – Taluka Agriculture Officer –Mandal Agriculture Officer – Agriculture Supervisor – Agriculture Assistant – Farmer through conducting Monthly district field visits, workshops, trainings and WhatsApp. On farmers field expression of various insect pest damage and plant diseases may be different than their typical expressions under study. Many times, single approach to management may not be sufficient to manage them, hence technological interventions should be made to manage the insect pests and diseases though integrated approach This article includes integrated management strategies to manage biotic and abiotic stress on farmers field, concluding with a brief outline of future directions that might lead to the integration of described methods in a system-based approach for more effective management of biotic and abiotic stress.

Results

State Agriculture Universities and ICAR research institutes have released various technologies for increasing production and productivity of rainfed areas. Technological intervention through extension activities is important for wide scale adaptation of these recommendations.

Cropping System:

Mixed cropping, intercropping and crop rotation are important practices that are widely emphasized around the world to break the life cycle of insect pests and to avoid the inoculums buildup of soil borne pathogens and these practices are proved most effective tool on farmers field to cope up from biotic and abiotic stress. Crop rotation is also associated with enhanced soil fertility, improvement in soil chemical and physical properties, good soil water management and soil erosion control.

Sowing method:

In soybean, use of BBF technology of sowing is proved to be climate resilient and cost effective by reducing seed rate and insect pest population on farmers field.

Soil Amendments:

Organic amendments to the soil are traditionally used for improving soil conditions and crop productivity, but they can also aid in suppressing soil borne pathogens. On farmers field, its an evident fact that crops sown in soil with good organic amendments do not show the viral expressions even though plant is infected.

Soil Fertility and Plant Nutrients:

Soil fertility and chemistry including soil pH, organic matter and available nutrient status, can all play a major role for healthy growth of plant. Soil nutrition, along with the use of fertilizers and amendments, has shown direct impact for developing tolerance against various biotic and abiotic stress. Adequate nutrition can make the plant more tolerant or resistant to diseases as mineral nutrients are components of plants that regulate metabolic activity which is related to plant resistance and pathogen virulence.

Conclusion

Among various crop production constraints management of biotic and abiotic stress is the key to potential crop production in rainfed areas. Many high-value crops and vegetable crops are vulnerable to the wide range of insect pests and diseases that either reduce the yield, marketability or many aspects combined. The phase-out of many chemicals and rising awareness towards resistance development, environmental health, and climate change necessitate the quest for suitable integrated management options. Many non-chemical options such as resistant cultivars/varieties, cropping system, sowing methods, soil amendments, soil fertility management and plant nutrient application methods, proved more effective in management of insect pests and diseases if integrated with chemical methods. Therefore, published research must be implemented in an integrated way to harvest its benefits on farmers field and for that RAEEC and KVKs are playing an important role in bridging the technological gaps on farmers field effectively.

UID: 1324

Development of Wellbeing Framework for Farmers in Rainfed Areas

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The concept of wellbeing has received much attention in academic and policy circles in the last decade. It is now a recognized goal of public policy in many countries and supra national organizations such as the EC, OECD, and UN who are targeting substantial resources to conceptualise and measure it (Bache and Scott 2017). The definition of Pluralistic agricultural extension and advisory services comprise "all the different activities that provide the information, [goods,] and services needed and demanded by farmers and other actors in agricultural settings to assist them in developing their own technical, organizational, and management skills and practices so as to improve their livelihoods and well-being"

(Christoplos 2010). However, current understanding of such human well-being outcomes is fragmented. Firstly, most relevant studies tend to focus on single indicators of human wellbeing such as income, consumption or poverty (Masanjala, 2016). Secondly, most current studies in agrarian contexts employ objective wellbeing measures, rather than measures of subjective well-being (e.g. satisfaction with life, happiness). While it is important to combine measures of objective and subjective wellbeing there are very few studies that have jointly used and contrasted them in agrarian contexts in India. Farmers' well-being is a dynamic process that gives people a sense of how their lives are evolving. More precisely, it refers to the welfare of the farmers which is influenced by both qualitative and quantitative parameters. Wellbeing may differ from individual to individual due to differences in their socio-economic characteristics and their cognitive styles. Hence, in the present study, a Multidimensional Wellbeing Assessment framework for Agrarian system was developed to study the wellbeing of the farmers in the dryland areas.

Methodology

Exploratory research design is applied for the study. The data was collected from Nagarkurnool District in Telangana and Chincholi Taluk in Karnataka. The data was collected through face to face interview method. This framework consisted of material, health, security, social relations and freedom as its component. Wellbeing was calculated using the following

$$\text{Farmer's wellbeing index} = \frac{\text{Material}(\bar{x}) + \text{Health}(\bar{x}) + \text{Security}(\bar{x}) + \text{Social relations}(\bar{x}) + \text{Freedom}(\bar{x})}{5}$$

Results

Wellbeing is one of the most important issues facing the world today and is central to the development of social policy for rural areas. Framers were categorized in three categories based on their wellbeing index. The result of the study indicated that about 54 percent of the farmers were in low category in wellbeing followed by 38 percent in medium wellbeing and about 9 percent in high wellbeing category. The wellbeing index was also studied for farmers based on landholdings. The findings indicated that majority of farmers in small and marginal category were low in their wellbeing index while only 11 percent of medium landholding farmers were in low category. The study revealed variations in the well-being of farmers across different farming systems. Majority (66%) of farmers who were having crops only were in the low category while only 25 percent farmers having crop+horticulture+livestock were in the low category of well-being. The highest category of farmers in the high wellbeing index was having crop+horticulture+livestock followed by crop+livestock, crop+horticulture and crops only respectively. The investigation further suggested that about 57 percent of women headed household were in low wellbeing category than 40 percent in Male headed household.

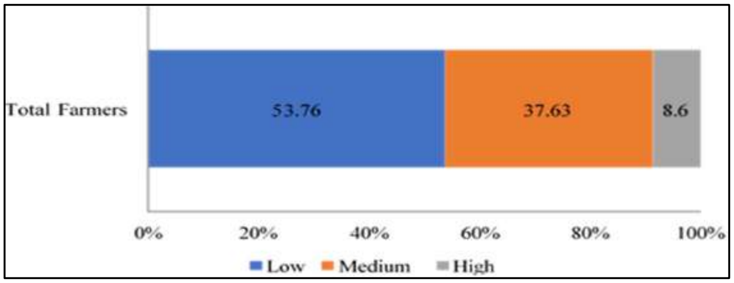

Fig 1. Wellbeing category for total farmers

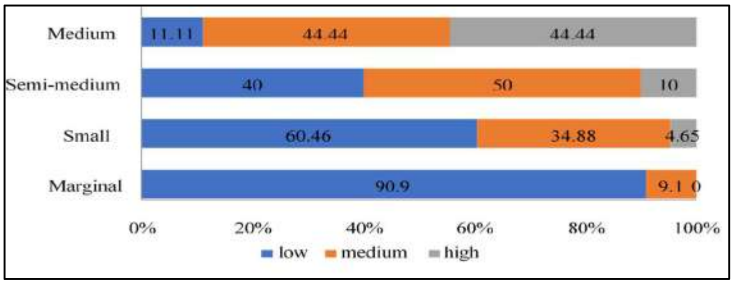

Fig 2. Wellbeing category based on land holdings

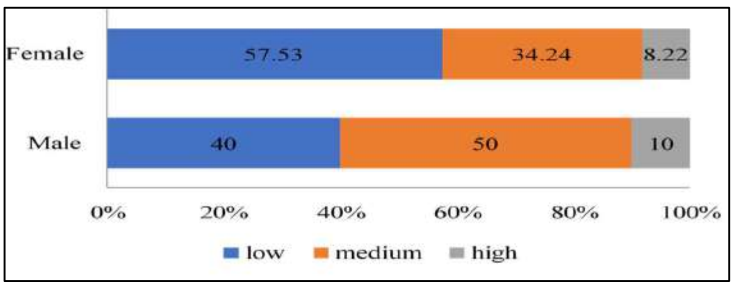

Fig 3. Wellbeing category based on farming system

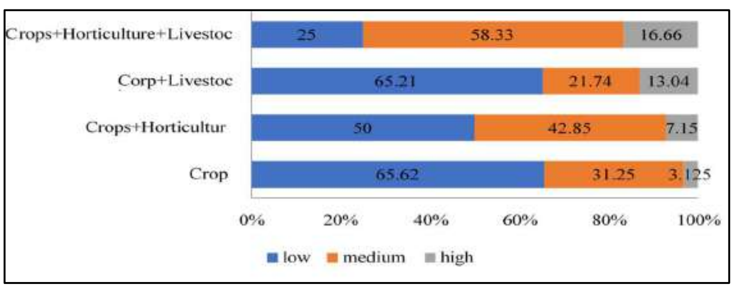

Fig 4. Wellbeing category based on gender

Conclusion

Benefit of wellbeing research for rural development is important because it allows to get information about the wellbeing situation of rural people, reveals existing problems and positive changes, gives an opportunity to observe how to improve the evaluation of wellbeing and informs rural actors about their role in the wellbeing research and their possible influence on the rural development.

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UID: 1349

Integration of Different Technological Interventions at a Household Level under Different Farming System Typologies in NICRA Village of Kullu District, hp

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India exhibits a wide range of farming practices, encompassing both traditional and modern systems, due to its diverse agro-climatic conditions. Traditional practices, such as mixed cropping and integrated crop-livestock farming, have been integral to Indian agriculture for centuries. Farming systems are classified based on various factors, including climate, available resources, and agricultural practices. Developing a farming system typology for adopting new technologies requires a comprehensive understanding of the region's agricultural systems and farmers' responses to innovations, particularly those aimed at enhancing climate resilience. In Kullu district, the predominant farming systems revolve around agriculture, with a focus on cereal crops (e.g., wheat, maize), horticultural crops (e.g., fruits, vegetables), and livestock rearing. The implementation of technological interventions at the household level within different farming system typologies, particularly in villages under the NICRA (National Innovations on Climate Resilient Agriculture) initiative, has significantly improved agricultural productivity, strengthened climate resilience, and enhanced livelihoods. Farmers in this region employ various strategies to adapt to climate change, such as diversifying their crops, cultivating multiple varieties including off-season vegetables, and adopting drought- and disease-resistant crop varieties. The integration of annual and perennial crops with livestock and poultry further boosts household income and resilience, creating a sustainable and adaptive farming system.

Methodology

National Innovation in Climate Resilient Agriculture (NICRA) project is being implemented since 2011 in different villages of the Kullu district. Under this project several technologies related to natural resource management, crops and cropping system, livestock system were demonstrated on farmer's field and assessed their impact during the normal and stress years**.** Farmer's perception on performance of the climate resilient technologies were recorded and the promising resilient technologies were identified **(**Singh et.al 2022**)**. The proven climate resilient technologies were scaled up in the cluster of villages in the districts in convergence with various ongoing developmental programmes of the state. During 2023-24, the farming system typologies were identified in the cluster of NICRA villages by conducting surveys to assess the current farming systems, climate-related challenges, and technological adoption levels in different villages. Interviews with the farmers were conducted for understanding their perceptions of new technologies and barriers to adoption. Based on the prevalent farming systems and technology adoption patterns, the farming system typology in the NICRA villages of Kullu District was divided mainly into two categories

1. Farming System Typology-I: Rain-fed-Agriculture + Horticulture +Livestock
2. Farming System Typology-II: Irrigated -Agriculture + Horticulture +Livestock

Under these two farming system typology the proven climate resilient technologies were integrated at household level to increase the productivity, resilience to climate and enhance the income of the farmers.

Results

The data highlights the comparative performance of NICRA farmers (those adopting climate-resilient technologies) versus non-NICRA farmers (conventional farming methods) under two distinct farming systems- Rain-fed and Irrigated Agri-Horti with Animal farming systems. The analysis focuses on productivity, net returns, and the overall impact on household income. The integration of diverse technological interventions at the household level in Choyal village under the NICRA project has shown promising results in terms of improving agricultural productivity and enhancing farmer income. NICRA farmers observed 22.5% higher productivity in intercropping (Plum & Pomegranate with Pea) compared to non-NICRA farmers. Similarly the Wheat variety (HPW-368), Maize (Early Composite) and ICM in pomegranate also performed significantly better for NICRA farmers, increasing productivity by 9.9 %, 6.9% and 6.5%, respectively.

Livestock Interventions on Year-round fodder production (with Oats, Berseem, and Chari) and mineral supplements for lactating animals led to 6.4% higher milk production and a 20.2% increase in net returns per animal. Backyard poultry using Palam Smridhi breed contributed an additional income of more than fifty thousand per year, while non-NICRA farmers had no returns from this intervention. Total household income for NICRA farmers (Rs 10.39 lakhs/ha) was 36.6% higher than that of non-NICRA farmers (Rs 7.60 lakhs/ha).

The key observation under irrigated farming system showed 28.4%, 11.8% increase in productivity of Garlic variety GHC-1 and wheat variety HPW-368 for NICRA farmers over non-NICRA farmers. Livestock Interventions. Demonstration on Year-round fodder production resulted in 12.5% higher milk production and a 20% increase in net returns per animal. Similar to the rain-fed system, backyard poultry using Palam Smridhi breed added a new source of income for NICRA farmers, while non-NICRA farmers earned nothing from this intervention. The Intervention high density planting of low chilling varieties of apple were also conducted in the farmers field. Since this intervention is a new plantation, returns are not yet realized, but it is expected to increase household income in the coming years. Total household income for NICRA farmers was 35.1% higher than that of non-NICRA farmers.

Table 1. Impact of Integrating Climate-Resilient Technologies in Rain-Fed Agri-Horti with Animal type of Farming System

Intervention /technology demonstrated	NICRA Farmer		Non NICRA farmer	
	Productivity (q/ha)	Net return (Rs./ha)	Productivity (q/ha)	Net return (Rs./ha)
Location specific intercropping in Plum and Pomegranate orchard with pea	163.33	191533.33	133.33	87900.00
Drought and yellow rust tolerant variety of wheat (HPW-368)	32.33	39774.67	29.43	32899.00
Short duration Composite variety of maize- Early composite	31.00	34100.00	29.00	29333.33
ICM in Pomegranate	136.67	683333.33	128.33	577500.00
Live stock interventions	**NICRA Farmer**		**Non NICRA farmer**	
	Productivity (L/animal/ year)	**Net return (Rs./ Animal)**	**Productivity (L/animal/ year)**	**Net return (Rs./ Animal)**
Year round production Fodder crops :Rabi : Oats and berseem, Kharif season -Chari, Bajra Maize (AT),UMMB / Mineral mixture for lactating animals during lean period	1531	38790	1439.25	32257.50
Backyard Poultry- Palam Smridhi	7283.33	50983	0	0
Average Total income at household level (Rs)		1038514		759889.8

Table 2. Impact of Integrating Climate-Resilient Technologies in Irrigated Agri-Horti with Animal type of Farming System

Intervention /technology demonstrated	NICRA Farmer		Non NICRA farmer	
	Productivity (q/ha)	Net return (Rs./ha)	Productivity (q/ha)	Net return (Rs./ha)
Improved variety of garlic GHC-1 as a Cash crop	190.44	571333.33	148.34	445333.33
Drought tolerant wheat variety (HPW-368)	34.47	73241.67	30.82	65485.33
Low chilling variety of apple on Clonal rootstock M9+ Mulching	New plantation	-	0	0
Livestock interventions	**NICRA Farmer**		**Non NICRA farmer**	
	Productivity (L/animal/ year)	**Net return (Rs./ Animal)**	**Productivity (L/animal/ year)**	**Net return (Rs./ Animal)**
Year round production Fodder crops :Rabi : Oats and berseem, Kharif season - Chari, Bajra Maize (AT),UMMB / Mineral mixture for lactating animals during lean period	1638	42877	1456	35740
Backyard Poultry- Palam Smridhi	7300	51100	0	0
Average Total income at household level (Rs)		738552		546558.7

The fig-1 compares two farming systems (FST1 and FST2) in terms of recycling of crop residue and animal by-product production. Crop residues are an important resource in integrated farming systems and have several uses. Crop residues like wheat straw and maize Stover, are used as fodder for livestock which is further recycled into the farming system. Utilizing crop residues and animal byproducts ensures resource efficiency, reduces dependency on chemical inputs, and enhances environmental sustainability.

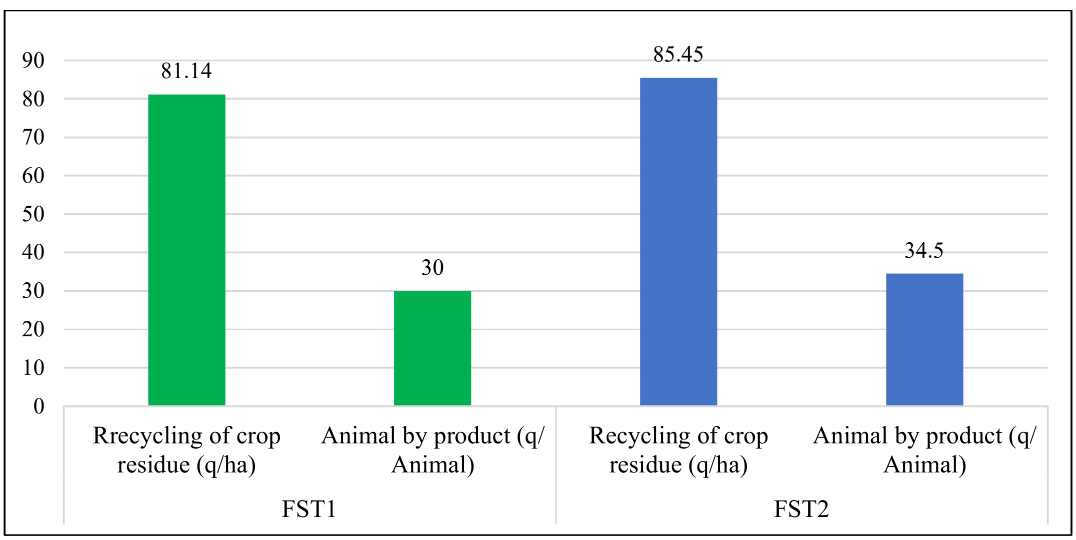

Fig 1. Quantity of crop residue / animal bioproduct produced under differnt farming system

Conclusion

The integration of climate-resilient technologies significantly enhanced farm productivity, income, and overall livelihood security for NICRA farmers in Choyal village. Both rain-fed and irrigated farming systems showed substantial benefits. Key interventions like intercropping, drought-tolerant varieties, improved livestock fodder management, and backyard poultry provided a more diversified and sustainable source of income. This approach serves as a model for promoting climate-resilient agriculture in similar agro-ecological zones.

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UID: 1367

Participatory Seed Production; A Case Study of Pulse Seed Village

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Non-availability of quality seed especially situation specific pulse variety at local level is the very crucial reason for low productivity in Pulses. After water, seed is the component through which we can increase productivity up to 40 percent. In state like Jharkhand where ninety percent agriculture is rainfed agriculture, climatic stress and aberration make major agriculture production system as complex diverse and risk prone. Most of farmers' especially small and marginal one is resource poor who depends on their own seed which they saved since ancestors for farming. There is pertinent need to ensure availability of quality seed of improved varieties at village level and integration of informal seed growers into mainstream. For this Farmer participation in seed multiplication and distribution may bring self-sufficiency in availability of pulse seed locally. In the light of this concept of farmers participation in bringing self-sufficiency in pulse seed production this study has been carried out with the following objectives.

Methodology

The central government implemented pulses seed hubs programme under NFSM "Creation of seed hubs for increasing indigenous production of pulses in India" during 2016-17. Krishi Vigyan Kendra (KVK) Dumka was one of among seed hub centre. Two seed village namely *jiapani* seed village and *Saraiya* Seed village were organised in two block of Dumka district namely Ramgarh and Saraiyahaat respectively in cluster of 12-15 village. In total 150 small and marginal farmers were selected as member of seed village on those plots pulse seed were produced. Six pulse crops *i.e,* pigeon pea, black gram, green gram, horse gram, lentil and chick pea were cultivated.

Present study were conducted in purposively selected Jiapani seed village cluster covering eight village namely *Tilanda,Jagatpur, Jirulia, Jiapani , Sadudih, Kurumtanr, Basuduma and Patharia*. Technologies demonstrated were improved variety, use of INM and use of biofertilizers and season long technological backstopping were given through training, exposure visit, and method demonstration as well as result demonstration. A sample of hundred respondents was selected randomly from the list of all pulse seed growers. For this study only kharif pulses Pigeon pea and Black Gram were taken into account and data were taken from fifty pigeon pea growers and fifty Black Gram growers.

The study was designed exploratory and farmers perceptions were documented through structured schedule were prepared in consultation with subject matter expert. Focused Group discussion was also followed to gather data on the opinion of respondent's towards the seed production.

Apart from the use of schedule, detailed information was collected through informal discussion with the respondents. Problem matrix on pulse cultivation was prepared through use of PRA tools and was categorized in Biophysical causes, Socioeconomic and Production constraints. Both primary and secondary level data were collected and analysed.

Results

As it has been shown in table 1. B: C observed were Rs.1.92 and 2.10 respectively for seed production of pigeon pea and black gram compared to production of grain pulse for pigeon pea and Black gram were 1.65 and 1.45 respectively. It's evident that seed production is a profitable venture for farmers. It was a custom among tribal farmers of exchanging grain among relatives and marriage purposes. It enhanced spread of variety through farmer to farmer. When secondary data regarding pulse sown area over years was analysed it was found that there was significant horizontal spread.

Production constraints of pulse seed production

In rainfed condition Production of pulses is constrained by both biotic and abiotic stresses. Constraints of seed production were analysed and categorized in biophysical causes and socioeconomic constraints. In rainfed condition Production of pulses is constrained by both biotic and abiotic stresses. Constraints of seed production were analysed and categorized in biophysical causes and socioeconomic constraints. Problem matrix were elaborated and it was observed that Eighty six percent respondents reported that lack of resistant varieties against Insect Pest was most limiting constraints followed by Poor pod bearing, Weed problem, Heavy Insect pest infestation, Low Soil fertility and low moisture availability in rainfed condition with corresponding value of 61,60 ,54 and 50 respectively in percentage. Anuratha A and M Ramasubramanian (2020) also reported similar observation and found out that different pulse variety behave differently with respect to insect pest infestation.

Economic analysis of seed production (pooled data (3yr)

Crop	Variety	Seed category	Productivity(q/ha)	B:C (seed)	B:C (Grain)	Horizontal spread (F-F)
Pigeon pea	IPA-203	FS	9.8	2.31		• 35to40 percent increase in area under cultivation of introduced variety of Pulses. • Now Seed not only cultivated in district rather it has been under cultivation of nearby district as well as nearby villages of west Bengal and Bihar.
		CS	12.2	1.92	1.65	
Black gram	IPU-2-43	FS	8.89	2.27		
		CS	11.82	2.10	1.45	

High price of input was the foremost socio economic constraints among other ten constraints enumerated and discussed with pulse seed growers. Other important constraints were lack of irrigation facility, poor marketing facility and yield fluctuation over years respectively stood second, third, fourth and fifth rank.

Conclusion

India needs around 32 million tons of pulses by 2030, to feed the estimated population of about 1.68 billion. The recent efforts and programs initiated by the government are bearing fruits and on the basis of experiences and findings of the study it can concluded that seed village programme would be a enabler in self-reliant of pulse seed as well as dissemination of situation specific varieties of pulses.

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UID: 1369

Adoption and Constraints Faced by Farmers in Cultivation of Oilseed Crops in Raigad District of Maharashtra

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The population is increasing, the demand for agricultural produce is increasing rapidly and the scope of bringing more land under cultivation is receding fast. Thus, increasing production per unit of available land is the only answer to the problem. Therefore, the Indian Council of Agricultural Research (ICAR), in order to boost the production and productivity by using the latest technologies introduced the concept of Front-Line Demonstrations (FLDs). In order to bring production to the forefront and to achieve even higher level of production, FLDs play the most pivotal role in terms of providing viable technological inputs. These demonstrations will also provide scientists with an opportunity to demonstrate the technology under actual farmer's conditions and get direct feedback from the field so that the performance of the new technology could be further modified and improved. Oilseeds form the second largest agricultural commodity in India after cereals sharing 15.5 % of gross cropped area and accounting for nearly 3.6 % of the gross National product and 10.4% of value of all agricultural products. The study revealed that the possible reason behind big farmer's adoption level to medium extent might be due to medium level of scientific orientation and risk bearing ability. Low adoption level was found in small farmer's category (45.68 per cent) as compared to medium and big farmer's category. In the practices like, recommended improved/hybrid variety, FYM application, fertilizer application, intercultural operations and weed/water management, the demonstrator farmers had more adoption level. Frequency of constraints related to technological and extension category was relatively less as compared to other constraints like availability of inputs and financial. Emphasis should be given on conduct of off campus training and field demonstrations on recommended agricultural technologies. Still there is a need for greater attention on the part of officials involved at the grass root levels and need to strengthen the staffing pattern and infrastructures of various technology transfer organizations.

UID: 1370

Perceived Drivers and Constraints in Adoption of Climate-Resilient Technologies

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The adoption of climate-resilient technologies is critical for ensuring sustainable agricultural productivity in India, where diverse agro-ecological regions face increasing climatic vulnerabilities. To address these challenges, the Indian Council of Agricultural Research (ICAR) launched National Innovations in Climate Resilient Agriculture (NICRA) project in 2011. The project has been implemented across 121 Krishi Vigyan Kendras (KVKs) in 28 states and one Union Territory, covering 370 villages and benefiting 2 lakh farmers across 2 lakh hectares (ICAR, 2011). NICRA focuses on natural resource management, crop production, livestock, fisheries, and institutional interventions to enhance resilience and adaptive capacity (Sreelakshmi et al., 2020). The project employs participatory demonstrations, capacity-building programs, and extension activities to promote climate-resilient technologies (Singh *et al.,* 2019). The drivers for adoption of technologies usually include increased awareness, economic benefits, and institutional support, while constraints such as financial limitations, inadequate infrastructure, and social barriers persist (NITI Aayog, 2018). Feedback from farmers, KVK staff, and district line department officials has been instrumental in identifying mechanisms to scale up these technologies. This paper explores the drivers and constraints influencing the adoption of climate-resilient technologies across India's agro-ecological zones, contributing to the discourse on sustainable agricultural practices. The main objective of the article is, to identify the key drivers and constraints influencing the adoption of climate-resilient technologies across India's agro-ecological regions.

Methodology

A study was conducted involving a sample of 30 Krishi Vigyan Kendras (KVKs) out of the 121 NICRA KVKs, ensuring adequate representation from diverse agro-climatic regions and addressing all identified climatic vulnerabilities. The Methodology , jointly standardized by IWMI and CRIDA, was utilized to analyze the drivers and constraints influencing the adoption of climate-resilient technologies (CRTs). The study gathered 18 responses per KVK, comprising 3 responses from KVK staff, 10 from farmers, and 5 from district line department officials. These responses were analyzed to identify the drivers and constraints for the adoption and scaling up of climate-resilient technologies. Key factors assessed included technical feasibility, cost, alignment with government schemes, farmer acceptance, financial requirements, input availability, awareness, labor and water demands, government support, extension services, and market linkages. The average weights assigned to each factor were used to rank the relative importance of the drivers and constraints.

Results

Implementation feasibility of climate resilient technologies

The data in Fig. 1. illustrates the implementation feasibility of climate-resilient technologies (CRTs) based on stakeholder evaluations across various parameters: technical feasibility, gender inclusivity (male and female), synergy with government plans, and benefits realized by individuals and groups. The cumulative analysis of all parameters highlights that crop production technologies have the highest implementation feasibility, driven by strong technical viability, alignment with government schemes, and tangible benefits at both individual and group levels. Water-saving and soil quality management technologies follow closely, reflecting their practical relevance and adoption potential. In contrast, institutional interventions and livestock and fisheries technologies score lower, indicating challenges such as limited direct benefits and technical complexities. Ex-situ water harvesting technologies show moderate feasibility, requiring targeted efforts to improve inclusivity and individual benefits. These findings suggest prioritizing high-scoring technologies for scaling-up while addressing constraints in lower-scoring interventions to enhance overall climate resilience.

Perceived adoption barriers

The data in Fig. 2. indicates the average scores of adoption barriers for climate-resilient technologies (CRTs) across various categories. The highest score, 3.26 for acceptability of technology, indicates that the perceived suitability of CRTs is a significant barrier, suggesting that farmers may be hesitant to embrace new technologies. Access to extension services (2.87) and awareness (2.98) point to moderate challenges in information dissemination, while barriers related to water availability (2.73) and labor (2.95) highlight environmental and resource limitations. Government support (2.52), inputs availability (2.55), and finance access (2.60) are also critical factors but score lower, indicating that while they remain challenges, they may be slightly less restrictive than other factors. These findings suggest a need for improved awareness, support, and financial mechanisms to enhance CRT adoption.

Conclusion

In conclusion, the adoption of climate-resilient technologies (CRTs) in India faces several barriers, with acceptability and awareness being the most significant challenges. While there is strong technical feasibility for crop production technologies, environmental factors such as water availability and labor constraints, alongside financial limitations, further hinder widespread adoption. The NICRA project has made valuable strides in promoting CRTs, but its success depends on addressing these barriers, particularly through enhanced awareness, government support, and access to resources. Focused efforts on improving farmer engagement and infrastructure are essential for scaling up these technologies and ensuring long-term resilience in India's agricultural systems.

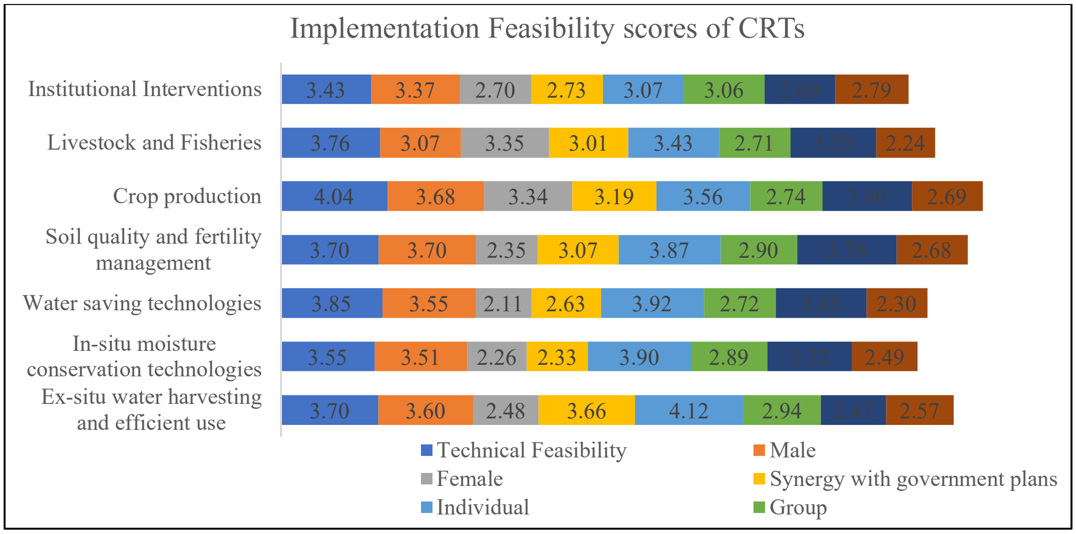

Fig 1. Implementation feasibility scores of Climate Resilient Technologies

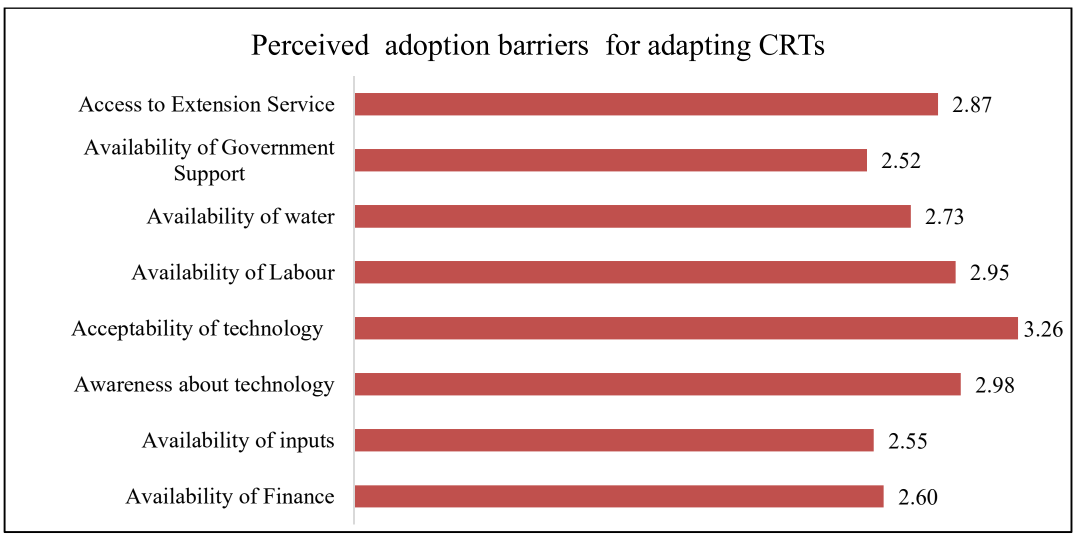

Fig. 2. Perceived adoption barriers for adapting Climate Resilient Technologies

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Impact of NICRA Intervention on Reclamation of Sodic Soil

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Uttar Pradesh possesses the biggest expanse of salt-affected soils (1.37 million hectares), characterized by pH levels more than 10, exchangeable sodium percentages (ESP) greater than 15, and fluctuating electrical conductivity (EC). Sodicity in the soil is a significant issue in the Indo-Gangetic plain, impacting both productivity and the livelihoods of the population. Under alkali soils, largest area is 123042 ha. in Mainpuri, followed by 97751 ha in Azamgarh, 69076 ha. in Etawah, 86586 ha in Raebareli and 72229 ha in Pratapgarh (Thimmappa *et al,* 2015). The Pratapgarh district of Uttar Pradesh is similarly impacted by soil sodicity, covering an area (>60,000 hectares). The district is located on the northern bank of the Ganga River. The whole geographical area is 3,717 square kilometres and is situated in the central plain zone. The average rainfall is 977.9 mm, ranging from 966.8 mm to 996.9 mm. The predominant soil types in the district are sandy loam and clay. Approximately 93% of the district's population is engaged in agriculture and related field operations. The NICRA village of Chhachhamau comprises 317 farming families and is situated in the Kalakankar block of the Kunda tehsil. The soil pH level ranges from 8.9 to 10.3, with 63% of the village area dedicated to monocropping and 32% affected by high pH levels in 2015. Condition of soil was very poor and cultivation of multiple crops was not possible. Keeping this in mind, the project was conducted with following objective. NICRA project was implemented by ICAR-CRIDA, Hyderabad through KVK Pratapgarh in the village chhachhamau in 2015 and its objectives are

1. Improve the soil health by the reclamation practices
2. Decrease the fellow area in village
3. Increase the multi crapping area in village

4. Increase more income per unit area
5. Increase cropping intensity

Methodology

Before implementation of NICRA project, KVK has conducted base line survey and PRA for identification of actual situation of the village. The project has four components viz NRM, Crop production, Livestock and fisheries and Institutional. Based on the findings of baseline survey and PRA, KVK was formulated an action plan for implementation of the project.

NRM - Demonstration of green manuring before paddy crop, Rice residue management in wheat/Mustard crop, Laser Land leveling.

Crop Production - Adoption of salt tolerant variety of wheat (Var. KRL-210, 283), Mustard (Var. CS-56/58/60) and paddy (var. CSR-36/60/83). application of fertilizer on soil test based and Site specific nutrient management.

Livestock and fisheries - Demonstration of fodder (Barseem and oat), mineral mixture and deworming for heath management for milch animal and Composite fish farming

Institutional- Capacity development programme and formation VCRMC (Village Climate risk Management Committee)

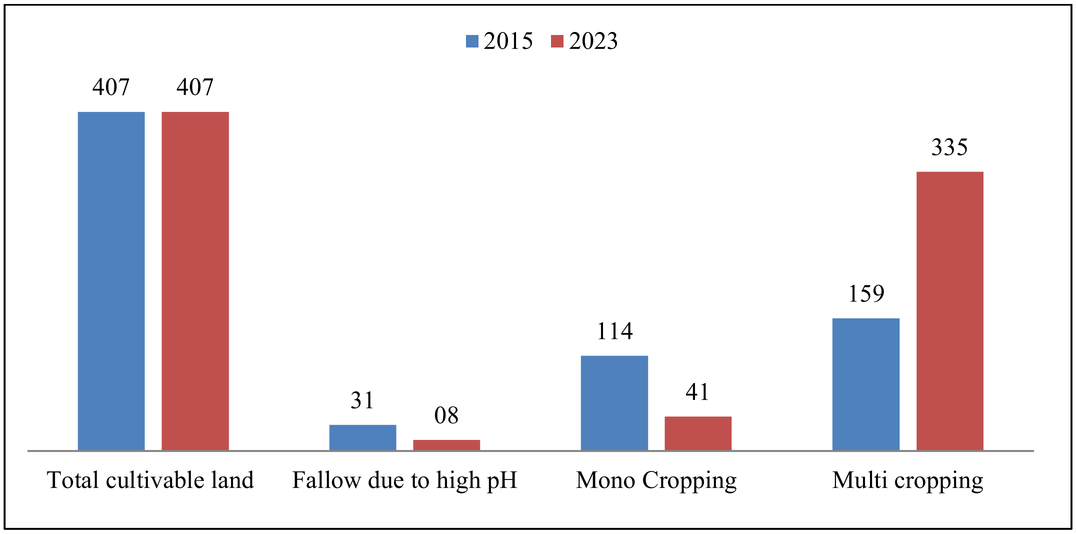
Results

It is evident from the figure below the total cultivable land of the village was 407 ha. in 2015 and same in 2023. In 2015, 31 ha. land was fallow due to high pH (8.9-10.3), the area of fallow land has reduced to only 8 hectares in the village through laser land levelling, residue management, green manuring, mulching with paddy straw and use of gypsum. 114 ha. land was cultivated with mono cropping in 2015 due to sodicity. Presently, scenario has been changed. A total area of 335 hectares is cultivated with multiple crops, including paddy (var. CSR-36, 60 and 83), mustard (CS-56,58,60), and wheat (KRL-210, 283). It is also evident that the significant role of salt tolerant variety of mustard for Conversion of mono cropping to multi cropping in paddy fallow area in the village.

The table below clearly indicate that the improving pattern of soil parameters in the village, in 2015 soil pH of the village was 8.9-10.3 and in 2023 was improve with 7.9-8.9. In case of carbon level in the soil 0.23 in 2015 and 0.36 in 2023. Electric conductivity (EC) was 0.91-2.221 in 2015 and 0.61-1.89 in 2023. Soil parameter improvement was done by the scheduled operation of laser land levelling, residue management, green manuring, mulching with paddy straw and use of gypsum.

Conclusions

After the implementation of NICRA intervention, the soil condition of the village has been gradually improved. Soil carbon level of village was increase by 0.13 % from 2015 to 2023. Soil pH was also reduced from (8.9-10.3) to (7.9-8.9). Now the farmers are easily cultivating paddy, wheat, chickpea and mustard. Improving the soil parameters resulted 335-hectare area was cultivated by multi cropping in the village.



Changing scenario of land use pattern

Changing scenario of soil parameter

Parameters	Pre – NICRA (2015)	Post – NICRA (2023)
Soil pH	8.9 - 10.3	7.9 - 8.9
Carbon (%)	0.23	0.36
EC	0.91 - 2.21	0.61 - 1.89

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Performance of Different Climate Resilient Technologies under Natural Resource Management Interventions of NICRA-TDC Project in Flood Affected Villages of Malda, West Bengal

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Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of large population depending onagriculture, excessive pressure on natural resources and poor coping mechanisms (Venkateswarlu et al., 2012). As a response to these challenges, both farmers as well as research community developed an extensive range of agricultural practices which could augment farming systems' resiliency to climate change (Wezelet al*.,* 2014).

Research on the impact of climate change and vulnerability on agriculture is a high priority in India. Developing the ability to confidently estimate the impacts of climate change on agriculture is critically important (Khan et al*.,* 2009). Looking into the concerns, Indian Council of Agricultural Research initiated the National Innovation for Climate Resilient Agriculture (NICRA) across the country in collaboration with ICAR research institutes, SAUs and KVKs. The project is being implemented in 151 districts involving over one lakh farm families across the country.

This project was also implemented by Malda Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya since the year 2011. Various modules implemented under Technology Demonstration Component (TDC) viz. natural resource management, crop management, livestock and fisheries and institutional interventions which deal with adaptation of crop and livestock production systems to climate variability (Mazumder et al., 2020).

Through NICRA project, Malda KVK has demonstrated and encouraged to adopt a wide-ranging technologies and improved practices for mitigating climate change to promote farming as business. This study was undertaken to assess the performance of different technological interventions related to natural resource management of NICRA TDC in the project area.

Methodology

The village of Malda district represent old alluvial agro ecosystem and mostly affected by flood, storm and high intensity and erratic rainfall. The project site was Brojolaltola, Mahendratola, Meherchandtola, Jairamtola and Deherutola villages of Manikchak block of Malda district of West Bengal to address the flood vulnerability. The project site under NICRA project was purposively selected to assess the performance of technologies under NICRA. In order to do this study, the technological options being implemented for last four years were taken into consideration and the area coverage (ha), production (q/ha) and benefit-cost ratio (BCR) were worked out.

The benefit-cost ratio indicates the relationship between the cost and benefit of project or investment for analysis as it is shown by the present value of benefit expected divided by present value of cost which helps to determine the viability and value that can be derived from investment or project.

Results

1. *In situ moisture conservation technologies*

Year-wise performance of various technologies for in situ moisture conservation has been presented in Table 1. Among various technologies, Zero Tillage in wheat/Maize/Other crops has been found to be demonstrated at the highest number of farmers field (140) during 2022-23; while the lowest being Application of Azolla in paddy (14) during 2019-20. Besides, other promising demonstrated technologies were Organic mulching in vegetables (2021-22) and Horticultural production through land embankment development (2019-20).

The highest area coverage for a single technology among different years was for Organic mulching in vegetables (22 ha) during 2020-21; the lowest being for Mulching (plastic mulching) in tomato (Arka Samrat) during 2021-22 (1.5 ha). Other technologies which covered significant area were Zero Tillage in wheat/Maize/Other crops during 2021-22 and 2022-23; and Horticultural production through land embankment development during 2019-20. The BCR was highest for Mulching (3.60) during 2019-20 and the lowest being for Summer Ploughing in rice (1.14) during the same year. Further, the technologies having comparatively higher BCR values were Organicmulchinginvegetables (2021-22) and ZeroTillageinwheat/Maize/Otherscrops (2021-22).

2. *Water harvesting and recycling for supplemental irrigation*

Renovation of pond for fish production and irrigation was demonstrated the highest (253); the lowest being the same technology during 2019-20. Other prominently demonstrated technologies were Renovationofirrigationchannel (2021-22) and Bundmakingand leveling in paddy field (2022-23).

Table 1. Performances of demonstration of *in-situ* moisture conservation technologies

Year	Technology demonstrated	No. of farmers	Area (ha)	Yield (q/ha)	Economics of Demonstration (Rs/ha)		
					Gross Cost	Net Return	BCR
2019-20	Green manuring (dhaincha) in rice	18	2.60	56	35500	13135	1.37
	Brown manuring in rice	15	2.00	58	34000	18700	1.55
	Summer Ploughing in rice	30	10.00	48	33500	4690	1.14
	Azolla in Paddy	14	5.40	61	34250	22947	1.67
	Zero Tillage in wheat / Maize/ Others crops	28	10.00	55	25700	31097	2.21
	Horticultural production through land embankment development	65	12.00	85	15750	26750	1.69
	Organic mulching in vegetables	42	20.00	130	22200	42800	1.92
	Mulching	30	10.00	150	16300	58700	3.60
2020-21	Mulching (organic)	50	22.00	181	86651	95349	2.08
	Conservation tillage where appropriate like zero tillage/ minimum tillage etc…	35	9.00	55	25700	31097	2.21
2021-22	ZeroTillageinwheat/Maize/Otherscrops	130	20.00	34.5	24750	30450	2.23
	Organicmulchinginvegetables	70	4.00	75	55000	107500	2.95
	Mulching (plastic mulching) in tomato (Arkasamrat)	50	1.50	100	65000	85000	2.3
2022-23	ZeroTillageinwheat/Maize/Otherscrops	140	20.00	34.5	23980	30120	2.25
	Organicmulchinginvegetables (straw mulching)	60	3.00	110	54700	88300	2.61
	Total	777	151.50	1233			

Artificial groundwater recharge measures (Through SRI by sub-soiler) were the technology that covered the highest area of 19 ha during 2020-21, while the lowest was Renovation of common pond (0.33 ha) during 2019-20. Besides, Artificial groundwater recharge measures (Field bunding for rice) during 2020-21 and Renovation of pond for fish production and irrigation during 2019-20 were among other prominently covered technologies.

In respect of BCR, the most profitable technology was Community ponds for fish production (3.95) during 2020-21 and the least being Artificial ground water recharge measures (Field bunding for rice) during the same year. Renovation of common pond during 2019-20 (3.92) and Renovation of pond for fish production and irrigation during 2019-20 (3.88) were the technologies having promising BCR.

3. *Rainwater harvesting structures*

Results of the present study showed that Smallditchesforjuteretting were the highest in number (25) during 2021-22 covering 20000 cu.m. of storage capacity while the highest number of farmers involvement was for Canal Renovation (425) during 2019-20 (Table 2).

From this canal, the protective irrigation potential was 165 ha (the highest) followed by Pond renovation (56 ha). The cropping intensity increased by 168% through the Canal renovation.

4. Performance of different water saving irrigation methods

During 2019-20, Application of vermi-compost from biodegradable wastes was demonstrated involving the highest number of farmers (45); the lowest being for Sprinkler irrigation in crops (Tomato) during 2021-22 (20). Apart from these, the application of biofertilizer in rice/crops was also demonstrated at considerable number during 2019-20.

As far as the area coverage is concerned, the Irrigation system (micro Irrigation system) has been demonstrated in 10 ha during 2019-20 which was the highest and the lowest was 1 ha for Sprinkler irrigation in crops (Tomato) during 2021-22. Other important technological options were application of biofertilizer in rice/crops during 2019-20 and Sprinkler irrigation in crops during 2020-21.

The highest and lowest BCR was recorded in case of Application of vermi-compost from biodegradable wastes (3.41) during 2019-20 and in Sprinkler irrigation in crops (1.17) during the same year. Other more profitable technological options were Sprinkler irrigation in crops (Tomato) during 2021-22 and Application of biofertilizer in rice/crops during 2019-20.

Table 2: Rainwater harvesting structures developed

Year	RWH structures	No.	Storage capacity (cu.m)	No. of farmers	Protective irrigation potential (ha)	Increase in cropping intensity (%)
2019-20	Pond Renovation	5	5650	365	56	142
	Canal	1	-	425	165	168
	Small ditches for jute retting	5	14000	150	10	128
2020-21	Pond Renovation	4	4550	286	47	131
	Canal	1	-	341	135	148
	Small ditches for jute retting	4	11000	128	12	114
2021-22	Pond Renovation	2	9000	80	16	90
	Canal	5	7000	150	19	75
	Small ditches for jute retting	25	20000	200	13	90
	Land shaping and rainwater harvesting structure	8	10000	300	22	95
2022-23	PondRenovation	1	7000	80	14	80
	Canal	3	5000	180	12	80
	Smallditchesforjuteretting	15	19000	200	17	80
	Land shapingandrainwaterharvesting structure	4	8000	250	11	80
	Total	83	120200	3135	549	108

Conclusion

From the present study, it can be concluded that the performance of certain climate resilient technologies were excellent in adaptation and mitigation of climatic hazard, i.e., flood in the selected villages of Malda district. These technologies can be tried in other areas of the country having the similar situations. The BCR of all the selected technologies indicated the economic viability of the technologies while addressing the climatic vulnerabilities too.

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Impact of Agromet Advisory Services of DAMU Project in Purulia District, West Bengal, India

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In Gramin Krishi Mausam Sewa (GKMS) scheme, the India Meteorological Department (IMD) established District AgroMet Unit (DAMU) in 530 districts, in addition to already operating 130 AgroMet Field Units (AMFUs). DAMUs receive weather forecast from IMD to prepare and disseminate sub-district level agromet advisory bulletins (Anonymous, 2020). ICAR through KVKs is working on improvement in weather based advisory and strengthening outreach of advisory bulletin to the farming community. ICAR maintains Agromet observatories as well as Automated Weather Stations (AWS) and records Agromet observations at its Institutions, National Research Centres, Project Directorates, Krishi Vigyan Kendras (KVK) etc. to generate agrometeorological information for use in studies of crops, pests and diseases, soil, agro-forestry, livestock, horticulture, agricultural physics, soil science etc. Such data help ICAR Institutes to study crop-weather relationship, relationship between crop-weather and pest/disease and develop region/location specific agromet predictive models. In Phase-I of GKMS, 16 KVKs (6 in West Bengal and 10 in Odisha) were selected to set up DAMUs which started functioning since 2018. These DAMUs are providing weather forecast bulletins to the farmers since inception of the project.

Weather forecast bulletins/special bulletins are generated regularly in English and local languages and communicated to the farmers well in advance. Agromet Advisory Bulletins are prepared twice a week (every Tuesday and Friday) and circulated among all the farmers of the district. Several modes of dissemination of advisories are used like email, messages, whatsapp group, social media, through input dealers, block level extension functionaries, through village-based clusters etc.The KVKs are enhancing outreach and dissemination of agromet advisories using new and effective means of communication i.e. emails, whatsapp, KVK facebook page and SMS (in m-Kisan portal), which are being used to deliver agromet advisory bulletins to registered members of different farmers clubs, FPOs, line departments and ultimately to reach the farmers (Singh *et al.*, 2020). With the help of Regional Meteorological Centers/Meteorological Centers, DAMUs are also using social media and whatsapp groups consisting of AMFUs (Nodal Officer, Technical Officer), DAMUs (Nodal officer, SMS-Agromet) and concerned officials viz. District Agriculture Officers etc. for quick dissemination of weather forecast, nowcasts, alerts & warnings, and agromet content to farmers at village level. They are utilizing this channel effectively for sending information on very high impact weather events like thunderstorm and lightning to farmers to reduce the casualties and other losses. During extreme weather conditions over Odisha, West Bengal and neighbourhood, these DAMUs prepare special bulletins of warnings in regional languages and circulate to the farmers well in advance, such as to complete harvesting of crops, strengthen the macha of vegetables and betel vine, to stay at home along with safety of cattle and livestock in this period, and fishermen are advised not to move into the sea. This helps the farmers to a great extent in minimizing the loss and crop damage during these extreme weather conditions.

Keeping the above importance in view, the present study was conducted in Purulia district of West Bengal under Red Lateritic Zone having Min. Temperature of 7.7 ^{o}C and Max. Temperature of 44.6 ^{o}C, and this district faces the climatic vulnerabilities of erratic rainfall, heat wave, drought and cold wave. The district recorded an annual rainfall of 1191 mm with soil type of red and lateritic. Out of 20 blocks of the district, all received the advisories on meteorological parameters while 2123 villages received the same out of 2667 villages of the district. This study aimed at the determination of impact of AAS of DAMU project in the district.

Materials and Methods

For this study, a total of 30 farmers were selected from the purposively selected villages of the district (between 22.60° and 23.50° North and between 85.75° and 86.65° East) and a range of data were collected using semi-structured open-ended questionnaire for recording different impact indicators including the farmers' profile, medium of communication of AAS and the satisfaction level as well as perceived economic benefit accrued due to use of AAS. The frequency and percentages were calculated following standard statistical procedures for the fulfillment of the objective of the study.

Results

The district profile of Purulia with respect to agro-meteorological parameters has been presented in Table 1. The impact of Agromet Advisory Services (AAS) was determined through estimation if the beneficiary and non-beneficiary farmers of the district. Since 2018 upto 2023, Purulia district recorded an increase of 468.1% in the beneficiary farmers, the values for 2019 being 12014 and that of 2023 being 68251. But the non-beneficiary farmers showed an increment of 212.4% during the same period. The major crop of the area was recorded to be rice. Mode of dissemination of the agromet advisories was mostly KVK weather station which created 21 whatsapp groups involving 2401 farmers during the year 2022; similar findings were reported by Ushasri *et al.* (2022). Mostly (100%) sowing, irrigation, harvesting and chemical spraying were the activities on which the decision was taken based on received advisories (Table 2). Whatsapp (96.7%) was the major medium of communication for the advisories while 100% of the farmers reported that the AAS was extremely useful. The satisfaction level of the farmers receiving the AAS was high in case of 96.7% while 3.3% of farmers rated the level at moderate. While 96.7% of beneficiary farmers were male 3.3% being female beneficiary. Around 56.7% of the beneficiary farmers fell under the age group of 36-50 years, majority of them were 12^{th} pass (43.3%). According to land holding, the beneficiary farmers recorded 48.1% under small (1-2 ha) farmer group, while the economic benefit showed that 44.4% had the benefit of Rs. 5000 to Rs. 10000 by receiving the AAS.

Conclusion

It can be concluded from the present study that there is immense importance of AAS of DAMU project in rice growing rainfed farming system of Red and Lateritic Zone of Purulia district of West Bengal. Farmers receiving the ASS were highly satisfied and they took decisions related to important farming operations based on the AAS. Farmers also found the AAS extremely useful for improvement of their livelihood indicated through the accrued economic benefit resulted from the use of AAS.

Table 1. District Agromet Profile of Purulia, West Bengal

Sl. No.	Parameters	Values
1	Total no. of blocks	20
2	Blocks receiving AAS	20
3	Total no. of villages	2667
4	Villages receiving AAS	2123
5	Agro-climatic Zone	Red and Lateritic zone
6	Soil type	Red and Laterite
7	Climatic vulnerability	Erratic rainfall, heat wave, drought, cold wave
8	Maximum Temperature	44.6 ^oC
9	Minimum Temperature	7.7 ^oC
10	Annual Rainfall	1191 mm

Table 2. Usefulness and related parameters of AAS in Purulia district

Sl. No.	Parameters	Values
1	Major crop	Rice
2	Farming system	Mostly rainfed (83.3%)
3	Land holding	Marginal (50%), Small (36.7%)
4	Age group	Mostly between 36 and 50 years (56.7%)
5	Gender	96.7% male
6	Education	66.7% upto 12^{th} standard
7	Weather event most important for farming operation	Normal rainfall (96.7%)
8	Whether farmers are receiving AAS	Yes (100%)
9	Farming operations for which the decision taken based on AAS	Sowing, irrigation, chemical spraying and harvesting (100%)
10	Satisfaction level of farmers with AAS	96.7% highly satisfied, 3.3% moderately satisfied
11	Economic benefit due to the AAS	Upto Rs. 15000 (76.7%)
12	Mode of dissemination of AAS	Mostly KVK/Weather Station (86.7%)
13	Medium of dissemination of AAS	Mostly whatsapp (96.7%)
14	Usefulness of AAS	100% extremely useful

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Performance of Zero Tillage Demonstration a Climate resilient Practice in Bihar

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At present, conservation agriculture (CA) constitutes a set of principles and practices that maintain soil structure and fertility while improving yield and profits (El-Shater *et al*., 2020) and is promoted by the United Nations Food and Agriculture Organization (FAO) and various other international development organizations. Zero tillage (ZT) involves field preparation with minimal soil disturbance, often by directly planting seeds in residues retained from the previous crop harvest (Kassam *et al*., 2009; Chabert and Sarthou, 2020). While ZT is widely adopted in many developed countries, its implementation is limited in developing nations, even though it has been shown to have advantages over conventional practices (Stewart *et al.,* 2008; Krishna *et al.,* 2022). While ZT use is increasing in many agricultural systems worldwide, there is a lack of knowledge regarding the scale of its adoption at the regional and national levels (Krishna *et al.,* 2022). This gap is especially pronounced in smallholder farming systems like those in India, where information about tillage practices is often unavailable through ground or census data (Jat *et al.,* 2020). Conservation agriculture is an important tool that help small farmers to save time, energy and inputs cost.

An essential part of conservation agriculture, zero tillage has the potential to significantly reduce emissions from burning residue, improve soil organic carbon and water retention, lower the cost of land preparation, and boost the farming system's long-term production and profitability (Deshpande, *et.al.* 2024). The implementation of zero-tillage technology has significantly improved the standard of living for farm households, increase in annual per capita various crop consumption. This adoption practice can be supported by economic and food security, as well as biophysical and environmental advantages by Singh *et al*. 2016.

Because zero tillage technology eliminates the need for recurrent tillage for field preparation and sowing, it lowers cultivation costs and allows for planting 10–15 days earlier than previously possible (. An adaptation to prevent terminal heat stress is an earlier sowing date. Following rice harvest, zero-tillage involves utilizing a zero-tillage drill or happy-seeder to drill wheat directly onto paddy fields without ploughing. Keeping above facts in view performance of the ZT has been evaluated in 9 districts of Bihar in four major crops paddy, wheat, lentil and green gram with the objective to save the time and yield loss due to heat stress. The study has been conducted by 09 KVKs namely Bhagalpur, Darbhanga, Lakhisarai, Saharsa, West Champaran1, Sitamarhi, Siwan, Buxar and Nalanda under the TDC the NICRA programme in the NICRA adopted villages.

Performance of Zero Tillage in various field crop

Name of KVKs	Name of the crops	No. of farmers	Area (ha)	Output (q/ha)	Economics (Rs. /ha)		
					Gross Cost	Net Return	BCR
Bhagalpur	Wheat	27	10.00	41.40	38420	45421	1.18
Darbhanga		36	12.21	32.00	24980	50400	2.01
Lakhisarai		71	24.00	33.83	31500	41160	2.31
Nalanda		41	16.40	50.50	28270	60257	2.13
Saharsa		40	16.00	34.60	36515	37265	1.02
Sitamarhi		35	7.00	37.60	32504	37060	2.14
Siwan		15	4.00	39.16	30879	56507	1.83
West Champaran I		12	8.00	42.50	26200	58800	2.24
Buxar		45	21.00	40.00	42600	48400	1.13
	Sub Total/Av.	322	118.61	39.07	40763	49474	2.19
Bhagalpur	Paddy	27	10.00	47.35	42000	56000	1.33
Darbhanga		31	10.51	53.15	34680	65670	1.89
Siwan		20	6.00	48.00	32750	63250	1.93
	Total/Average	78	26.51	49.50	36477	61640	1.71
Bhagalpur	Lentil	21	12.00	12.30	68880	47880	3.28
Darbhanga		25	6.06	11.42	26840	48737	1.81
Nalanda		22	4.40	14.60	24730	65000	3.24
	Sub Total/Av.	68	22.46	12.77	40150	53872	2.78
Bhagalpur	Green gram	24	12.00	11.40	88407	59407	3.04
Darbhanga		122	33.19	4.57	16300	28865	1.77
Sitamarhi		25	6.00	8.60	17300	44620	3.57
	Sub Total/Av.	171	51.19	8.19	40669	44297	2.79
Grand Total		639	218.77	--	--	--	--

In this study altogether 218.77 hectares area was covered involving 639 farmers. Among these, under wheat 118.61 ha area and 322 farmers; in paddy 26.51ha involving 77 farmers, in lentil crop 22.46 ha involving 68 farmers and under green gram 51.19 ha area involving 171 farmers. Result revealed that in zero tillage demonstration yield of paddy ranged 47.35 to 53.15q/ha in NICRA adopted village of Bhagalpur and Darbhanga respectively, with average yield of 49.50q/ha. In case of wheat yield ranged between 32.0- 50.50q/ha in Darbhanga and Nalanda KVKs respectively with average yield of 39.07q/ha. Grain yield for lentil ranged between 11.42 to 14.60q/ha in Darbhanga and Nalanda respectively with average yield of 12.77q/ha. However, in case of green gram grain yield ranged between 4.57 to 11.40q/ha in Darbhanga and Bhagalpur with average yield of 8.19q/ha. The maximum B:C ratio in paddy was 1.93, in wheat 2.31; in lentil 3.28 and in green gram 3.57 was recorded with average 1.71, 2.19, 2.78 and 2.79 respectively. The success of zero tillage in Bihar farmers condition are based on the creation of viable, dynamic innovation systems, building on a successful and sustainable business model by creating custom hiring centre in each NICRA adopted village. Zero tillage is financially attractive to farmers and thereby has created farmers demand and findings are in agreement with the findings of Singh, 1997 in his adoption surveys reveal that 60 percent of zero-tillage adopters did not had own a zero-tillage drill machine.

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Impact of CRA Program on the Productivity of Different Crops in the Bhagalpur District

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In Bhagalpur district, different type of cropping systems are practiced, among all the systems rice-wheat (RW) cropping sequence is most prominent followed by rice-maize (RM) and rice-mustard before CRA program. The existing cropping sequences in North Bihar (NB) have resulted in low productivity, profitability and degradation of environmental, water, and soil degradation, endangering sustainability. A comprehensive three-year study of CRA program was carried out at the five adopted village i.e., Kasimpur, Tarchha, Sakrama, Laungain and Damuchak of Bhagalpur district. CRA program was implemented since 2019 by adopting various intervention i.e., direct seeded rice (DSR), zero tillage in wheat (ZTW), raised bed in maize (RBM) and zero tillage in lentil and mustard (ZTL and ZTM). The maximum productivity and net return of RBM and ZTL was >40% but slightly less benefit i.e., only 10-15% higher yield and economics was noticed in rice cultivation with respect to existing one. After adopting the CRA intervention in the adopted village that omits 12-23% in cultivation cost of DSR, ZTW, RBM, ZTL and ZTM. This program also improved the cropping intensity of Bhagalpur district from 202% to 261% during pre CRA and post CRA respectively. CRA intervention augments the productivity of cereals, pulse and oilseeds crops, enrich the nutrient status of soil (N, P, K, Organic Carbon etc.) as well as 26% water saving was reported under CRA programme.

UID: 1477

Enhancing Climate Resilience through Zero Tillage Practices in North Bihar: Evidence from Large-Scale Demonstrations

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Climate-resilient agricultural practices are essential for enhancing productivity, sustainability, and livelihoods in rainfed agro-ecosystems. Zero tillage, as a resource-conserving technology, has shown potential to mitigate climate change impacts by reducing soil disturbance, conserving soil moisture, and lowering production costs. This study presents findings from large-scale demonstrations of zero tillage practices in major crops focusing on wheat, lentil, mustard, and mung bean, implemented across thousands of acres in multiple districts of Bihar.

Methdology

Demonstrations were conducted on farmers' fields across varying agro-climatic conditions. Data on yield, cost-effectiveness, and resource use efficiency were collected and analyzed for zero tillage and conventional tillage systems. Key indicators included yield performance (average, maximum, and minimum), input costs (seed rate, labor, intercultural operations, and irrigation), and qualitative observations on soil health and climate resilience.

Results

Zero tillage practices across various Rabi and summer crops demonstrated substantial improvements in yield, cost-efficiency, and climate resilience compared to conventional tillage systems. In wheat, an area of 3655 acres involving 3668 demonstrations recorded a 16.59% higher average yield (44.72 q/ha) under zero tillage compared to conventional tillage (38.50 q/ha), with yields ranging from 34.48 to 53.09 q/ha. This practice also reduced input costs, including seed rate, labor, and irrigation, making it more resource-efficient and economically viable. Similarly, zero tillage lentil cultivation across 550 acres with 919 demonstrations achieved a 24.68% increase in yield (13.05 q/ha) over conventional tillage (10.45 q/ha), with yields varying between 10.25 and 16.02 q/ha. In mustard, an area of 312 acres encompassing 469 demonstrations reported a 29.65% higher yield (13.24 q/ha) compared to conventional methods (10.35 q/ha), affirming the scalability of this practice. For mung bean during summer, demonstrations covered 2475 acres with the IPM-205-7 (Virat) variety, yielding 10.63 q/ha on average, a 31.56% improvement over conventional tillage (8.08 q/ha). The practice also facilitated the incorporation of green manure into the field after harvest, supplying additional nitrogen for succeeding Kharif crops, with yields ranging from 8.06 to 13.50 q/ha. These findings collectively underscore the agronomic and economic benefits of zero tillage, enhancing soil fertility and promoting sustainable agricultural practices in rainfed agro-ecosystems.

Improving Soil Health through Zero Tillage Based on Energy and Carbon Parameters

Zero tillage is an innovative agricultural practice that eliminates soil tillage, leading to significant benefits in fuel consumption and greenhouse gas emissions. Below is an analysis of its impact using data from before and after interventions across a 1410-hectare area.

Energy Smart: Fuel Consumption (Diesel)

- Before Interventions: The total diesel consumption was 253,729.5 liters, with a rate of 179.95 liters per hectare.
- After Interventions: The total diesel consumption reduced drastically to 84,600 liters, with a reduced rate of 60 liters per hectare.
- Impact: Zero tillage led to a 66.6% reduction in total diesel consumption, demonstrating significant energy savings.

Carbon Smart: Greenhouse Gas Emissions

- Before Interventions: Total emissions were 679,972.50 kg, with a rate of 482.25 kg per hectare.
- After Interventions: Emissions decreased to 226,728 kg, with a rate of 160.8 kg per hectare.
- Impact: Zero tillage resulted in a 66.6% reduction in total emissions, significantly contributing to climate-smart farming practices.

Conclusions

Zero tillage practices in Rabi cropping systems have demonstrated significant yield advantages and cost efficiencies over conventional tillage. These interventions reduced diesel consumption and greenhouse gas emissions by over two-thirds, making it an environmentally and energy-efficient practice. These reductions not only lower the cost of production but also enhance sustainability by minimizing the carbon footprint of agricultural activities. Scaling up these practices in rainfed regions can build resilient agro-ecosystems, sustain livelihoods, and promote sustainable agriculture.

Recommendations

To maximize the benefits of zero tillage practices, it is imperative to:

- Strengthen extension services and capacity building among farmers.
- Invest in zero tillage equipment and support mechanization.
- Integrate zero tillage with complementary practices like crop diversification and precision nutrient management.

UID: 1513

Evaluating Frontline Demonstrations for Yield and Economic Enhancement of Cumin GC-4 in Western Rajasthan

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The Indian government has introduced numerous initiatives aimed at enhancing agricultural production and boosting the income of the farming community. However, the results have often fallen short, with limited success in achieving significant improvements in agricultural output (Singh and Singh, 2004). A key reason identified for this underperformance is the farmers' inadequate understanding of the technological recommendations provided by research institutions. It is widely recognized that farmer training plays a crucial role in improving technical efficiency.

In light of this, institutions like ICAR, State Agricultural Universities (SAUs), and State Departments of Agriculture have intensified their focus on farmer training programs. In the districts of Nagaur and Jodhpur, where cumin is widely cultivated due to its low water requirement, farmers face challenges such as low yields resulting from the use of outdated seed varieties and insufficient knowledge of scientific cultivation practices.

To address this issue, Krishi Vigyan Kendra (KVK), Nagaur, has implemented extensive training programs, both on-campus and off-campus, to empower farmers and farm women with the necessary skills and knowledge. Furthermore, a significant number of farmers in NICRA-adopted villages were included in front-line demonstrations to showcase best practices in cumin cultivation.

This study aims to evaluate the impact of these training programs and other extension activities undertaken by KVK. Specifically, it seeks to assess farmers' knowledge and adoption levels of the recommended package of practices under front-line demonstrations and to analyze the yield gap in cumin production.

Materials and Methods

The present study was carried out by the Krishi Vigyan Kenra, Athiyasan, Nagaur under Agriculture University, Jodhpur under Centrally Sponsored Schemes- National Innovation Climate Resilient Agriculture (NICRA) project of Directorate of Central Research Institute of Dryland Agriculture (CRIDA) Hyderabad, during rabi season from 2022-23 to 2023-24 (2 years) in the farmers' fields of villages Deshwal of Nagaur district of Rajasthan. In total 40 frontline demonstrations in 16 ha area in adopted villages were conducted. Materials for the present study with respect to FLDs and farmers' practices are given in Table 1. In case of local check plots, existing practices being used by farmers were followed. In general, soils of the area under study were sandy loam to clay loam, low in fertility status. The FLDs were conducted to study the gaps between the potential yield and demonstration yield, extension gap and technology index. In the present evaluation study, the data on output of cumin cultivation were collected from FLD plots, besides the data on local practices commonly adopted by the farmers of this region were also collected. In demonstration plots, a few critical inputs in the form of quality seed, balanced fertilizers, agro-chemicals etc. were provided and non-monetary inputs like timely sowing in lines and timely weeding were also performed whereas, traditional practices were maintained in case of local checks. The demonstration farmers were facilitated by KVK scientists in performing field operations like sowing, spraying, weeding, harvesting etc. during the course of training and visits. The technologies demonstrated are mentioned in Table 1 and compared with local practices. From village 30 farmers were selected thus, making a total sample size of 30 farmers. The data were collected through personal interview by designing a questionnaire. The data were collected, tabulated and analysed by using statistical tools like frequency and percentage.

Results and Discussion

To assess the effectiveness of training programs on farmers' knowledge of cumin cultivation practices, the data were analyzed in pre-training and post-training phases (Table 2). Before the training, a majority of farmers (70%) had low knowledge levels, with 16% falling into the medium category and only 13% demonstrating high knowledge. Post-training, the transformation was remarkable—low knowledge levels dropped to just 10%, medium levels remained at 10%, and an impressive 73% of farmers achieved high knowledge. These results underscore the significant impact of KVK programs, both on-campus and off-campus, in empowering farmers with the expertise needed to excel in cumin cultivation.

The extension gap, technology gap and the technology index were worked out as per formulae given by the Samui *et al.* (2000).

Technology gap = Potential yield - Demonstration yield

Extension gap = Demonstration yield - yield under existing practice

Technology index = {(Potential yield - Demonstration yield)/Potential yield} x 100

The practices followed under the front-line demonstration (FLD) and farmers' practices are given in Table 1.

Table 1. Particulars showing the details of cumin cultivation practices under FLD and existing practices

SI. No.	Operation	Existing Practice	Improved practices demonstrated
1.	Use of quality seed	Local seed	GC 4 an improved variety from SDAU, Gujarat
2.	Seed treatment	None	Fungicide Carbendazim @ 2gm/kg
3.	Sowing method	Broadcasting	Line sowing by tractor operated seed drill Followed by thinning at 30 DAS
4.	Fertilizer Application	20:0:0 (Kg. N:P:K/ha)	30:20:15 (Kg N:P:K \ha)
5.	Weed control	Two hand weeding	Oxadiargyl 6% EC @50 gm a.i. per ha. at 20 DAS followed by one hand weeding at 45 DAS
6.	Control of cumin aphid	No any control measure	One spray of Thiamethoxam, 25 WG @ 100 gm dissolving in 500 litters of water/ha followed by one spray of Acephate, 75 WP @ One Kg dissolving in 500 litters of water/ha, respectively at 15 days interval.
7.	Control of powdery mildew and blight disease	Spray with Mancozeb 75WP @ 2 gm/liter water	For control of blight disease two sprays with Mancozeb 75WP @ 2 gm/litter water, one spray of Matiram 55% + Pyraclostrobin 5% @ 3.5gm/ litter of water and for control of powdery mildew, one spray of wettable sulphur 80% @ Two Kg/ha.

An analysis of the data (Table 3) revealed a compelling outcome: the demonstration of advanced production technologies significantly boosted adoption levels, reaffirming the adage, *"Seeing is believing"*. While numerous factors influence the adoption of farming practices, the economic factor stands out as the most decisive. Observations from front-line demonstrations (FLDs) highlighted that while farmers utilized all necessary inputs on their plots, they often deviated from recommended practices in terms of application methods, dosage, or timing. Instead, many relied on advice from fellow farmers, leading to suboptimal results.

The implementation of FLD programs emerged as a vital initiative by KVK, bridging this gap and driving increased adoption of demonstrated technologies. The data exhibited a remarkable transformation: the percentage of farmers with low adoption levels dropped from 70.0% to an impressive 73.0% post-training. Additionally, the overall knowledge and adoption levels of farmers regarding cumin cultivation practices surged to 70.0% and 76.0%, respectively, after participating in training programs at KVK, Nagaur-I.

These outcomes underscore the critical role of hands-on demonstrations in empowering farmers and fostering the adoption of best practices in agriculture.

Table 2. Change in knowledge level of farmers before and after training

Sl No	Knowledge level	Pre-training	Post training
1.	Low	70	10
2.	medium	16	10
3.	High	13	73

Table 3. Change in adoption level of scientific cultivation of cumin

Sl No	Category	Before training (%)	After training (%)
1.	Low level of adoption	70	06
2.	Medium level of adoption	23	16
3.	High level of adoption	04	76

Yield Gap Analysis of Cumin Cultivation

Frontline demonstrations (FLDs) conducted during the *rabi* seasons of 2022-23 and 2023-24 across 12 hectares in the Deshwal village of Nagaur district have delivered remarkable results. The demonstrations showed advanced cumin cultivation practices, including the use of improved variety GC 4, line sowing, balanced fertilizer application (N:P:K @ 30:20:15 kg/ha^{-1}), and effective pest and disease management using insecticides and fungicides at economic threshold levels. These practices resulted in a significant 22.55% average yield increase compared to traditional methods (Fig. 1).

A closer analysis revealed that cumin yields increased by 25.68% in 2022-23 and 19.42% in 2023-24 when compared to farmers' conventional practices. Year-to-year variations in yield and cultivation costs were influenced by social, economic, and microclimatic conditions specific to the village, highlighting the dynamic nature of agricultural production.

These findings align with earlier studies by Mukherjee (2003), Haque (2000), Tiwari and Saxena (2001), and others, which emphasize the importance of tailored interventions for enhancing system productivity. The impact of FLDs in promoting scientific practices has been widely documented and proven effective in various contexts.

Moreover, the successive yield improvements over the years underscore the positive influence of FLDs on the farming community of Nagaur. Farmers were inspired to adopt modern agricultural technologies, as evidenced by the significant outcomes observed in the demonstration plots. This success story highlights the transformative potential of FLDs in fostering innovation and improving productivity in cumin cultivation (Table 5).

From the first year onwards, farmers enthusiastically participated in the Front Line Demonstrations (FLDs), leading to increasingly promising outcomes in subsequent years. The adoption of advanced production technologies and high-yielding varieties has shown the potential to reverse the alarming trend of the widening extension gap. With the gradual discontinuation of outdated varieties in favor of innovative practices, this gap is expected to narrow significantly.

During the study period, the average extension gap was recorded at 1.62q/ha. These findings highlight the pressing need to educate farmers through tailored programs and initiatives, encouraging the adoption of improved agricultural technologies. The observed technology gap, attributed to variations in soil fertility, farming practices, local climate, rainfed conditions, and timely input availability, highlights the importance of variety-specific and location-based recommendations to bridge this gap effectively. As noted by Sagar and Chandra (2004), a lower technology index reflects greater feasibility of the demonstrated technology.

The economic analysis of yield performance further bolstered the case for FLDs. Demonstration plots consistently achieved higher cost-benefit ratios compared to control plots, with ratios of 6.68 and 5.58 in 2022-23, and 5.34 and 4.63 in 2023-24, respectively. These favorable cost-benefit ratios confirmed the economic viability of the interventions and successfully convinced farmers of their value. Similar results were observed in other crops, as reported by Haque (2000) in rice, Sharma (2003) in moth bean, and Singh and Meena (2011),Jaitawat (2006)in cumin, ,Dubey*et al.,*(2010) in black gram.

Ultimately, the FLDs demonstrated substantial positive results, providing researchers with an invaluable platform to show the productivity potential and profitability of scientific management under real-world farming conditions. This success story not only highlights the transformative power of FLDs but also emphasizes their role in driving sustainable agricultural development.

Conclusion

The results and discussions clearly illustrate that the knowledge and adoption levels of farmers have significantly improved through targeted training and Front Line Demonstrations (FLDs) conducted by KVK scientists. Acting as a knowledge hub for advanced agricultural technologies in Rajasthan's Agro-climatic Zone IA, the KVK has been instrumental in transforming farming practices in the region.The FLDs on cumin conducted in the farmers' fields of Deshwal village, Nagaur district, demonstrated the potential for significant yield and quality improvements when farmers follow the recommended package of practices. These productivity gains not only highlighted the effectiveness of scientific crop management but also inspired neighbouring farmers to adopt high-yielding cumin varieties and modern agricultural methods.The findings emphasize the importance of intensifying training programs, expanding FLDs, and leveraging extension education tools to educate cumin growers. These efforts can drive higher productivity and ensure sustainable increases in net returns for farmers.In conclusion, timely and well-structured FLDs, conducted under the expert guidance of KVK scientists, have emerged as powerful extension tools. They effectively showcase newly developed crop production and protection technologies and their management practices in real-world farming scenarios across diverse agro-climatic conditions. By motivating farmers to embrace improved agricultural technologies, these initiatives are not only enhancing yields and profitability but also contributing to sustainable agricultural development. Through such dedicated efforts, KVK continues to empower farmers, fostering a brighter future for agriculture in the region.

Table 5. Exploitable productivity, technology gaps, technology index, extension gaps and cost benefit ratio of cumin as grown under FLD and existing package of practices

Year	Area (ha)	No. of FLDs	Increase over existing practices	Extension gap (q/ha)	Technological gap (q/ha)	Technology index (%)	Cost benefit ratio	
							FLD	Existing practice
2022-23	8	20	25.68	1.71	1.79	17.04	6.68	5.58
2023-24	4	10	19.42	1.51	1.2	11.42	5.34	4.63

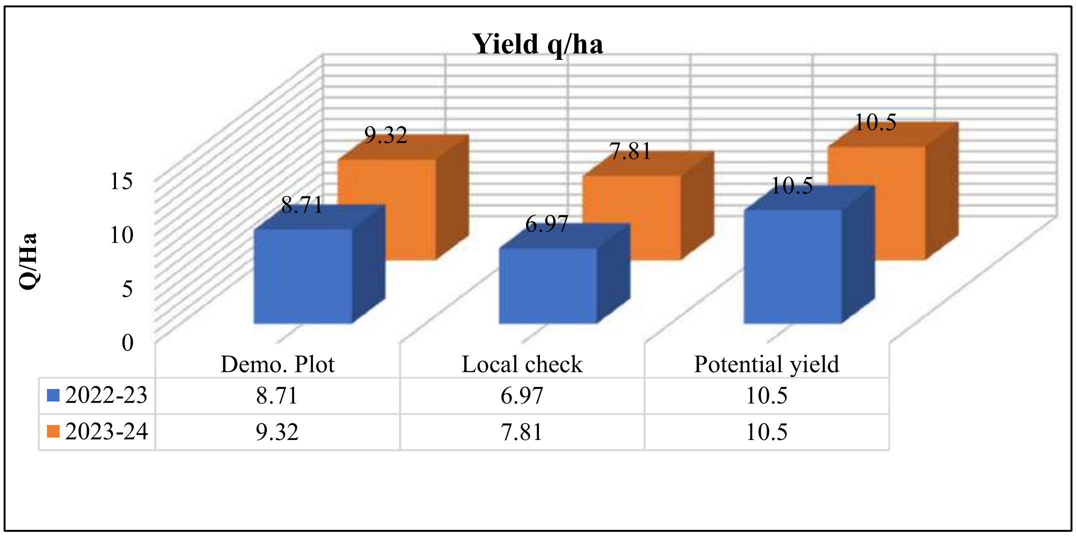

Fig 1. Yield of cumin during two consecutive years (Rabi 2022-23 and Rabi 2023-24)

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Economic Analysis of Zero Tillage (ZT) and Direct Seeded Rice (DSR) Technologies in Bihar

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In Bihar, Conservation Agriculture (CA) program has been initiated to cope up the risk of changing climate and impact of climate change on the agricultural sustainability. Among all the CA technologies, the study primarily focusses on Zero Tillage (ZT) wheat, maize and Direct Seeded Rice (DSR) technology adopted by different categories of sample farmers in Purnea district of Bihar. The study was carried out using simple random sampling without replacement technique on 150 farmers of Bihar with the primary objective were to examine the level of technology adoption, compare the profitability of conservation agriculture using CACP Cost Concept and factors affecting adoption of technology using Logistic Regression model. It was observed that about 43 per cent of farmers adopted ZT and DSR technology, with the lowest adoption rates among marginal and small farmers, followed by semi-medium farmers. Due to lower explicit cultivation costs (hired labour, irrigation, seeds, etc.), conservation agriculture adopters on average earned 47 paisa more than conventional farmers over each rupee invested in paddy. This was because DSR technology reduced average total costs by 18 per cent in paddy as compared to conventional method of cultivation. While in case of ZT wheat and ZT maize the adopter farmers earned 32 percent and 26 per cent more than the non-adopter farmers. Although the technologies are resource and cost efficient, the farmers are not adopting the technology as they possess small and fragmented land holding and most of the farmers did not have knowledge and training. The adopters were convinced that the technology is labour saving, reduces input resources and enhances the profitability. It also reduces drudgery for both male and female farmers. While on the other side the farmers also faced constraints in adopting the technologies such as higher weed infestation, unavailability of machinery at time as well as lack of technical knowhow. Peer influence, monitoring and evaluation, and farmer-to-farmer learning may also play significant role in promoting uptake and guaranteeing the long-term sustainability of CA practices.

UID: 1550

Technological Interventions for Mitigating Climate Risks in NICRA Villages in the Districts of Srikakulam

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Global climate change causes for variation in rainfall and in the rainfed areas which affect the availability of moisture on the surface, which was most important for germination of the seed and withstand of the crop. To stabilize farm income and crop yield ,farmers should adopt quickly due to change in climate variability and increasing frequency of floods and other events. In order to overcome this challenge, by applying science and technology, National Innovations in Climate Resilient Agriculture (NICRA) is a national project has been working since 2011.There was a great opportunity to work with farmers, for application of technologies under field conditions and On-farm trials and method demonstrations for climate resilience under Technology Demonstration Component (TDC) which were implemented in villages under NICRA through KVK, Aamadalavalasa. Some of the existed technologies brought nearby marginal, small farmers and to develop newly required technologies to meet the demands of the climate change like flood tolerant paddy varieties under the NICRA programme. Due to heavy rains flood inundation occurs in the field. So that crop was damaged and causes for easily attack of pest and diseases. The adaptation of good management practices in paddy fields provide best results such as selection of flood tolerant paddy varieties also implementation of various modules like Natural resource management activities, crop management practices, nutritional garden and under institutional intervention, introduction of new varieties in fodder cultivation and livestock production to provide additional income due to climate variability. From its bigining to mitigate the climate change NICRA project supported and developed a wide ranging technologies. Increased climate risk requires more resilient technologies, infra structure and also new agricultural practices.

Methodology

Programme was implemented by Programme Coordinator of KVK, Amadalavalasa. The farmers in each selected village were stratified based on size into: marginal farmers (less than 1 ha), small farmers (one to two ha), medium farmers (two-four ha), Large farmers (>4). The farmers for this study were selected based on stratified random sampling representing 10% of population in each category. The training on production skills of different crops were imparted to the participants before conducting demonstrations. The study was conducted at

Kondavalasa, Isukalapalem villages (Sarubujjili mandal); Sirusuwada (kotturu mandal) and Ponnam (Srikakulam mandal) comes under Srikakulam district, North coast Agroclimatic zone. The four villages were purposively selected for the study with sample size 75 farmers under NICRA project. The main crops were growing viz. Paddy, Cotton, Green Gram, Black gram, Maize in this villages. Project is working on six modules to address the climate vulnerability through suitable intervention in NICRA villages.

1. Introduction of flood tolerant varieties.
2. Promotion of mechanization through custom hiring centre
3. Introduction of marigold, red gram on field bunds
4. Upscaling of nutritional garden
5. Natural Resource Management
6. Upscaling of Zero Tillage Miaze

Results

Introduction of flood tolerant Paddy varieties: Under the Srikakulam district, for paddy cultivation in rainfed environment, flood is the problematic abiotic stress among extreme weather events. Another major constraint due to flash flooding In rainfed lowland areas leading to submergence of rice seedlings for 10–15 days (Toojinda *et al.,* 2003; Vishnuvardhan Reddy. A *et al*., 2015). Majority of the paddy varieties unable to survive for complete submergence behind one week such as BPT-5204, Swarna, MTU-1001, and MTU 1318.The results indicated that the improved varieties MTU-1061 and MTU -1064 were found tolerant to submergence. MTU-1061 (Indra) a fine grain variety can tolerate inundation up to 10 days and was found to have higher tolerance to submergence than local traditional Swarna variety. Heavy lodging of Swarna variety was noticed due to heavy rains from July to August while MTU-1061 escaped. When compared to the farmers practice Swarna variety, MTU-1061 gave an additional seed yield of 6.7 q/hactare and got net income of 8468 Rs/ha.

Promotion of mechanization through custom hiring centre

Continuous changes occurs from man power to machine power in Agricultural system. The cultivation needs machinery in changing the climate scenario when the high energy efficient, farm tools with high capacity and different machineries become necessary. In present scenario farmers having their own tractor were highly indebted when comparing with the other farmers hire-in tractor and also for required machinery. For that, custom hiring centre brought nearby small farmers to get the benefit from machinery related to agriculture. Agricultural productivity increased by the application of mechanization technology. In the NICRA adopted villages such Custom Hiring Centre has been introduced. Machineries provided to NICRA village farmers like pipes, power sprayers, power weeder, sprinkler irrigation system and others which help the farmers to carry out field operations in particular time and also to overcome the climatic disasters. A committee was formed by the farmers to manage custom hiring centre and the rates implemented by Village climate risk management committee members (VCRMC). For repair, maintaining the implements the funds generated by this committee were used and remaining money is kept for revolving fund and 25% of the revenue goes into the sustainability fund (Prasad *et al* 2014). One bank account was opened under the name of members and it was maintained by signatories.

Table 1. Comparative Economic Analysis of Grain and Fodder Yields per Hectare

Particulars	Yield from the grain (q/ha)	Yield from the fodder (Kg/ha)	Entire cost (Rupees per ha)	Gross income (Rupees per ha)	Net income (Rupees per ha)	Benefit: cost
Farmers	51.5	5756	46000	105060	59060	2.28
Improved varieties	58.2	6460	50200	118728	67528	2.36

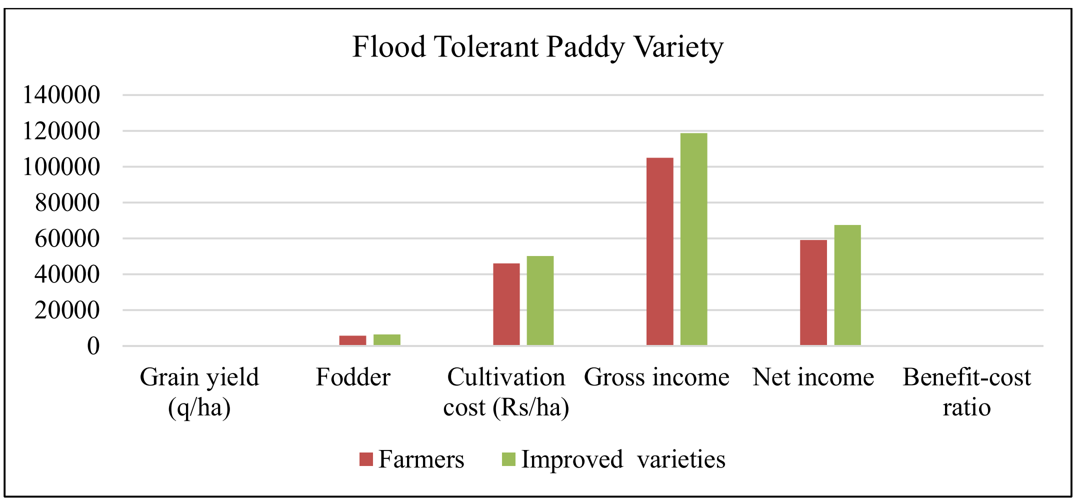

Fig 1. Comparative Economic Analysis of Grain and Fodder Yields per Hectare

Table 2. Crop Demand and Impact of Custom Hiring Center Services on Area and Farmers

Sl. No.	Crops in demand custom hiring center services	Area covered with CHC services (ha)	Number of farmers benefitted
1	Rice	20	40
2	Maize	15	40
3	Sesame	10	20

Introduction of marigold & red gram on field bunds

In rice cultivating areas, large area of the field bunds remain unused and the left spaces is used for cultivating Marigold and Red gram which act as trap crop. Red Gram helps in increasing soil fertility by developing soil physical properties and fix atmospheric nitrogen also important used as feed for human and animal. These two crops provide additional income to the farmers. For that the Marigold seedlings and Red Gram seeds were provided to the NICRA village farmers by conducting training programmes. Regarding Marigold, Cost of cultivation is 3000 Rs, gross returns per acre is 30,000 Rs. with net returns 27,000Rs which was an additional income to the farmer.

Natural Resource Management Activities : The Interventions such as in-situ and ex-situ moisture conserving modules, recycling and water harvesting of rain water used as supplemental irrigation, improving removal of excess water through channels in flooded areas and water storage irrigation methods. Distribution and the amount of rainfall, soil type, slope, texture and depth, mainly the clay type and composition in clay, which highly influence hydraulic conductivity and holding capacity of water mainly impacting run off and soil erosion which are highly used for appropriate selection of water and soil conservation measure (Srinivasrao *et al.,* 2016).During high intensity rains, excess runoff water collected in check dams, farm ponds, recharge pits, percolation tank and wells with recharging structures as rainwater harvesting. The villages under NICRA project are highly flood prone areas for that in sirusuwada village Jagannadha naidu tank was constructed for rainwater harvesting. The harvested water utilized up to 50 ha during summer to cultivate irrigated crops. We can also reduce the flood inundation in the field crops. Field level drainage arrangements in flood prone area helped the farmers up to 25 ha whereas Removal of Eichhornia crassipes in irrigation channels at NICRA villages covered 20 households with an extent of 30 ha.

Upscaling of nutritional garden:

Bio-fortified and Natural vegetables and fruits which have high nutritive value where the selection of species is inclusive of roots, green leafy vegetables , tubers and others is considered as Nutrition gardens. Majorly for consumption purpose in backyard area at household was used to grow vegetables also an alternative way to generate additional income to the farmers. In the NICRA villages to bring awareness among the farmers training programmes conducted and seed kits were supplied to the farmers. A reduction in expenditure for food was also observed per year.

Upscaling of Zero Tillage Maize: The second most significant crop grown in Srikakulam district after paddy is Maize with an extent of 11,000 ha in kharif and 12944 ha in Rabi respectively. It is also predominant crop in NICRA Villages *i.e.,* Isukalapalem, Sirusuvada.

Zero tillage maize ensures the conservation of soil moisture and reduction of labour and effective management of weeds which in turn reduces cost of cultivation. Higher seed yield was recorded at In-situ moisture conservation practice (8750 kgs/ha) while comparing with the farmer practice of maize (8272 kgs/ha). Whereas Higher Benefit:Cost ratio was recorded with zero tillage maize (1:3.96) compared to farmer practice (1:3.26). with an increased income of Rs.128300/-(zero tillage maize) when compared to farmer practice of Rs 112381/-. Net returns increased by 15919 Rs/- per ha.

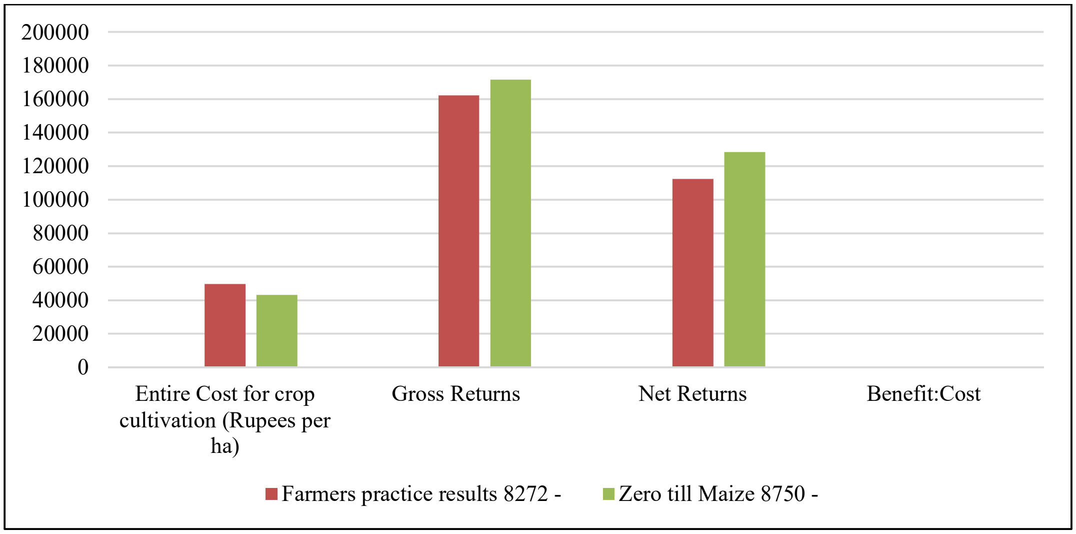

Fig 2. Comparative Analysis of Economic Returns from farmers practices vs. Zero Till Maize

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UID: 1555

Extent of Adoption of Climate-Resilient Agricultural Practices under the NICRA Village

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Climate is changing gradually, at its own pace, since the evolution of earth but presently, it has gained momentum due to unintended manmade disturbances. These changes are having adverse impact on human health and the overall environment on which we depend. As agricultural production is one of the sectors of society most vulnerable to climate variability and change it is important to explore linkages between agricultural ecosystems, uncertain trajectories of future climate, and land use changes over periods of time (Parry and Carter 1989, Meinke *et al*. 2006). Modifications in the surface and groundwater availabilities with the rainfall change are difficult to be observed when the land use and land cover are so rapidly changing (Khan *et al.* 2009). The Technology Demonstration Component (TDC) of NICRA involves on-farm participatory demonstrations in 121 vulnerable districts across India. In Karnataka, Krishi Vignyan Kendras (KVKs) Chintamani in Chikkaballapur district are implementing the NICRA project.. In Chikkaballapur district, the study assesses the impact of NICRA interventions on rural livelihood security, comparing beneficiary and non-beneficiary farmers. The interventions include initiatives such as in-situ moisture conservation, contouring, terracing, rainwater harvesting, livestock promotion, and strengthening institutional support. Understanding the effectiveness of NICRA in enhancing rural livelihood security is crucial for shaping future climate resilient agricultural policies and practices. The study aims to provide insights into the tangible benefits and challenges faced by farmers in the face of climate change, contributing to the broader discourse on sustainable agriculture and climate adaptation strategies.

Methodology

The study, conducted in Hanumaigarahalli and Sunapagutta within Chintamani taluk, Chikkaballapur district, offers a comprehensive assessment of the impact of the National Innovations on Climate Resilient Agriculture (NICRA). Hanumaigarahalli, deliberately chosen as an NICRA implementation site since 2021-22 with the support of Krishi Vignyan Kendra (KVK) Chintamani, served as the focal point for understanding the outcomes of climate-resilient agricultural interventions. In contrast, the neighboring village of Sunapagutta, devoid of NICRA implementation, was selected for comparative analysis. The sample size comprised 60 farmers from Hanumaigarahalli (NICRA beneficiaries) and 30 farmers from Sunapagutta (non beneficiaries), randomly selected to form a total sample size of 90. the study adopted an ex-post facto design, a robust research methodology suitable for evaluating the effects of interventions after their implementation. data collection involved personal interviews, ensuring qualitative insights into the experiences and perceptions of the farmers.

The research design and methodology were meticulously chosen to facilitate a rigorous assessment and comparison of the livelihood security of farmers in nicra beneficiary and non-beneficiary villages. by adopting this scientific approach, the study contributes valuable insights into the efficacy of climate-resilient agricultural practices, offering a basis for informed decision-making in sustainable agricultural development and policy formulation. in this study the climate resilient agricultural practices is operationally defined as recommended practices addressing climate change-related challenges developed by singha and baruah (2011). these practices aim to enable individuals to navigate extreme climatic conditions, promoting stability and sustainability.

Results

Adoption of climate resilient soil and water conservation practices by beneficiaries and non-beneficiaries

The data in the Table below indicated the extent of adoption of climate resilient soil and water conservation practices by beneficiaries and non-beneficiaries. Majority of the beneficiary farmers adopted practices like intercropping system (80.00%), conservation of rainwater by check dams (73.33%) and Agri-horti-silvi pasture system (61.67%). Nearly 50 per cent of the beneficiary farmers adopted green manuring (56.67%) and tank silt application (51.67). With respect to the non- beneficiary farmers, 40 per cent of farmers have adopted tank silt application for fertility enrichment. Further, nearly fifty percent of nonbeneficiaries have adopted intercropping system and majority of farming practices are less than fifty percent adopted like practices like Conservation of rainwater by Check dams (43.3%), Agri-horti-silvi pasture system (36.7%), Green manuring (23.30%).

The NICRA project tackles all aspects of development of dry zone area in a holistic approach coming within ridgeline. In the first instance, soil and water conservation structures and practices were taken up on free of cost. three check dams, De silting and tank silt application to the beneficiaries farm fields which helped the beneficiaries in storage of rainwater, which can used for cultivation purpose. This has maximized the rainwater storage and conservation of soil and water by preventing the soil erosion and water run- off. It is important to note that more than eighty per cent of the beneficiary farmers have adopted water saving techniques like drip irrigation in horticulture crops. These practices were not adopted or less adopted by non-beneficiary farmers due to low extension efforts in the non-NICRA village and high cost of establishment of those structures. There was neither an incentive nor educational efforts to promote soil and water conservation practices in the non-NICRA village. Hence, a distinct difference was observed between beneficiaries and non-beneficiaries. The findings are similar to the findings of Narayana Gowda (1992) & Wezel *et al*. (2014).

Table 1. Adoption of climate resilient soil and water conservation practices by beneficiaries and non-beneficiaries N=90

Sl. No	Practices	Beneficiaries (n_1=60) Non						Beneficiaries (n_2=30)					
		Full adoption		Partial adoption		Non adoption		Full adoption		Partial adoption		Non adoption	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1.	Conservation of rainwater by Check dams	44	73.33	10	16.67	6	10.00	13	43.3	7	23.3	10	33.3
2.	Intercropping system	48	80.00	8	13.33	4	6.67	17	56.7	5	16.7	8	26.7
3.	Agri-horti-silvi pasture system	37	61.67	12	20.00	11	18.33	11	36.7	9	30.0	10	33.3
4.	Green manuring	34	56.67	14	23.33	12	20.00	7	23.3	12	40.0	11	36.7
5.	Tank silt application to farmers field	31	51.67	15	25.00	14	23.33	5	16.7	13	43.3	12	40.0

Adoption of climate resilient crop production practices by beneficiaries and non-beneficiaries

The study indicated that using latest high yielding varieties (81.67%) were fully adopted, application of micro nutrients like vegetable special and mango special (71.67%), redgram based intercropping system has followed in NICRA village (70%), crop diversification (66.67%) and planting tree species like Mango, Cashew, Tamarind, coconut by the beneficiary farmers. The horticulture-based interventions have the potentiality to increase farm and family income among farmers and bring about positive changes in the socio-economic and nutritional condition (Patel *et al.,* 2023). With respect to nearly fifty percent of the non-beneficiary farmers have adopted recent high yielding varieties, intercropping system (43.30%), crop diversification (40%) and only one third of non-beneficiaries are used application of micro-nutrients (30%) and adopted Planting tree species like Mango, Cashew, Tamarind, coconut (36.7%) Dhaka *et al.* (2010), Shanker *et al*. (2013) and Gopal *et al*. (2014) reported that more awareness and adoption of climate resilient technologies like intensification of multitier cropping, intercropping, rotation, substitution by crop diversification, changing planting dates, drought resistant crops by the farmers due to frequent fluctuation in rainfall pattern to mitigate changing climate.

Adoption of climate resilient fodder and animal health practices by beneficiaries and non-beneficiaries

The Table below revealed the extent of adoption of climate resilient fodder and animal health management practices by beneficiaries and non-beneficiaries. NICRA beneficiaries have adopted health management interventions (78.33%) and two- third of them established multi-cut fodder sorghum (66.67%), Establishment of fodder bank (73.33%) and nearly fifty per cent of farmers adopted silage making and mineral mixture to dairy animals Whereas none of the non-beneficiary farmers have adopted animal health camps (60%) and established fodder bank (56.7%). Less adoption in multi cut fodder (33.3%) and silage making (23.3%) in non NICRA villages. The adoption of fodder demonstration plots as well as the fodder banks by beneficiaries is mainly due to the efforts of Krishi Vigynan Kendra in the adopted village. KVK has conducted intensive educational activities along with the demonstrations that resulted in higher fodder yield and milk yield. The findings are similar to that of findings of Mani (2016)

Table 2. Adoption of Climate Resilient fodder and animal health practices by beneficiaries and non-beneficiaries N=90

Sl. No	Practices	Beneficiaries (n_1=60) Non						Beneficiaries (n_2=30)					
		Full adoption		Partial adoption		Non adoption		Full adoption		Partial adoption		Non adoption	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1.	Multicut fodder sorghum	40	66.67	11	18.33	9	15.00	10	33.3	7	23.3	11	36.7
2.	Establishment of fodder bank	44	73.33	13	21.67	3	5.00	17	56.7	9	30.0	4	13.3
3.	Animal health camps (deworming, Vaccination)	47	78.33	10	16.67	3	5.00	18	60.0	7	23.3	9	30.0
4.	Silage making, mineral mixture	33	55.00	10	16.67	17	28.33	7	23.3	9	30.0	14	46.7

Demonstration of green fodder round the year was conducted on farmer field. Further mineral mixture, deworming and vaccination were conducted during animal treatment camp. The milk production in village has increased by 20- 25 percent due to adaption of this intervention. Due to urea treatment protein content of fodder was increased from 0.5 to 4.5 percent. This finding was in line with finding of Jasna *et al*. (2014).

Conclusion

The study reveals a stark contrast in the adoption of climate resilient practices between NICRA beneficiaries and non-beneficiaries. NICRA has significantly influenced soil and water conservation, crop production, and fodder and animal health practices, leading to higher productivity among beneficiaries. The findings underscore the importance of targeted interventions and extension efforts in promoting sustainable agricultural practices. NICRA's holistic approach has not only enhanced climate resilience but also improved the livelihoods of farmers in the study area. These results contribute to the broader understanding of the effectiveness of climate-resilient agricultural interventions in addressing the challenges posed by climate change.

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Jal Kund-a Farmer-Friendly, Low-Cost and Sustainable Resource Conservation Technology in the Hills

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The state of Manipur is at present witnessing a scenario of acute climate change, and is dealing with one of the biggest environmental threats which is having adverse effects on the natural resources and could adversely affect food production and security, availability of water supply, biodiversity of forests and other natural ecosystems, human health and settlements. Chandel is the aspirational district of Manipur, India, which has immensely borne the brunt of climate change. The challenge is more visible wherever the local stakeholders' livelihoods are vulnerable and dependent directly or indirectly on natural resources. In these vulnerable areas, acceptance of resource conservation technologies is of prime importance for ensuring sustainable farm income and for sustainable tribal development. The district is characterized by intense precipitation with more than 1500 mm total rainfall during 2023 and erratic distribution pattern with 3 and 2 numbers of long dry spells of 31 days and above during 2022 and 2023 respectively. The present situation of highly erratic rainfall and unavailability of assured irrigation facilities for crops are the main reasons why fields in the district remain fallow after the paddy season and farming is considered non-remunerative. The rain water harvesting thus becomes more critical to provide the farmers with access to water sources for life saving irrigation. Care needs to be taken in areas along the hill slopes because of the inherent high seepage/infiltration loss nature of the soil. Proper and systematic harvesting of rainwater is one of the most prime pre-requisite for any form of successful and sustainable agriculture and allied sectors under such unreliable rainfall patterns. During the rabi season when rainwater harvested in poly-lined ponds (*Jal Kund*) which are dug in the size of 5 X 4 X 1.5 m with a storage capacity of 30,000 litres enables the farmers to provide life-saving irrigation to the seasonal vegetable crops. Farmers are now able to obtain enhanced farm income as well as farm productivity. The cropping intensity increased from 110% to 212 % after the intervention.

UID: 1559

Waves of Frontline Demonstration on Management of Chickpea Pod Borer (*Helicoverpa armigera* Hubner) in Rainfed Situation of Bundelkhand

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Chickpea is cultivated worldwide over an area of 13.54Mha with a production of 13.10MT and productivity 968.0kg/ha. Major chickpea producing countries are India (67.41%), Australia (6.21%), Pakistan (5.73%), Turkey (3.86%) and Myanmar (3.74%) (FAOSTAT, 2015). In India, this crop is accounted for about 44.5% of total pulse production and inhabits about 35.25% total pulse area (DAC&FW, 2018). Bundelkhand region of Uttar Pradesh is an important chickpea producing region of the country (Dubey et al., 2010). Traditional methods of cultivation, heavy prevalence of insect-pests and diseases as well as semi-arid farming situations are major regulating factors in the chickpea productivity. The most economically important insect-pest is the chickpea pod borer, *Helicoverpa armigera* Hubner. With these backgrounds, a frontline demonstration on IPM module for chickpea pod borer in rainfed situation of bundelkhand was conducted at farmer's field with the objective to establish the production potential of chickpea in rainfed situation bundelkhand. Methodology The frontline demonstrations on management of chickpea pod borer in rainfed situation of bundelkhand were carried out at the field of 10 farmers during *Rabi*, 2022-23 and 2023-2024. The farmers were selected on the basis of participatory rural appraisal (PRA), farmer's interest to participate as well as site uniformity. The management module had following components as selection of suitable site (field) and variety + deep summer ploughing + seed dressing/treatment + soil health management + timely sowing + intercropping with mustard/linseed + nipping + weed management + water management + monitoring of key insect-pest through pheromone traps + facilitation of natural predation of insects through erection of bird perches + need based and judicious use of safer pesticides. The impact of module was observed with respect to existing practice of farmers for chickpea cultivation. The chickpea var. JG-36 was grown at farmer's fields by following recommended agronomic practices which includes above mentioned components of IPM module. To observe the effect key insect-pest (pod borer) per cent pod damage was calculated as per the formula given below:

$$\text{Per cent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

The yield of crop was recorded from each farmer's field and calculated treatment wise mean yield. The observations recorded were subjected to transformed and analyzed statistically by following appropriate software. The benefit: cost ratio was computed by the total cost of cultivation and net return obtained from each plot. It was calculated by using the formula:

$$\text{Benefit: cost ratio} = \frac{\text{Net return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

Results

The observations recorded during the crop growth period revealed the lowest per cent pod damage of 10.4% and 6.8% was recorded from plots having IPM module. However, the highest per cent of pod damage of 22.8% and 20.6% was recorded from plots having existing practice of farmers during *Rabi*, 2022-23 & 2023024 respectively (Table- 1). The management module created favorable environment to produce better yield, minimized the risk of biotic and abiotic stresses and augmented the activities of natural enemies in chickpea agro-ecosystem. Thus, it had recorded lowest per cent plant/pod damage and highest yield. These results are supported with the findings of Vikram et al. (2000) and Sanap et al. (2001). Similarly, Mahmudunnabi et al. (2014) indicated that the IPM package provided the highest yield. The sowing of chickpea at optimum time affected the yield of crop positively as well as reduced pod damage caused by chickpea pod borer. These observations were supported by Singh, et al., 2002 and Parmar et al., 2015. Intercropping in chickpea with mustard/ linseed showed reduced pod damage and increased net return. Some authors as Lal et al., 2002 and Borah et al., 2010 reported in similar line.

The observations on mean yield indicate that IPM module produced the highest yield of 15.68 q/ha and 17.42 q/ha, however existing practices of produced the lowest yield of 9.16 q/ha and 10.67 q/ha during both the cropping seasons (Table- 2). The highest average gross returns of ₹ 90032.0/ha was obtained from plots having management module. Correspondingly, cost of production as well as net returns (₹ 28500/ha & ₹ 61532/ha) was found higher from fields, where management module was implemented as compared to farmer's practices (₹ 22350.0/ha & 43619.8/ha). The benefit: cost ratio of management module (1:2.15) was computed higher as compared to farmer's practices (1:1.41) (Fig.-1). In said line of observation Chavan et.al. (2003) reported the highest return per rupees investment with the IPM module than farmer's practices. This observation was also supported by Bhosale et al., (2009) and Bajia and Srivastava(2022).

Conclusion

The participatory frontline demonstrations were conducted on IPM module for chickpea in rainfed situation of Bundelkhand concluded as management module was found significantly superior over farmer's practices. The lowest per cent pod damage (9.3 & 6.3%), highest incremental yield advantage (968.30 kg/ha) and net return (₹ 80044.9) in chickpea crop were recorded from plots having IPM module. Majority of the farmers perceived problem of seed dressing/treatment and weed management in chickpea crop.

Table 1. Extent of pod damage in different technology options during cropping seasons

Technology	Extent of pod damage (%)			Pod damage reduced over control	Percent pod damage decrease over control
	2022-23	2023-24	Average		
IPM Module (Intervention)	10.4[a] (3.30)	6.8[a] (2.70)	8.6[a] (3.02)	13.1[a] (3.69)	60.36[a] (51.27)
Farmer's practices (Check)	22.8[c] (4.83)	20.6[c] (4.59)	21.7[bc] (4.71)	0.0 (0.71)	0.00 (4.05)
SEm	0.43	0.36	0.40	0.43	5.94
CD $_{(0.05)}$	1.38	1.15	1.27	1.38	19.01

Figure in parentheses are statistically transformed values

Table 2. Effect of management module on yield of chickpea during cropping seasons

Technology	Yield (q/ha)			Incremental yield over control (q/ha)	Percent increase in yield over control
	2022-23	2023-24	Average		
IPM Module (Intervention)	15.68[a]	17.42[a]	16.55[a]	6.64[a] (2.67)	67.00[a] (55.24)
Farmer's practices (Check)	9.16[c]	10.67[c]	9.91[c]	0.00 (0.71)	0.00 (4.05)
SEm	1.90	2.12	2.01	0.31	6.40
CD $_{(0.05)}$	6.08	6.77	6.43	1.01	20.47

Figure in parentheses are statistically transformed values

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Evaluating the Performance of Direct Seeded Rice and Transplanted Rice in North Bihar Under Climate Resilient Interventions

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Present day agriculture is being impacted by climate change, and in the coming decades, this impact is only expected to grow. Small-scale and marginal farmers in India are extremely dependent on agriculture for their livelihood. Thus, agronomic techniques need to be more climate resilient in nature for effective utilization by the farmers. Climate Smart Agriculture is an integrated approach which aims to mitigate climate change, promote other development objectives and provide food security in the face of it. The scaling-up strategies can be based on based on value chains and private sector involvement, information and communication technologies and agro-advisory services and policy engagement. Being the major crop, "Rice is life" is quite appropriate for India as the crop plays a pivotal role in the national food security and source of livelihood for millions of rural households. The scarcity of good quality fresh water for irrigation, uneven or poor distribution of rainfall, the rising cost of cultivation, scarcity of labour, growing concern over climate change, etc., make it necessary to readjust rice cultivation to make it resource-efficient, cost-effective, and climate-resilient. Thus, climate resilient agronomic practices were introduced in rice across different villages of North Bihar under Climate Resilient Agriculture (CRA) Programme and experimental data were recorded with the aim to determine crop performance for helping the small and marginal farmers cope with the changing climatic condition and provide stability to the agricultural sector in the state.

Methodology

Two villages in West Champaran district (i.e., Gahiri and Jhakra) and eight villages in Samastipur district (i.e., Ladaura, Basudevpur, Mirzapur, Rampura, Teera, Gopalpur, Kalyanpur, Phulhara) of Bihar were selected for this study. Thirty farmers from each village were chosen for practicing different agronomic interventions under CRA Programme for both direct seeded rice (DSR) and transplanted rice (TPR) during *kharif* seasons of 2020-23. Each farmer practiced an intervention in a 0.5 acre area. The soil of the fields varied from sandy loam to clay loam. The farmers' fields were regularly monitored for collecting observation and recording data. For the purpose of the study, farmers' fields from the same village were selected in a way so that the inter-field variability was minimal, so that observations could be observed with minimum error. Considering the proven climate-resilient nature of DSR, direct seeding of rice is being promoted under this programme with three treatments viz. broadcasting, line sowing and zero tillage during 2022-23 at West Champaran district. Growth attributes, yield performance and economics of DSR variety CoR-15 were recorded and analysed in laser levelled vs. mechanically levelled fields. Alternate wetting and drying (AWD), water harvesting and field bunding technologies were demonstrated at Samastipur district in transplanted rice (TPR) variety Rajendra Mahsuri-1. Computerized decision support tools like Green seeker (GS), Nutrient Expert (NE) and leaf colour chart (LCC) were also demonstrated among the farmers cultivating DSR and TPR for providing rapid nutrient recommendations in absence of soil data. 3 hp single phase tubewells were installed in those CSA villages under community irrigation (CI) programme. Capacity building programme for youth facilitators and farmers were also organized. Community grain dryer (STR Dryer) was also installed in those villages for proper drying of the cereal grains under this programme. These initiatives have ultimately proven to be a profitable venture, bringing economic benefits for the poor farmers of North Bihar.

Results

From the recorded observations, it was found that farmers of those climate smart villages consistently achieved higher productivity and economic benefits in DSR and TPR through climate resilient interventions of CRA programme. Average plant height, tiller count as well as yield attributing parameters (panicle length, number of panicles m^{-2}, number of grains panicle^{-1}) was observed to follow an increasing trend from broadcasting to zero tillage operation which ultimately resulted in significantly superior grain yield (4.73 t ha^{-1}) in DSR at Gahiri and Jhakra. Among the practices, zero tillage showed lowest cost of cultivation achieving B:C ratio of 2.41 where corresponding values for other two were 1.90 and 1.97 respectively. DSR technique also provided 17.66% yield advantage in CoR-15 variety at villages of Samastipur. Laser levelled DSR was proved to be advantageous over mechanically levelled fields in terms of yield (10.36%) and economic benefits. Relative yield performance was 8.03% better in DSR compared to TPR in tested varieties at CSA villages. AWD was adopted in TPR across 150 ha with 375 number of demonstrations which on average reduced water use by 30% and methane emission by 48%. GS, NE and LCC recommended nutrient application in Rajendra Mahsuri and Rajendra Kasturi variety showed 18.42% yield increase (43 q ha^{-1}) with 15% saving in nitrogen dose. 25 number of tubewells were installed under CI programme through which 625 farmers were benefitted during the period. Drying services were given to 350 farmers by drying 6.25 tonns of paddy grains at Ladaura, Basudevpur, Mirzapur and Rampura villages through live demonstrations. 120 number of capacity development programme and 6 number of skill development activities were also performed in those villages for implementing those practices.

Conclusion

From the above-mentioned agronomic interventions, we may conclude that, zero tillage has huge potential in improving productivity, economic profitability and enhancing resource use efficiency in the northwest alluvial plain zone of Bihar. Further, CSA interventions like AWD, water harvesting, community irrigation programme, computer-based decision support tools for nutrient recommendation, community drying services, capacity building programmes can be very much beneficial for rice farmers. The overall program created awareness among farmers towards adoption of climate smart interventions in their farming, also entrusted them with the extension activities of the program.

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An Analysis of Adoption Determinants of Adaptation Technologies in Semi-Arid Tamil Nadu

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Climate Change is associated with increasing incidence of floods, droughts, heat waves, cold waves and hailstorms, and agriculture is one of the sectors affected by climate change. Climate change by affecting the monsoon pattern is likely to have higher impact on Indian agriculture (Swami *et al.,* 2017). Small and marginal farmers and landless labourers are the most vulnerable to the ill effects of climate change (Harvey *et al.,* 2018). Besides affecting the monsoon and agriculture, climate change also impacts the health status of farmers, and small and marginal farmers are more prone to it (Talukder *et al.,* 2021). Governments are promoting various mitigation and adaptation strategies to reduce climate change's impact. In this direction, the National Innovations in Climate Resilient Agriculture (NICRA) project has been promoting climate-resilient agriculture technologies such as improved varieties, water conservation technologies, and water-saving techniques in the farmers' fields. The present study attempted to analyse the factors contributing to adopting Climate Resilient Agriculture Technologies in the Ramanathapuram District of Tamil Nadu.

Methodology

The study was conducted in Ramanathapuram District, which is one of the most drought-affected districts in Tamil Nadu. Data were collected from a sample of randomly selected 100 farmers in NICRA village and 50 farmers in non-NICRA village. The determinants of adoption of CRA technologies were identified through logistic regression (Gujarati, 2004, Neelima et al., 2024).

Results and Discussion

The district has a cropping area of 1.98 lakh ha, about 70 per cent of which is under rainfed conditions. Rice (1.21 lakh ha) is the district's principal crop, cultivated in rainfed and irrigated conditions during the northeast monsoon. Chilli, with an area of 0.19 lakh ha, is the second most important crop. In this context, the NICRA focused on promoting CRA technologies for rice, chilli and cotton. The technologies introduced include improved variety, seed drill, sticky traps, mineral mixture (micronutrients), and drum seeder in rice, improved variety and sticky traps in chilli, and improved variety and integrated pest management (IPM) in cotton. Fig depicts the socio-economic characteristics of the respondents that influence the adoption of any given technology. Farm income and information access significantly affected adoption decision; farm income influenced negatively and access to information positively. Gender of decision maker, possession of smartphone, asset endowment, and membership in the farmer's groups also affected adoption. Owning a smartphone significantly contributed to the communication process as most communications were sent through social media like WhatsApp, indicating the changes in communication. Most of the beneficiaries had good connections with *Krishi Vigyan Kendra*, Agriculture Department and Agriculture Engineering Departments, which have influenced the adoption of Climate-resilient measures, and as a result, 'Access to information' was significant. The results align with those of Aryal et al. (2018) and Neelima et al. (2024). These factors stress the importance of formal/informal groups and the requirement of a good communication channel in the adoption process. Hence, the Government should prioritize establishing the farmer's groups, viz., FPCs/FPOs, which help disseminate the knowledge. Also, preference should be given to organizing awareness and training programmes on accessing agriculture information using smartphones.

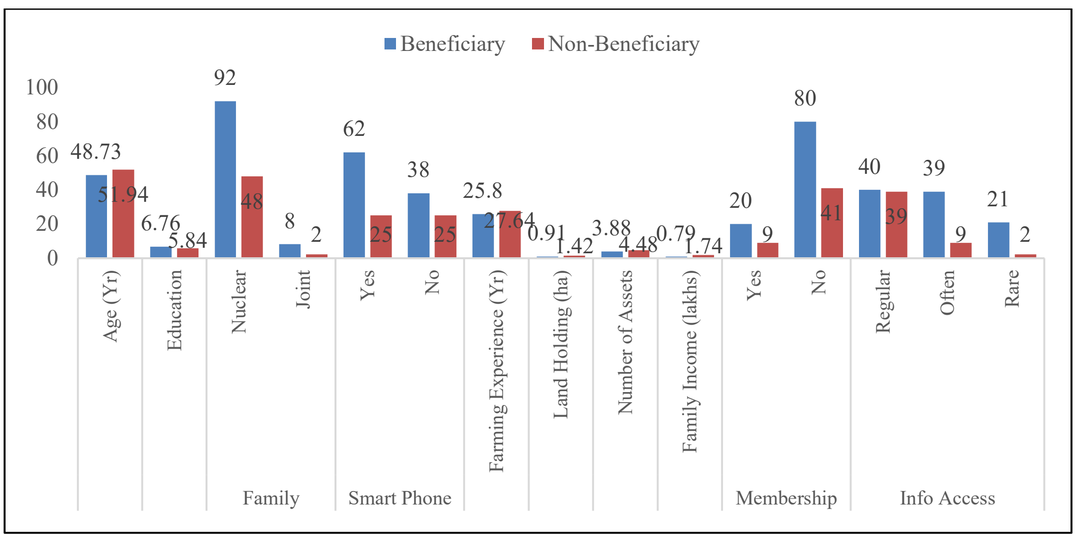

Fig: Socio-economic characteristics of the respondents in the study area

Conclusion

Climate-resilient agriculture technologies are found to be enhancing productivity while sustaining yield levels during drought periods. The study assessed the farm and socioeconomic factors responsible for adopting the CRA technologies and found that gender, possession of smart phone, asset endowment, household income, social capital and access to information have significantly influenced adoption. Based on the results, it is recommended that the government should focus on establishing farmer groups, such as FPCs/FPOs, to facilitate the dissemination of knowledge among farmers. Additionally, preference should be given to organizing awareness and training programs for farmers on accessing information using smartphones.

Factors affecting the adoption of climate-resilient agriculture technologies

Particulars	Coefficients	S.E.	Wald Statistic
Constant	0.419	2.505	.028
Gender	1.308**	0.554	5.568
Age	-0.010NS	0.033	.084
Education	-0.038NS	0.058	.443
Type of Family	2.072NS	1.301	2.536
Possession of smart phone	1.296**	0.658	3.884
Farm size	-0.126NS	0.143	0.778
Asset endowment	-0.308**	0.156	3.904
Income	-1.188***	0.290	16.728
Membership in CBOs	0.702**	0.325	4.663
Information Access	1.820***	0.513	12.577

*** - Statistical significance at 1% level. ** - Statistical significance at 5% level

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Creating Sustainable Larger Impact Through Low Input Mushrooms Cultivation

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Mushrooms are one of the most loved food not only for its exotic taste but also for the benefits with which it comes. It can be consumed in various forms like fresh, pickled, dried, powdered, canned etc. Its farming has picked up a fast pace among contemporary entrepreneurs owing to its nutritional and medicinal benefits and low-cost input with high output. The fleshy fungus known as a mushroom (Basidiomycota, Agaricomycetes) has a stem, a cap, and gills beneath the cap. The oyster mushroom, or *Pleurotus ostreatus* (white-rot fungus), is a significant commercial player in the global mushroom industry. Oyster mushroom is an edible mushroom having excellent flavor and taste. *P. Ostreatus* has received increasing attention for applications in bio-bleaching and the catalysis of difficult chemical conversions in the paper industry, textile dye decolorization and detoxification of environmental pollutants (Park *et al.,* 2014). Mushrooms are prized for their exclusive flavor and deliciousness, they are rich in proteins, contain less fat, less carbohydrates and salt and rich in fibres and have high vitamin B12 and folic acid which are uncommon in vegetables. High availability of lysine, tryptophan and other amino acids usually absent in cereals make them ideal for food of patients suffering from hypertension, diabetes and obesity (Carel *et al.,* 2013). The primary nutrients for mushrooms are carbon sources like cellulose, hemicellulose and lignin, and it is advised that different wastes be used to support *P. Ostreatus* growth. Mushrooms also need nitrogen and inorganic chemicals. In addition to being wild and edible, some of them can also be poisonous. Farmers' incomes in traditional agriculture are declining. To ensure that the farmer gets assured income year after year, there is a need for diversification in agriculture, that is, needs to cultivate different type of crops. Straws and other agricultural waste can be used to produce mushrooms, which is one of the options. In contrast to plants, mushrooms are grown in indoor. Mushrooms can be grown in a certain season under natural settings and all year round under controlled conditions. The fact that producing mushrooms requires very little land is another benefit.

Mushroom cultivation is one of the important components under the Farmer FIRST project and have been equipped with advanced techniques for cultivating Oyster mushrooms, including optimal substrate preparation, environmental control and post-harvest handling. This technology emphasizes sustainable production methods to increase yield, improve mushroom quality and minimize costs. With detailed guidelines on maintaining humidity, temperature and light, this technology has enabled farmers to produce consistently high-quality Oyster mushrooms. Farmers have also been trained in the production of mushroom spawn, a crucial aspect of mushroom farming that enables them to become self-reliant in spawn supply. This technology covers aseptic culture methods, selection of mother cultures and preparation of various media and substrates for spawn production. By producing high-quality spawn locally, farmers reduce dependence on external suppliers, enhancing the sustainability of their operations. Integrated pest and disease management practices specific to mushroom cultivation have been disseminated. These include the identification of common pests, pathogens and environmental factors that affect mushroom growth. Farmers have been educated on preventive measures, biological controls and safe use of fungicides or other treatments, ensuring healthier crops and reducing losses due to contamination and disease.

Methodology

The technological intervention on mushroom cultivation was conducted among the farmer and women SHGs under the supervision of ICAR-ATARI, Zone VI and Assam Agricultural University, Jorhat from 2018-19 to 2022-23. A total of 490 beneficiaries have been selected for conducting demonstrations under the Farmer FIRST project. A total of 40 SHGs of 240 farm women covering 5-6 farm women per group and 250 numbers of farmers were selected for cultivating oyster mushroom. Inputs like mushroom spawn, ready to use mushroom cylinders, plastic bag, lime powder, bleaching powder, plastic wrap, PUC spray, mug, aluminium utensils and buckets were provided to the farmers for conducting the demonstrations.

Results and Discussion

During the year 2018-19, 122 kg spawn have been given among the selected beneficiaries which yielded 35 kg/beneficiaries of mushroom with net return of Rs.5200/- per beneficiary. Similarly, 39 kg/ beneficiary yield obtained from 92 kg spawn with net return of Rs.5840/- per beneficiary during the year 2019-20. Due to COVID-19 no intervention was undertaken during the year 2020-21. During 2021-22, a total of 400 numbers of ready to use mushroom cylinders were provided to 40 numbers of beneficiary out of 100 numbers of beneficiaries. An average yield of 26.84 kg obtained with net return Rs.5368/- per beneficiary covering 100 numbers of beneficiaries during the year 2021-22. On the other hand, 25 kg spawn provided to 50 numbers of beneficiary out of 150 numbers of beneficiaries during the year 2022-23.

An average 40.72 kg yield obtained with net return Rs.8144/- per beneficiary covering 150 numbers of beneficiaries during the year 2022-23.

It has been observed that wild mushroom consumption and traditional cultivation of edible mushroom by a few farmers were the major problems identified due to lack of awareness, timely availability of quality spawn, technical knowhow and market linkage lead to hindrance of economic upliftment of the farmers. Therefore, dissemination of knowledge about the various interventions is very much necessary for scaling impacts on mushroom production technology by organizing capacity building and awareness programmes among the rural farmers or farm women. A total of 713 numbers of farm women were covered under different activities conducted for various technology dissemination such as scientific production technology of Oyster Mushroom, mushroom spawn production techniques, integrated pest and disease management practices etc. To disseminate these mushroom technologies, nine (9) awareness programme on mushroom farming covering 172 number of farm women, sixteen (16) training & demonstration covering 279 number of farm women, four (4) number of exposure visit covering 37 number of farm women, three (3) number of value addition & spawn production training covering 57 number of farm women were conducted and ten (10) number of advisory services & technical support provided to 168 number of farm women. Value chain approach has provided fruitful performance in edible mushroom cultivation for economic empowerment of small and marginal farm woman. It has contributed Rs.18728/- to Rs.29000/- to the annual income of individual farm, availability of quality spawn through establishment of spawn production unit, capacity building and skill development among the woman farmers in spawn production, scientific mushroom cultivation, value addition to surplus product, recycling spent mushroom cylinders into vermicompost and marketing of the products.

Year wise performance of Oyster mushroom cultivation

Year	No. of beneficiary	Yield/ beneficiary	Net return (Rs.)/ beneficiary
2018-19	120 (20 SHGs)	35 kg	5200/-
2019-20	120 (20 SHGs)	39 kg	5840/-
2021-22	100	26.84 kg	5368/-
2022-23	150	40.72 kg	8144/-
Total	490		

Conclusion

Mushrooms are a popular food enjoyed for both their unique flavour and nutritional value. They are versatile and can be prepared and preserved in various ways, including fresh, pickled, dried, powdered, and canned. However, several obstacles hinder mushroom cultivation and the economic progress of farmers. These include reliance on wild harvesting and small-scale traditional farming by a limited number of producers, coupled with a lack of knowledge, inconsistent access to high-quality spawn, insufficient technological expertise, and inadequate market linkages. To address these challenges, government agencies should prioritize public education on mushroom research and production. While non-governmental organizations should also contribute, their current efforts are insufficient to reach the entire population of a large nation. Agricultural extension services should focus on disseminating information about mushroom cultivation technologies to maximize their impact and ensure that these technologies reach farmers at the grassroots level. Additionally, financial institutions should offer financial support to benefit these farmers.

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Gender Issues in Rainfed Agriculture

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Agriculture sector is the backbone of Indian economy with about 54.6 percent of total workforce engaged in agricultural and allied sector (Census 2011). Women are extensively engaged in the agriculture and allied sector activities. Women are engaged at all levels of agricultural value chain such as production, pre-harvest, post-harvest processing, packaging, marketing etc. Studies show that the ratio of women to men working in agricultural sector has increased over time and also made a greater contribution to per capita GDP (Pingali *et al.*, 2019). The workforce participation rate for rural females is significantly higher at 41.8 percent against urban women participation rate of 35.31 percent (MoSPI, 2017). With increased feminisation and pro-women initiatives, the percentage of female operational holdings in the country has increased from 12.78 percent during 2010-11 to 13.78 percent during 2015-16 (Ministry of Agriculture and Farmers Welfare, 2019). It is projected that women-oriented reforms, ensuring equal access to resources, skill development and opportunities in agriculture would increase agricultural output in developing countries between 2.5 and 4 percent (FAO, 2011). In most of the countries, women as a group do not fully enjoy all their human rights. They experience high levels of gender inequality and discrimination, especially in rural areas.

Social Constraints

Generally, Indian society is patriarchal in nature except for a few states. Men have the choice to migrate to urban areas or more skilled sectors for better employment, while a woman's role in the society prevents her from doing so. Due to the migration of male members, the percentage of females employed in agriculture remains high in both urban and rural areas. This underscores that the benefits of better job opportunities are only transferred to the male members. In most of the societies, women are responsible for activities like child rearing, other household chores, rearing of small livestock, etc. these are unpaid kind of work and requires women to stay near their home and thereby limiting female member to engage in income earning activities and also their options to work for a wage.

Land Ownership Issues

Women’s land rights are frequently violated due to discriminatory customary practices and relatively lower levels of education and awareness about their rights. Many lacks the confidence to claim these rights even if they are aware of them. As a result, women’s ability to exercise their basic rights, such as the right to food, housing and an adequate standard of living, is often constrained. In general, with respect to land and natural resources rights, women are likely to be disproportionately and more negatively affected than men because of the existing patterns of gender discrimination. Discriminatory patterns are existing in terms of access, ownership and control of productive resources, relative income poverty, physical vulnerability, and lack of fully equitable and meaningful participation at all levels of decision-making processes.

Financial Constraints

For the same work done, women are paid lower wages as compared to men and face severe exploitation. The wage differentiation can be attributed to lower education level and less work experience of females. This also reduces their bargaining power to negotiate due to which they are bound to accept lower wages and irregular working conditions. Women have no ownership rights over either crop or livestock, and income from all activities (except income from small poultry) usually belongs to men (National Commission for Women, 2005).

Lack of Skills and Extension Services

Delivery of Extension and Advisory Services (EAS) has not equally benefited men and women farmers in rural areas. Male extension workers usually do not cater towards gender sensitive service delivery skills that address the cultural practices that limit women's participation. Issues such as lack of mobility, limited technology that is women-friendly and, the domestic child rearing and providing nutrition duties that women are responsible for (MoAD, 2017). The dominance of male extension service workers also limits female participation in cultures that do not allow women to interact with men that are not family/in the same household. Addressing the shortage of female extension workers could promote innovation and change in a community (Beevi *et al*., 2018).

Strategies for Gender Mainstreaming

Ensure that women are equal partners and productive and self-reliant participants.

Special emphasis to the women in animal husbandry and dairying training programmes.

Incorporate gender into the "guidelines for Land Use Planning"

Carry out gender-targeted training programmes on the technical and managerial aspects.

Develop methodologies to increase women's access to the natural resource management.

Equal involvement of both the genders in political and policy making activities like Water Users Associations.

Identification of problems associated with natural resource degradation and concentration of training programmes to solve them.

women are major stakeholders in growth of agricultural sector for the New India. Mainstreaming rural women through assuring access to resources, technology, education, health facilities, ownership rights and skill development will improve agriculture productivity and help in building an empowered nation.

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UID: 1594

Transforming Agriculture Through Modern Technology, Knowledge Dissemination and Resilient Livestock

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Agriculture farm of Pawan Mandal was prone to flood resulting in severe devastation of paddy crop. Flood outbreak result in water stagnation in paddy field causing heavy mortality of paddy seedling resulting in complete crop loss. Even in mild flood, excess moisture predispose crop to weed, insect and disease infestation & infection. All these biotic and abiotic stress caused heavy reduction of paddy yield. The water of paddy field used to take long to withdraw and resulted in delayed wheat sowing which in turn increase susceptibility of wheat against terminal heat followed by reduced wheat yield. Flood tolerant var. Swarna sub-1 seedlings can withstand ten days under water submergence condition and escape from damage of flood. In addition to this Bispyribac Sodium (for weed control) +Fipronil (management of stem borer) + Imidachloprid (Management of Brown plant hopper) + Propiconazole (management of sheath blight of rice) were also incorporated during paddy cultivation to manage various biotic stress. In order to catch wheat sowing on time, Zero tillage technology was introduced among farmers coupled with high yielding variety HD-2967 and use of herbicide (Sulfosulfuran + Metasulfuran) to control weeds in wheat. For paddy-wheat cropping system intervention was designed as Flood tolerant paddy var. Swarna sub-1+Bispyribac Sodium + Fipronil + Imidachloprid + Propiconazole followed by Zero tillage wheat+HD-2967+ Herbicide (Sulfosulfuran + Metsulfuran) followed by Green gram var. Shikha (IPM-410-3) was adopted by farmers. These technologies paddy-wheat cropping system furnished higher yield of 96.4 quintal in climate resilient plot in comparison to 87.5 quintal of control plot. Adopted cropping system increased23.38 % income of farmer. Prior

NICRA program, dairy sector of these village was highly disorganised. Farmers were not keenly aware regarding proper nutrition of dairy animal and adverse effect of parasites in milk production. Green fodder, mineral mixture and dewormer were introduced among farmers for enhanced nutrition and reduction of ecto& endo parasite in cow. Post-NICRA intervention of these technology in dairy animal (cow) significantly increased milk production (2560 litres) in villages as comparison to pre-NICRA (1850 litres). Enhanced milk production caused 38.37 % increase in income. Farmers were rearing local desi breed of goat. These local breeds were of low average body weight of 15 kg. NICRA intervention also encouraged farmers to cross their goats with Beetel male (provided to farmers under NICRA program). The progeny of this cross has average body weight of 18 kg of 6month old goat whereas the average body weight of parents was 15 kg only. It also increased 20% income of the farmer from goat rearing. All the above-mentioned intervention significantly increased total income (30.61%) of farmer. Adoption of modern technology, dissemination of knowledge and resilience through livestock paves the way of higher farm produce and income of farmers which in turn encouraged other farmers of same as well as nearby village to adopt these technologies for higher yield and income. This farming system can be replicated among farmers of Lakhisarai as well as other district of Bihar for higher farm produce and economic upliftment.

UID: 1597

Submergence Tolerant Rice Variety Ranjit Sub-1: A Boon for The Flood Prone Ecology of Assam

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The region faces significant challenges due to frequent floods that threaten crop production and food security. This study evaluates the economic performance of submergence-tolerant rice variety (STRV) Ranjit Sub-1 in NICRA village of Dhubri district in Assam. Under the NICRA project, Ranjit Sub-1 was introduced as a promising option. Results revealed that Ranjit Sub-1 yields significantly higher net return (Rs. 43,454/ha) as compared to the local variety (Rs. 28,915/ha). B:C ratio was thus 1.82 for Ranjit Sub-1 and only 1.40 for the local variety. This study demonstrates the productivity and economic feasibility of the improved STRV in flood-prone areas of Dhubri district of Assam.

Flood-tolerant rice varieties are urgently needed because of the significant yield losses caused by the frequency and severity of floods throughout rainy season. Adopting rice varieties that can withstand floods in places at risk is a particularly effective risk mitigation approach and survival mechanism for farmers to avoid losses from flood damage (Anusha *et al.* 2021).

During floods, this type of rice may survive submersion for up to two weeks (Bhowmick *et al.* 2014). In response to the persistent threat of flood, KVK Dhubri has initiated a technology demonstration program under the NICRA project which introduced a flood-tolerant rice variety "Ranjit Sub-1" to mitigate the losses incurred by farmers during floods. This paper seeks to examine the economic performance of the variety in recurrent exposure to floods, whether it is ideal for studying the impact of flood-tolerant rice varieties on farmers' incomes and agricultural productivity.

Methodology

The study was conducted in Dhubri district of Assam under the NICRA-TDC component during the year 2023. The district was selected due to its susceptibility to seasonal flooding and significant rice cultivation areas. A total of 11 demonstrations were carried out for both demonstration plot & farmers' fields. The improved variety has a characteristic of submergence up to 15 days & is a medium duration variety. During the year, total 3 hectare of land was covered by covering 11 farmers in the village Sreegram Pt. I. The study focused on productivity and economic implication between NICRA farmers who cultivated flood-tolerant rice varieties and non-NICRA farmers who practiced local varieties.

Results and Conclusion

The local variety yielded 30 q/ha, while the submergence-tolerant Ranjit Sub-1 (STRV) achieved a yield of 45.1 q/ha, representing a significant yield increase of 50.33%. Cost analysis revealed that the total cultivation cost for Ranjit Sub-1 was Rs. 53,136, compared to Rs. 42,985 for the local variety. Notably, Ranjit Sub-1 incurred higher expense for fertilizers and labor days, indicating that a more resource-intensive cultivation process was followed. The technology gap, extension gap, and technology index for Ranjit Sub-1 were recorded at 16.17 qt/ha, 15.1 qt/ha, and 35.02%, respectively. These gaps may stem from variations in soil fertility, local weather conditions, and deviations from standard agricultural practices, which can be mitigated through improved management strategies (Singh *et al.,* 2018). The extension gap highlights the necessity for increased farmer awareness regarding the adoption of enhanced submergence-tolerant rice varieties. The technology index reflects the feasibility of implementing improved technologies in the field; according to Chauhan (2011), a lower technology index value indicates greater feasibility. Ranjit Sub-1 generated a net income of Rs. 43,454/ha, significantly higher than the local variety (Rs. 28,915/ha), resulting in a better benefit-cost ratio of 1.82 compared to the local variety (1.40). This higher profitability is attributed to effective resource utilization, timely cultivation, and adherence to proper management practices with scientific oversight. These findings align with previous research by Goswami *et al*., (2020) and Sharmah *et al*, (2023).

The parameters were worked out using the methods given by Samui *et al.,* (2000)

1. Technology Gap = Potential yield - Farmer's practice yield
2. Extension Gap = Demonstration yield - Farmer's practice yield
3. Technology Index (%) = (Potential yield - Demo yield)/ Potential yield × 100

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UID: 1600

Climate Resilient Technologies Demonstrated at Maruthomkara Panchayat-Kozhikode District NICRA Village

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The major climatic constraints identified in the NICRA village (Maruthonkara Grama Panchayath) include intense and heavy rainfall during the monsoon season and unexpected rainfall, and prolonged dry spells during the summer. This Panchayath covers approximately 2991 hectares, with a coconut-based farming system as its predominant land use. The major resource constraints include runoff / erosion, low water holding capacity, deficit in nutrients and acidity nature of soil and the unawareness of improved agronomic practices / varieties for climate smart vegetable and paddy cultivation. To address these challenges, KVK has initiated NICRA project since 2022 and the major interventions taken are presented in this paper as follows along with its outputs. Among the interventions the crop-based interventions showed short term outputs while the long term NRM and Coconut crop improvement is yet to show its impact, while study is in progress.

NRM Related Interventions

In-situ Soil and water conservation measures, including bund formation (146 km) were implemented covering an area of 71.06 hectares. Additionally, 1,857 rainwater harvesting pits (1 m^3 size) were constructed covering 71.06 hectares through a convergence mode of implementation involving the Panchayat and technical support from KVK. Awareness programs on soil health management, in-situ soil moisture conservation measures and the efficient utilization of rainwater through fish farming and tree planting were conducted for natural resources conservation. .

Crop Related Interventions

The introduction of intense rainfall with standing vegetable varieties such as okra (Sal Keerthi), Amaranthus (KAU Vaika, Vlathamkara Cheera) and Yard Long bean (KAU Deepika) has been undertaken. New crop / varieties like black pepper (IISR-Thevam) and marigold (Arka Bhanu) were also successfully introduced to increase farmers' income. Early planting of ginger (IISR Varada), turmeric (IISR Pragathi), and nutrient efficient tubers like elephant foot yam (Sree Padma) and tapioca (Sree Raksha) has been carried as the major climate resilient seed production activities.

Table 1. Impact of different climate resilient technologies in NICRA Village

Intervention	Yield (q/ha)	Gross Cost (Rs./ha)	Gross return (Rs./ha)	BC ratio	Yield (q/ha) By Farmers practice
Amaranth (KAU Vaika)	114	261370	569785	2.18	104
Amaranth (Vlathamkara Cheera)	158.6	284910	642606	2.25	119
Yard long bean (KAU Deepika)	155.5	428700	1011732	2.36	138.5
Okra (Salkeerthi)	116.5	246000	567000	2.30	102
Marigold (Arka Bhanu)	130	420000	640000	1.52	NA
Ginger (Varada)	138	701500	1417030	2.02	101
Turmeric (IISR Pragathi)	257.25	242330	277315	1.14	212.4
Elephant Foot Yam (SreePadma)	320	1032260	1920000	1.86	280
Soil acidity, scientific management in coconut	8660	61454	76203	1.24	7810

Liming and scientific nutrient management practices in coconut along with opening of basins, soil test-based fertilizers application, in-situ green manuring using cowpea and husk burial improved the overall health of the palms, leading to increased yield. Another major threat to coconut ie., Tanjore wilt was also managed successfully through cluster awareness programs and demonstrations.

Livestock and Fisheries

Awareness and demonstrations on cow dung-based agriculture (Natural farming) have been demonstrated along with summer care for milch cows through nutrient supplement, fertility management through mineral feed supplements and hormonal treatments. The introduction of fodder crops such as KAU Susthira, has been increased the homestead level fodder availability.

The demonstration of the cage system for rearing layer chicks has been carried out to enhance egg production, achieving an average of 196 eggs per year. Additionally, air breathing fishes like murrels were introduced to tide over water scarce situations and integrated fish farming in coconut palm channels was promoted to efficiently utilize both water and space.

Table 2. Cultivation of fish in low lying coconut channels which otherwise less productive / fallow

Interventions	Yield (q/ha)	Gross Cost (Rs/day)	Gross returns (Rs/day)	Net Return (Rs/day)	BC ratio
Murrels	238	4100000	8330000	4230000	2.03
Farmers Practice (Tilapia)	79.5	787500	1590000	802500	2.02

Plantation and Wetland Ecosystem

Introduction by planting of high yielding cashew grafts of early and midseason varieties such as Anagha, Akshaya, Vengurla, and Dhanasree has been undertaken. Melia trees have been planted as block plantations in common land and establishment of Agroforestry (tree + grass) is in progress at farmer fields. Rice fallows have been utilized for planting short duration pulses such as green gram (KKM- 3), which also contribute to soil fertility improvement and provide leguminous fodder for cattle. A limited area of rice fallows has additionally been demonstrated for the cultivation of summer vegetables. Farm mechanization through utilization of tractors, tillers, sprayers, drone, post hole digger, brush cutter etc. were also carried in these plots.

Farm Mechanisation and Value Addition

A custom hiring center equipped with implements such as sprayers, rubber tapping machines, coconut climbing machines, arecanut harvester, tree auger, weighing balance, urbanas and dewatering pumps has been established and benefiting approximately 250 farmers annually. Hands on trainings on brush cutter, sprayer, rubber tapping machine, coconut climber and arecanut harvesters have been conducted benefiting around 120 individuals per year. Small scale entrepreneurship development has been promoted through skill development trainings on bush pepper production and farm mechanization. This initiative has led to the establishment of small nurseries and enhanced utilization of farm machinery. Implements such as the power sprayer, brush cutter, wheelbarrow (single and double), and telescopic carbon pole were used for 3, 2, 11, and 4 days, respectively. Women farmers have also been trained on value addition of spices through masala powder production and value addition of fruits, etc helping them to generate income and improve their livelihoods.

UID: 1603

Development of Integrated Farming System for Enhancing Farm Income and Climate Resilience

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The Integrated Farming System (IFS) is a holistic approach that combines various agricultural practices, such as crop production, livestock, poultry, fisheries and agroforestry to optimize land use, improve resource use efficiency and enhance farm productivity. IFS as an aquaculture system integrated with animal farming, where fresh animal waste is utilized to feed fish. This system promotes synergies and complementarity between crop and animal enterprises, forming the foundation of the IFS concept (Edwards, (1997) and Jitsanguan (2001). IFS offers a promising solution to small-scale and marginal farmers, particularly in semi-arid regions, where water scarcity, land degradation and climate variability pose significant challenges. In such regions, IFS helps diversify farm activities, reduces economic risks and improves ecological sustainability.

In Kotapally mandal, Mancherial District, Telangana farmers faced challenges related to water scarcity, poor soil quality and low agricultural productivity. Despite the potential of IFS to address these issues, many farmers in the region were unaware of this approach. To bridge this knowledge gap and demonstrate the benefits of IFS, IFS model was created under SC Sub Plan of ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, Telangana. The objective of was to create awareness of IFS and implement it as a practical demonstration for improving farm income and promoting climate resilience.

Methodology

IFS model was initiated during 2021-22 with the renovation of a 15-year-old farm pond in Kondampet village, Kotapally mandal, Mancherial district which spread over an area of 0.75 acres. This renovation increased the water-holding capacity farm pond, ensuring reliable water availability throughout the year. With adequate water storage, farmers were able to cultivate paddy during both *kharif* and *rabi* seasons, thus maximizing land use and improving productivity.

In 2023-24, fish farming was introduced by stocking the renovated pond with fingerlings of high value fish species, such as Rohu, Catla and Grass carp. Poultry farming was also integrated by installing poultry cages within the pond area. The poultry droppings served as natural feed for the fish, establishing a mutually beneficial relationship that reduced feed costs and enhanced system efficiency.

Agroforestry practices were incorporated along the borders of the farm pond by planting teak and bamboo, which are well suited to the semi-arid conditions of the region. These species not only contributed to biodiversity and improve soil fertility but also offered long-term economic benefits through teak and bamboo production.

Data on farm productivity, fish yields, poultry income and paddy production were collected to assess the effectiveness of the IFS model in improving farm income and sustainability.

Results

The implementation of the IFS model led to significant improvements in productivity and income for farmers. The renovation of the farm pond enabled year-round water availability, which supported the cultivation of paddy during both the *kharif* and *rabi* seasons. As a result, the yield of paddy increased from 36 quintals per acre to 40 quintals per acre, reflecting the positive impact of consistent irrigation and integrated practices.

The introduction of fish farming resulted in the production of 1,650 kg of fish over six harvests, generating a net profit of Rs. 2,39,300. The integration of poultry farming further contributed to the farm income, generating Rs. 10,000 from the sale of birds. The combination of fish farming and poultry created a diversified income stream, reducing the economic risks associated with dependency on a single crop or livestock.

The agroforestry component involving the planting of teak and bamboo, also contributed to the sustainability and income of the farm. These species enhanced biodiversity and improved soil fertility, while offering long-term economic benefits from timber and bamboo sales. Agroforestry practices helped mitigate the adverse effects of soil erosion and contributed to better water retention, improving the overall health of the farm's ecosystem and contributed to the farm's resilience against climate-induced stresses such as drought and irregular rainfall.

The results of the study underscore the substantial benefits of adopting an Integrated Farming System (IFS) model in semi-arid regions. This approach is multi-disciplinary and highly effective in addressing the challenges faced by small and marginal farmers (Gangwar, 1993). The renovation of the farm pond was a critical intervention that provided year-round water availability, enabling consistent crop production and fish farming. This facilitated the cultivation of paddy in both the *kharif* and *rabi* seasons, resulting in higher crop yields and better resource utilization.

The integration of fish farming and poultry created a mutually beneficial system, where poultry droppings served as natural feed for the fish, reducing feed costs and improving overall system efficiency. The production of 1,650 kg of fish and the sale of poultry birds contributed significantly to the farm's income, demonstrating the effectiveness of integrated farming practices in boosting productivity and profitability.

Agroforestry practices, particularly the planting of teak and bamboo, enhanced the farm’s ecological balance and biodiversity while providing long-term economic potential. The study highlights the importance of diversifying farm activities to reduce the economic risks associated with mono-cropping or single-livestock farming. By integrating multiple farming components, the IFS model helped optimize land use, improve resource efficiency, and enhance income diversification. The model's ability to provide year-round water availability was a key factor in supporting continuous production of both crops and fish, ensuring consistent income for farmers.

Conclusion

The Integrated Farming System (IFS) model demonstrated its potential as a sustainable and scalable solution for small-scale farmers, particularly in semi-arid regions. Adopting IFS offers a modern, holistic approach that delivers various benefits, including boosting farm resilience, securing farmers' incomes, ensuring food security and promoting adaptability and sustainability (Paramesh et al., 2022). The renovation of the farm pond, integration of fish farming and poultry, and adoption of agroforestry practices proved to be effective strategies for enhancing farm productivity, promoting climate resilience, and ensuring long-term sustainability.

The IFS model has the potential to be replicated in other semi-arid regions, offering smallholder farmers a pathway to improved livelihoods, food security and sustainable agricultural development. (Gupta et al., 2020) indicated that the reliance upon a few crops in combination with a high risk of crop failure due to a range of factors such as diseases, drought, etc. exposes farmers to a high degree of variability concerning yields and income and therefore risk. The study highlights the importance of integrating diverse farming components to optimize resource use, reduce economic risks, and promote ecological balance. By demonstrating the benefits of IFS, contributed to the ongoing efforts to promote sustainable farming practices and improve the economic prospects of resource-poor farmers.

Overall, the findings of this study underscore the effectiveness of IFS in improving farm productivity, diversifying income sources, and enhancing farm resilience to climate change. The successful implementation of this model in Kotapally mandal offers valuable insights for policymakers, extension agencies, and farmers interested in adopting sustainable agricultural practices in semi-arid regions.

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UID: 1620

Participatory Approach for Adaptation of DSR – A Drought Resilience Technology Through FLD

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Climate change has become an important area of concern for Indian agriculture. The climate change are global, but countries like India are more vulnerable in view of the high population depending on agriculture. Among the different state, Jharkhand is one of the most affected state by climate vulnerability. A study examined the spatial variability and climate extremes over the state of Jharkhand during 1984 to 2014. The spatial analysis of the trend maps and climate index maps, demonstrates the regions with increasing number of summer days, increasing trend of maximum temperature and solar radiation, decreasing rainfall and thereby increasing periods of consecutive dry days during monsoon season. The average consecutive dry days for the whole of Jharkhand has an increasing trend particularly in Garhwa, with 3.8 - 4.2 days dryness during the monsoon. The negative impact of climate extremes was observed as delay in transplanting of rice/vegetative phase and reduced crop production.

Direct seeded rice is a viable alternative to conventional puddled transplanted rice, Direct Seeded Rice is with strong potential to mitigate and adapt to climate change. This system empowers poor farmers to better cope with climate-induced changes by providing flexible rice establishment methods and reducing the water needed for both crop establishment and growth. Additionally, in the event of early drought, farmers can opt for direct seeding with minimal soil moisture, rather than waiting for adequate rainfall to begin transplanting. DSR promotes early crop establishment, which reduces the risk of yield loss due to late season drought and minimizes the need for costly additional irrigation. This method also helps to protect soil structure, soil moisture.

To boost up the production of rice in the climate vulnerable district of Garhwa, front line demonstrations on direct sown rice (DSR) are carried under rainfed situation in two NICRA villages (Tenar & Sangbaria) by Krishi Vigyan Kendra, Garhwa (Table). A total 181 full package FLDs on DSR, 103 in Tenar and 78 in Sangbaria village were conducted during three seasons from 2022 to 2024 under close supervision of KVK scientist. Sowing of variety IR64 (drt-1) was done in DSR with onset of monsoon in second frontline of June with 40kg seed/ha. Fertilizer (N:P:K) was applied @80:40:30 kg/ha. Pendimethaline @3 lite/ha was applied as pre-emergence for management of weeds. Carbendazim @2 litr/ha and Imidacloprid @1litr/ha were sprayed at vegetative stage for management of of false smut and insect. Data obtained revealed that there were increase in yield by 20.76 %,17.64% & 15.40

and net return by 36.27,31.73 & 24.22% (Table) over conventional transplanting method of rice cultivation, during 2022,2023,2024 respectively.

Effect of FLDs on DSR at 2 NICRA villages from kharif 2022 to 2024

Year	No. of farmer		Yield (Q/ha)		Increase (%) in DSR over Transplanting	Net return (Rs/ha)		
	Tenar	Sangbaria	DSR	Transplanting method		DSR	Transplanting method	Increase (%) in DSR over Transplanting
2022	36	14	31.4	26.0	20.76	33470	24560	36.27
2023	32	36	34	28.9	17.64	43062	32689	31.73
2024	35	28	36.7	31.8	15.40	42410	34140	24.22

UID: 1636

Effect of Potassium Management in Kharif Groundnut (*Arachis Hypogaea* L.)

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Groundnut (Arachis hypogaea L.) is an essential oilseed crop widely cultivated in semi-arid regions, where potassium (K) deficiency often limits productivity (Marschner, 1995). Potassium enhances enzymatic activity, photosynthesis, and nutrient translocation, contributing to improved growth and yield (Abbas et al., 2011). Despite its importance, potassium management in groundnut cultivation remains underexplored. Addressing this gap, the study evaluates the effects of varying potassium levels on growth, yield attributes, and overall productivity of kharif groundnut under Indian conditions

Methodology

The field experiment was conducted during the kharif season of 2015-16 at Oilseed Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola on the soil, characterized as clayey and moderately alkaline, was analyzed for its initial fertility status, Maharashtra. The experiment was framed in Randomized Block Design (RBD) with six treatments (control, 10, 20, 30, 40, and 50 kg/ha potassium) replicated four times. All treatments included basal applications of 25 kg/ha nitrogen (urea) and 50 kg/ha phosphorus (single super phosphate). The groundnut variety TAG-24 was sown on with a spacing of 30 x 10 cm after seed treatment with bio-fertilizers (Rhizobium japonicum and PSB).

Results

The data pertaining to number of developed pods per plant, dry pod, haulm and biological yield, harvest index and oil yield was given in Table. Results revealed that application of potassium at 50 kg/ha (T6) yielded the highest number of developed pods per plant (22.80), significantly superior to control (17.50). Treatments with 40 kg/ha (T5) and 30 kg/ha potassium (T4) were at par with the best treatment, likely due to enhanced photosynthetic availability. Application of 50 kg/ha potassium resulted in the highest dry pod yield (1921 kg/ha), significantly superior to control (T1) (1622 kg/ha). Treatments with 40 kg/ha and 30 kg/ha potassium yielded 1913 kg/ha and 1892 kg/ha, respectively, and were at par with the best treatment. Potassium improves water retention and nutrient uptake, boosting yield. The haulm yield was significantly higher with 50 kg/ha potassium (3695 kg/ha) than with control (3216 kg/ha). Treatments with 40 kg/ha and 30 kg/ha potassium yielded 3661 kg/ha and 3621 kg/ha, respectively, at par with the best treatment, as potassium supports biomass production.

Effect of potassium on yield contributing characters, yield and quality of groundnut

Treatments	Number of Developed pod plant^{-1}	Dry Pod Yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	oil yield (q ha^{-1})
T1 - Control	17.50	1622	3216	4838	33.53	5.32
T2 - 10 kg /ha K	18.90	1659	3309	4968	33.38	5.55
T3 - 20 kg /ha K	20.10	1775	3464	5238	33.88	6.05
T4 - 30 kg /ha K	21.75	1892	3621	5513	34.33	6.54
T5 - 40 kg /ha K	22.50	1913	3661	5574	34.32	6.67
T6 - 50 kg /ha K	22.80	1921	3695	5616	34.20	6.76
SE (m) ±	0.55	17	36	46	0.24	0.06
CD at 5 %	1.67	52	108	138	0.72	0.19

The biological yield followed a similar trend, with 50 kg/ha potassium resulting in 5616 kg/ha, significantly higher than control (4838 kg/ha). Treatments with 40 kg/ha and 30 kg/ha were statistically equivalent to the best treatment, enhancing overall plant growth. The harvest index was highest at 30 kg/ha potassium (34.33%) but was statistically at par with 50 kg/ha and 40 kg/ha potassium, indicating balanced partitioning between pod and haulm yield. Oil yield peaked at 50 kg/ha potassium (6.76 q/ha), significantly higher than control (5.32 q/ha). This was due to the role of potassium in oil synthesis. Treatments with 40 kg/ha potassium (6.67 q/ha) were at par with the best.

Conclusion

Potassium application significantly enhanced yield and yield-contributing characters, with 50 kg/ha showing the best results. However, 40 kg/ha and 30 kg/ha treatments were statistically at par in most cases, suggesting optimal resource utilization. Statistical significance emphasizes the reliability of these findings.

UID: 1653

To Study the Impact on Yield and Economics of Rice and Wheat Varieties in Rice-Wheat Cropping System Under Sodic Soils at Farmers Field of District Kanpur Dehat (U.P.)

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In the sodic soils of Uttar Pradesh (U.P.), selecting specific rice and wheat varieties with salt tolerance can significantly impact on crop yield and economic viability with salt tolerant varieties generally producing higher yields and generating better returns compared to non-tolerant varieties, specially under conditions of high salinity and alkalinity in the soil; this allows for more stable crop production in challenging soil condition. Singh *et al* (2013) reported that higher grain yield and economics of salt tolerant varieties of rice and wheat was produced in rice-wheat cropping system of sodic soils. The present investigation was carried out to study the impact of newly released salt tolerant varieties of rice and wheat on yield and economics of rice-wheat cropping system of sodic soil at farmer field of Kanpur Dehat.

Methodology

The study was conducted during 2022-2023 and 2023-2024 at farmers field under NICRA Project (National Innovations in Climate Resilient Agriculture) was started in 2021-2022 at Village Aurangabad, Block Maitha, District Kanpur Dehat. Under this project the Rice variety viz., CSR-46 which is a tolerant to sodic soil and salt tolerant Wheat variety KRL-213 was distributed to 30 farmers of the selected village. Sesbania seed was also distributed to farmers and after 40 days the dhaincha was buried in the soil as a green manure. After one week of green manuring rice was transplanted in the field. The observation of grain and straw yield and economics were taken after harvest of crops in the system.

Results

The result data showed in Table 1, that the highest grain (48.37q/ha) and straw (57.07q/ha) yield was recorded in salt tolerant variety of rice, while, it was lowest grain (41.5 q/ha) and straw yield (48.97q/ha) in non-salt tolerant variety of rice. The increase in grain yield of paddy to the extent of 16.55 percent in salt tolerant variety of rice than non-tolerant variety of rice. It was also observed that the highest grain (50.0 q/ha) and straw (56.30 q/ha) yield was recorded in salt tolerant variety of wheat and minimum of grain (40.0 q /ha) and straw (45.6

q/ha) yield was obtained in non-tolerant variety of wheat under sodic soil at farmers' field. The increase in grain yield of wheat to the tune of 25 percent in salt tolerant variety than non-salt tolerant variety of wheat in sodic soils.

Highest gross (Rs. 121251/ha) and net return (Rs.52899/ha) of rice was fetched in salt tolerant variety, however, lowest gross (Rs.100850/ha) and net return (Rs.35887/ha) was recorded non-salt tolerant variety of rice under sodic soils. It was also observed that highest gross (Rs.144715/ha) and net (Rs.89037/ha) return of wheat was recorded in salt tolerant variety of wheat under sodic soils. The minimum gross (Rs.114000/ha) and net (Rs.54436/ha) return of wheat was obtained in non-salt tolerant variety of wheat. The benefit: cost ratio of rice (1.77) and wheat (2.20) was recorded in rice and wheat in rice-wheat cropping system under sodic soils at farmers' field. The minimum benefit: cost ratio of rice (1.54) and wheat (1.91) was obtained in non-salt tolerant variety of rice and wheat of sodic soils at farmer field of Kanpur dehat district. Kumar *et al* (2024) and Singh et al (2014) also reported similar results on grain yield and economics of salt tolerant varieties of rice and wheat under sodic soils conditions.

The use of green manuring with Dhaincha before transplanting of paddy not only increases the availability of nutrients but also decreases the pH of the soil. Application of the green manure with Dhaincha improved the efficiency of Phosphorous as well as biological activities of micro-organism.

Conclusion

It may be concluded that the use of green manuring with salt tolerant varieties of rice and wheat in Rice-Wheat cropping system is beneficial and economically feasible in respect of producing higher grain yield and net return under sodic soils of District Kanpur dehat (Uttar Pradesh).

Yield and economics of different salt and non-salt tolerant variety of rice and wheat in rice-wheat cropping system under sodic soil condition

Treatments	Grain Yield (q/ha)	Straw (q/ha)	Cost of cultivation (Rs/ha)	Gross Return (Rs/ha)	Net Return (Rs./ ha)	B:C Ratio
Rice variety, CSR-46	48.37	57.07	68352	121251	52899	1.77
Wheat variety KRL-213	50.0	56.30	65677	144715	79037	2.20
Farmers Practice (Rice)	41.5	48.97	65263	100850	35587	1.54
Farmers Practice (Wheat)	40.0	45.6	59563	114000	54436	1.91
Mean	44.96	51.98	64714	120204	55490	1.85

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UID: 1664

Enhancing Climate Resilient Agriculture Through Rural Advisory Services

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Climate change is a major area of concern for Indian agriculture in view of its high vulnerability and dominance of small holder farms. Agriculture sector is exposed to extreme events like droughts, floods, heat wave, cold wave, unseasonal rains, cyclones etc. causing immense loss year after year. Indian agricultural research and development system has evolved a number of crop and livestock management practices to cope with abiotic stresses induced by climate variability, but climate change impacts continue to remain a major challenge to both policy makers and farmers.

Climate resilient agriculture (CRA) is about the ability of an agricultural system to maintain viability in the face of climate variability and extremes. This is achieved through improving people's capacity for resilience through increasing the adaptability, and transformability of agricultural practices (Eeswaran et al., 2021). Climate resilient agriculture comprises different approaches such as climate-smart agriculture, that focuses on: sustainable increases to agricultural productivity and incomes, adapting and building resilience to climate change, and reducing greenhouse gas emissions (Lipper et al., 2014).

Rural Advisory Services (RAS) consist of "all the different activities that provide the information and services needed and demanded by farmers and other actors in rural settings to assist them in developing their own technical, organizational, and management skills and practices so as to improve their livelihoods and well-being". RAS collectively comprise several types of providers, known by different names - namely extension agents, community knowledge workers, agronomists, facilitators, advisors, promoters, knowledge intermediaries, programme managers, etc. and provide a range of services and support to rural communities including technical, organisational, entrepreneurial and managerial support.

Implementing Climate resilient Agriculture (CRA) practices requires changes in the behavior and strategy of millions of farmers. Rural Advisory Services (RAS) can play a crucial role in transitioning to CRA and help build resilient agrifood systems if a conducive environment for their effective functioning is created. In risk-prone environments, efforts to foster the transition toward more productive and resilient agricultural livelihoods must therefore be supported by strategies, programmes and policies that enable vulnerable populations to overcome the obstacle of climate risk.

Rural Advisory Services (RAS) contribute to achieving climate resilient agriculture (CRA) by disseminating climate information and technologies and information on production practices for climate adaption through innovative approaches, such as plant clinics and participatory video. Use of mobile phones, videos, radios etc. was done to address the issue of climate change by creating awareness among the farmers about the availability of different adaptation and mitigation strategies.

Extension providers can play a major role in supporting CRA through the following: technology development and information dissemination, strengthening farmers' capacity, facilitation and brokering, and advocacy and policy support. Rural advisory services (RAS) need to improve their effectiveness with regard to CRA and require capacity development at individual and organizational level and institutional reform at the systems level.

Effective adaptation of the CRA advisories generated by different project can only be achieved if farmers had sufficient awareness and knowledge on climate change issues, like what is climate change, how it is affecting the agriculture, what are the consequences and impact and so on. So different projects used different methods according to their clients, location and objectives, some of them are mentioned below.

Short Messaging Services: Short text messages in the local language was sent to registered mobile numbers of farmers. Maximum two SMS per week based on weather advisories and contingency plans were sent to the farmers.

Climate Wallpapers: One-page advisories in the form of tables or posters related to weather prediction of agricultural operations needed to be performed were pasted on common display boards of villages to provide advisory services to the farmers.

Climate Voice Messages: SMS was converted into voice messages in the areas with low literacy rate and disseminated to the farmers.

Folk media: Some street plays related to effect of climate change on agriculture were prepared so farmers could know more about the changing climatic conditions.

Use of Public Addressing System (PAS): Urgent information dissemination to the villagers like in the villages where SMS was not delivered due to network and electricity problems.

In view of the above it is summarized that

1. Rural Advisory Services (RAS) can effectively support farmers in adopting Climate resilient Agriculture (CRA) practices.
2. Mechanisms fostering the coordination of public, private and civil society actors should be facilitated by governments.
3. Research and training of RAS personnel should be strengthened to identify relevant field practices and promote capacity development, respectively.
4. Increased financial investments should be made available for RAS to promote CRA.
5. Contribution of RAS to the design and implementation of national climate adaptation and mitigation plans should be acknowledged. (Rasheed Sulaiman,v. 2017)

However, financing for RAS Promoting CRA is challenging, as it involves provision of personalized support to farmers depending on their vulnerability to climate change at the household level, as well as according to their risk profile and the availability of other livelihood options. In most countries, RAS face resource constraints that prevent them from deploying an adequate number of qualified staff. Enhanced investments in RAS would allow them to deploy more and better qualified staff, and to enhance capacities of RAS personnel in aligning their CRA support interventions to National Adaptation Plans (NAPs) and Nationally Appropriate Mitigation Actions (NAMAs).

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UID: 1702

Impact of Low-cost water harvesting for High Value Crops (Jalkund) and Rice- Fish integration under NICRA project in West Jaintia hills, Meghalaya

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Climate variability and climate change has gained global significance and its' impacts are farfetched in acreage and intensity. Such variabilities also have immense ramifications on crop production and farming. This calls for attention from all those who are involved in food production systems. There should exist a system of trained personnel who are prepared to mitigate the vulnerabilities and reduce the effects of climate variability. To enhance the resilience of Indian agriculture towards such issues, requires educating the farmers at the grassroots levels, encourage researchers for location specific and climate resilient technologies at the research level and enhancing the skills and knowledge component of the extension personnel on these challenges that lie ahead. Since the operationalization of NICRA Project at Umjalasiaw Village, West Jaintia Hills District, have always attempted to ensure that the farmers of the village understand the challenges of climate change and also have tried to provide farmers access to climate resilient technologies. Presently the newly adopted villages are WAhiajer and Niriang of West Jaintia hills District. The KVK Jaintia Hills has attempted, at its best, to work along the objectives, components and approach of this scheme and sincerely believes that the attempts may not be in vain but strengthen all stakeholders in enhancing the resilience of Indian agriculture at the local level.

Methodology

The NICRA project under KVK, Jaintia Hills has been implemented since 2015. To describe the success and impact of the climate resilient technologies under NICRA project, the newly adopted village, Niriang and Wahiajer of West Jaintia hills, Meghalaya was selected for the study. The impact of these technologies is calculated by the differences of variables before and after intervention of the project. The cost of production, net returns and B.C ratio were worked up to analyse the impact of the technologies on the income generation. Further, the percentage growth of each technology since inception was analysed on the basis of area and farmers' adoption rate.

Results

Technology No.1: Natural resource management Technology - *Low-cost water harvesting for High Value Crops (Jalkund)*

In the absence of major and medium irrigation potential/ facilities, the alternative method is to explore minor irrigation potential through effective water-conservation measures. Hill farmers suffer from extreme water scarcity during November to March. Rainwater harvesting has tremendous potential of being an irrigation water resource for domestic use as well as for agricultural purposes for the resource-poor farmers in this vulnerable environment. One of the main climatic vulnerabilities of the adopted NICRA village is unavailability of adequate amount of water during the dry season (October – April) which poses a serious problem for successful *Rabi* vegetable cultivation.

To counter this, KVK, Jaintia Hills demonstrated low-cost water harvesting structure technology - *Jalkund* of size 5x4x1.5 m with silpaulin lining which has a storage capacity of 30,000 litres for harvesting rainwater during the rainy season. The stored water is subsequently use during dry periods to provide critical irrigation to high value winter vegetables. The impact of this technology as depicted in Table 1, implies that the usage of low-cost water harvesting technology- *Jalkund* has improved the yield of tomato (290qtl) and has enabled the farmers to cultivate cabbage during the dry spell (*Rabi* season) attaining a yield of 268 qtl.

Although the cost of production was much higher under low-cost water harvesting technology (Rs 2,63,080 per ha), the net return (Rs 5,73,920 per ha) gained however was much higher for the technology implemented practice. The B.C ratio (3.18:1) worked out evidently indicates the success of the usage of low-cost water harvesting technology-*Jalkund*. With the introduction of *Jalkund*, it has not only boosted the vegetable production in the village and improve their livelihood but also provided them with better nutritional security.

Table 1. Impact of low-cost water harvesting for high value crops (Jalkund)

Intervention	Yield (q)	Cost of production (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
Farmers' practice (single crop of tomato)	Tomato - 272q/ha	149500	408000	258500	2.73
Using Jalkund (Two crops can be taken in a year)	Tomato- 290q/ha Cabbage- 268q/ha	2,63,080	8,37,000	5,73,920	3.18:1

The water use efficiencies of the different crops under Jalkund and rainfed conditions was worked out and the results indicates higher water use efficiencies under Jalkund as depicted in Table 2.

Table 2. Comparisons of Water use efficiency of crops in Jalkund vs crops under rainfed conditions

Particulars	WUE (kg/ha/mm)
Jalkund	Tomato-36.25 Cabbage-53.6
Rainfed	Tomato- 34.25

Technology No. 2: Rice- Fish integration

Small landholding and lack of integration between farming components are one of the major shortcomings for upliftment of the farming community in Jaintia Hills district. This eventually leads to low productivity and income. Therefore, integrated farming system was introduced in the NICRA adopted village for sustainable productivity and higher income throughout the year.

The technology demonstrated under IFS was Rice-Fish integration model. This integration model of farming was conceived as climate resilient technology in NICRA village to enhance the productivity and profitability as the two crops *i.e.* paddy and fish can be ensured from a unit of scarce cultivable area and secures the living of small and marginal farmers whose livelihood are under the intimidation of climate change. A low-lying area which retains water for 4-6 months has been opted for rice-fish farming under mid hill condition. The rice fish plot (500sq.mt) was design with perimeter canal (size 1mt width & 0.5m depth) for rearing improved variety of common carp called Amur carp and local common carp at a stocking density of 4000 nos. per ha. A Paddy (local variety) was transplanted in the 2nd week of July and after 21 days of transplantation, fish variety Amur carp and local common carp of size 10-15 cm length was released in the ratio of 1:1. The total nos. of fingerlings released was 200 nos. The fishes were harvested in the month of November at the time of harvesting of paddy. Apparently, Amur carp obtained an average growth of 250 gm and the average growth of local common carp was recorded to be 190 gm after 120 days culture duration. The survival percentage of fish was 90-95%.

From Table 3, before the intervention of the technology, the farmer attained a yield of only 26 qtl from paddy with a net return of Rs 67,000 per hectare. However, after the integration of rice-fish model, he attained a yield of 27.5 qtl from paddy and 6.2 qtl from fish yield with a net return of Rs 1,50,000 per hectare. This technology did not only assist the community to gain higher economic returns but also helped in pest management. The incorporation of the fishes in the paddy field controlled the occurrence of the pest as the fishes fed on the larvae of the pest and insects. Thus, the paddy crop acted as a substrate to enhance food for the fishes.

The B.C ratio in both demonstrated integrated technology (Table 2) were high which indicate high profitability return for the ventures. Integrated farming system has thus helped in reducing the socio-economic risk due to diversification in use of resources as the failure of one component could not affect much the farmer's income.

Table 3. Impact of Integrated Farming System

Intervention	Yield (q/ha)	Cost of cultivation (Rs. /ha)	Gross return (Rs. /ha)	Net return (Rs. /ha)	B:C ratio
Farmers' practice (Paddy cultivation)	Paddy yield-26q/ha	50,000	1,04,000	67,000	2.08:1
Rice-fish Integration (demonstrated)	Fish yield-6.2q/ha Paddy field-27.5q/ha	87,000	Fish -1,24,000 Paddy-1,10,000 2,34,000	1,50,000	2.6:1

Adoption level of the different climate resilient technologies

Many of the farmers on observing the success of the demonstrated technologies adopted the technologies at their own field. Table 4 depicts the growth in the area and the percentage of farmers adopting the technology. Thus, the high adoption rate of the farmers for each of the climate resilient technology signifies the success and local specific of the technology. Further, widespread awareness or trainings of these technologies to non-adopted NICRA villages will be rewarding for the farming community.

Table 4. Percentage increment of the technologies since inception

Technology	Area (%)	Adopted farmers (%)
Jalkund	14.20	40
Paddy cum fish	91.17	50

The present paper accentuated the impact of the different climate resilient technologies demonstrated by KVK, Jaintia Hills at the adopted NICRA village. For each of the technologies demonstrated the yield, cost of production and income return were found to be higher than the farmers' practice. This might be due to implementation of climate resilient improved varieties tied with better water and healthy soil management practices. All the above findings exhibited an encouraging impact of the demonstrated technologies in various spheres of farmer's life of NICRA village. The various climate resilient technologies have been up-scaled to neighbouring villages and they have proved to be successful in coping with the current climatic variability in the district. They are able to reduce risks, tackle the climatic uncertainties, provide nutritional security and enhance the livelihood of the small and marginal farmers.

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UID: 1724

Impact of Scientific Interventions on Popularization of Brown Sarson in Bandipora District under Rainfed Conditions

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Oilseeds play a critical role in the agricultural economy of India, ranking second only to food grains in terms of area and production. Despite an increase in the cultivated area and production, the productivity of oilseeds remains low compared to other major oilseed-producing countries. Factors contributing to this include cultivation on marginal lands, dependency on rainfed conditions, and limited use of modern inputs. India imports significant quantities of edible oils due to the demand-supply gap, underscoring the need for enhancing domestic production through improved agricultural technologies. Brown Sarson (*Brassica rapa var. Brown Sarson*) is a vital oilseed crop, particularly in Jammu and Kashmir, where rainfed agriculture dominates. Brown Sarson is cultivated during the rabi season in Kashmir and is predominantly rainfed. Scientific interventions, including improved varieties, optimal nutrient management, and timely sowing, can address yield gaps and enhance farmers' economic returns. This study evaluates the impact of such interventions in the Bandipora district of Jammu and Kashmir.

Methodology

was conducted in the Bandipora district of Jammu and Kashmir during the rabi seasons of 2022-23 and 2023-24. Demonstrations were carried out under the NICRA project with active involvement of KVK staff and local farmers.

Experimental Design A total of 85 farmers participated in the demonstrations, covering an area of 22 ha over two years. Scientific practices (SP) were compared against farmers' traditional practices (FP).

Parameters Measured

1. Yield Gaps:
   - % Increase in the yield = [(Yield in demonstration plots – Yield in farmers' practice plots) / Yield in farmers' practice plots] × 100
   - Technology yield gap (kg/ha) = Potential yield (kg/ha) - Demonstration yield (kg/ha)

- Extension yield gap (kg/ha) = Demonstration yield (kg/ha) - Farmers' practice yield (kg/ha)
- Technology index (%) = [(Potential yield (kg/ha) - Demonstration yield (kg/ha)) / Potential yield (kg/ha)] × 100

2. Economic Analysis:
   - Gross returns, net returns, and benefit-cost (B:C) ratio.

KVK provided the inputs used in the demonstration plots. Additionally, each farmer was responsible for paying their own labour costs, planting fees, post-harvest expenses, etc.

Data Collection Yield data were collected through random crop cutting. Qualitative data from surveys were converted into quantitative measures for analysis.

Results

Yield Performance: The productivity of demonstration plots was significantly higher than farmers' practices. The average yields, potential yields, and calculated gaps are presented in Table below.

Table 1. Performance of Demo plots in comparison to farmers from 2022-23 to 2023-24 at Bandipora district of Jammu and Kashmir, India

Year	Farmers (No.)	Area (ha)	Potential Yield (q/ha)	Demo Yield (q/ha)	FP Yield (q/ha)	% Increase Over FP
2022-23	33	10	17	11.5	8.5	35
2023-24	52	12	17	12.5	9.0	39

The average yield increase of 35% demonstrates the efficacy of scientific practices, such as timely sowing, recommended fertilizer doses, and integrated pest management. The results clearly show that the Shalimar Sarson-2 variety's performance had a significant positive impact on grain yield, which may be credited to the adoption of recommended agro-technologies in demonstration plots (Adivappar et al., 2018; Singh et al., 2021).

Economic Benefits

The demonstrations achieved an average productivity of 13.5 q/ha compared to 8.5 q/ha in FP. Economic analysis indicated a significant increase in net returns and B:C ratios. Farmers reported increased incomes due to improved yields and reduced production costs.

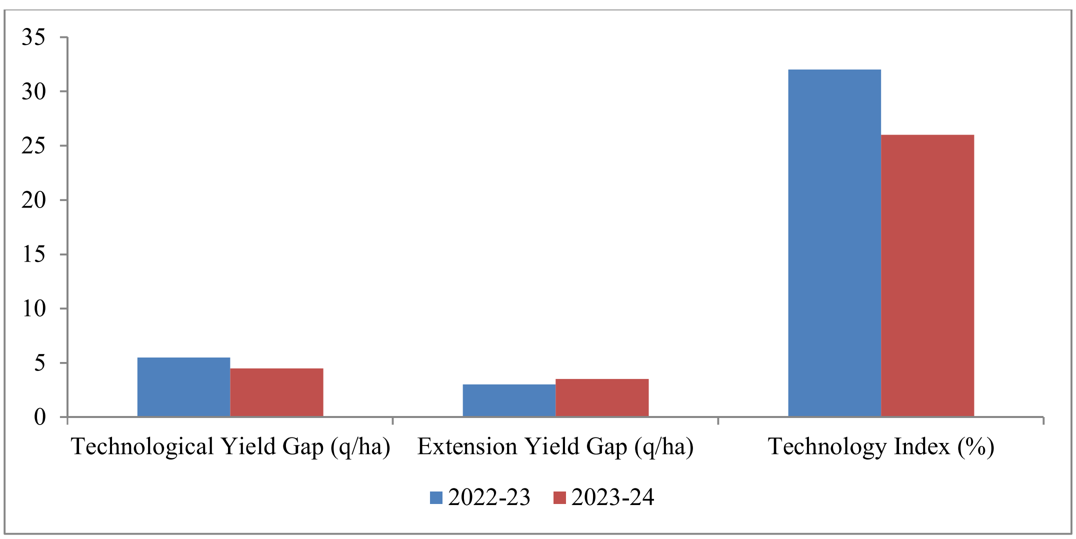
Table 2. Performance of Demo plots in comparison to farmers plots in terms of economic parameters from 2022-23 to 2023- 24 at Bandipora district of Jammu and Kashmir, India

Year	Yield (q/ha)			Economics of Demo (Rs/ha)			Economics of Farmers' Practice (Rs/ha)		
	Demo	Farmers Practice	% Increase Over FP	Cost of Cultivation	Net Return	BCR	Cost of Cultivation	Net Return	BCR
2022-23	11.5	8.5	35	40000	40500	2.01	33500	26000	1.77
2023-24	12.5	9.0	39	40000	47500	2.18	33500	29500	1.88

Technology and Extension Gaps: The technology gap, extension gap, and technology index were analysed to identify bottlenecks in achieving potential yields.

Brown sarson technology yield gap (kg ha-1), extension yield gap ((kg ha-1) and technology index (%) from 2022-23 to 2023-24 at Bandipora district of Jammu and Kashmir, India

Key findings include a significant disparity between the technology developed at research institutions and its adoption by farmers in the field (Sheikh et al., 2013; Rai et al., 2020; Deka et al., 2021).



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UID: 1757

Assessment Study of Resilient Technologies in Agriculture to Mitigate Climate Change in West Siang District of Arunachal Pradesh

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In Indian agriculture, year-to-year fluctuations in output and variations in productivity across space have remained issues of significant concern for researchers as well as policy makers. Likewise in North-eastern India, more specifically West Siang district of Arunachal Pradesh, various anthropogenic and natural factors have led to change in clime i.e. rainfall patterns, frequent forest fires, increased insect pest infestation, and the drying of mountain springs and watersheds, which is ultimately affecting the agricultural systems of the region. Considering these aspects, the ICAR-Krishi Vigyan Kendra West Siang, introduced various climate resilient technologies under National Innovations in Climate Resilient Agriculture (NICRA) i.e. low cost poly house structure for vegetable cultivation, vermicomposting, custom hiring centre for ensuring availability of high cost machinery to farmers, Jal kund as a water harvest structure for off season, Improved Piggery, Improved Poultry and Duckery. Results from study of impacts of these interventions has resulted in increase in vegetable cultivation i.e. king chilli in off season, increase in sustainable soil quality and health due to increased use of vermicompost, increase in water storage capacity as well as increase in no of farmers having access to irrigation water, improvement in area under mechanized agriculture, increase in

income of farm households, conversion of wastelands into paddy cultivation and improved crop management practices i.e. zero tillage, mulching, intercropping, direct seeded rice. Approximately 80 per cent farmers have preferred low cost poly house technology and vermicomposting among all the interventions. Moreover the adoption rate of these technologies is near 74 per cent. Lack of adequate proper climate resilient technology, reluctance among the beneficiaries to adopt climate resilient new technology and lack of coordination, interest for social service and proper understanding among the farmers in West Siang are the major constraints faced by the farmers. The interventions from KVK can solve farmer's problem in participatory mode involving other allied departments while increased demonstration and adoption of these technologies may create greater impact to mitigate climate change which can lead to sustainable livelihoods in future.

UID: 21398

Natural Resource Management through Farmers' Participation – A Farmers FIRST Approach

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Natural resource management (NRM) plays a pivotal role in ensuring sustainable agricultural productivity, particularly in rainfed regions where water availability is scarce. This paper discusses a series of NRM interventions undertaken under the Farmer FIRST Programme (FFP) by five institutes under ICAR-ATARI, Hyderabad: ICAR-IIMR, ICAR-CRIDA, ICAR-IIOPR, TANUVAS, and ICAR-IIOR. Andhra Pradesh, Telangana and Tamil Nadu.

Methodology

The Farmer FIRST Programme (FFP) adopts a participatory research approach, where farmers and scientists collaborate to develop and implement technologies suited to local conditions. Participatory Rural Appraisals (PRA) and baseline surveys were conducted to assess the socio-economic conditions, resource use patterns, and challenges of farmers. Identified interventions were well discussed with the farmers during farmer scientist interface meetings and necessary modifications were made to suit the local conditions. Each institute implemented these location-specific interventions with the participation of farmers.

Results

1. Weather based irrigation scheduling in oil palm

Weather based irrigation scheduling strategy in oil palm orchards was introduced and popularized by ICAR-IIOPR to save irrigation water. In this method accurate amount of water required during different months in oil palm will be scheduled by adjusting the irrigation schedule with the help of mobile pump starters. Awareness was created among farmers to adopt micro irrigation based on weather based irrigation scheduling during different months. WhatsApp messages were sent on requirement of irrigation to be given (for keeping alarm) to the groups. With this intervention about 40000 to 45000 litres of water could be saved per day in one ha of oil palm orchard. In addition, 3 - 4 hours/ day electricity could be saved apart from one manpower per day in normal irrigation. Farmers are taking up additional crops like Banana, Cocoa, Maize and fodder crop with this saved irrigation water.

2. Plastic film embedded gabion check dams

In farmers FIRST project, an intervention was made; the gabion structures were embedded with 1 mm HDPE film at the centre of the structure by ICAR-CRIDA. These plastic films embedded gabion structures reduced the sediment concentration by 70% than the traditional gabion check dam without using plastic films. These gabions were able to store the rainwater in the range of 9000-15,000 m^3/structure and conserve the rainwater up to 60%, increasing the water table in the surrounding wells by 0.6 m. The stored rainwater in each structure was able to provide irrigation to an area of 1 ha.

3. In-Situ Moisture Conservation for Redgram

Moisture conservation is crucial in rainfed farming systems, where water availability is inconsistent. To address this, a moisture conservation method was demonstrated using conservation furrows in red gram by ICAR-IIOR, Hyderabad. The furrows helped retain moisture in the soil, improving the water-holding capacity and reducing the risk of crop failure during dry periods. Seventy demonstrations across 30 hectares showed a yield increase of 27.5% compared to control plots without furrows. This intervention provided clear evidence of the effectiveness of in situ moisture conservation in enhancing crop productivity under rainfed conditions.

4. Recycling of Biomass in Oil Palm Plantations

Biomass of 7-10 t/ha is produced in oil palm plantations every year which is not being economically used, rather burnt, or thrown outside. ICAR-IIOPR introduced and popularized biomass recycling through mulching and vermicomposting to promote organic matter decomposition and improve soil health in oil palm plantations of Andhra Pradesh. Farmers used chaff cutters and brush cutters to chop oil palm fronds and other biomass. Chaffed material was used for mulching in oil palm basins as well as base material for vermicomposting. This technique was demonstrated to 174 farmers' fields covering 1281 ha. By seeing the advantage of this technology oil palm growers adopted in an area of 6425 ha. This increased the availability of organic compost round the year and insitu mulching for soil and moisture conservation. Soil and moisture conservation through mulching, paved way for organic farming and reduced application of fertilizers (25-30%) through inorganic source.

5. Line Sowing Method for Enhanced Yield

In the pursuit of improving cultivation practices, the line sowing method was introduced by ICAR-IIMR to optimize plant density and facilitate easier intercultural operations. A total of 90 field trials were conducted on millets, with crops like sorghum, pearl millet, finger millet and foxtail millet. Line sowing resulted in significantly higher yields (11-23%), as the method allowed plants to grow uniformly and with better access to sunlight and nutrients. Farmers also found that line sowing reduced labor costs for weeding and fertilization.

Conclusion

The Farmer FIRST Programme has demonstrated significant success in addressing natural resource management challenges in rainfed regions through participatory approaches. Interventions such as weather-based irrigation scheduling, plastic film-embedded gabion check dams, and in situ moisture conservation have significantly improved water efficiency and crop productivity. Biomass recycling and line sowing practices have enhanced soil health, organic farming adoption, and yield outcomes, fostering sustainable farming practices. Active farmer participation ensured the adaptation of interventions to local conditions, maximizing their impact. Overall, this initiative highlights the critical role of collaborative efforts in achieving sustainable agricultural development.

UID: 21400

Summary of NICRA-TDC Programme

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Climate change has emerged as the biggest challenge of the present era to the sustainable development. Anthropogenic activities are the main cause for increase in green house gas emissions and increase in global temperature causing greater change in the cardinal temperatures. A change in temperature has been observed in both maximum and minimum temperatures over past decades causing increased frequency of extreme weather events like flood, dry spells, heat and cold stress. These climate variations have significant impact on agriculture production and farm livelihood at micro level (Naveen *et al*., 2019). Hence, there is a need to develop climate resilient technologies at agro-climatic zonal level, location specific research and development, diversified and flexible interventions. In this context the NICRA (National Innovations in Climate Resilient Agriculture) project was initiated during

2011 by the Indian Council of Agriculture Research (ICAR) under Ministry of Agriculture and Farmers Welfare, GOI. The project attempts to develop and promote climate resilient technologies in agriculture which will address vulnerable areas of the country. The outputs of the scheme will help the districts and regions prone to extreme weather conditions like droughts, floods, frost, heat waves, *etc*. to cope with such events. The Technology Demonstration Component (TDC) of NICRA aims at demonstrating the climate-resilient technologies which addresses immediate challenges posed by climate vulnerability and also in their potential to foster long-term sustainability at the farmer field level.

Methodology

The TDC-NICRA is working in risk prone districts which are selected based on comprehensive risk assessment made by the ICAR-CRIDA. Based on the vulnerability assessment, the districts are classified in to very high risk (1-109), high risk (110-310), medium risk (311-514), low risk (515-563) and very low risk (564-573) (Rama Rao *et al*., 2019). Initially during 2011, under TDC-NICRA programme, 100 risk prone districts were selected and during 2015-16 it was increased to 121 districts. In 2021 it has increased to 151 risk prone districts. At present 151 districts in different states of the country were operational under TDC-NICRA out of which 73 districts comes under very high risk prone and 73 districts comes under high risk prone areas. Initially many different resilient technologies were demonstrated in the farmers field under 3 modules viz.

1. Natural Resource Management (NRM): Ex-situ moisture conservation, *In-situ* moisture conservation, land levelling, zero tillage, direct seeding, residue mulching, foliar nutrition *etc*.
2. Crops and cropping systems: Improved crop varieties, cropping systems, crop diversification *etc*.
3. Livestock management practices: Improved breeds, year-round fodder production, improved fodder varieties, shelter management, animal nutrition *etc*.

During 2023, the demonstration modules were modified in to four farming system modules in the risk prone districts to address the climate variabilities like drought, flood, cyclone, heat/cold wave, frost and high temperature stress.

1. FST1: Rainfed Farming Systems without livestock component
2. FST2: Rainfed Farming Systems with livestock component
3. FST3: Irrigate Farming Systems without livestock
4. FST4: Irrigate Farming Systems with livestock

Results and Discussions

Several interventions such as *in-situ* moisture conservation, Farm ponds and providing supplemental irrigation from harvested water, drought tolerant varieties (rice- JR206, TKM-13, PR-126, wheat-VL-967, K1317, K 1006, HI 8759, sorghum - CSH-30, chickpea -Jaki-9218 *etc*) were taken up in NICRA villages to minimize the drought and dry spell impacts. Some of the drought tolerant rice varieties demonstrated in different villages of Garhwa, Ganjam are Swarna Shreya, IR64 (DRT-1), Sahabhagi Dhan which contributed to the yield improvement up to 22-30% in comparison to farmers' practice during the *kharif* season, where deficiency of rainfall was observed. In North-Eastern states, water harvesting and its efficient use by way of Jalkund was taken up with high value vegetable crops such as tomato, broccoli, cabbage, cauliflower. High value fruit crops such as dragon fruit, kiwi, *etc*. were introduced. Supplemental irrigation with harvested water resulted in increased yield and income of vegetables to an extent of 23% in yield and 165% in returns in tomato.

During 2023, heat stress was experienced in many parts of the country *viz*. Rajasthan, Punjab, Uttar Pradesh, West Bengal and Odisha. To overcome this heat stress some of the technologies demonstrated were timely wheat sowing with zero tillage, short duration rice verities which realized wheat yields up to 97% of normal yields. Further, adoption of heat tolerant wheat varieties, HD 3059, K1317 resulted in yields of 10-12% higher than farmers practice, heat tolerant pea variety IPFD 12, and frequent sprinkler irrigation in onion. Foliar application of 1.5% KNO_3 in wheat recorded 4 and 8% higher yields and net returns. Heat tolerant cabbage variety Pusa Cabbage at Odisha improved 27% yields.

Drainage channels, submergence tolerant crop varieties were demonstrated in several cyclone and flood affected areas of Bhadrak, Srikakulam, Dhubri. Flood tolerant rice varieties Swarna Sub-1, MTU 1061, Ranjith Sub-1 were demonstrated and the extent of yield improvement observed was up to 20-30% over the local varieties. Improved blackgram variety Indra-1 at Bhind recorded 30% higher yields in the flood prone areas.

Technologies which can minimize crop residue burning such as happy seeder, mulcher/chopper/shredder, baler cum knotter, zero till drill and incorporation with rotavator were demonstrated in the states of Punjab, Haryana and Western Uttar Pradesh which resulted in 16-35% yield improvement in wheat and mustard. Improved fodder varieties like bajra (BL-101), Napier grass (DHN-6), multicut fodder sorghum (CoFS-31) increased the milk yield by 12-125% in livestock.

Village institutions established as part of the project, viz., seed bank, fodder bank and custom hiring centres contributed towards the adoption and spread of the resilient practices. Over all TDC-NICRA is aiming to demonstrate climate resilient technologies on the farmers field to address the long-term impact of climate vulnerabilities in the country along with improving crop and livestock productivity, sustainability and net income of the farmers.

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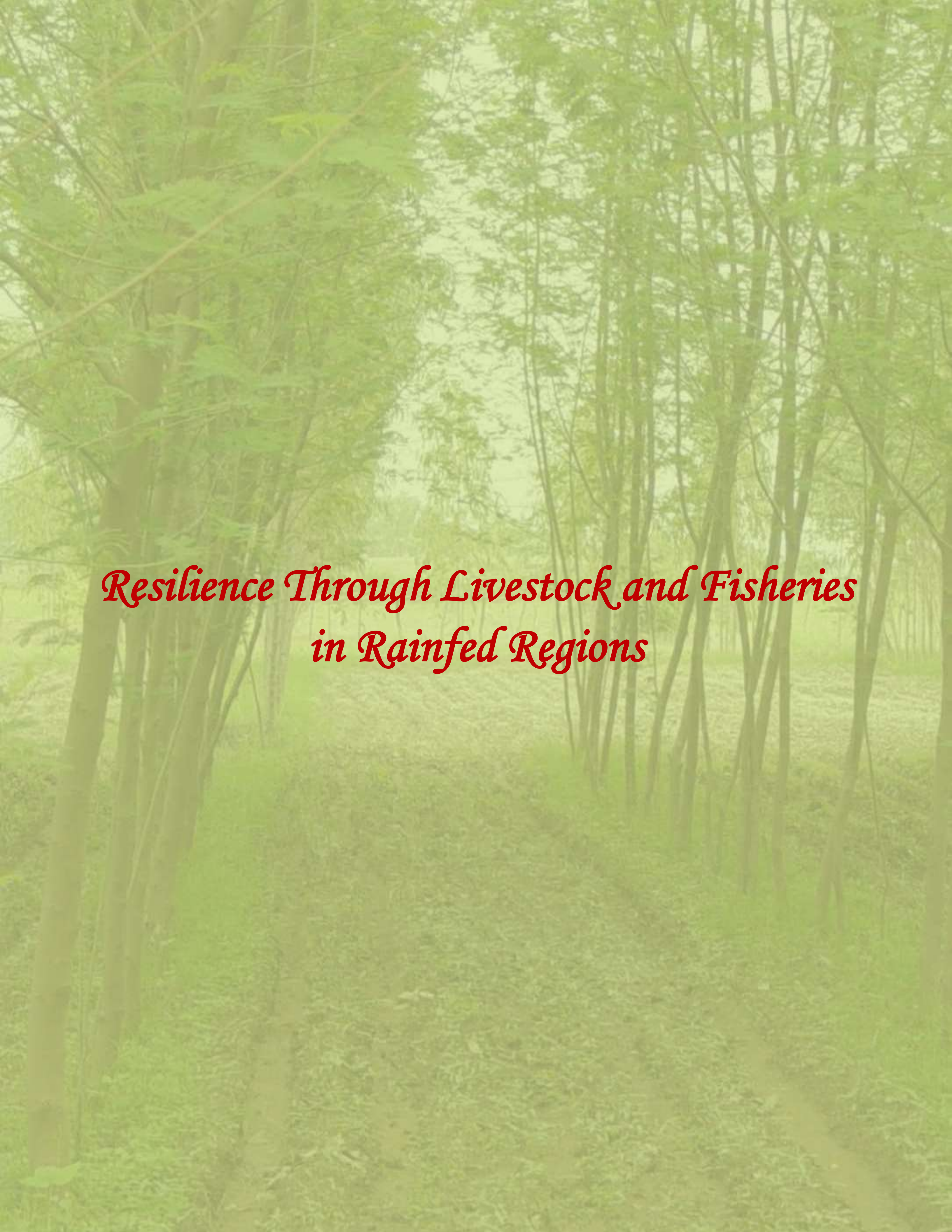

Resilience Through Livestock and Fisheries in Rainfed Regions

UID: 1031

Summary of NICRA Work Done: ATARI Jodhpur

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During the year 2023-24 under NICRA project eighteen KVKs (13 in Rajasthan and 5 in Haryana) actively involved in carrying out different activities under Technology Demonstration Components comprised of various modules. Under this project 23318 partner farmers (NRM-771, crop production-2638, livestock and fodder production-1194, institutional interventions including custom hiring -3554, capacity building-3239, extension activities-11922) were involved.

Natural Resource Management Module

Total 762 demonstrations were conducted, covering 963.1ha area which involved 771 practicing farmers of 18 districts. *In-situ* moisture using resource conservation technology 115 demonstrations were conducted which have been successfully implemented in the NICRA villages and covered 83.0ha area during the year. Similarly, interventions on low cost rain water harvesting structure and recycling for supplemental irrigation achieved in renovating the old check dams, constructions of new farm ponds and village water ponds involved 33 farmers and covered 120.0ha area. Significant success achieved in soil health cards issued for 200 ha area in which 90 farmers participated.

Interventions on summer deep ploughing which involved 126 farmers covering 230.5ha area. Several demonstrations were conducted on use laser land leveller technology through 80 trials were conducted involving 80 practicing farmers covering an area of 52.0ha during the year 2023-24.

Crop Production Modules

were implemented through 2702 demonstrations by KVKs of Rajasthan and Haryana which covered 1023.0ha area. On short duration varieties total 255 demonstrations were conducted which covered an area of 92.4 ha; including clusterbean (RGC- 1066), mustard (DRMRIJ-31, RIJ-31), pearl millet (RHB-173), Til (RT-351), Cow Pea (RC-19), Paddy (PB-1121). On drought tolerant varieties total 225 demonstrations were conducted which covered an area of 90 ha; including barley (RD-2849, RD-2786), chickpea (GC-5), sesame (RT-351), cluster bean (RGC-1066), green gram (GAM-4, GAM-5), pearl millet (MPMH-17), moth bean (RMO-257) Cumin (GC-4).

Advancement of planting dates of rabi crops with terminal heat stress was demonstrated on 51 farmers' field covering an area of 14.4 ha using mustard (Giriraj) and cumin (GC-4) Wheet (Raj-4120). The percent increase yield in these crops recorded, respectively 19.72 and 37.30 as compared to farmers' practice. Under crop diversification 44 demonstrations were conducted in 17.6 ha area including Spring Maize. Demonstrations were conducted on nutrient management, crops on partner farmers' fields in 7.0ha area.

Livestock and Fodder Production

Various livestock related interventions were carried out through 1076 demonstrations which covered 5436 different categories of livestock during the year 2023-24. Breed improvement porgramme through 50 interventions using Murrah buffalo bull, Tharparkar bull, Jamnapari and Sirohi bucks was conducted in NICRA villages, which involved 465 animals. Due to feeding of mineral mixture and UMMB, deworming and vaccination of the lactating animals a significant improvement in the milk production of animals (7.0 to 15.7%) was recorded.

Total 96 demonstrations were conducted on 1470 backyard poultry in NICRA villages. Total 2747 livestock were vaccinated; owing to 376 livestock farmers. To mitigate the mineral deficiency about 258 animals were provided balanced nutrition through mineral mixture and green fodder owing to 373 livestock farmers.

Institutional Interventions

Custom hiring for timely operations, community fodder production, compost-pit and silage making, community seed and fodder bank, kitchen gardens and establishment of bio-gas units etc. (monitoring and technical guidance) covered 4200.5 ha area of 3554 partner farmers in Rajasthan and Haryana states. Further, establishment of fodder banks and seed banks helped 381 and 88 partner farmers, respectively to get fodder and seed during the scarcity period. NICRA KVKs under ATARI Jodhpur earned total revenue of Rs 1.83lakh through Custom Hiring Centres by which 3085 farmers completed different agricultural operations timely covering an area of 3440.5 ha during the year under report.

Capacity Building Activities

A total of 107 courses were conducted on various thematic areas during the year, in which 3239 partner farmers and farm women (2335 male and 978 female) actively participated. Thematic areas were; crop diversification and management, agricultural farm implements and machineries, NRM, feed, fodder and livestock management, pest and disease management, resource conservation technology, rodent and weed control, nursery raising, vermi-compost, value addition, alternate energy source, human nutrition and child care and drudgery reduction through farm implements for women etc.

Extension Activities

Total 345 activities were organized on various thematic areas which involved 11922 partner farmers and farm women (6676 male and 5246 female) during the year 2023-24. The major extension activities conducted were on awareness programmes, method demonstrations, exposure, diagnostic field visits, celebration of field and farmers' day, community meeting, group discussion and agro-advisory services etc.

Impact of NICRA Interventions

- **Water Positive Interventions**
  - In-situ moisture conservation/tubewell recharge technology augmented groundwater table
  - mono-cropping area (280 ha) diversified to double cropping (400 ha) in adopted villages.
- **Climate Resilient Varieties**
  - Seeds of CRVs upscaled in district increased yield by 15 to 45%.
- **Livestock and Avian**
  - livestock output improved by 12-25% due to breed, feeding and health interventions
  - 40 Backyard poultry units started by unemployed youth.
  - Green fodder feeding to cattle and buffalo enhanced milk yield by 15%.
- **Institutional Interventions**
  - Machineries provided under CHC reduced cost of cultivation and post-harvest losses by 25 to 70%.

UID: 1040

Resilience through Livestock and Fisheries in Rainfed Regions

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Livestock keeping in India has a long history, spanning thousands of years, and plays a crucial role in the relationship between local ecosystems, livestock breeds, and human communities. Around 21% of India's land is made up of common property resources (CPRs) like gochars and orans, which are essential for feeding livestock in rain-fed, arid, and semi-arid areas. These regions mainly depend on CPRs for fodder, as only one crop can usually be grown each year due to limited rainfall during the monsoon. Traditional livestock systems are vital for food and nutritional security, especially for women and children. They provide important resources like meat, milk, manure, and draught power in places where growing crops is difficult, such as the Himalayan pastures and the Thar Desert. Local livestock breeds have adapted well to their environments. Breeds from nomadic communities, like the Gaddi and Raika, can travel thousands of kilometers each year to find good grazing land. Research shows that these indigenous breeds have lower metabolic rates, helping them survive better in drought conditions compared to high-performance exotic breeds, which tend to struggle during times of feed shortage. In India, there is a significant shortage of dry fodder, green fodder, and for concentrates. Indigenous breeds, such as Bos indicus, are known for their heat tolerance and disease resistance. For example, Sahiwal cattle can handle ticks and blood parasites better than many exotic breeds, and native Nari cattle in Rajasthan show low susceptibility to diseases. However, these traditional livestock systems face growing threats from development pressures and changing land use policies. Many grazing lands are now labeled as 'wastelands' and are being converted for bio-fuel production or industrial use. This shift, along with the weakening of traditional management practices, puts the livelihoods of pastoralists at risk. It is essential to protect the genetic diversity of local livestock breeds and their ecosystems to ensure sustainable agriculture and food security in India. Recognizing and safeguarding CPRs is vital for maintaining traditional livestock systems, which support the livelihoods of millions of pastoralists throughout the country.

UID: 1044

Vanaraja Based Backyard Poultry Flock Size for Livelihoods of Farmers in Dryland Rural Telangana

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The rural populace of Telangana, especially those without land and small-scale farmers, depends on poultry farming for their sustenance (Krishna *et al*., 2020). Nonetheless, the limited production capacity and inadequate returns hinder the involvement of rural and tribal communities in the poultry production-marketing-consumption chain, leading to a scarcity of poultry products at elevated prices (Pankaj *et al*., 2019). Vanaraja, a widely recognized dual-purpose poultry variety, has the potential to improve profitability, nutritional security, and livelihoods within the current poultry rearing framework (Pankaj *et al*., 2018). Consequently, various organizations are providing between 5 to 25 chicks per farmer to improve their livelihoods. Nonetheless, there is a lack of information regarding the number of chicks that can be raised by these resource-limited landless or small-scale farmers to ensure optimal profit per bird for them. To develop an optimal model for landless or small farmers that can facilitate backyard poultry through family labor, the Vanaraja variety of chicks, with a capacity ranging from 5 to 25, was showcased to farmers.

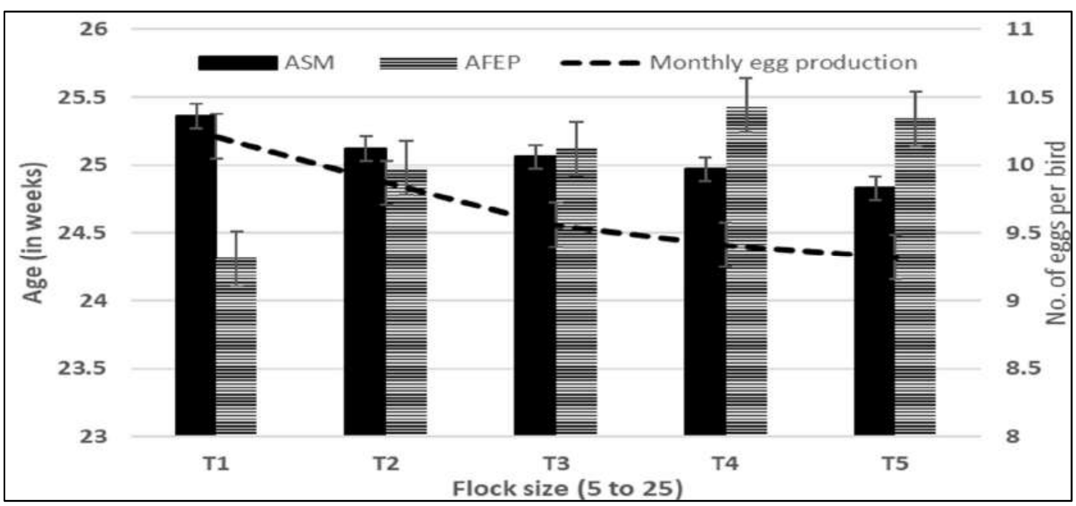
Methodology

The assessment of the backyard poultry model utilizing the Vanaraja variety for landless or small farmers was conducted in various rural regions of Telangana, specifically in the Vikarabad, Mancherial, and Adilabad districts, as part of the Farmers First Project, Scheduled Caste Sub Plan (SCSP), and Tribal Sub Plan (TSP) from 2021 to 2024. A total of 26,250 day-old chicks of the Vanaraja variety were distributed to landless farmers, with allocations of 2,500, 4,000, 6,375, 6,500, and 6,875 chicks to 500, 400, 425, 325, and 275 farmers, respectively, in varying flock size of 5, 10, 15, 20, and 25 chicks each. The demonstration model included a 5-chick model (4F, 1M), a 10-chick model (8F, 2M), a 15-chick model (12F, 3M), a 20-chick model (16F, 4M), and a 25-chick model (20F, 5M), designated as T_1, T_2, T_3, T_4, and T_5, respectively. Given that the farmers faced poverty and resource limitations, starter feed and additional technical support were provided to them.

Improved management practices, like starter feed, brooding management, feeder, waterer, health care, etc were imposed for scientific management of chick. All the chicks had *ad lib* availability of clean drinking water. The productive and reproductive data was collected and analyzed as per the standard statistical protocol.

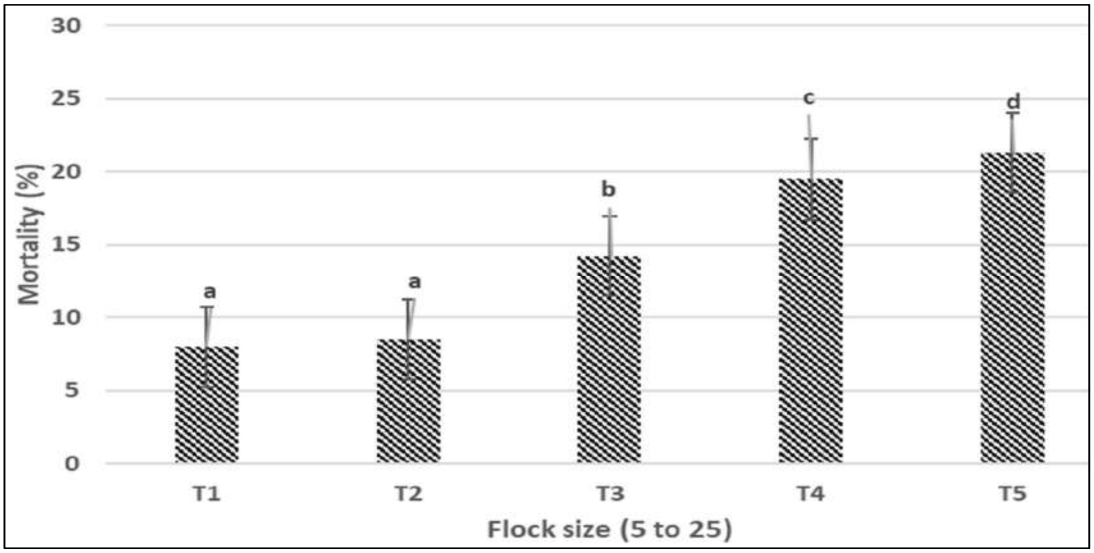
Results

In the backyard production system of the dryland region of Telangana, the dual variety Vanaraja demonstrated resilience, reaching a body weight of 1.5-1.7 kg at 5 months of age. The adult body weights were recorded at 2.2-2.7 kg for males and 1.7-2.0 kg for females, with an annual egg production ranging from 100 to 130 eggs and variable productive and reproductive traits, within a rearing unit of 5 to 25 (Fig-1).



Productive and reproductive traits of poultry observed under variable number model (ASM=Age at sexual maturity; AFEP=Age at First Egg Production)

In a study of various flock sizes of chicks (5-25) managed by different farmers, it was found that there was no significant difference in the age at which sexual maturity was reached. However, egg production commenced significantly earlier ($p<0.05$) in flocks of 5-10 chicks, indicating that farmers may provide better support for this smaller flock model. Due to improved care, management, and nutrition, annual and average monthly egg production were significantly higher ($p<0.05$) in the 5-10 chick model. This has resulted in a significantly superior body weight ($p<0.05$) in a 5-10 chick flock. The mortality pattern further corroborated this trend, as a significantly lower mortality rate ($p<0.05$) was noted in the 5-10 chick model (7.98-8.48%) compared to the 15-25 chick model (14.2-21.34%) (Fig-2).



Mortality pattern in variable flock size of Vanaraja chicks

The production cost per bird was significantly lower ($p<0.05$) for the 5-10 chick model (₹97.5) compared to the 15-25 chick model (₹788.5-832.5) (Table), which can be attributed to reduced reliance on external inputs.

Cost benefit analysis of poultry production under variable flock size of Vanaraja chicks

Sl. No.	Particulars	T_1	T_2	T_3	T_4	T_5
1	Variable cost (Chick, starter, medicine, vaccine)	425	850	1275	1700	2125
2	Fixed cost (Land, shed, drinker/feeder)	-	-	1650	1650	1650
3	Total cost of production	425	850	2925	3350	3775
4	Cost of production per bird (₹)	97.5	97.5	832.5	805.0	788.5
5	Gross income from sale of egg, cock and spent hens (₹)	5070.3	11142.8	15488	18595.2	23085
6	Net income (₹)	4645.3	10292.8	14213	16895.2	20960
7	Net income per bird (₹)	929.06	1029.28	947.53	844.76	838.4
8	Benefit-cost ratio (BCR)	9.53	10.56	1.14	1.05	1.06

Net income per bird was highest in the 10-chick model (₹1029.28), followed by the 15-chick model (₹947.53), the 5-chick model (₹929.06), the 20-chick model (₹844.76), and the 25-chick model (₹838.4). Similar observations were evident in the B:C ratio of variable flock size chick rearing, with the highest ratio recorded for the 10-chick model (10.56), followed by the 5-chick model (9.53), and the 15-25 chick models (1.05-1.14).

Conclusion

In free-range or backyard poultry settings with minimal feed supplementation, a flock size of 10-chick model demonstrated superior profitability and reduced mortality compared to other flock sizes. The 10-chick model yielded the highest net income per bird compared to other flock sizes, attributed to the inadequate support system in tribal and scheduled areas. Farmers' earnings will increase if they can sell their produce at higher prices. A unit comprising 10 Vanaraja birds (8 females and 2 males) is optimal and sustainable for landless and marginal farmers, yielding an additional income of approximately ₹10,293, while also enhancing nutritional and livelihood security.

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UID: 1071

Diversified Livelihoods for Women Farmers in Rainfed Areas through Poultry Farming

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Rice is the major crop grown as mono-cropping under rainfed situation in an area of 1.25 lakh to 1.39 lakh hectares in Ramanathapuram district of Tamil Nadu depending on the monsoon support both South West Monsoon and North East Monsoon. Monsoon is having the character of extremities by the way of erratic rainfall, delayed monsoons, intermittent droughts, and terminal moisture stress or flooding at harvest stage. The risk is higher in agricultural activities and income and also provides limited employment for the period of 120 days to 140 days. Eighty percent of the agricultural activities carried out by the women folk. Apart from agricultural activities they were involved in cutting of *Prosopis julifera* and supporting for charcoal making with higher risk of health and drudgery for livelihood of the women farmers.

Animal husbandry is one of the alternate sources of income for the farmers and farm women. Higher costs of feed and health risk of animal management during extreme weather condition also reduce the earnings of farm women. With this background, KVK, Ramanathapuram made intervention on providing poultry breed (Aseel cross), which is able to tolerate under extremities and also provide income and nutritional security to the farm family.

Methodology

The study aimed to identify the impact of the intervention implemented on supply of poultry chicks (Aseel cross) to the farmers of Karukathi village of Ramanathapuram district under NICRA scheme. Necessary training, awareness and advisories on production, health management of poultry in addition to the supply of improved breed chicks @ 25 numbers/family. The study compared local breed and Aseel breed and non NICRA farmers as control. Birds survival rate, production capacity, income generation and economics were considered as parameters for this study. The sample size of 25 farmers was selected with 25 numbers of chicks /farmer in NICRA operational area after one year period of intervention completed.

Results and Discussion

Survival rate and production capacity of poultry bird

The results indicate that survival rate (Table 1) was higher, with less mortality due to tolerance of improved breed to the extremities of weather events, when compared to the local breed. The production capacity of egg and meat by the improved breed was higher by uniform quality and fetched higher price.

Table 1. Performance of breeds and their production potential per poultry unit of 25 numbers

Technology	Survival number	Survival rate (%)	Production		Selling price	
			Egg (No./year	Meat (kg /year)	Egg (Rs./Egg)	Meat (kg /year)
Poultry (Improved breed: Aseel)	21.68	86.72	910.56	58.10	10.00	350.00
Poultry (local breed)	16.74	66.96	468.72	29.13	8.00	300.00

Performance of breeds on Economics

The cost involved (Table 2) on feed and health management for the improved breed and local breed was same, where as higher production potential of egg and meat resulted on higher gross return, net return and BCR in improved breeds when compared to the local breeds.

Table 2. Performance of breeds on Economics

Technology demonstrated	Cost of cultivation (Rs./ year)	Gross return (Rs./ year)	Net return (Rs./ year)	BCR
Poultry (Improved breed: Aseel))	4680	29,441	24731	6.29
Poultry with local breed	4680	12489	4809	2.67

Income and employment generation

Irrespective of the poultry breed maintenance added income and employment generation to the women farmers was higher when compared to non NICRA farmers (control). Among the breeds, improved breeds earned higher net return, BCR and employment opportunity during offseason as a part time work and supported for the livelihood of the farming community in addition to the income from the agriculture on cropping. The study revealed that 57.5% of the respondents totally depends on poultry for their family essential needs, and that 92.5% respondents poultry income contribute in their family welfare (Mohammed *et al*.2020).

Conclusion

Training, awareness and advisories created confidence among the women farmers on management of improved poultry breed aseel. The mindset and acceptance of improved breed increased and shifting of local breed to improved breed was happened to the level of 25-40 %. The livelihood security of women farmers was secured and standard of living especially during the celebration of festival also enhanced. Introduction of improved poultry chicks is the best additional alternate income source in the drought prone area of Ramanathapuram district for the livelihood of women farmers. The nutritional security by the consumption of egg and meat also indirectly improved.

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UID: 1077

Identification of Suitable food-fodder Intercropping System under Hot Arid Region of Rajasthan

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The agricultural production systems in India are based upon mixed farming in which two major enterprises are crops and livestock. Livestock rearing is an integral part in the Indian agriculture and plays a vital role in rural economy. The successful management of livestock will depend upon feeding of productive animals with sufficient quantity of nutritious fodders, but farmers are not able to allocate even a small portion of their land exclusively for fodder production in the cropping season. An integral approach of fodder production system aims at obtaining grain as well as fodder concurrently in space and time to cater the balanced nutrition of livestock was evaluated in order to increase the land productivity and ultimately increase the profit of the farmer. Legumes are good source of protein and can be used to compensate cereal protein shortage (Gebrehiwot et al., 1996). Thus, growing of crop mixtures with legumes, which referred to intercropping, can boost the forage protein content of diets. Fodder legume has a high protein concentration, palatability and digestibility and can be useful as a supplement to livestock feed with mature cereal crop residues that are often low in nutritive value (Hamdollah et al., 2009). Widely spaced crops grown in rows can conveniently be intercropped with short duration fodder crops with minimum detrimental effect on the base crop yield. Therefore, the study was planned to identify suitable intercropping system for better productivity and quality of fodder.

Methodology

A field experiment was conducted with food and fodder crops viz., pearlmillet, clusterbean and cowpea were intercropped in the row ratios of 2:2, 3:2 and 3:3, as legume and cereal intercropping keeping pearlmillet multi-cut fodder as base crop and compared with their sole stands also. Pearlmillet was harvested once after 35 days of sowing as green fodder, giving space to the companion crops to grow better. AVKB1 of pearlmillet, BL-4 of cowpea and RGC-1033 of clusterbean was the test varieties in experiment. The experiment was laid out in factorial randomized block design and replicated thrice.

Results

Fodder yield of individual crops was significantly higher in their sole stands; however, total fodder yield was higher in intercropping systems. Intercropping systems recorded 28.8, 80.1 and 74% higher fodder yield in pearlmillet, clusterbean and cowpea over their sole stands, irrespective of row ratios (Table). Seed yield of individual crops was recorded highest in sole stand but total yield was highest in intercropping. Pearlmillet equivalent yield (PMEY) on fodder and seed basis was recorded highest in pearlmillet and clusterbean intercropping especially in 3:3 row ratio. The intercropping of pearl millet + clusterbean recorded 8.1% higher yield and 16.3% higher B:C ratio over pearl millet + cowpea, irrespective of row ratios. In rabi season mustard and fenugreek were equally profitable but higher yield of mustard resulted in higher net returns and B:C ratio.

Effect of intercropping ratios on green and dry fodder yield of different forage crops

	Green fodder yield (t/ha)			Total GFY (t/ha)	Dry fodder yield (t/ha)			Total DFY (t/ha)
	PM	CB	CP		PM	CB	CP	
Sole PM	31.9	-	-	31.9d	8.02	-	-	8.02b
Sole CB	-	23.7	-	23.7d	-	4.65	-	4.65d
Sole CP	-	-	22.7	22.7d	-	-	3.55	3.55e
PM+CB (2:2)	26.7	16.4	-	43.1a	6.23	2.23	-	8.46ab
PM+CB (3:2)	28.2	15.7	-	43.9a	6.89	1.86	-	8.75a
PM+CB (3:3)	23.4	17.8	-	41.2ab	5.46	3.26	-	8.72a
PM+CP (2:2)	26.1	-	14.3	40.4b	6.05	-	1.88	7.93bc
PM+CP (3:2)	27.3	-	12.2	39.5bc	6.83	-	1.36	8.19b
PM+CP (3:3)	22.8	-	15.8	38.6c	5.19	-	2.27	7.46c

PM: pearlmillet, CB: clusterbean, CP: cowpea

Conclusion

It can be concluded from the study that intercropping of fodder crops along with food crops will help in augmenting forage productivity and quality especially from marginally eroded lands that prevails in arid region of Rajasthan.

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UID: 1082

Life Cycle Assessment Approach to Evaluate Environmental Impacts in Shrimp Aquaculture

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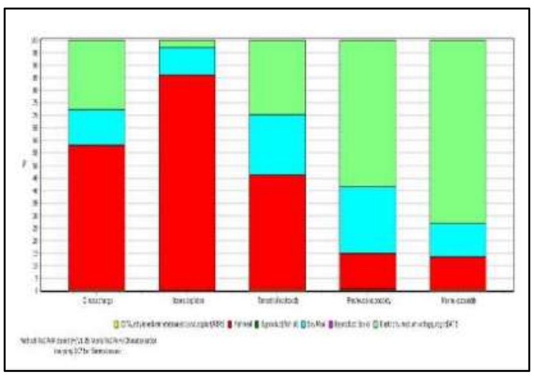
Shrimp contributed about 68% (US$ 5482 million) of India's total seafood export earnings of US$ 8.09 billion in 2022-23 **(**MPEDA 2023**).** From 2011 to 2018, the shrimp aquaculture in India witnessed an impressive growth rate of 23%. However, shrimp farming particularly in intensive systems is known to have environmental impacts due to its reliance on energy, feed inputs, and natural resources. Life cycle assessment (LCA) is an important tool for estimating cradle-to-gate environmental impacts and identifying the sources and hot spots responsible for the impacts. LCA studies were reported in aquaculture species from different countries (Ayer and Tyedmers, 2009; Aubin et al., 2015; Biermann and Geist., 2019) The shrimp aquaculture starts from the hatchery, where broodstock shrimp are procured either from the sea or from the Aquatic Quarantine Facility (AQF) or Broodstock Multiplication Centers (BMCs) to produce post larvae, and farming to grow the post larvae to marketable size shrimp.

Methodology

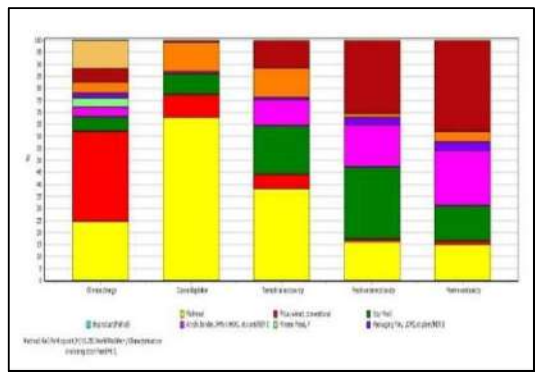
The present study under National Innovations in Climate Resilient Agriculture (NICRA) project, employs LCA to quantify and compare environmental impacts associated with Pacific white-legged shrimp, *Penaeus vannamei* production in India. The system boundaries included were hatchery, feed mill, and farming. The primary data was collected from each facility for data inputs. These foreground data supplemented by the secondary data were used to determine the environmental impacts. The environmental impacts linked to the production of vannamei were assessed using LCA following ISO guidelines. The system boundary included hatchery, feed mill and farming. The functional unit chosen for this analysis is 1000 kg (1 ton) of live-weight shrimp at the farm gate. For the feed mill, the relevant background data, including electricity production, raw material extraction and processing, and transportation were collected from published references and databases such as LCA food DK and Ecoinvent within the SimaPro software. The environmental impact categories assessed were the standard LCA categories viz., global warming potential (GWP), ozone depletion potential (ODP), and terrestrial ecotoxicity potential (TEP) based on the Life Cycle Impact Assessment (LCIA) of the functional unit performed using the ReCiPe 2016 Midpoint (H) V.1.02 LCA method using SimaPro software.

Results

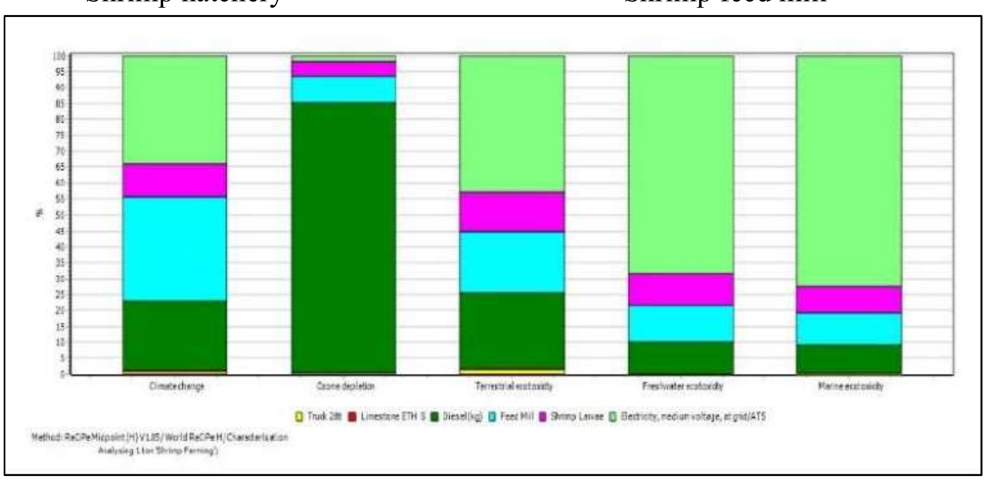
The values of environmental impact categories are depicted in Fig. 1. Shrimp farming is the key stage significantly contributing to the environmental impacts followed by the feed mill and hatchery. The GWP, ODP, TEP of shrimp farming were 3230 kgCO_2eq, 6.88 E-3 CFC11eq, and 0.268 kg 1,4-DB eq, respectively. Overall, the cumulative GWP, ODP, and TEP values across the system boundary starting from the hatchery to the farming were 4,265 kgCO_2eq, 7.595 E-3 kg CFC11 eq, and 0.335 kg 1,4-DB eq, respectively. The results of the percent contribution of processes to each category revealed that energy used through electricity and diesel during various processes including transportation was the largest contributor to global warming potential. A comparison of the various species and production systems of aquaculture and agri-food indicated that aquaculture farming generates lower greenhouse gas emissions compared to some competing meat sources. For instance, the emissions from farmed shrimp are significantly lower than those reported for beef (24,900 CO_2 eq by Hietala et al,. 2021) or salmon (6,414 CO_2 eq by Philis al., 2022).



Shrimp hatchery



Shrimp feed mill



Shrimp farming

Fig.1. Environmental impacts across the system boundary: shrimp hatchery, fed mill and farming

Conclusion

For the system boundary in the present study, the energy consumption through electricity & diesel, and feed preparation are the major hotspots for global warming potential. The environment-friendly shrimp aquaculture sector inevitably requires the adoption of alternative renewable energy sources to enhance cleaner production initiatives and achieve sustainability.

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UID: 1093

Impact of Rainfall Pattern Variability on Changes in Water Quality, Immune Parameters and Incidence of White Spot Disease in Tiger Shrimp

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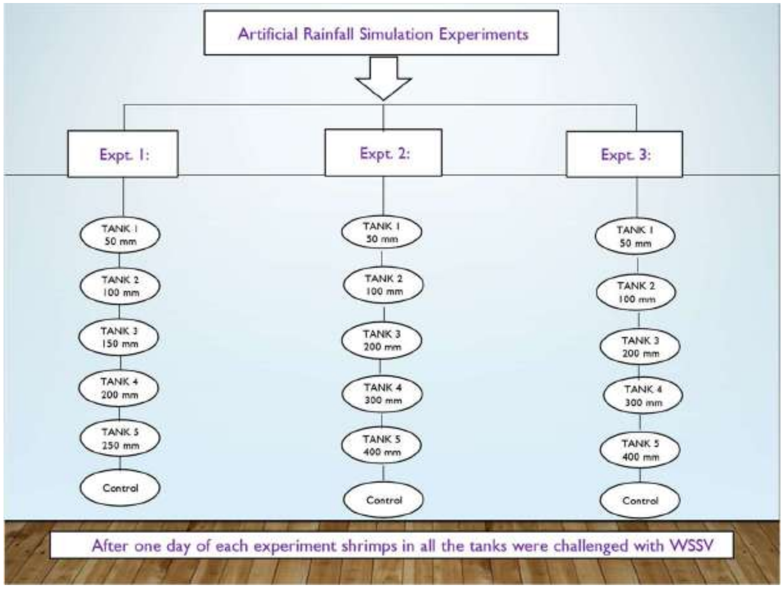
Shrimp aquaculture is crucial for India's economy, as it exported 716,004 metric tons of frozen shrimp, generating $4.88 billion in 2023-24. Excessive rainfall and floods often intensified by climate change are a direct threat to sustainable shrimp aquaculture, impacting water quality in shrimp ponds and posing a risk of disease outbreaks, which can reduce shrimp yield in India (Nagothu et al., 2012; Muralidhar et al., 2021) and Bangladesh (Ahmed and Diana, 2015; Islam et al., 2016). Shrimp thrive in specific salinity ranges and any abrupt shift can stress the organisms, making them more susceptible to diseases (Pradhan and Dash, 2021). The altered precipitation patterns and extremely heavy rainfall lead to the dilution of pond water resulting in a drastic decrease in salinity and fluctuations in water temperature, oxygen levels, and pH, further compromising shrimp health. These environmental changes can encourage the proliferation of pathogenic organisms, while the weakened shrimp immune systems struggle to resist infections. The reported loss for the global shrimp sector due to viral diseases was US$ 6 B in 2016, and the economic loss due to white spot disease (WSD) caused by white spot syndrome virus (WSSV) was US$ 250 M (Patil et al., 2021).

Our studies under the 'National Innovations in Climate Resilient Agriculture (NICRA)' project on extreme weather events in shrimp farming areas such as extremely heavy rainfall of 73 to 200 mm per day in Alappuzha, Kannur and Kottayam after Cyclone 'Shaheen' in Kerala during September 2021; flood in Narsapur Mandal in West Godavari District, Andhra Pradesh due to cumulative rainfall of about 480 mm during 2nd week of July 2022 which is 35% excess compared to normal rainfall; and a maximum rainfall of 530 mm in the three days between 2-4 December 2023 in Gudur Mandal, Andhra Pradesh showed changes in pond water quality and shrimp immune parameters. However, we could not quantify and correlate the variation in rainfall patterns with these parameters and disease incidence in the field. Hence, the objective of this study is to understand the impact of heavy rainfall i.e., rainfall pattern variability on the changes in water quality, immune parameters and incidence of white spot disease.

Methodology

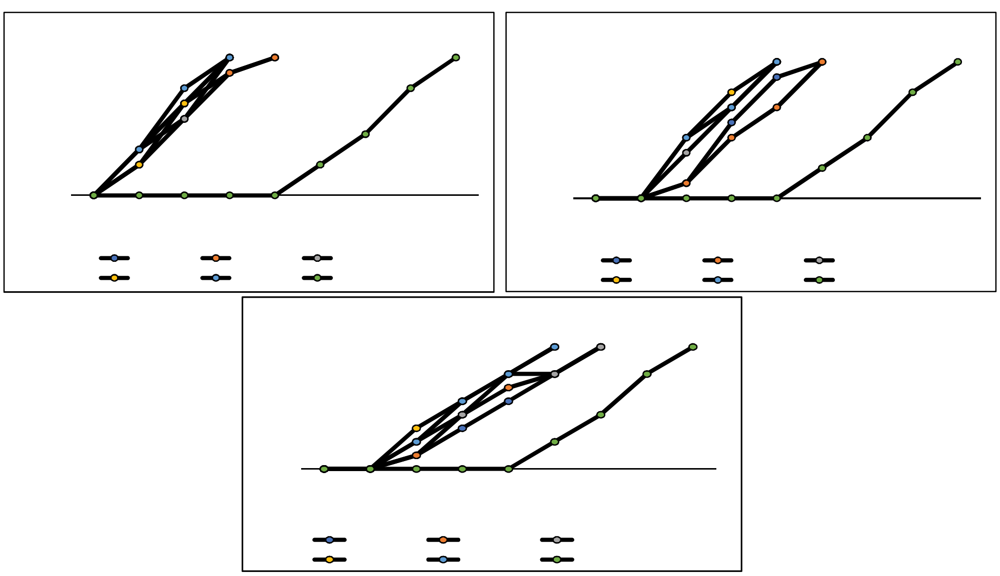
Three artificial rainfall simulation experiments were conducted in 500 l FRP tanks with Tiger shrimp *Penaeus monodon* (8.2 ± 0.2 g). The variation in rainfall pattern was simulated using artificial rainwater and showers, and the flow was regulated using water flow gauges. The shrimps were exposed to varying rainfall patterns i.e., intensity and duration in the three experiments, and the treatment details are shown in Fig.1. After one day of each experiment, the animals were challenged with WSSV by oral administration. The changes in water quality parameters viz., pH, salinity, nutrients, metabolites and minerals were monitored, and the immune parameters (phenol oxidise and superoxide dismutase) in the shrimp were analysed. After challenging with WSSV, the shrimp mortality was monitored on every day.



Experiments and treatment details

Results

Water parameters showed a decreasing trend in all the treatments. Animals were under stress as evidenced by changes in immune parameters. Gradual mortality was observed between 4 to 7 days in various treatments compared to 9 days in control (Fig.2). In Expt. 1 (1-Day) shrimps survived up to 5 days in tanks with 50 mm & 100 mm and up to 4 days in 150, 200 & 250 mm of rainfall. In Expt.2 (3-Days) shrimps survived up to 6 days in 50 mm & 100 mm and up to 5 days in 200, 300 & 400 mm of rainfall. In Expt. 3 (7-Days) the shrimps survived up to 7 days in 50,100 & 200 mm and up to 6 days in 300 & 400 mm of rainfall.



Mortality of shrimp after exposure to heavy rainfall variations and challenge with WSSV

Conclusion

In all the treatments, shrimps were under stress as evidenced by the changes in immune parameters. The impact of heavy rainfall stress within a short span accelerated the shrimp mortality due to WSSV. Farmers are advised to implement better management practices immediately after heavy rainfall to reduce the stress to shrimps.

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UID: 1094

Effect of Supplementation of Phospholipid for Amelioration of Temperature Stress in Pacific White Shrimp

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Aquaculture is the fastest-growing food-producing sector and plays a crucial role in supplying high-quality protein to millions of people worldwide. The Pacific whiteleg shrimp, *Penaeus vannamei*, is the most widely farmed shrimp species globally, primarily due to its fast growth rate and high tolerance to various environmental conditions (Kir et al., 2023). However, water temperature is a crucial environmental factor that significantly affects shrimp physiology, including growth, feeding, metabolism, and resistance or susceptibility to pathogens (Millard et al. 2021). Previous studies revealed that *P.vannamei* can tolerate water temperatures between 25°C to 35°C (Ponce-Palafox et al., 1997). Strategic adjustments in feed formulation can simultaneously promote robust growth and improve overall health and resilience of shrimp in aquaculture systems (Zhang et al., 2013). The inclusion of dietary phospholipids has been shown to enhance thermal tolerance in various aquaculture species, increasing their resilience to fluctuations in water temperature. Soy lecithin, a dietary source of phospholipids, is a potent non-protein energy source that not only meets energy requirements but also serves as an attractant, antioxidant, enhances vitamin absorption, and increases resilience to stress (Roy et al., 2006).

This study carried out under 'National Innovations in Climate Resilient Agriculture (NICRA)' project aims to investigate the influence of soy lecithin on temperature stress tolerance in *P. vannamei* juveniles, providing insights into a cost-effective and natural strategy to enhance shrimp aquaculture productivity under adverse pond environmental conditions. The primary objectives are to evaluate the growth performance of *P. vannamei* juveniles fed diets with varying levels of soy lecithin and to optimize soy lecithin inclusion levels to mitigate temperature-induced stress.

Methodology

Feed Preparation:

Three iso-nitrogenous and iso-lipidic experimental diets were formulated to assess the effects of dietary lecithin levels on the temperature stress response in *Penaeus vannamei*. The diets contained graded levels of soy lecithin at 1.00%, 1.25%, and 1.50%.

Feeding Trial:

A 45-day indoor experiment was conducted in 18 rectangular glass tanks, each with a 100 L capacity. The experimental setup maintained two constant temperatures 31°C (Control) and 35°C, using heaters installed in each tank. The formulated diets were distributed among the tanks in triplicate, ensuring each lecithin level was tested under both temperature conditions. At the end of the experiment, weight gain, specific growth rate (SGR), Feed Conversion Ratio (FCR) and Protein Efficiency Ratio (PER) were determined.

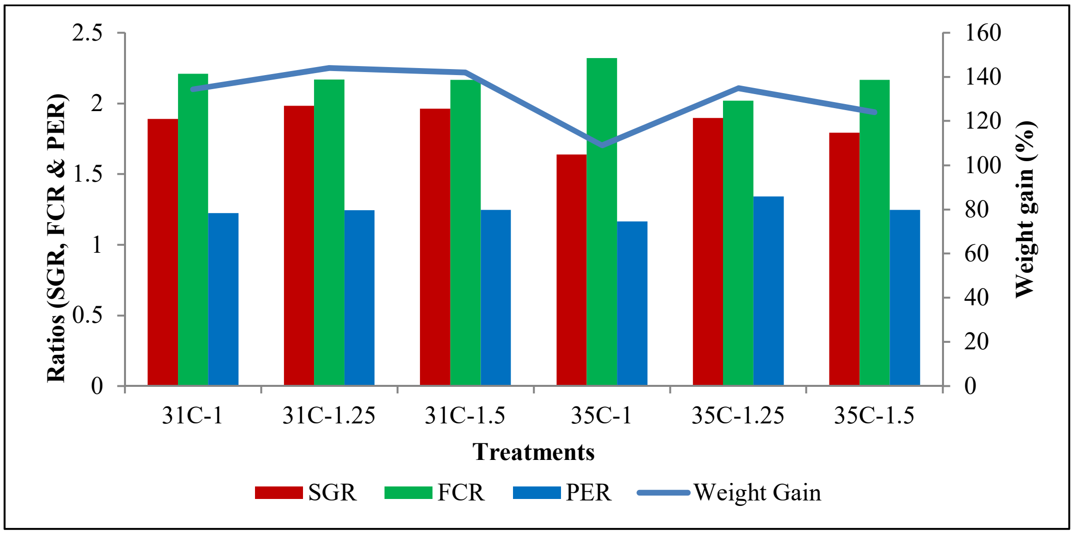
Results

A 25% increase in lecithin supplementation significantly improved weight gain from 134.2% to 144.03% at 31°C. Weight gain was 134.9% at 35°C with a 1.25% lecithin inclusion and 109.0% at 1% inclusion (Fig).

This suggests that 1.25% lecithin is the optimal level at higher temperatures. Supplementation beyond 1.25% lecithin at both 31°C and 35°C resulted in a decline in weight gain, indicating a potentially adverse effect at higher concentrations. At 35°C, FCR reduced from 2.32 to 2.02 as lecithin inclusion increased from 1% to 1.25% indicating an improvement in the feed conversion efficiency.

Conclusion

Lecithin supplementation at 1.25% positively influenced the weight gain in *P.vannamei* at both 31°C and 35°C. The observed reduction in FCR at 1.25% lecithin inclusion, particularly at 35°C, is significant, as it indicates improved feed efficiency and greater profitability.



Effect of supplementation of lecithin on growth and nutrient utilization in P.vannamei reared at temperatures 31 and 35°C

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UID: 1107

Establishing *an In vitro* repository of native Indian livestock adapted to rain-fed regions

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Indigenous farm animal diversity is fundamental to resilient agricultural systems in the Indian context where >60% of arable land is under Rain-fed agriculture. Continuous evolution and selection resulted in diverse breeds of indigenous livestock adapted to the harsh and marginal conditions prevailing there. Livestock underpins agricultural sustainability, offers economic security, and is deeply rooted in the socio-cultural fabric of natives, all of which are pillars of the Sustainable Development Goals (SDGs). However, economic, developmental, and social drivers are threatening the precious diversity. Consequently, the need for conserving them is more than ever before. As a key strategy, somatic cell lines of different breeds across livestock species were generated and cryo-preserved. Ear tissue samples of male and female animals were used to generate somatic cells using DMEM+10% FBS in a humidified incubator at 37^{o}C and 5% CO_2. Fibroblast cells (1x10^6cells/ml) of the 4th passage that were following normal sigmoid growth curve and free from any contamination were cryo-preserved at -196^{o}C in the LN_2. Inventory is maintained at National Gene Bank of ICAR-NBAGR, Karnal. So far 106 indigenous breeds of challenged agro-ecosystems have been cryopreserved by *Ex situ in vitro* conservation. It corresponds to the 98 breeds of 10 livestock species (Cattle, buffalo, sheep, goat, camel, donkey, horse, yak, mithun, pig) as somatic cells, while, 8 chicken breeds were conserved as the Primordial Germ cells. This endeavor contributes towards strengthening the *in vitro* conservation effort of national livestock biodiversity and also addresses SDG target 2.5.1 which imbibes the maintenance of existing plant and animal genetic diversity in the gene banks.

UID: 1109

Evaluation of Pigeon Pea (*Cajanus cajan* L) based Fodder Systems for Kharif in Scarcity Zone of Maharashtra

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Pigeonpea (Cajanus cajan L.) is an important *kharif* pulse crop of India with 75.7% area and 64.9% of production of the world (FAOSATAT, 2013). It is cultivated under diverse agroclimatic conditions either as sole or in mixture with cereals, pulses or oilseeds under rainfed conditions. Intercropping is always preferred over sole cropping as intercropping systems minimize weather risk, ensure yield and income from the component crops in an abnormal year and enhance resource use efficiency. Pigeopn pea based intercropping system have proved sustainable in respect of yield and income with short duration intercrops of cereals, pulses and oilseed crops across diverse rainfed agroecologies in India (Kantwa *et al*, 2005; Ravindra chary *et al*; 2012). Pigeon pea is cultivated in scarcity zone of Maharashtra, during *kharif* under diverse biophysical (soil and rainfall types) and socioeconomic settings, thus always risk prone due to in season drought, particularly in the shallow to medium deep black soils often resulting in unsustainable yields and income. Thus, it becomes necessary to develop an efficient and profitable pigeon pea based intercropping system for scarcity zone of Maharashtra to minimize the risk and increase the productivity per unit of land.

Methodology

The field experiment was conducted during *kharif* season for two years (2018 to 2019) at AICRPDA, Main Centre Solapur, Maharashtra. The experimental site was characterized as Vertisol having clay loam, pH 8.1, EC (1:2.5) - 0.30 dS/m. The treatments were T_1: pigeon pea + sorghum fodder (1:3), T_2: pigeop pea + cowpea fodder (1:3), T_3: pigeonpea + pearl millet fodder (1:3), T_4: pigeonpea + maize fodder (1;3), T_5: sole pigeonpea, T_6: sole sorghum fodder, T_7: sole cowpea fodder, T_8: sole pearl millet fodder and T_9: sole maize fodder. The experiment was laid out in randomized block design with three replications. Fertilizer was applied to crop as per recommended dose. Base crop pigeon pea cr was planted at 90x 20cm, and fodder crops were planted at 30 cm spacing.

Results

The treatment Sole pigeonpea (T_5) recorded higher grain (1267 kg/ha), stover yield (1568 kg/ha), MCEY (1366 kg/ha) and RWUE of main crop (11.31 kg/ha-mm), as compared to other treatments. Among the different sole fodder crops treatment (T_8) Sole pearlmillet fodder recorded higher green fodder yield (25891 kg/ha), MCEY (1216 kg/ha), net monetoary returns (Rs. 25369 /ha) with B:C ratio (1.96). Among the different fodder inter crops, the treatment (T_4) Pigeon pea + Maize fodder (1:3) recorded maximum grain yield (831 kg/ha), stover yield (1242 kg/ha), and RWUE (8.82 kg/ha–mm). The treatment (T_3) Pigeon pea + pearl millet fodder (1:3) recorded higher MCEY (1850 kg/ha), net returns (Rs. 39633/ha) and B:C ratio (2.01).

Conclusion

Among pigeon pea based fodder ntercropping systems evaluated on semiarid Vertisols at Solapur in scarcity zone of Maharashtra, either pigeon pea + pearlmillet (1:3) or pigeon pea + maize (1:3) fodder intercropping system is recommended under dryland condition

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Effect of fish meal replacement with raw or fermented groundnut oil cake on growth, nutrient utilization and greenhouse gases emission in Pacific white shrimp, *Penaeus vannamei*

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In aquaculture, particularly shrimp farming, the development of cost-effective and environmentally sustainable alternatives to fish meal is of critical importance. One of the primary concerns with the use of alternative protein sources is their potential environmental impact, in terms of greenhouse gas (GHG) emissions. Consequently, exploring nutritionally valuable oilseed cakes, such as groundnut oil cake (GNC), a by-product of groundnut oil extraction, offers a promising solution. GNC is widely available, reasonably priced, and contains a favorable nutrient profile, making it a potential plant-based alternative to fishmeal in shrimp feed formulations. However, its raw form may have limitations in terms of digestibility and nutrient utilization by shrimp. Fermentation, of plant-based feed ingredients particularly with microorganisms like *Aspergillus niger* has been shown to improve nutritional quality by enhancing protein digestibility and reducing anti-nutritional factors (Jannathulla et al., 2016). While the benefits of using GNC in shrimp diets regarding the impact of raw versus fermented GNC on shrimp growth and nutrient utilization are well-documented in our earlier studies (Jannathulla et al., 2018), there is limited information on GHG emissions.

The primary objectives of this study are to compare the digestibility of raw and fermented GNC in shrimp diets, to evaluate the growth performance, and nutrient utilization of *P. vannamei* juveniles fed with diets containing varying levels of raw and fermented GNC and to assess the impact of these diets on the emission of GHGs from the shrimp culture system. The present study carried out under the 'National Innovations in Climate Resilient Agriculture (NICRA)' project aims to address these gaps in knowledge.

Methodology

Diet Preparation:

Seven experimental shrimp diets were formulated with different inclusion levels of raw and fermented GNC. These included one control diet (0% GNC) and six treatment diets with GNC levels at 5%, 7.5%, and 10% for both raw and fermented GNC. The GNC was subjected to solid-state fermentation using *Aspergillus niger*, a fungal species known for its ability to improve the digestibility and nutritional quality of plant-based proteins.

Feeding Trials:

The prepared diets were fed to juvenile *P. vannamei* (initial weight: 3.89 ± 0.046 g) in a 500-liter fiberglass-reinforced plastic (FRP) tank system with three replications per diet. The feeding trial lasted for 45 days, during which growth parameters and nutrient utilization were measured.

Greenhouse Gas Emission Measurement:

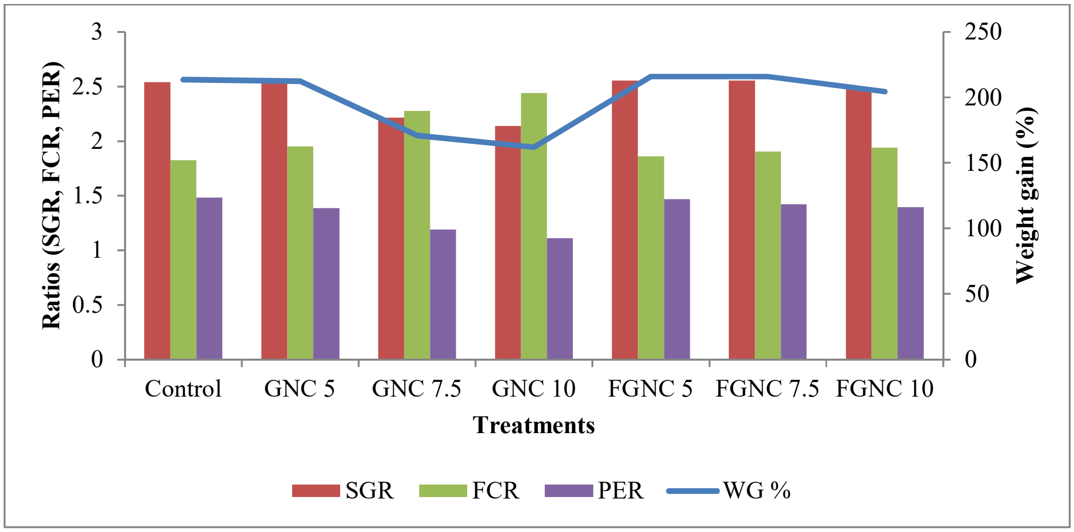
After the feeding trial, six shrimp from each replicate tank were transferred to a separate 100-liter FRP tank designed specifically for measuring GHG emissions. Gas samples were collected as reported by Vasanth et al., 2016. Gas chromatograph, 8890 GC System (Customized) with three detectors, flame ionization detector (FID), electron capture detector (ECD) and thermal conductivity detector (TCD) was used to analyse the gases, nitrous oxide (N_2O), carbon dioxide (CO_2) and methane (CH_4). OpenLab CDS software was used to automatically integrate peak area, produce calibration curves, and calculate the sample concentrations. The GHGs were measured once in every three days for a total of 12 days. The emission data was then analyzed to evaluate the impact of dietary treatments on GHG production.

Results

The inclusion of raw GNC beyond 7.5% and fermented GNC beyond 10% significantly reduced both growth performance and nutrient utilization efficiency in *P. vannamei*. This suggests a threshold above which the inclusion of GNC, either in its raw or fermented form, negatively affects shrimp growth. The digestibility of raw GNC was found to be lower compared to fermented GNC. Specifically, raw GNC had an apparent dry matter digestibility of 57.52% and crude protein digestibility of 78.84%, whereas fermented GNC had higher values (62.96% and 87.09%, respectively). The N_2O emission was significantly influenced by the dietary treatments ($P<0.05$). At a 10% inclusion level, fermented GNC reduced the emission of N_2O from 0.330 ppm (raw GNC) to 0.324 ppm (fermented GNC). The inclusion of either raw or fermented GNC did not significantly affect the emissions of CO_2 or CH_4. These results suggest that while fermentation of GNC impacts the emission of N_2O, the inclusion of GNC in shrimp diets does not have a notable effect on CO_2 or CH_4 emissions.

Conclusion

In conclusion, the use of fermented GNC as a protein source in shrimp diets is a promising alternative that balances cost-effectiveness, improved nutrient utilization, and reduced GHG emissions. Further research may be required to explore the long-term impacts and scalability of fermented GNC in commercial shrimp farming systems.



Effect of fishmeal replacement with varying levels of unfermented and fermented groundnut oil cake in the diets of *P. vannamei* on growth and nutrient utilization

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Growth Rate of Sheep and Poultry in Duplex Model House in Scarce Rainfall Zone of Andhra Pradesh

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Rainfed agriculture extends over 87.5 m ha (55%) of net sown area in different agro-climatic zones of our country, spread over in 177 districts and contributes over 40 % to our food basket, supports 40% of human and 60% of livestock populations. Due to ever increasing population and decline in per capita availability of land in the country, practically there is no scope for horizontal expansion of land for agriculture. Only vertical expansion is possible by increasing livestock intensity or by integrating livestock components requiring lesser space and time and ensuring reasonable returns to farm families (Sahadeva Reddy *et al.,* 2021). Rearing of ram lambs for fattening is a common practice in scarce rainfall zone of Andhra Pradesh. Farmers provide s shelter made of roof with thatched material or galvanized sheets and ram lambs stay on the floor throughout the night with mix of excreta and urine. It was observed accumulation of ammonia in the shed causing bronchopneumonia in the lambs. To overcome these problems in small ruminants in traditional housing system, a new duplex model housing system was evaluated for growth rates by integrating with sheep and poultry components.

Methodology

Duplex model (two-tier) house was constructed during June 2023 with 18 X 12 feet at Balapanur village of Panyam mandal by accommodating ram lambs on wooden slatted floor (upper housing) and Aseel poultry on the ground floor of the house. The elevated floor was constructed at 5feet height from the floor. The height of the total shed was 12feet. Entire shed was fenced with one inch mesh to protect the poultry and ram lambs from predators. Feeders and drinkers were placed in the shed. A total of forty male Nellore brown lambs of 3 months age 12 kg body weight and 60 Aseel birds of five weeks age were divided into two groups at the rate of 20 ram lambs + 30 Aseel birds for evaluation of growth rates for a period of 120 days in sheep and 150 days in poultry in Duplex model house (T1) and traditional free-range system (T2). The lambs were fed with black gram crop residues and concentrate mixture @200grams per day as per ICAR 2013 standards. The experiment was conducted for a period of 120 days until the lambs reached the age of 7-8 months. A pre-experimental period of 10 days was given to the animals to acclimatize themselves to the local environment. The birds were fed with ground sorghum and maize @50grams per day along with scavenging for 4-6hours. Deworming and medication were done to the ram lambs and poultry as per recommendation and requirement. Data on body weight at an interval of 40 days and 50 days in ram lambs and poultry were collected and growth rate were calculated respectively.

Results

The mean initial body weight of Nellore lambs before the experiment was 14.28±0.29 and 15.05±0.46kg and at 120 days 22.83±0.25 and 20.88±0.51kg in duplex house and traditional method, respectively. The average daily weight gain of Nellore brown lambs after 120 days was 95.12±1.75 and 87.22±1.85 g in duplex house and traditional method, respectively. The mean initial body weight of Aseel birds before the experiment was 469.9±18.02 and 428.8±16.05 g and at 150 days recorded 1910.2±48.03g and 1372.4±28.03g in duplex house and traditional method respectively. The average daily weight gain of Aseel birds after 150 days was 15.77±0.53and 10.49±0.25 g in duplex house and traditional method, respectively.

The body weights and average daily weight gain (gm) of Nellore brown lambs and Aseel birds under different types of systems.

Treatments	Initial	I	II	III	Mean
Ram lambs -Body weights (kg)					
Duplex house	14.28±0.29	17.08±0.33	20.05±0.32	22.83±0.25	
Traditional practice	15.05±0.46	17.15±0.51	19.10±0.48	20.88±0.51	
Ram lambs- Average Daily weight Gain (g)					
Duplex house	--	93.33±4.75	99.17±4.76	92.51±5.61	95.12±1.75
Traditional practice	--	71.23±3.75	65.13±4.51	59.17±3.31	87.22±1.85
Aseel birds- Body weights (g)					
Duplex house	469.9±18.02	1012.5±29.62	1522.73±37.19	1910.2±48.03	
Traditional practice	428.8±16.05	722.5±20.02	1064.7±24.87	1372.4±28.03	
Aseel birds- Average Daily weight Gain (g)					
Duplex house	--	18.09±1.06	17.01±0.84	12.92±0.89	15.77±0.53
Traditional practice	--	10.15±0.47	11.41±0.60	10.26±0.71	10.49±0.25

The higher body weights in the present study were recorded in lambs housed in elevated slatted floor which might be due to amelioration of thermal stress and ventilation resulted in improved feed efficiency leading to beneficial effect on lambs in terms of better body weight gains. It allows manure, urine and debris to drop through the slatted floor, thus eliminating a major source of disease and parasitic infestation. Slatted floor is easy to clean and maintain, and the waste that falls through it is easily collected and used as manure. It allows ventilation to circulate through the slats. Lower mean maximum temperature (°C) and lower average maximum relative humidity (%) values were observed in elevated slatted floor house compared to mud floor with galvanized sheets (Kasala *et al.,* 2023).

Conclusions

Growth rate of ram lambs and Aseel poultry under Duplex model house in rainfed areas indicated that higher body weight and average daily gain was recorded in two-layer livestock system compared to the farmer practice of free-range system. This system provides ambient environment to livestock and poultry in rainfed areas. It is evident that Elevated sheep houses offer many advantages in tropical and subtropical areas.

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Effect of Mineral Mixture Spplimentation During Winter on Milk Production and Composition of Dairy Cows Under Humid Subtropical Ecosystem

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Dairy animals are a major contributor to the rural economy in India, which is primarily an farming society. Grass, forage, and crop residues are used as livestock feed sources, but these are insufficient to meet the nutritional requirement of dairy animals for optimal productive performance because Indian soils are mainly deficient in Zn (48.1%), iron (11.2%) and copper (7%) (Gupta, 2005). Shukla *et al*. (2016) reported that 67.0% zinc, 10.2% Fe, 1.08% Mn and 0.57% Cu is deficient in the soils of Madhya Pradesh.

Minerals are micronutrients that are crucial for their growth, cellular processes, immunity, and other productive processes in dairy animal. Animals are also lacking in certain minerals since soil often contains less of them than feeds or fodder. More than 70-80% of mineral deficiencies in cattle exist at subclinical levels, leading to reduced productivity and leads to abnormal behaviour. Although it is imperative to address these problems with mineral supplementation, the use of different mineral combinations and vitamins as supplements is still relatively uncommon (Singh *et al*., 2016). Numerous experts have documented the issue of mineral deficiency disorders in dairy animals due to the limited supply of certain vital minerals, both macro and micro, in various feed items. Tiwari *et al*. (2013) observed that milk production has increased when dairy animals' diets are regularly supplemented with mineral mixtures. Therefore, the aim of the present study was envisaged to assess the effect of mineral mixture spplimentation during winter on milk production and composition of dairy cows under humid subtropical ecosystem.

Materials and Methods

The present study was conducted at Krishi Vigyan Kendra Jaora, Ratlam India, located at an Malwa platu at 23 05' North to 23 52' North Longitude and 74 31' East to 75 41' East Latitude. The climate is humid subtropical in nature with temperature ranging between 4°C. winter and 45°C in summer respectively. The area receives an annual rainfall of 992.90 mm.

Experimental Animals and Data Recording

This experiment was carried out in dairy cows in two different year (2022-23 & 2023-24)as on-farm trials to assess the effect of mineral mixture supplementation during winter on milk production and composition of dairy cows under humid subtropical ecosystem in adopted NICRA villages, Nawabganj and Sabalgarh. Twenty dairy cows similar in lactation stage, milk yield, and parity, were selected for this experiment under similar feeding and management practices, were selected from each farmer and split equally into two groups (10 milch cows/group): control (T1-no supplementation of mineral mixture) and treatment (T2-supplement of 100gm mineral mixture/cattle/day).Data on production and composition traits viz., average daily milk yield (lit/day), total milk yield for 90 days (liter), Fat(%) and SNF(%) were collected and utilized for this study.

Statistical Analysis

The data were analyzed statistically as per Snedecor and Cochran (1989) and student's t-test of significance (Two-Sample Assuming Unequal Variances) between groups were performed using SPSS for Windows (version 17.0 Microsoft).

Result and Discussion

The overall least squares mean for average daily milk yield (lit/day), total milk yield for 90 days (liter), Fat(%) and SNF(%) were depicted in Table 1. It was observed that the average daily milk yield was significantly higher in the treatment group (7.10 ±0.35 liters) compared to the control group (5.66 ± 0.35 liters). Similarly, total milk yield for 90 days in the treatment group 638.7 ± 32.30 liters) was significantly greater ($p < 0.05$) than in the control group (509.4±32.54 liters). Tanwar *et al.* (2019) observed the similar finding, which reported a daily milk yield of 9.88 liters in the treatment group, higher than the control group's yield of 9.72 liters per day. The average milk produced each day is increased by 1.05 liters. These findings are in line with another study (Akila *et al*., 2013; Saxena *et al*., 2008 and Sharma *et al*., 2009), they reopted that mineral mixture supplementation boosted milk output. The findings, which showed a 25% increase in milk production with area-specific mineral mixture supplementation in field trials, were comparable to the 16.64% improvement in milk production as a percentage (Tiwari *et al*., 2013).

Table 1. Least square means for Milk yield & its composition (2022-23 & 2023-24)

Milk yield parameter	2022-23		2023-24		Average	
	T1	T2	T1	T2	T1	T2
Average daily milk yield (lit/day)	5.01[a]±0.34	6.34[b]±0.32	6.31[a]±0.39	7.86[b] ± 0.39	5.66±0.35	7.1±0.35
Total milk yield for 90 days (lit)	450.9[a]±31.13	570[b]±29.27	567.9[a]±33.95	707.4[b]±35.34	509.4±32.54	638.7±32.30
Fat (%)	4.07±0.13	5.01±0.091	3.95±0.16	4.87±0.12	4.01±0.14	4.94±0.10
SNF (%)	8.5[a]±0.10	8.8[b]±0.10	8.25[a]±0.10	8.5[b]±0.11	8.37±0.10	8.65±0.10

Means with different letter (a, b) indicates significant difference ($p < 0.05$).

Moreover, the average percentage of milk fat and solid not fat ($p<0.05$) was higher in the treatment group (4.94±0.10 and 8.65±0.10) compared to the control group (4.01±0.145) and 8.37±0.10). These findings align with Madke*et al.* (2018) and Verma *et al*. (2009).

Economic parameters

Mineral mixture supplementation in dairy cows boosted milk yield by 25.44% in the treatment group, according to the economic analysis of the data (Table 2).

Table 2. Economics of mineral mixture supplementing in dairy cows (2022-23 & 2023-24)

Particulars	2022-23		2023-24		Average	
	T1	T2	T1	T2	T1	T2
Average Cost of cultivation (Rs.)	9740	10530	4980	5100	7360	7815
Average Gross Return (Rs.)	13500	17730	12000	13200	12750	15465
Net returns (Rs.)	3760	7200	7020	8100	5390	7650
B:C ratio	1.38	1.68	2.40	2.58	1.73	1.97
Additional milk yield by supplementing mineral mixture (lit)	-	1.33	-	1.55	-	1.44
Milk yield increases over control (%)	-	26.54	-	24.72	-	25.44
Value of additional milk (Rs./day)	-	45	-	47	-	46
Cost of area specific mineral mixture supplementation (Rs./day)	-	2.5	-	3.0	-	2.75

T1:- Control, no supplementation

T2:- Treatment, supplement of 100 gm mineral mixture/cattle/day

The treatment group received higher average gross returns from milk sales during a ninety-day period (Rs. 15,465) than the control group (Rs. 12750). Furthermore, the treatment group's net profit per animal (Rs. 7650) was substantially higher than that of the control group (Rs. 5390). Additionally, the treatment group's benefit cost ratio (1.97) was larger than the control group's (1.73).

Conclusion

From the present study, it is concluded that feeding of mineral mixture to dairy cows can improve their overall productivity and benefit-cost ratio, enabling farmers to profit more from the same animals. Therefore, it is recommended that farmers be trained on how to feed their milking cows mineral mixtures in a scientifically balanced way in order to boost production and profitability in dairy farming.

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Milkfish (*Chanos Chanos*) A Promising Climate Resilient Species for Semi-Intensive Culture in Coastal and Inland Regions

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Milkfish (*Chanos chanos*) is one of the most promising species for aquaculture diversification due to its wide tropical distribution, euryhaline nature, disease resistance, feeding on the lower food chain and rapid growth. It is one of the most preferred brackishwater food fish in Southeast Asian countries and India (Chaudhary et al., 1976; Lee et al., 1986). Realising the potential of milkfish farming in the underutilized brackishwater and inland saline waters of India, ICAR-CIBA achieved a breakthrough in captive breeding and seed production of this species in the year 2015 for the first time in India (Bera et al., 2019b). In consecutive years, technology was developed for extended breeding of milkfish for eight months from March to October (Bera et al., 2019a & 2021). Due to the availability of hatchery-produced seed scientific farming of milkfish gained importance in states like Kerala, West Bengal, Odisha, Gujarat, Goa, Karnataka, Tamil Nadu and inland saline states. Real-time production data of different farming models is scanty from farmer's ponds. In this context, the objectives of this study are to understand growth patterns, feeding efficiency, climate tolerance and productivity of milkfish throughout the year in different seasons and culture systems.

Methodology

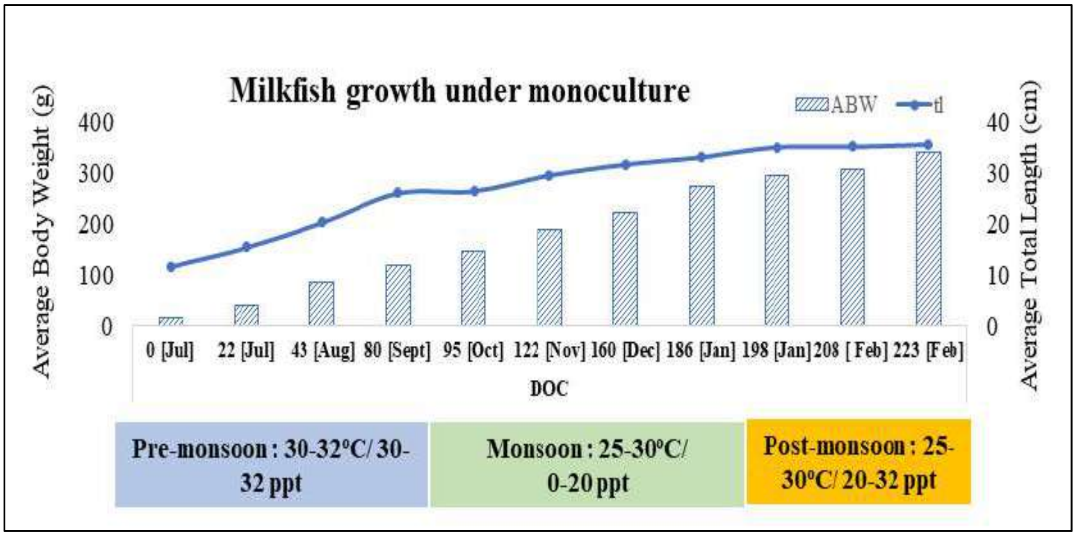
Milkfish fingerlings and stunted yearlings were produced after rearing of ICAR-CIBA hatchery seeds. Two farming trials were conducted at Kovalam Experimental Station (KES) and Muttukadu Experimental Station (MES) of ICAR-CIBA in earthen (1156 m^2) and lined ponds (450 m^2) respectively during 2022 and 2023. In the first trial milkfish fingerlings (20 g abw, 11.6 cm tl.) were stocked @ 1.5 numbers/ m^2. In the second trial, stunted milkfish yearlings (120.75 g, 23.56 cm tl.) were stocked @ 1.0 no./m^2. Fishes were cultured for 240 days (DOC) and fed *ab-libitum* with ICAR-CIBA Milkfish Grow-Out ^{Plus} (Protein 30-35%, Fat 6%) @ 5- 3 % of body weight. Growth parameters such as daily weight gain, feed conversion ratio, specific growth rate, length-weight relationship and abiotic parameters such as water temperature and salinity variations and weather parameters rainfall, extreme weather events (flood) were recorded during entire farming trials (July to February). This study was conducted with a funding support from NICRA project and CIBA institute project.

Results

Milkfish farming in earthen pond culture (first trial) was conducted during pre-monsoon; monsoon and post monsoon periods where salinity fluctuated between 0 ppt to 32 ppt as a result of rainfall variation from 0 to 84 mm including moderate flooding; pond water depth varied from 60-90 cm. During the entire culture period maximum and minimum air temperatures recorded were 31.92±1.59 ºC and 21.80±0.96 ºC respectively. In the lined ponds (second trial), initially, milkfish fingerlings (ABW: 17 g, tl. 11.7 cm) were stocked in higher density (3 no./ m^2) and reared for one year with partial pellet feed to produce stunted yearlings (120.75 g, 23.56 cm tl) and those were used in the second year for final trial to harness compensatory growth. Biotic parameters such as daily weight gain, specific growth rate, length-weight relationship, feed conversion ratio, survival, and productivity of non-stunted milkfish in earthen ponds and stunted fingerlings in lined ponds during culture trials are given in Table 1. The harvested biomass in earthen and lined ponds was 478 kg and 247.5 kg respectively. The length-weight relationship of milkfish in both culture systems showed the allometric growth. The water temperature, salinity and milkfish growth pattern in the earthen ponds is depicted in Fig.1. Daily weight gains of stunted yearlings (2.33 g/day) were higher than non-stunted fingerlings (1.43 g/day) during first 210 DOC. Similarly, SGR was also higher in stunted group (1.5) compared to non-stunted (1.34) fishes during culture trial.

Growth comparison between farming of non-stunted and stunted milkfish

Parameters	Farming of non-stunted yearlings	Farming of stunted fingerlings
Total length (cm)	35.43	42.08
Average body weight after 210 DOC (g)	340	589
Length-weight relationship	LogW = 2.647 LogL -1.4801	LogW = 1.274 LogL-0.0343
SGR	1.34	1.5
Daily weight gain (g)	1.43	2.33
FCR	1.38	1.2
Survival (%)	93.7	93.37
Final harvest (kg)	478	247.5
Estimated productivity (t/ha)	4.78	5.5



Water temperature and salinity variation and milkfish growth pattern in earthen pond

Conclusion

Milkfish can be a suitable climate-resilient species having a higher growth rate, temperature and salinity tolerance, and the outcome of these studies is useful to formulate advisory for juvenile production (fingerling and stunted seed) and semi-intensive farming of milkfish for stakeholders in coastal and inland areas of India.

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UID: 1250

Alteration of Micro-Environment of Animal Shed through Roof Insulation by *Kheep* (*Leptadenia Pyrotechnica*) and its Impact on Production: An Innovative Climate Resilient Technology in Dairy Housing Management

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India experiences a tropical climate and has 75 to 85 temperature humidity index (THI) in more than 85 % area during summer season. Scientific animal housing system is important component in dairy production in tropics. Crossbred cows and buffaloes suffer negative effect of high THI on milk production, reproduction and health aspects. Cross bred cow loose more than 100 liters and buffaloes 30 litres of milk in a year due to extreme climatic conditions. Indigenous cattle breeds (Tharparkar, Rathi, Kankraj and Nagori etc.) are heat tolerant and highly acclimatized to this climatic condition. Proper housing management strategies become essential to minimize the risk of high temperature (heat stroke) in dairy animals of western Rajasthan. In an animal housing system, proper roofing material is essential aspect of housing. Roofing material should be light, strong, durable, weather proof, bad conductor of heat and free from tendency to condense moisture inside. Insulated roofing sheet/false ceiling is a desirable technique in animal housing but it is not practiced for animal housing by the villagers. The objective of the present study was to find out the effectiveness of roof thermal insulation by locally available material i.e. *Kheep* (*Leptadenia pyrotechnica*) for the alteration of micro-environment in cow shed and its impact on milk yield and reproduction.

In this study two type of housing systems were compared one is modified shed with Kheep thatching as false ceiling under asbestos roof and another has only asbestos roof. In present study, animal housing was insulated with 6 inches *Kheep* underneath the roof. *Kheep* is indigenous vegetative material and easily available in western Rajasthan. It is having excellent thermal insulation, long life and low maintenance cost. The study was conducted in NICRA- TDC adopted villages of KVK and improved housing technology has been adopted by surrounding villages of Jodhpur district. The study was conducted in 10 villages from

2016-2024. The dimension of animal shed was 12 f x 15 f with east west orientation. The roof was made of asbestos sheets. The temperature was recorded 3 times a day in morning, afternoon and evening. The THI of normal shed and modified shed moderate and mild heat stress range respectively. The mild heat stress range i.e. 72-78 during study period indicated a comfortable ambient condition for the animal in summer season. Significant increase (P>0.05) in milk production and 3-5 °C lower temperature was recorded in modified shed. Reproductive performance was observed better in cows in terms of time of estrus and conception rate. It can be concluded that modified shed had better result and provide excellent thermal insulation, resistant to weather in harsh climatic condition. In addition to this, insulation materials have got fairly long life if it is fixed below the roof and very meager maintenance cost.

UID: 1251

Ensuring Resilience through Livestock and Poultry in Different Farming System Typology (FST) for Bundelkhand Region of Uttar Pradesh

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Bundelkhand region is situated at the heart of our country, located below the Indo-Gangetic plain to the north having undulating Vindhyan mountain range spreading across northwest to the south. This region is characterised by drought facing enormous problems of low rainfall, water crisis, low agricultural and animal productivity, fodder crisis, degradation of water resources, high rate of cattle mortality, non-sustainable sources of livelihoods, etc. It is primarily an agricultural economy where 80% of the inhabitants are dependent on agriculture and livestock related activity, generating 96% of the farmers' income, showing significant dependency on these sectors in Bundelkhand (Rathod and Dixit, 2020).

In a study of Bundelkhand region prominent livestock production system followed by marginal farmers and small farmers was Buffalo+ Goat+ Sheep and Buffalo+ Goat respectively. Whereas dominant livestock production system pursued by semi-medium, medium and large farmers was cattle+ Buffalo. Also it was found that livestock was the major contributor to gross income accounting for more than 55percent of the household's income (Gautam & Jha, 2022).

Poultry production is key component in food, nutrition and livelihood security for resource poor farmers in drought prone area like Bundelkhand due to less investment and quick returns and smooth integration with crop and livestock (Gupta *et al.*, 2014). In a study of backyard poultry faming in Mahoba district it was found that birds are mostly reared by women and children for their own consumption, social and cultural activities and as ready cash (Rawat *el al.,* 2015).

Though the role of dairy and backyard poultry in nutritional and livelihood security is indispensable and considered as risk mitigating factor against climatic vulnerability in Bundelkhand region. But fact is avg. milk production in Bundelkhand region is 2.93 Kg/day against avg. milk yield of Uttar Pradesh 4.02 Kg/day, showing a huge gap that may be fulfilled by some adaptive mechanism (Rathod & Dixit, 2020). Same gap also appeared in case of backyard poultry revealing the need of improved varieties with optimum production. Under technology demonstration component (TDC) of NICRA (National innovations on climate resilient agriculture) different technologies related with milk production, fodder production and improved poultry varieties has been demonstrated in Banda, Jhansi, Chitrakoot and Jalaun as an adaptive measures to combat climatic vulnerability and lower productivity of livestock for assurance of resilience through livestock and poultry.

Methodology

The present study was performed in two farming system typology (FST) namely rainfed with animals and irrigated with animals in Bundelkhand region. In test villages called as NIRCA village two category of farmers have been selected, one farmer where technology of Mineral mixture feeding, green fodder production and improved poultry verities have been demonstrated called as NICRA farmer and other one with traditional farming system called as non NICRA farmer. The parameters collected were milk production, egg production, live weight of bird and B:C ratio. The gross cost was calculated on the basis of all the operational cost incurred by the farmers and gross return was calculated on the basis of sale of the products.

Results

A. Performance of Livestock and poultry interventions under farming system typology (FST) of Rainfed farming with animals

Under FST (rainfed farming with animals), in NICRA farmers, demonstrations were conducted for nutritional intervention in buffalo.With feeding of mineral mixture the milk production was enhanced by 20.16% (Table 1). In case of poultry, birds were reared in Semi-intensive condition. In one unit 20 improved varieties namely CARI Shyama were reared with NICRA farmers with 50% increased live weight/bird as compared to native chicken (Table 1).

Table1. Performance of Mineral supplementation and improved native chicken in Bundelkhand

Effect of Mineral Mixture on milk production of buffaloes						
Technology demonstrated	**Production (lit./ lactation)**	**Selling price (Rs/ unit)**	**Gross cost (Rs./ Animal)**	**Gross returns (Rs./ animal)**	**Net Return (Rs./ Animal)**	**BC ratio**
NICRA Farmer						
Mineral Mixture feeding (10 farmers)	2916.66	50	82879.17	145833.3	62954.17	2.02
Non NICRA farmer						
Traditional practice (10 farmers)	2427.33	50	60076.5	121366.67	61290.17	1.76
Advantages (%)	20.16				2.71(Rs.1664)	
Performance of CARI Shyama in Banda district of Bundelkhand						
Technology adopted/ demonstrated	**Live weight**	**Selling price (Rs/ unit)**	**Gross cost (Rs./ 20 birds)**	**Gross returns (Rs./ 20 bids)**	**Net Return (Rs./ 20 Bird)**	**BC ratio**
NICRA farmer						
CARI Shyama (100 birds for 05 families)	2.66/Bird	800	9434	21200	11766	2.25
Non NICRA farmer						
Non-Descript (100 birds for 05 families)	1.32/Bird	260	7141.33	13866.67	6725.33	1.94
Advantages (%)	50.38				74.95 (Rs.5040.67)	

Table 2. Performance of Mineral supplementation with Green Fodder on milk production of buffaloes

Technology adopted/ demonstrated	Production/ year/Animal	Selling price (Rs/Lit.)	Gross Cost(Rs./ animal)	Gross returns (Rs./animal)	Net Return (Rs./Animal)	BC ratio
NICRA Farmer						
Mineral supplementation & Napier Grass (10)	1430	45	32163.5	67000	34836.5	2.05
Non NICRA farmer						
Without Mineral supplementation & Napier Grass (10)	1120	45	27424.25	52500	25075.75	1.88
Advantage (%)	27.68				38.93 (Rs.9760.75)	

B. Performance of technologies demonstration under farming system typology of Irrigated farming with animals

The demonstrations of Mineral mixture supplementation along with green fodder showed 27.68% increase in milk production for NICRA farmers with B:C ratio of 2.05 (Table 2)

Conclusion

The TDC of NICRA in Bundelkhand region has showed improved production of livestock and poultry paving the pathway towards resilient and sustainable livelihood.Improved native chicken varieties like CARI-Shyama and CARI-Debendra has shown better adaptability in the adverse climatic conditions of Bundelkhand. A shift from traditionalfeeding of livestock to feeding mineral mixture and green fodder etc. would ensure optimised production. Suitable models towards integration of livestock, fodder crops with the intensive agricultural practices needs to bedeveloped in this region.Capacity building should be of paramount importancefor various stakeholders' as a priority for farmers, field.

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UID: 1256

Integration of Fodder Crops in Conventional Cropping and Tree-Based Systems for Enhancing Resilience of Livestock Production Systems

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Livestock plays a vital role in India's rural economy, contributing significantly to livelihoods, food security, and national GDP. Fodder production is crucial for sustaining livestock productivity, as it directly impacts livestock health and productivity. Integrating fodder crops into existing conventional farming systems enhances fodder and feed availability, boosts milk and meat production, and improves farmers' incomes. Strengthening fodder production is essential to meet the growing demand for livestock products while ensuring sustainable resource use. Incorporating fodder crops into conventional cropping and tree-based systems is vital and a sustainable approach for enhancing resilience in livestock production systems, especially in the face of climate change, feed and fodder resource constraints. This integration ensures year-round availability of quality green fodder along with nutritive crop residues, reducing dependency on degraded grazing lands. The availability of balanced nutrition from these systems improve livestock productivity and health, minimize the environmental footprint of livestock systems while addressing the growing demand for livestock products in a manner that safeguards natural resources for future generations.

Material and Methods

Five fodder-based cropping systems, integrating conventional crops with annual or perennial fodder species viz., Sorghum: fodder cluster bean-fodder cowpea-fodder horse gram (SCCH), sorghum + pigeon pea: hedge lucerne (SPH), sorghum + pigeon pea: guinea grass (SPG), castor: hedge lucerne (CH), and castor: guinea grass (CG) at a 50:50 ratio were studied over six years to assess their potential in producing green and dry fodder for enhancing sheep productivity. In another experiment, *Eleusine coracana* and *Stylosanthes hamata* were sown as inter-row and intra-row components of multipurpose tree species (MPTS) viz., *Ailanthus excelsa, Azadirachta indica, Dalbergia latifolia, Madhuca longifolia, Hardwickia binata, Butea monosperma, Syzygium cumini, Aegle marmelos*, and *Bauhinia variegate* and evaluated the potential of these integrated systems for three years in production of dry fodder, green fodder, and top fodder and its feeding impact on improved nutrition and goat productivity.

Results

Integration of fodder crops such as fodder cluster bean, fodder cowpea, fodder horse gram, hedge lucerne, and guinea grass into sorghum, pigeon pea, and castor crops resulted in 9.5, 15.4, 16.8, 16.0, and 16.7 t of green fodder production along with dry crop residues from SCCH, SPH, SPG, CH and CG cropping systems. These systems produced on average 1611, 2876, 1011, 2897, 889, and 144 kg crude protein (CP), and 101,847, 159,170, 134,734, 150,007, 115,889, and 22,673 MJ of metabolizable energy (ME), respectively. Feeding these feed resources resulted in 86.7 to 106.7 g of average daily gain in growing lambs (Fig 1). Similarly, integrating crops and fodder in *A. excelsa, A. indica, D. latifolia, M. longifolia, H. binata, B. monosperma, S. cumini, A. marmelos,* and *B. variegatae* tree-based systems yielded 0.65 to 1.18 t of crop residues from *E. coracana*, 0.18 to 0.30 t of green fodder from *S. hamata*, and 0.08 to 0.17 t of top fodder per hectare annually (DM basis) from these MPTS based systems. The top fodder contained 19.3, 15.1, 17.5, 8.6, 12.2, 13.8, 9.8, 11.9, and

14.6% CP, whereas *S. hama* and *E. coracana* contained 13.9 and 4.9% CP, with metabolizable energy (ME) content ranged from 7.6 to 9.4 MJ/kg. Feeding these resources resulted in more than 90 g/d average daily gain (ADG) in goats (Fig 2). Animals benefited from the high ME and protein content in these feed and fodder resources, directly contributing to weight gain. These integrated crop and tree-based systems ensured feed availability for 8-9 months, meeting the daily nutritional requirements of 15 kg growing sheep/goat with 100 g ADG (16 g CP/d and 6.5 MJ ME/day).

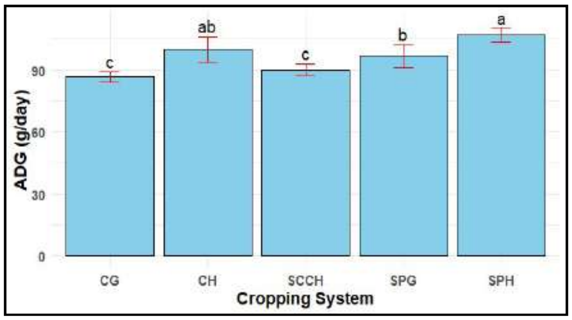

Fig 1. Performance of sheep

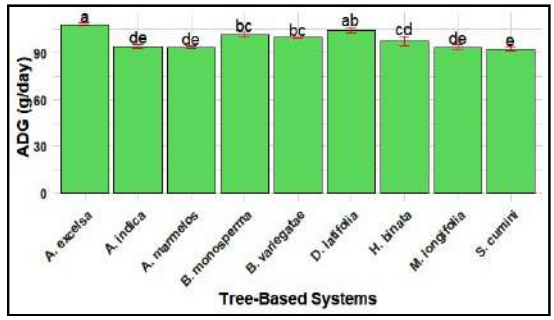

Fig 2. Performance of goat

Conclusions

Integration of fodder crops in conventional cropping and tree-based systems demonstrated significant potential for improving green and dry fodder availability, livestock productivity, and resource efficiency. These systems ensured a sustainable feed supply, meeting the nutritional requirements of growing sheep and goats while achieving potential average daily gains. These systems enhance livestock resilience and strengthen livelihoods while contributing to sustainable agricultural landscapes.

UID: 1335

Efficacy of Herbal Feed Additives in Mitigating Heat Stress in Bannur Sheep Under Hot-Dry Tropical Conditions

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In the present climate change scenario, heat stress is a major challenge for livestock production systems particularly sheep in hot and humid climates across the world, leading to reduced productivity, impaired reproduction, and compromised immunity and welfare. Bannur sheep, native to Karnataka, are known for meat quality and their hardiness but are still susceptible to heat stress. Addressing this concern is crucial for sustainable livestock farming. One promising approach is the use of herbal feed additives, known for their potential to mitigate the adverse effects of heat stress Herbal feed additives are derived from plant-based sources and are recognized for their bioactive compounds, which possess various therapeutic properties (Binuni Rebez et al., 2024). These compounds often exhibit antioxidant, anti-inflammatory, and adaptogenic effects, making them suitable candidates for alleviating heat stress in animals. Identifying effective interventions, such as herbal feed additives, becomes crucial to enhance sheep resilience and productivity in hot and humid tropical regions. Herbal feed additives exert their heat stress ameliorative effects through multiple mechanisms. Antioxidant compounds, such as polyphenols and flavonoids, scavenge free radicals generated during heat stress, preventing cellular damage. Additionally, adaptogenic properties help the animals cope with stress by regulating hormonal responses and promoting homeostasis. The present study investigates the potential of herbal feed additives to alleviate negative effects of heat stress in Bannur sheep.

Methodology

The experiment was conducted in a state-of-the-art climate chamber facility at the Centre for Climate Resilient Animal Adaptation Studies (CCRAAS), ICAR-National Institute of Animal Nutrition and Physiology (NIANP), experimental livestock farm, Bengaluru, India. A total of 24 one year old Bannur female sheep were used in this study, the experimental animals were randomly divided into four groups: control, control supplemented with herbal additives, heat-stress and heat stress with herbal feed supplements, control groups were housed in thermo-neutral zone chambers with a constant temperature maintained at 23–24 °C throughout the experimental period (10:00 a.m. to 04:00 p.m.). The heat-stress groups were accommodated in a heating chamber with a simulated heat-stress model from 10:00 a.m. to 4:00 p.m. consistently for the entire 60 days. Body weight, feed intake, and allometric measurements were recorded fortnightly. At the end of the study, all sheep were slaughtered for liver tissue collection and gene expression analysis. The expression of heat shock proteins (HSF1, HSP27, HSP40, HSP70, HSP90 and HSP110) genes linked to heat stress response was investigated. The total RNA was isolated from the liver and converted into cDNA. Quantitative PCR (qPCR) was performed using SYBR green chemistry (Maxima SYBR green qPCR master mix, Fermentas, Waltham, MA, USA) by adopting a similar methodology as described by Archana et al. (2018). The relative expression of the targeted genes was assessed by adopting the $2^{-\Delta\Delta CT}$ method (Livak and Schmittgen, 2001) using geometric means of HPRT and GAPDH genes. The data was analysed by one- way analysis of variance (ANOVA) SPSS (version 18.0) software. The changes in relative expression of targeted genes in relation to house keeping gene were analysed by one-way ANOVA with Tukey's post hoc analysis to compare the means between the groups and the significance level was set at $P < 0.05$.

Results

Heat stress significantly reduced dry matter intake, average daily gain, and final body weight in the heat stress group compared to the control group. These findings reaffirm the detrimental impact of heat stress on sheep growth performance. Heat stress significantly elevated respiratory rate, pulse rate, and rectal temperature in Bannur sheep. Concurrently, it induced upregulation of Heat Shock Transcription Factor 1 (HSF1), Heat Shock Protein 27 (HSP27), HSP40, HSP70, HSP90, and HSP110. These findings suggest that these physiological and molecular markers can reliably quantify heat stress response in this breed.

Importantly, the study demonstrated the effectiveness of herbal supplements in mitigating the adverse effects of heat stress. The treatment group exhibited significantly reduced physiological responses and downregulation of heat shock proteins compared to the control and heat stress groups. These results indicate that the herbal combination used in this study has the potential to alleviate the negative impacts of heat stress in Bannur sheep.

Conclusion

Addressing heat stress in Bannur sheep is essential for maintaining their well-being and productivity in the face of changing climate patterns. This study demonstrates the promising potential of herbal feed additives as a natural approach to alleviate heat stress in Bannur sheep. By improving growth performance and potentially altering gene expression patterns, these additives offer a valuable strategy for enhancing sheep resilience in hot environments. Further research exploring the specific components of the herbal blend and their individual effects could pave the way for optimizing this approach for wider application in sheep production.

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UID: 1359

Interventions to Improve Livelihood to Farmers through Backyard Poultry Rearing

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Backyard poultry a traditional system of poultry keeping is a part of livestock rearing practices by rural arears. India ranks third in egg production & fifth in meat production in world but unfortunately availability of chicken & its products is far below the recommended levels. Wide gap has been exsisting between the percapita consumption of chicken & egg among Rural and urban people. The percapita consumption of egg is almost 100 eggs & chicken is 2,250 g per annum in urban areas whereas 15 eggs and 750 g chicken meat in rural areas against recomended level of 180 eggs and 10.25 kg meat. The rural areas are dependent on cereal vegetable protein sources which are deficient in aminoacids like lysine, methionine & threonine. Although the need for more eggs & poultry meat is obvious and the availability of these products can go a long way to meet protein needs of growing population. There are several constraints to the future development of poultry industry like availability and cost of feed ingredients, emerging diseases and shortage of workforce. Under these circumstances tapping and involving rural and tribal people with backyard/free range farming may add substantially to the overall development of rural/tribal sectors. The backyard/free range farming was given paramount importance since last decade and various institutes developed different improved chicken varities for last ten years. Backyard poultry serves as small scale business for generating income controlled by women. The enterprise provides regular income using little inputs and the production can be solely managed by women in the household. Most women in the rural areas rear the indigenous types of domestic fowl in extensive system of poultry production (Awasthi *et al*., 2015).

Drought is a major challenge experienced by farmers of Anantapuramu district in Andhra Pradesh. To address the problem of farmers in the drought prone area, Indian council of Agricultural Research-Central Research institute for Dryland Agricultural Research (ICAR-CRIDA), Hyderabad has implemented National Innovations on Climate Resilient Agriculture

(NICRA) scheme through Krishi Vigyan Kendra (KVK), Reddipalli at Singanamala mandal, Andhra Pradesh. The main objective of the Scheme is to promote climate resilient technologies in agriculture & improve livelihood of farmers through various technologies implementation & adaption. The scheme focuses the interventions by covering technologies under Natural resources, Crop production & Livestock & Fisheries interventions. Since the environment has great impact on livestock production & productivity, KVK, Reddipalli has implemented technologies under Livestock with backyard poultry rearing to enhance the farmers with good productive potential by adaption of technologies to cope up with Climate change.

Methodology

Each year 30 households were covered by distribution of 10 Kadaknadh birds of 8wks old poultry birds. The households were selected in such a way that landless farmers & economically weaker section were taken into consideration to promote the income generation for their livelihood (Khan. 2004). Apart from distribution of birds the households were provided awareness programmes on feeding & management practices. Trainings were conducted on seasonal vaccinations & deworming to reduce the mortality. The eggs(50%) laid by the birds were utilized for consumption of households which enhanced the nutritional security & remaining 50% of eggs were kept for hatch which thereby enhanced the number of birds & promoted the production potential (Table 2). Apart from distribution of birds Azolla pits were promoted for feeding azolla as an additional source of protein to birds (Valavan *et al*., 2016). Seasonal housing management practices were initiated to reduce the production loss by decreasing mortality rate by initiation of full coverage of gunny bags around the shed during winter to reduce the cool breeze & providing light source to maintain the optimal temperature. During summer the gunny bags were sprinkled with water to enhance cool breeze & providing with plenty of water with addition of Suspensions Vimerol/ E Care Se to reduce the stress.

Results

Table 1. Prophylactic control of diseases in backyard poultry

Particulars	2020-21	2021-22	2022-23	2023-24
Birds	300	300	300	300
ND Vaccination	Mass Deworming &Vaccination	Mass Deworming &Vaccination	Mass Deworming &Vaccination	Mass Deworming &Vaccination
IBD Vaccination	Mass Deworming &Vaccination	Mass Deworming &Vaccination	Mass Deworming &Vaccination	Mass Deworming &Vaccination
Establishment of Azolla Pits	-	2	3	3

Table 2. Backyard poultry (Kadaknath) as an additional source of income to Rural women

Year	No. of Rural Women	No of birds distributed	Avg weight gain kg/bird	Avg egg production No./bird	Cost incurred for feed Rs./ bird	Income by sale of eggs/ Rs/bird	Income by sale of meat Rs./ bird	Total income Rs./ bird
2020-21	30	300	3.4	68	620	238	748	986
2021-22	30	300	3.2	84	598	294	704	998
2022-23	30	300	3.4	77	680	266	857	1123
2023-24	30	300	3.6	98	654	343	900	1340
Mean	120	1200	3.4	82	638	286	802	1112

Conclusion

Kadaknadh as a dual purpose bird the income of small and marginal farmers have raised by rearing Kadaknadh under backyard poultry. Challenge was addressed by the KVK initially by providing Initially vaccinations at field levels on regular basis & seasonally in colloboration with Animal husbandry department to aware farmers on vaccinations as prophylactic measure to prevent birds from attack of seasonal diseases & reduce the mortality (Table 1). After a series of mass deworming & Vaccinations services provided by KVK to farmers, they were aware on vaccination in reduction of mortality rate & enhanced production. KVK extended support by conducting method demonstration on Azolla cultivation at 3 areas in each village & motivated the farmers in establishment of Azolla unit at livestock holders of the selected villages . In addition to feeding on grain diet azolla cultivation was initiated thereby feeding azolla as an additional protein source enhanced the weight gain thereby promoted the production potential in poultry & enhanced the livelihood of farmers.

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UID: 1363

Effect of Deworming and Mineral Mixture in Buffaloes under Climate Resilient Practices in Bundelkhand Region

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India has the largest buffalo population in the world and ranks first in milk production (187.75 million) during 2018-19. The per capita milk availability in the country is 394 gram/day which is much more than the world average consumption of milk 302 gram/day **(BAHS)**. Inadequate nutrition is one of the factors that frequently limit the full utilization of the productive and reproductive potential of livestock in this region. Heat waves, which are projected to increase under climate change, are directly impacting the livestock. Exposure to high temperature events can cause heat-related losses to livestock farmers. Heat stress affects animals both directly and indirectly. Over time, heat stress can increase vulnerability to reduce productivity. Drought may impact pasture and feed supplies. Drought reduces the amount of quality forage available to grazing livestock. In Hamirpur district of Uttar Pradesh, the maximum temperature rises above 47 C in summer. There is also intense heat wave during summer. Livestock suffer extreme heat stress which affects their performance during this period. Almost Farmer practice were animals fed on low quality roughages e.g. wheat straw and rice straw which are characteristically low in fermentable nitrogen, mineral, and readily available carbohydrate. These deficiencies result in low animal growth, poor reproduction, long calving interval, and infertility in animals.

Methodology

The present study was conducted under front line demonstration laid out during 2021-22. 2022-23 in NICRA adopted Village Pachkhura Khurd of District Hamirpur, UP. 52 lactating buffalo were selected to carry out this study. A total of 52 lactating buffaloes of nearly at the same lactation stage, milk yield and parity were selected of 52 farmers. To maintain similarity in feeding and management practices, two buffaloes of each farmer were selected and one buffalo was kept as control (T1) and Climate resilient practice was Supplementation Feeding of mineral and vitamins blend Liquid mixture @ 100 ml /day for period of two months and deworming with ivermectin and considered as demonstrated group (T2). A training programme was conducted for the farmers before starting the demonstration to educate them for correct method of data recording on different parameters. The daily milk yield was recorded in morning and evening by the farmers in a diary and at monthly interval by the researcher.

Results

Milk production parameters of lactating buffalo in the demonstrated group (T2) and control group (T1) have been have been presented in table 1 The results indicate that application of dewormer against endoparasites improved overall health of animals by relieving them from parasitic infestation and further supplementation of mineral mixture strengthens productivity of animals. The average milk yield during the trial period was observed 6.9 and 5.5 litre/day/buffalo in demonstrated and Farmers Practice, respectively. It indicates that the average milk yield of buffalo in demonstrated group was higher. Similar results were also reported by Rathore et al. (2017) and Kantwa et al , (2021) significantly increase milk production in buffalo during supplementing mineral mixture and deworming. It increased around 24.44 per cent which was indicating in cumulative yield and BCR (1.98) as compared to local check (1.76).

Table 1. Performance of Minerals mixture and deworming on the milk production in buffaloes

Year	No. of Farmers	No of animals	Milk yield (litre/day/buffalo)		Yield gap (litre/ day/ buffalo)	% increase in milk yield	B.C ratio	
			Farmer's Practice (T1)	Demo Practice (T2)			Demo	Farmer's practice
2021-22	15	15	5.4	6.5	1.1	19.63	1.95	1.78
2022-23	22	22	5.6	7.2	1.6	28.57	2.11	1.81
2023-24	15	15	5.6	7.0	1.4	25.14	1.9	1.7
Total/Avg.	52	52	5.5	6.9	1.4	24.44	1.98	1.76

Conclusion

It can be concluded from the present study that Supplementation Feeding of mineral and vitamins blend Liquid mixture and deworming to the lactating buffaloes under field conditions not only increases the milk yield, but consequently improving socio-economic conditions. Hence, it is needed to awareness created among the dairy farmers to supplement mineral and vitamins blend liquid mixture and deworming to their animals to get more profit from dairy animal farming.

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UID: 1371

Production Performance of Improved Poultry Breeds under Backyard Farming

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In the NICRA-adopted village of Iti, farmers traditionally reared indigenous poultry breeds characterized by low egg and meat production potential, high mortality and lack of scientific management. To address these challenges, Krishi Vigyan Kendra, Latur, introduced improved poultry breeds such as Vanaraja and Grampriya for backyard poultry farming during 2021-22 and 2022-23.

Under this initiative, selected families were provided with 50 vaccinated 4-week-old birds, comprising 25 males and 25 females. Farmers received training in scientific poultry management practices, including housing, feeding, and healthcare. The birds were housed in low-cost poultry shelters made from locally available materials. They were allowed to forage freely in open areas and were supplemented with locally available grains. Continuous technical support was provided by KVK to ensure effective implementation. Mortality rates in improved breeds were significantly lower, at just 4% in the field, compared to 10% in indigenous breeds.

The economic comparison highlighted the superiority of improved breeds over indigenous ones. Improved breeds attained an average weight of 2.6 kg at maturity and produced 158 eggs per year, whereas indigenous breeds reached only 1.6 kg and laid 56 eggs annually. The gross income for improved breeds was ₹61,320, with a net income of ₹36,250 and a B:C ratio of 2.52. In contrast, indigenous breeds yielded a gross income of ₹29,810, a net income of ₹15,060, and a B:C ratio of 2.02.

The intervention demonstrated the potential of improved poultry breeds in enhancing productivity, reducing mortality, and increasing profitability for rural farmers. The scientific management practices, combined with the technical support provided by KVK, significantly improved the economic viability of backyard poultry farming in Iti. This initiative serves as a successful model for improving rural livelihoods and addressing the limitations of indigenous poultry breeds.

UID: 1394

Enhancing Rural Resilience and Food Security through Black Australorp Backyard Poultry: a study in Hanumangarh District of Rajasthan

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A study on the resilience and profitability of the Black Australorp breed for backyard poultry was conducted in selected villages in Hirnawali and Chistiyan of KVK, Hanumangarh-I with 30 households beneficiaries under the technology demonstration component-NICRA project district during 2022-23 and 2023-24.The study aimed to assess the breed's adaptability, productivity, and disease resistance in local conditions environment along with its impact on household's food security and income enhancement. Black Australorp breed of poultry were introduced as a sustainable poultry option due to their robust resilience, higher egg production, and low maintenance requirements. Results of the study indicated a significant improvement in household egg and meat supply after introduction of the intervention. The beneficiaries also reported to that the birds needs low feed which reduces external poultry feed from market and less veterinary care due to high natural resistance to diseases. Further, families observed an increase in household income from surplus egg sales which adds economic stability. The introduction of the Black Australorp breed demonstrated promising resilience towards weather vulnerability and adaptability, hence supporting project objectives to enhance rural livelihoods and reinforce food security through backyard poultry. This intervention showcases the potential of resilient poultry breeds as a viable, low-cost approach to boosting nutritional self-reliance and income generation for smallholder farmers in Hanumangarh district.

UID: 1413

Impact of Balanced Nutrition and Water quality on Fish Seed Survival and Growth performance

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The Successful fish seed rearing from the spawn to fry stage is a critical step in aquaculture, significantly influencing subsequent growth and survival rates. This process demands meticulous management of various factors, including water quality, feeding, and larval health. This study, conducted under the National Initiative on Climate Resilient Agriculture (NICRA) in Parsa village, West Champaran, aimed to optimize fish seed rearing practices. Mixed species fish spawns were stocked at a density of 3-5 million/hectare and reared for 22 days. A locally farm made balanced diet, comprising protein, carbohydrates, and lipids, were fed to the fishes for optimal growth and development. The Continuous monitoring and maintenance of water quality parameters were implemented to prevent diseases and stress. The observation was recorded, Survival (%), Weight gain (gm) Net return (Rs/ha), and BC ratio. The study compared improved rearing practices with traditional farmer practices. Results showed that improved practices significantly enhanced fish seed survival rates. A 47.20% survival rate was achieved in 22 days, compared to 31.20% in 30 days using traditional methods. While there was no significant difference in weight gain of fishes between the two practices, the improved practices resulted in a higher benefit-cost ratio (2.78) compared to traditional methods (1.70). These findings highlight the potential of improved fish seed rearing practices to enhance fish production and profitability for farmers.

UID: 1445

Intercropping of Fodder Legumes with Fodder Pearl Millet under Different Row Proportions

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India has only 2.29% of the world's geographical area but has 17% and 11% of world's human and livestock population, respectively. It stands first in world's milk production. Share of agriculture in national GDP is 10% and the share of livestock in agriculture GDP is 28.4% (Anonymous, 2019). But still productivity per animal per year in India is very low. It is well known that contribution of feed and fodder is upto 50% towards livestock productivity and production. At present, there is no feed and food security for more than 500 million animals in the country. The adequate supply of nutritive fodder and feed is a crucial factor impacting the productivity and performance of the animals. As per estimates of Directorate of Economic & Statistics, Department of Agriculture, Co-operation and Farmers Welfare, Government of India, fodder crops are cultivated only in about 4.9% (9.13 m ha) of the gross cropped area of the country and this area has been static for last 25 years. Profit of a dairy farmer heavily depends on sources of feed and fodder as feeding cost accounts for about 65 to 70 per cent of the total cost of livestock farming. As a solution for limited land under fodder crops, deficit fodder both in terms of production, quality and meagre returns of the farmer, an effort was made with an objective to identify a profitable and sustainable row proportion of forage legume crop (cowpea, clusterbean, mothbean) which can enrich the quality and enhance the yield of multicut fodder pearl millet.

Methodology

A field experiment was planned during *Kharif* season 2019 at the Agronomy Instructional farm, Chimanbhai Patel college of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. The soil of the experiment plot was loamy sand, low in organic, available nitrogen (149.5 kg/ha), medium in available phosphorus (38.4 kg/ha) and high in potassium status (282 kg/ha) with pH (7.5) and electrical conductivity 0.15 dS/m. The experiment comprised of ten treatments (Table) with sole cropping and intercropping fodder pearl millet with cowpea, clusterbean, mothbean. The varieties selected for different crops were GFB 1 for fodder pearl millet, EC 4216 for fodder cowpea, BG 1 for fodder clusterbean and GMo 1 for fodder mothbean. Sowing was done in the furrows opened at 30 cm apart. The crops were fertilized with nitrogen and phosphorus using urea and DAP. Nitrogen recommendation was 100 kg/ha for fodder pearlmillet which was applied as 25 kg in basal application and 75 kg as topdressing with 25 kg in first split at 33 DAS and 50 kg in second split after first cut whereas for fodder legumes, entire requirement of nitrogen and phosphorous was applied as basal @ 20 kg/ha. and 40 kg/ha, respectively for each fodder legume crop. All the seeds of fodder crops are treated with bio fertilizers *Azotobacter* and Phosphorous Solubilising Bacteria @ 250 g/8 kg seed. Seed rates of fodder pearlmillet and legumes adopted in the experiment were 12 and 40 kg/ha, respectively.

Results

Significantly the highest pearl millet green fodder equivalent yield (919.50 q/ha) of the two cuts was observed in treatment, fodder pearl millet + fodder cowpea with 2:2 row ratio. Overall mean crude protein of fodder pearl millet was significantly the highest in fodder pearl millet + fodder cowpea with 2:2 row ratio. Significantly maximum Benefit cost ratio, Land

Equivalent Ratio and Net realization were noticed under fodder pearl millet + fodder cowpea in 2:2 ratio.

Effect of various row ratios of fodder legumes with fodder pearl millet on green fodder equivalent yield, crude protein content, Net realization, BCR and LER

Treatment (All fodder crops)	Pearl millet green fodder equivalent yield (q/ha)	Crude protein (%)		Net realization (₹/ha)	B:C	LER
		Mean of two cuts	Fodder legumes			
Sole pearl millet	734.47	12.09	-	60570	1.22	-
Sole cowpea	433.78	-	18.21	31024	0.91	-
Sole clusterbean	269.86	-	17.32	7663	0.23	-
Sole mothbean	305.96	-	17.25	15261	0.50	-
Pearl millet + cowpea (2:2)	919.50	14.43	17.76	93939	2.14	1.43
Pearl millet + cowpea (4:2)	750.46	12.94	17.57	68268	1.54	1.15
Pearl millet + clusterbean(2:2)	619.08	12.34	17.04	49084	1.12	1.18
Pearlmillet+clusterbean (4:2)	632.84	12.34	16.78	51304	1.18	1.02
Pearl millet + mothbean (2:2)	547.79	12.23	16.84	38806	0.89	1.02
Pearl millet + mothbean (4:2)	630.51	12.16	16.88	51233	1.18	1.05
S.Em.±	21.97	0.19	0.36	3296	0.08	0.04
C.D. at 5 %	63.76	0.58	NS	9564	0.22	0.12
C.V. %	7.52	3.11	4.19	14.11	13.98	6.85

Conclusion

From the results of experimentation, it is concluded that significantly higher pearl millet green fodder equivalent yield, quality, profits and land use efficiency can be obtained by growing cowpea as an intercrop with fodder pearl millet in 2:2 ratio.

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UID: 1473

Predictive Modelling Driven by Artificial Intelligence to Assess the Impact of the Climate Change on the Transmission of FMD Diseases in India

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India has one of the largest livestock populations globally, with a total of 535.78 million, including 302.34 million cattle and buffaloes (DAHD&F, 2019). Livestock production contributes 4.11% to the national GDP and 25.6% to agricultural GDP. Around 20.5 million people in India depend on livestock for their livelihoods, with the sector contributing 16% of income to small farm households. Climate change significantly affects the environment, leading to negative consequences for both human and animal health. Experts believe that climate-induced environmental changes will enhance the emergence and spread of animal diseases (Caceres, S.B. 2012). Foot and Mouth Disease (FMD), a viral infection impacting cloven-hoofed animals such as cattle, pigs, and sheep, is influenced by the Temperature-Humidity Index (THI). THI, which measures the combined effects of temperature and humidity on animal stress, shows that high levels can weaken the immune systems of animals, increasing their susceptibility to diseases like FMD (Kowal et al., 2021). The present study examines the impact of the Temperature-Humidity Index (THI) on Foot and Mouth Disease (FMD) rates over a 20-year period in two agro-climatic regions of India: Zone 9 and Zone 12.

The study investigates the spatiotemporal distribution of Foot and Mouth Disease (FMD) rates in livestock in relation to the climatic factor, the Temperature-Humidity Index (THI), across two agro climatic regions of India (Zone 9 and Zone 12).

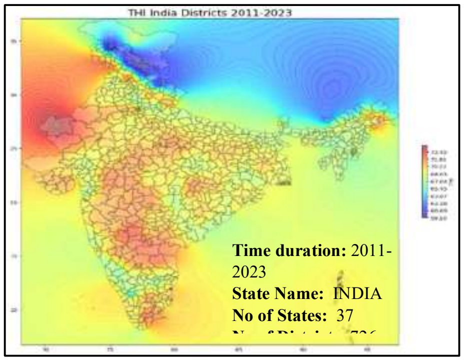
Materials and Methods

The present study calculating THI for whole India from 2011 to 2023 using artificial intelligence modelling procedure namely Krigging analysis and variogram modelling by Anaconda. Navigator under Jupyter-notebook version 6.5.4 using Python programming language. Descriptive details-(Time duration 2011-2023, 37 states included, 726 districts with 50 km/grid, gridded points 202032). THI data for whole India was obtained from web portal https://search.earthdata.nasa.gov/ Temperature humidity index (THI) was calculated using formula THI= (1.8*AT+32)−[(0.55−0.0055*RH)× (1.8* AT −26)] (Habeeb et al 2018) where AT = air temperature (◦C), and RH = relative humidity (%) and Reported that THI thresholds for heat stress in cattle as following: Comfort (THI < 68), Mild discomfort (68 < THI < 72), Discomfort (72 < THI < 75), Alert (75 < THI < 79), Danger (79 < THI 84). The

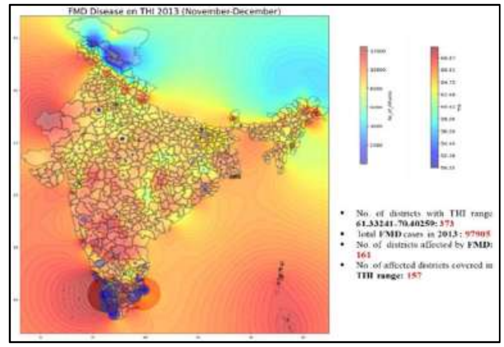
FMD disease incidence rate from 2011 to 2023 obtained NADRES website from 2011 to 2023, for each year, the period with more than 75% FMD incidence in a year was identified, and the corresponding THI values were recorded. Using Krigging analysis and variogram modelling FMD disease attack rate plotted against THI range to whole India, especially for agro climatic zone 9 and 12. Further to find seasonal variation in FMD attacks we adopted periodic regression analysis.

Results

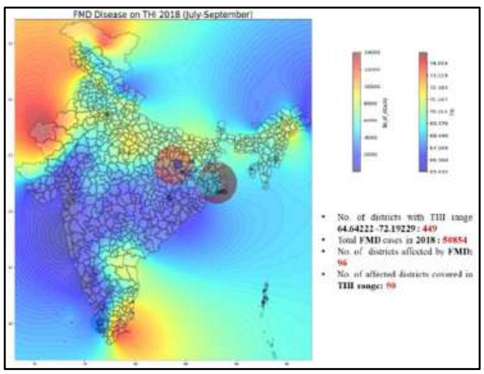
A predictive modelling-driven artificial intelligence assessment of the Temperature Humidity Index (THI) and its impact on the transmission of Foot-and-Mouth Disease (FMD) in India revealed that, between 2011 and 2023, districts across various states showed alarming trends. The THI index values in these States-Tamil Nadu (8 districts), Karnataka (12 districts), Andhra Pradesh (13 districts), Telangana (10 districts), Maharashtra (15 districts), Madhya Pradesh (20 districts), Uttar Pradesh (30 districts), Gujarat (14 districts), Rajasthan (9 districts), and the North-eastern states (12 districts)-indicated that an increase in THI was pushing these areas into the discomfort-to-alert zone for livestock rearing. THI values above 72% may hinder animal growth and increase disease susceptibility. This is particularly concerning as it correlates with the increased incidence of FMD in the region. The disease risk range, calculated based on attack counts and mapped using kriging, offers a reliable method for monitoring animal diseases. From 2011 to 2023, the periods with more than 75% FMD incidence were identified, and corresponding THI values were recorded. Notably, three years-2013 (Nov-Dec), 2018 (July-Sept), and 2021 (June-Nov)-showed epidemics with over 75% FMD incidence, coinciding with increased THI levels. In 2013, the THI range of 61.33-70.40% affected 373 districts, with 97,905 FMD cases reported, of which 157 districts were affected. In 2018, the THI range was 64.64-72.19%, affecting 96 districts and resulting in 50,854 FMD cases, with 90 districts falling within this THI range. In 2021, 523 districts had THI values between 64.21% and 72%, with 19,363 FMD cases and 116 districts affected, of which 110 were within the THI range. This approach enables the identification of areas with higher disease vulnerability, allowing for more efficient resource allocation for disease prevention and control. By using the disease risk range, we can better manage and mitigate animal health threats proactively.



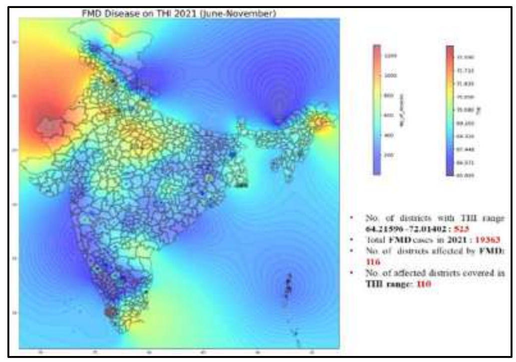
THI of Indian districts 2011-2023



FMD Disease plot of THI for India 2013 (November – December)



FMD Disease plot of THI for India 2018 (July - September)



FMD Disease plot of THI for India 2021 (June - November)

Conclusion

The predictive modelling of THI and FMD transmission highlights the significant impact of increased THI on livestock health in India. Identifying regions with higher disease risk allows for targeted interventions, efficient resource allocation, and proactive management, ultimately improving disease prevention and control efforts for better animal health outcomes.

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UID: 1476

Artificial Intelligence-Driven Forewarning System for Livestock Disease Management in India: The National Animal Disease Referral Expert System (NADRES v2)

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India's livestock sector is integral to the country's economy, contributing significantly to GDP and agricultural outputs. However, livestock diseases lead to substantial economic losses, highlighting the critical need for effective forecasting and risk assessment systems. Traditional methods of disease control often fail to mitigate the widespread effects of outbreaks, making advanced technologies such as Artificial Intelligence (AI) and Machine Learning (ML) essential for proactive disease management. (Suma et al.,2015). The National Animal Disease Referral Expert System (NADRES v2) addresses this need by providing early warning for livestock disease outbreaks up to two months in advance. By integrating diverse data sources disease outbreak histories, environmental conditions, remote sensing data, and livestock population statistics NADRES v2 enables the prediction of disease risks, allowing for better preparedness and timely intervention. This system is crucial for minimizing economic losses and preventing disease transmission by offering decision-makers reliable predictions and risk assessments.

Materials and Methods

Livestock disease outbreak data are sourced from the All India Coordinated Research Projects (AICRP), NADEN centres, and State Veterinary Departments, and are structured for secure storage and processing. This data includes outbreak occurrences, species affected, district codes, and geographic coordinates, all of which are cleaned and spatially referenced to ensure accuracy. Village-level livestock population data from the 20th Livestock Census (2019) is integrated into the system, providing essential information on cattle, buffalo, sheep, goats, and pigs. Meteorological data, comprising 23 parameters including temperature, rainfall, soil moisture, wind speed, and 5 remote sensing variables (NDVI, EVI, PET, LAI, and LST), are retrieved from various sources, including the Global Land Data Assimilation System (GLDAS v2), MODIS, CRU, and NCEP. For forecasting environmental parameters ARIMA models are applied. Two datasets were constructed, one using a 10-year average of risk parameters (static) and the other using a 2-year average (dynamic). To reduce noise in the input data, a weighted scoring system was applied to annual disease outbreak records. Additionally, Principal Component Analysis (PCA) is utilized to enhance risk parameter data.

A total of 16 machine learning models are employed to predict disease outbreaks. These models include Generalized Linear Models (GLM), Generalized Additive Models (GAM), Random Forest (RF), Boosted Regression Trees (BRT), Artificial Neural Networks (ANN), Multivariate Adaptive Regression Splines (MARS), and Flexible Discriminant Analysis (FDA), among others. The best-fitted models output the probability of disease occurrence, which is then categorized into six risk levels: Very High Risk (p=0.81-1.0), High Risk (p=0.61-0.80), Moderate Risk (p=0.41-0.60), Low Risk (p=0.21-0.40), Very Low Risk (p=0.0-0.20), and No Risk (p=0.0). Linear Discriminant Analysis (LDA) is conducted to identify significant risk parameters linked to disease outcomes.

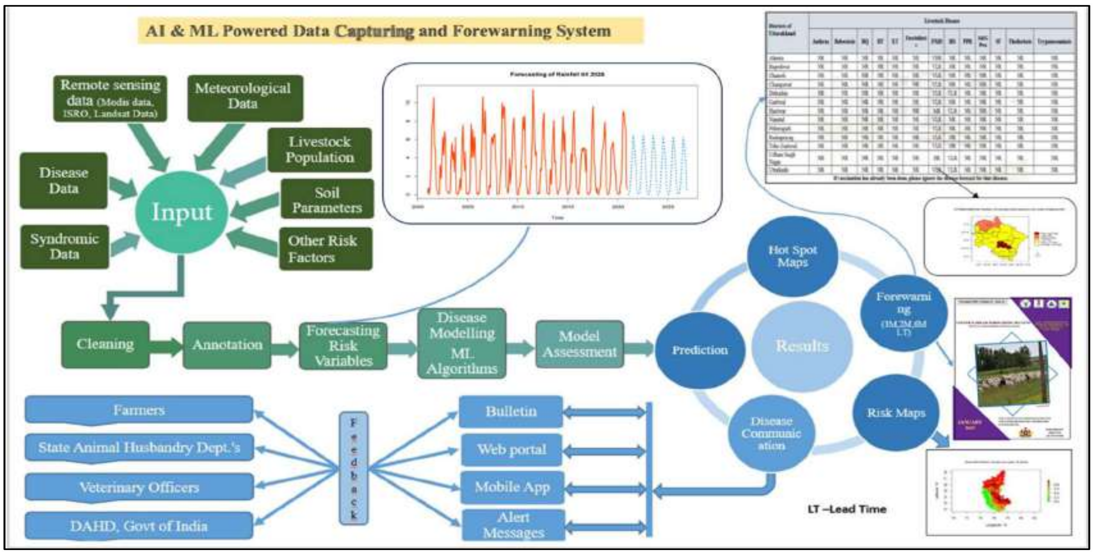

Fig. 1. Artificial Intelligence enabled Data Capturing and Forewarning System

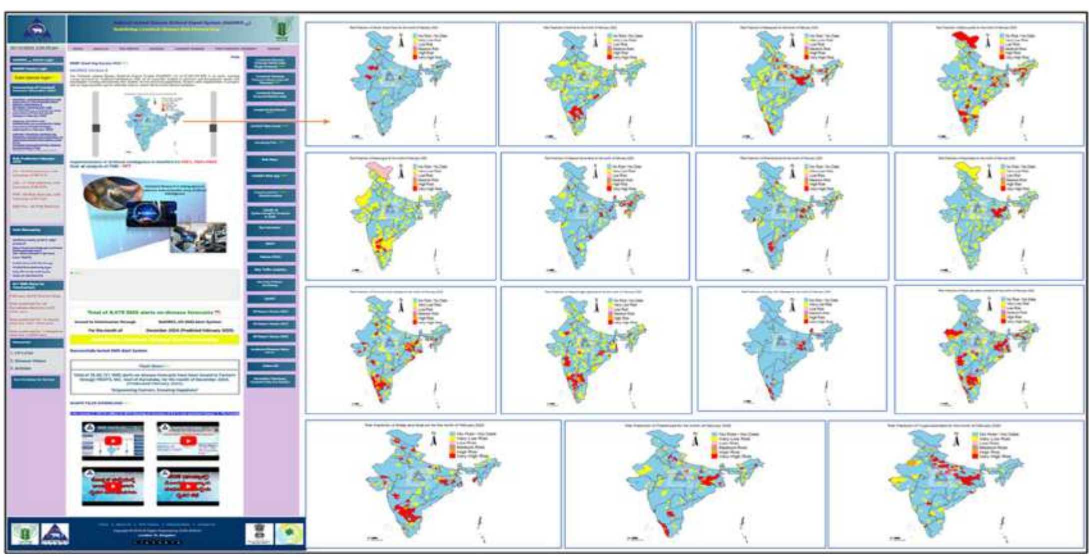

Fig. 2. Preview of National Animal Disease Referral Expert System (NADRES) of ICAR-NIVEDI home page and disease risk prediction maps for February 2025.

This forewarning system uses AI tools to capture, clean, align, and annotate diverse data formats from multiple sources before subjecting the data to machine learning algorithms. (Suresh et al., 2019). A schematic diagram of the NADRES v2 application, illustrating AI tools for data capture and processing, is presented in Fig. 1, while the home page and disease risk prediction for February 2025 are shown in Fig. 2.

Results and Discussion

The NADRES v2 system significantly enhanced livestock disease risk prediction across India by integrating traditional statistical methods and advanced machine learning algorithms. Sixteen models demonstrated high accuracy in forecasting disease outbreaks, with eleven evaluation indices such as Kappa, ROC, TSS, precision, recall, F1-score, and accuracy indicating robust performance across diverse datasets. One of the system's key features is spatial risk mapping, which categorizes districts into six risk levels: No Risk (NR), Very Low Risk, Low Risk, Moderate Risk, High Risk, and Very High Risk (VHR). This categorization facilitated targeted interventions and resource allocation. For instance, the forecasting results for December 2024 predicted disease risk maps for February 2025, accurately reflecting disease outbreaks. (OIE, WHO. 2006). This allowed veterinary officers to prioritize high-risk areas for preventive measures. Additionally, AI integration with spatial data helped identify geographic hotspots for disease outbreaks. By analysing both historical and environmental data, the system predicted high-risk regions and provided early warnings to local authorities. Environmental forecasting models, such as ARIMA, were particularly effective in predicting conditions like temperature, humidity, and rainfall, which influence disease spread. These forecasts, extending up to two months, provided valuable lead time for proactive disease risk management.

Conclusion

The NADRES v2 system advances livestock disease management in India by utilizing AI and machine learning to predict outbreaks with a two-month lead time. By integrating data from outbreak histories, meteorological conditions, and remote sensing, it enables timely preventive measures to reduce livestock losses. The system has proven effective in delivering reliable predictions, aiding decision-makers in mitigating risks. However, challenges such as incomplete data, the exclusion of socio-economic variables, and limited adaptability across diverse disease scenarios persist. Overcoming these challenges will enhance its effectiveness, expand its applicability, and solidify its role as a critical tool for livestock disease management.

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Enhancing Livestock Productivity: Climate-Resilient Fodder Varieties for Sustainable Agriculture in western India

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Agriculture and livestock farming are critical to the livelihoods of millions of people in India, particularly in states like Maharashtra and Gujarat. Both states are major contributors to India's livestock sector, with Maharashtra housing 29.17 million cattle and Gujarat 23.53 million, according to the 20th Livestock Census (2019). Despite the large livestock populations, these regions face significant challenges in fodder production. Maharashtra, for instance, experiences a fodder deficit of approximately 28.5%, while Gujarat grapples with similar shortages in both green and dry fodder. This situation is compounded by climate variability, including erratic rainfall, droughts, and floods, which further hinder fodder availability.

To address these challenges, the study focuses on the performance of various climate-resilient fodder varieties under the National Initiative on Climate Resilient Agriculture (NICRA) project, which operates in Maharashtra and Gujarat. This initiative aims to enhance the resilience of rainfed agriculture and improve fodder production to meet the growing demand for livestock feed. The project has introduced improved fodder varieties such as Anand Lucerne-2, Hybrid Napier (BNH-10), and Sorghum (Sugargraze), which has demonstrated at Krishi Vigyan Kendras (KVKs) in states of Maharashtra and Gujarat.

The study evaluates the yield potential, environmental vulnerability and economic viability of these improved fodder varieties. Results show that certain varieties offer significant improvements in yield, with increases ranging from 21.86% to 48.23% compared to traditional varieties. For example, Anand Lucerne-2 demonstrated the highest yield, averaging 1013.83 q/ha, which was a 28.85% increase over the check variety. Similarly, Hybrid Napier (BNH-10) produced an average yield of 1074.56 q/ha, showing a 21.86% yield increase, making it particularly suitable for intensive fodder production systems.

The climate-resilient varieties have proven to be more adaptable to the varying climatic stresses in Maharashtra and Gujarat, such as drought, heat, and flooding. For instance, Sorghum (Sugargraze) exhibited the highest yield increase of 48.23%, making it a promising choice for regions prone to drought. The Benefit-Cost Ratios (BCRs) for these varieties further demonstrate their economic viability, with values as high as 5.31 for Lucerne Anand-3 and 4.65 for Sorghum (COFS29), indicating substantial returns on investment.

Variety	Name of KVK	Season	Vulnerability situation
Maize (African Tall)	Amravati, Jalna	Summer	Drought
Fodder Maize	Pune	kharif	Drought
Sorghum (Phule Godhan)	Ahmednagar	Summer	Drought
Sorghum (Sugargraze)	Ahmednagar	kharif	Drought
Sorghum (GFS-5)	Banaskantha	kharif & Rabi	Drought
Sorghum (Gundri)	Kutch, Rajkot	kharif	Drought
Anand Lucerne-2	Banaskantha, Kutch, Jalna, Amreli, Nandurbar	Kharif	Drought & Heat Stress Drought (Nandurbar)
Lucern (RL-88)	Nandurbar	multicut fodder	Heat Stress Drought
Lucerne Anand-3	Amreli	kharif	Drought
Lucern (GAL-2)	Banaskantha	Rabi	Drought
Hybrid Napier (BNH-10)	Jalna,Valsad	multicut fodder	Drought & Flood (Valsad)
Hybrid Napier (Co-3)	Ratnagiri	kharif	Flood
Hybrid Napier (Yashwant grass)	Amravati, Buldhana	Summer	Drought
Peral millet (Nutrifeed)	Ahmednagar	kharif	Drought
Makhhan Grass	Amreli, Rajkot	Rabi	Drought
Jinjvo Marvel grass	Rajkot	kharif	Drought
sorghum variety-COFS29	Ahmednagar	multicut fodder	Drought

The Role of Regional Climate Adaptation

In Maharashtra, areas like Ahmednagar, Amravati, and Jalna have faced significant drought stress, making the introduction of drought-tolerant varieties such as Sorghum (Phule Godhan) and Fodder Maize critical to improving fodder security. Similarly, Gujarat's regions like Banaskantha, Amreli, and Rajkot have benefited from varieties like Anand Lucerne-2, which has shown resilience to both drought and heat stress. The study also highlights the importance of selecting region-specific varieties based on local climatic conditions, ensuring that farmers can adopt the most suitable varieties for their particular challenges.

Economic and Environmental Impact

The economic analysis reveals that the adoption of climate-resilient fodder varieties not only increases fodder yields but also enhances the overall profitability of livestock farming. For instance, the BCR for Anand Lucerne-2 was 3.03 in demonstration plots, indicating a profitable return compared to the check variety, which had a BCR of 2.37. In areas where farmers have adopted Hybrid Napier (BNH-10) and Sorghum (Sugargraze), the BCRs of 3.16 and 3.79, respectively, demonstrate their economic feasibility as high-yielding fodder options.

Additionally, the improved fodder varieties contribute to environmental sustainability by reducing the dependency on traditional fodder crops that often require more water and fertilizer. Varieties like Hybrid Napier (BNH-10) and Anand Lucerne-2 have been shown to be more resilient to extreme weather events, such as floods and droughts, which are increasingly common due to climate change. This resilience ensures a more stable fodder supply for livestock, reducing the risk of feed shortages and supporting sustainable farming practices.

Variety wise performance of improved fodder

Variety	No of farmers	Area (ha)	Fodder Yield (q/ha)		% increase	BCR	
			Demo	Check		Demo	Check
Maize (African Tall)	80	19.50	656.28	603.27	8.79	6.63	5.04
Sorghum (Phule Godhan)	63	9.45	105.64	82.89	27.45	4.36	3.31
Sorghum (Sugargraze)	50	7.50	252.68	170.47	48.23	3.79	3.18
Sorghum (GFS-5)	20	8.00	279.00	264.00	5.68	1.76	1.55
Sorghum (Gundri)	85	24.00	333.41	281.00	18.65	2.28	1.57
sorghum variety- COFS29	20	2.00	520.00	380.00	36.84	4.65	4.23
Anand Lucerne-2	203	44.10	1013.83	786.80	28.85	3.03	2.37
Lucern (RL-88)	120	1.60	892.09	789.18	13.04	2.79	1.75
Lucerne Anand-3	5	2.00	951.25	845.00	12.57	5.31	4.80
Lucern (GAL-2)	5	2.00	642.00	593.00	8.26	1.74	1.51
Hybrid Napier (BNH-10)	162	5.02	1074.56	881.82	21.86	3.16	2.62
Hybrid Napier (Co-3)	26	5.20	764.67	714.17	7.07	4.11	3.50
Hybrid Napier (Yashwant grass)	35	12.00	287.25	217.55	32.04	2.97	2.19
Peral millet (Nutrifeed)	10	1.50	189.50	155.00	22.26	2.31	2.26
Fodder Maize	**20**	8.00	313.88	228.61	37.30	3.16	2.00
Makhhan Grass	5	2.00	454.00	421.60	7.69	2.74	2.47
Jinjvo Marvel Grass	10	4.00	80.00	70.00	14.29	2.88	2.13

Conclusion

The findings of this study emphasize the importance of adopting climate-resilient, high-yielding fodder varieties in Maharashtra and Gujarat to address the challenges of fodder scarcity, livestock nutrition, and food security. The improved varieties like Anand Lucerne-2, Hybrid Napier (BNH-10), and Sorghum (Sugargraze) not only show significant improvements in yield and economic returns but also demonstrate resilience to the climatic stresses faced in these regions.

As India continues to face the challenges of climate change, the adoption of such climate-resilient agricultural practices can play a crucial role in ensuring sustainable livestock production. By selecting appropriate fodder varieties based on local climate conditions, farmers can enhance livestock productivity, reduce feed costs, and contribute to food security. This approach is particularly important for Maharashtra and Gujarat, where the integration of climate-resilient fodder into farming systems can help mitigate the impacts of climate variability and ensure the long-term sustainability of the livestock sector.

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Enhancing Climate Resilience and Livestock Productivity through NICRA Interventions

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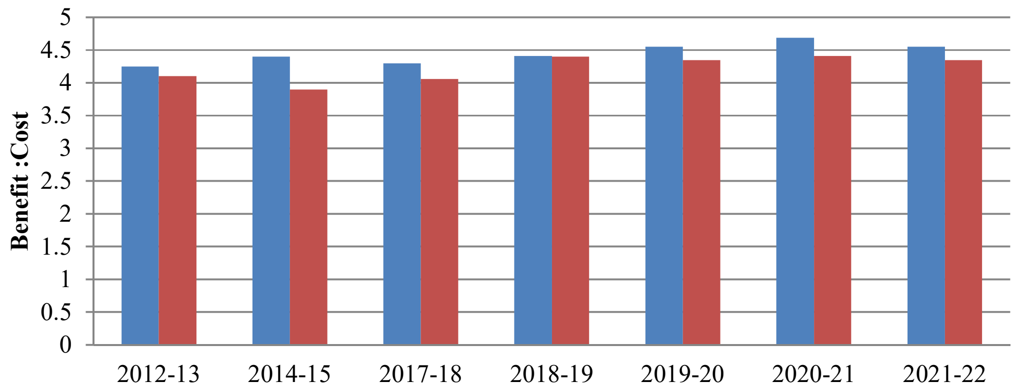
Sirsa district, located in the northwestern part of Haryana, is amongst the largest districts in the state. Under the NICRA project, Krishi Vigyan Kendra, Sirsa, adopted Rupana village in Nathusari Chopta block to address its climatic challenges. The village has about 780 hectares of cultivable land, including 70 hectares of rainfed fields and 60 hectares affected by salinity. Livestock rearing is a key livelihood activity, supporting commercial dairy farming and household needs. However, during summer, abrupt weather conditions like hot winds exacerbate mineral deficiencies in livestock, affecting their health and productivity.

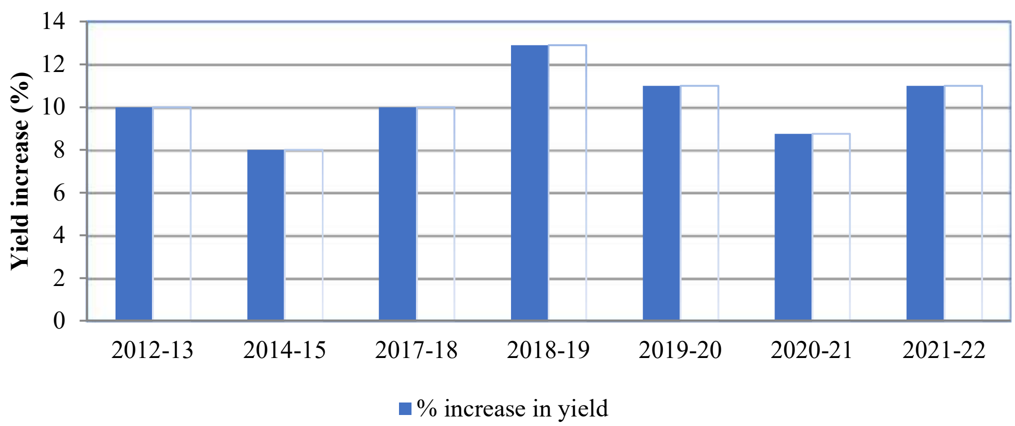
Methodology

Based on a baseline survey, Rupana village in Sirsa district was selected for the implementation of climate-resilient technologies under the NICRA (National Innovations in Climate Resilient Agriculture) project, ongoing since 2011. To combat the challenges of hot summer winds and mineral deficiencies in dairy cattle,mineral mixture was provided to lactating animals at a dosage of 50 g/day/animal. The impact of this intervention was assessed by evaluating improvements in milk yield compared to animals not receiving the supplement, demonstrating the effectiveness of mineral supplementation in enhancing dairy productivity.

The fig compares the benefit-cost (B:C) ratio of demonstration plots and control groups from 2012–13 to 2021–22. Demonstrations consistently show a higher B:C ratio than controls, highlighting the economic viability of interventions under NICRA. Increase in B:C ratio due to NICRA interventions has also noticed by Pise et al (2018) and Medhi et al (2018). Fig illustrates the percentage increase in milk yield due to mineral mixture supplementation over the same period. Yield improvements range from 8% to 12%, with the highest increase observed in 2018–19. Together, these graphs demonstrate the effectiveness of mineral supplementation and related climate-resilient practices in improving livestock productivity and economic returns for farmers. Similar results have also been obtained by Tajpara et al (2018)



Graph 1 Benefit: Cost ratio of demonstrations and control.



Graph 2: % increase in milk yield due to mineral mixture over different years

Conclusions

The NICRA project in Rupana village has effectively addressed climatic challenges and improved agricultural and livestock productivity. The provision of mineral mixtures to lactating animals has significantly enhanced milk yield, with improvements ranging from 8% to 12% over the years. Demonstration plots under the project consistently showed a higher benefit-cost ratio compared to controls, emphasizing the economic viability of these interventions.

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Ten-Cent Model Fodder Plot for Sustainable Ruminant Production

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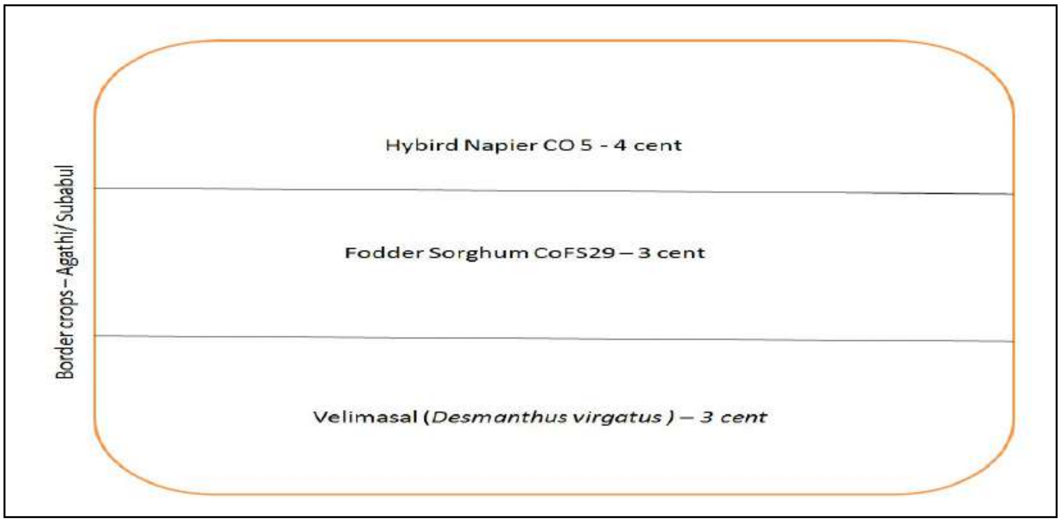
Livestock farming remains as an integral component of farmer's culture and livelihood. It also plays a pivotal role in the rural economy. Tamil Nadu, holds 4.56% 11 of India's livestock population contributing 4.39% to country's milk production and 7.88% to meat production (DAHDFD, 2021). In Tamil Nadu, the area under fodder crops is 0.09 million hectare which is approximately 1% of total cultivated green fodder and 15% of dry fodder. Non availability of feed and fodder for livestock could be a serious limitation to livestock production (Kaasschieter *et al.,* 1992; Earagariyanna *et al.,* 2017). Farmers with small holdings show little interest in planting pasture and cultivated fodders. So, there is need to cultivate the fodder in an intensive manner to feed the livestock. Intensive fodder production through promotion of sustainable fodder production model under irrigated condition (ten-cents) is one of the projects implemented by Government of Tamil Nadu in the year 2019. Hence the present study was carried to validate the fodder production potential of the ten-cent model fodder plot for livestock feeding.

Materials and Methods

This experiment was carried out in NICRA adopted village, located at Kurumbalur cluster. A ten cent land was prepared as per standard agronomical practices for fodder cultivation. High biomass yielding grass fodder like Hybird Napier grass varietys Co (BN) 5 was planted in 04 cents area; Cereals fodder sorghum (CoFS 29) in 03 cents area and perennial legume, velimasal were cultivated in 03 cents area each. Tree fodders, Agathi and Subabul were cultivated as boundary plantation. The fodder yield was recorded at recommended harvesting period for 10 months.



Results and Discussion

Biomass yield of fodder crops

The total biomass yield of the fodder crops harvested during the study period of 10 months in ten-cent model fodder plot was 7112 kg. The average yield/cut (kg) of Co5, Fodder sorghum, Desmanthus and Agathi/Subabul were 1405 kg, 246 kg, 82 kg and 95.0 kg respectively. (Table). The highest fodder yield (5620 kg) was recorded in hybrid Napier Co5 which remained high on subsequent cuttings also as compared with other fodder cops. The harvest days of different fodder crops were presented in Table 1. The initial harvests were as per recommendation but subsequent harvest days were longer in this study.

On an average a crossbred cattle weighing 300 kg requires 20 kg green fodder per day and 30 kg goat requires 4 kg green fodder per day. The total quantity of fodder obtained from ten-cent model fodder plot can support one adult cattle or five goats. However, the biomass yield of fodders in the ten-cent model fodder plot is not uniform throughout the year. This may due to sowing and harvesting interval between the crops and seasonal variations (Dhillon and Sidhu, 2020). In this study, out of 10 months, only 5 months the fodders were harvested in excess.

This may be due to the sowing of fodder crops at the same time without following the standard staggered sowing. The above issue can be trouble shooted by adopting the following strategies.

(i) Staggered sowing of different fodder crops for extended supply of fodders throughout the year.

(ii) Optimize the cutting schedule of different fodder crops.

(iii) In this ten-cent model fodder plot, crops were harvested 2-4 times excess as required. This excess fodder crops can be preserved as quality silage and it can be used whenever there is a shortage of green fodder.

(iv) Tree fodders as boundary plantations provide feed for animals during lean periods. These ten-cent model fodder plots is suitable for cut and carry system of fodder feeding which is widely practised by small holders where access to grazing land is prohibited. This model is helpful to increase milk yield and maximize the forage production in limited space and time.

Biomass yield and days to harvest for different component crops of the 10 cents plot

Sl. No.	Fodder	No. of. Harvest	From date of sowing to first Harvest (days)	Total yield for 10 months (kg)
1	Hybrid Napier CO 5	4	72	5620
2	Fodder sorghum - CoFS29	4	65	1056
3	Desmanthus	3	90	246
4	Agathi and Subabul	2	178	190
	Total biomass yield (Kg)			7112

Conclusion

The Small and marginal farmer can get green fodder round the year maximum of 2 cows whereas in case of sheep and goat they can maintain 5-8 numbers with the help of multi cut 10 cent fodder unit.

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Alfa Alfa Poultry Model -A Climate Resilient Profitable Poultry Farming for Cold Arid Condition of Ladakh

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Presently our country is facing a great challenge of producing adequate food from shrinking natural resource base for the ever-increasing population and on the other hand competition for land and water is increasing from non-farm sectors. Hence, intensification of agricultural activities through enhanced productivity and efficient resource use is the only option available. Every sector is badly hit and the most prominently affected is agriculture farming- the feeding bowl of this planet (Aggarwal, 2008). The impact of climate change is witnessed first in high altitude zone and like rest of the world, Ladakh – a high altitude sparsely populated cold arid region at the northern most tip of India is not an exception. Under the influence of global climate crisis, Ladakh's agricultural landscape is also witnessing significant transformations owing to shifting climate patterns, marked by temperature fluctuations, irregular precipitation, and heightened occurrences of extreme weather events. These changes pose distinct challenges to the region's old age traditional farming practices, demanding adaptive solutions to sustain agricultural productivity amidst the evolving climatic scenario. An economic survey in 2017-18 cautioned that "climate change might be reducing annual agriculture income in the range of 15 per cent to 18 per cent and up to 20 per cent to 25 per cent for unirrigated areas". This creates food shortages, nutrient deficiencies in humans due to inadequate intake of healthy food makes humans vulnerable to health issues. It is high time that rationale of climate-resilient agriculture (CRA) is valued and implemented more rigorously. In other words, more production is needed with reduced natural resources under a variable climate. Our country also need to take steps towards a carbon and energy efficient economy and all this calls for a Climate Resilient Agriculture (CRA) leading to sustainable food security (Policy Paper 65 CRA,NAAS 2013).

Ladakh is the only cold arid region of the country with extreme type of climate and high altitude (11000 ft to 16000ft asl). The agriculture farming is very limited to summer season only with very poor soil quality and scanty precipitation. During the severe winter season Ladakh is cut off from rest of the world for 5-6 months and there is a severe shortage of green vegetables and fresh poultry product during the winter season (Sheikh, 2022). Most of poultry and food products in the market are frozen with very high cost and vulnerable to adulteration and spoilage. Now a days, in Ladakh though lots of improvement in vegetable production during winter season has taken place through various technologies of protected cultivation, but no initiative has been taken for livestock and poultry production.

Backyard poultry production among rural farmers of Ladakh was a part of an age-old natural farming practice like other parts of our country, every rural farmers used to have 3-4 local indigenous bird at their house with the broodiness character, but presently there is not a single indigenous bird left which can brood their eggs and the precious germplasm is lost for ever. It is the most cost-effective way for rural farmers to double their income within a short period of time with minimal input. (Rajkumar *et al*. 2010a).

With the passage of time, the impact of Climate Change can be clearly seen in Ladakh region due to which lots of changes are coming in the farming system. Poultries are severely sensitive to temperature-associated problems, particularly heat and cold stress due to which there will be reduced feed eating by poultries leading to lesser body weight and egg production (Deng et al., 2012). It also affects the quality of meat. There is decreases in the density of eggshell and causing more egg breakage (Lin *et al.,* 2004). Raising of indigenous poultry breeds in backyard is an important source of livelihood for the rural people. The small holdings containing 5-10 hens per unit were found to be more efficient producer of eggs compared to those with 50 or more hens per unit. In comparison to commercial birds, Indigenous birds reared in rural areas are resistant to many diseases and pests and do not require high level of inputs. Now a days, Backyard Poultry Farming is emerging as a source of employment opportunities and additional income to rural households improving the socio-economic life of the people. It brings more income with low output and can be easily sustain on kitchen waste, worms, insects, weeds, grains, rice etc (Sapcota *et.al.,* 2002). The housing structure is cheap and eco-friendly, made up of mud bricks and poplar tree cuttings. It provides quality food in the form of egg and meat, control pests and the growth of weeds, reduces food wastage and also provides women empowerment since backyard birds are managed by them. The demand for local egg and chicken and duck in the local markets and towns is high as locally reared poultry birds have low cholesterol and provides the necessary nutrients and protein to the people especially women and children (Kumaresan *et.al.,* 2008). Furthermore, it aids in enhancing the soil fertility in backyards (15 chickens produce 1-1.2 kg of manure/day) and birds reared under free range conditions give eggs and meat of low cholesterol concentration compared to those produced under intensive poultry farming (Jha *et.al.*2017).

Materials and Methods

Keeping in view the need of fresh healthy chicken meat and eggs under the present climate change scenario in Ladakh (Erratic and more precipitation and warmer winter) a trial to study the performance of Vanraja (Backyard poultry breed) was carried out at KVK-Leh under

NICRA Project. The main objective of the study was to introduce a new farming system suitable and profitable for the farming community of Ladakh under the present climate change condition.

Under the trial day old chicks (500 Nos) were procured from Poultry Directorate Hyderabad to KVK-Leh Stakna in the month of October 2021. The birds were raised in a clean hygiene room with a temperature maintained above 30 Degree The birds were fed brooder mesh for first two weeks and grower mesh afterwards up to 4 weeks age old. After 4 weeks the grower mesh was reduced to 50% and the birds were raised on the alfalfa fodder land (Range Chicken Farming). Birds are generally reared on free range system. The birds are let loose in day time for foraging and sheltered in shed at night. After purchase, brooding arrangements are required to be provided to the day old chicks in first week. Brooding can be done by using any heating source – electric bubs, bukhari. The floor was covered with 1-2 inches of paddy/ wheat straw to avoid soiling and injuries to birds. Similarly, birds are to be protected from attack of predators. The shed were cleaned regularly to prevent dampening and thereby fungal and microbial infections. For better health care in backyard poultry farming the birds were vaccinated against diseases at proper time. Deworming for internal and external parasites were also done to maintain a healthy flock. Data on body growth, egg production, mortality were taken from time to time along with feeding and other management activities. The cost benefit ratio was also calculated. The other traits like, age at sexual maturity(day), egg production (no.) at 500 days, egg weight (gm) at 40 week and mortality of the birds were recorded.

Economics analysis of rearing Vanaraja birds in free range system was done. The production cost involved in the study were day old chick, feed, vaccine and medicine. The feed cost includes the amount of brooder mesh offered up to 14 days of age and starter feed up to age of 44 days. The return cost included selling of eggs, live cocks and spent hens. The eggs and birds were sold directly to the consumer at the prevailing market rates. The net returns were calculated by deducting the returns from net cost of production. The cost benefit ratio was calculated by dividing the total gross return by net cost of production. The mortality rates in Vanaraja birds were considered as 8% during the whole experimental period. Data were statically analyzed in SPSS (version 16.0) and as per the procedures described by Snedecor and Cochran (1994).

Results and Discussion

Adult Body weights: The body growth/weights performance of different age groups of Vanaraja birds at KVK-Leh in comparison to Poultry Directorate are presented in Table 1. The average body wt for female birds at 2 weeks , 4 weeks, 6 weeks, 13 weeks, 26 weeks and 40 weeks age were recorded as 214±8.12 gm, 470±12.3 gm, 634± 11.43 gm, 1040± 15.32gm, 1430± 17.98gm and 2328±21.21 gm respectively. The average body wt for males 2 weeks , 4 weeks, 6 weeks, 13 weeks, 26 weeks and 40 weeks age were recorded as 269±9.74 gm, 522±5.43 gm, 765± 10.65 gm, 1263± 12.32gm, 2437± 16.65 gm and 4104±23.32 gm respectively.

Egg Production: The birds start laying at the age of 170 days. The average age at sexual maturity in Vanaraja birds were recorded to be 172± 2.72 which is very much at par with the performance recorded by Poultry Directorate Hyderabad (175-180 days). The mean egg production at 500 days in Vanaraja birds were recorded as 87± 3.26 numbers, which is lower than the recorded data by Poultry Directorate Hyderabad, with a corresponding values of 140-150 eggs in 500 days. Kumaresan *et al* (2008) reported that annual egg production of Vanaraja birds was 176 ± 9 under the backyard system of rearing. Egg production is important trait from farmers' financial point of view. (Chutia 2010) recorded annual egg production of indigenous chicken of Assam was ranged from 53.8 ± 0.23 to 58.4 ± 0.26. The mean egg weights at 40 week of Vanaraja birds at KVK-Leh were recorded as 54.47 ± 1.73 which was almost similar to range given by Poultry Directorate Hyderabad i.e. 52-58 gram respectively. The present findings of Vanaraja birds are comparable with the findings of Islam *et al*. (2005), who reported that the average egg weight of 58 gram under traditional rearing system in Assam.

Mortality Rate: The mortality rate was recorded as 6%, 2% and 0.3% during the 1st week, 2-4 weeks and above 4 weeks respectively. The maximum mortality was during the 1st week, which was due to hypothermia and crowding. The overall low mortality rate of 8% was recorded which may be due to hardiness and resistant of the breed towards extreme condition and diseases. Kumaresan *et al.* (2008) also recorded 8.4% of mortality in Vanaraja birds up to 5th week of age. In contrast to the present findings, Ghosh et al. (2005) reported higher mortality percentage of 22.63% in Vanaraja birds up to 6 weeks of age in high altitude of Arunachal Pradesh. The results of study indicate that survivability percentage of Vanaraja birds was well within the standard range 90-95 percent.

It clearly indicated that the performance of Vanaraja birds were excellent in Ladakh region beside of extreme climatic condition of the region.

Economics of rearing Vanaraja birds: The economics of rearing Vanraja birds shows a very promising and handsome income for farmers if proper managemental practices are followed. The detailed economics with total production cost, gross income and net income were calculated as per the available market rates and are presented in Table3. The production cost include cost of chick, feed, supplements and medicines and Gross income from sale of eggs and birds. The total cost of production was calculated to be Rs 189380 for rearing of Vanaraja birds 500 Nos with an average expenditure of Rs. 3787.6 for 10 birds. The cost of rearing Vanaraja could have been higher as indicated due to higher day old chick and transportation from Hyderabad to Leh by air and high cost of transportation of poultry feed from other parts to Leh. Though using alfalfa we have reduced the cost of feed by almost 50%. The total gross income earned from sale of eggs and birds for Vanaraja birds were Rs. 624500.00 which is due to demand of organic poultry meat and eggs in Leh district. The benefit cost ratio in Vanaraja birds were also calculated which comes to 1: 3.3 which is very good due to optimal use of resource (Ref) In addition to this this birds produces manure @ of 1.2 kg/bird/day and this manure are having very high demand in Ladakh region for agriculture purpose as the soil quality are very poor in Ladakh. Banja *et al*., (2017) also reported higher benefit cost ratio (4.47 to 5.72) in Vanaraja bird reared in the Khordha district of Odisha.

Conclusion

Ladakh has been deprived of a suitable backyard poultry bird which can become a part of farming system. Our study on performance of Vanraja in cold arid condition of Ladakh has shown that Vanraja bird reared under range system on alfalfa field with a minimal input and management system can boost the income of Ladakhi farmers especially among the women flocks.

Table 1: Growth Performances (Mean ± SE) of Vanraja birds at KVK- Leh

Quantitative Traits	Vanraja Bird	
	At KVK-Leh	Poultry Directorate Hyderabad
Age at Sexual Maturity (Days)	172± 2.72	175-180
Egg Production-500 (Days)	87±3.26	14-150
Egg Weight at 40 weeks (g)	54.47±1.73	52-58
Mortality 1 week (%)	6	
(%) Mortality 2 to 4 week	2	
Above 4 weeks	0.3	3-7

Table 2: Production Performances (Mean ± SE) of Vanaraja birds at KVK-Leh

Age of bird	Body weight (gram) Vanraja Bird			
	At KVK-Leh			Poultry Directorate Hyderabad
	Female	Male	Overall	Overall
Day old	40-50	40-50	40-50	37.07±0.07
1Week	-	-	187±3.45	--
2Week	214±8.12	269±9.74	241±8.93	147.13±0.61
4Week (1 Month)	470±12.3	522 ± 5.43	496.±8.86	334.67±1.44
6 Week	634±11.43	765±10.65	699±11.04	662.38±2.54
13 Week (3 Month)	1040±15.32	1263±12.32	1151±13.82	--
26Week (6 Months)	1430±17.98	2437±16.65	1933±17.32	--
40 Weeks (9 Months)	2328±21.21	4104±23.32	3216± 22.66	2550.83±0.42

Table 3: Economics of rearing Vanaraja birds at KVK-Leh

Items	Vanaraja bird (500 Nos)
Cost of day old chick	
Rate of Vanaraja chick- Rs 40	Rs 20000/-
Cost of feed up to 500 days	
a. 1.00 kg of Brooder Mesh/Prestarter for Vanaraja per bird for 14 days Rate of feed- Rs. 60/Kg	30000/-
b. Starter Mesh @ 2Kg/Bird for 30days Rate of Feed- Rs 45/Kg	45000/-
c. Locally made feed (crushed Barley, Maize, pea) @ 10 gm for 455 Days Rate of local Rs 40/Kg	81900/- (450 Birds)
d. Layer mesh for layers @ 10gm/bird/day 1.250 Kg= 312Kg Rate of Layer Mesh = Rs 40/Kg	12480/=
Cost of Min Mix, Medicines and Calcium feeding	
Birds feed up to 330 days @ Rs 10/bird for 500 birds	5000/-
A. Cost of Production	189380/-
Income of sale of eggs Total Egg Production for sale= 17400Nos Price of egg- Rs. 15	261000/=
Income of sale of cocks Total No of Cock Sold= 197 Nos Price of Bird = Rs. 1000	197000/=
Income of sale of spent hens Total No of birds Sold= 185 Price of Vanaraja- Rs. 900/-	166500/=
B. Total gross income	6,24500/-
Net income (B-A)	435120/=
B:C ratio	1: 3.3

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UID: 1691

Climate Change and Livestock Management in Mandi District, Himachal Pradesh

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KVK Mandi, CSKHPKV Palampur

Mandi district in Himachal Pradesh, with its reliance on mixed crop-livestock farming systems, faces significant challenges due to climate change. Erratic rainfall patterns, increasing temperatures, and extreme weather events, such as the 2023 flashfloods, have severely disrupted livestock health, fodder availability, and farmer livelihoods. Climate-induced vulnerabilities in livestock systems necessitate robust adaptive strategies to sustain productivity and secure livelihoods. The Krishi Vigyan Kendra (KVK) Mandi has been instrumental in implementing innovative strategies to combat these impacts, focusing on sustainable practices tailored to local conditions while drawing on global research.

Impacts of Climate Change on Livestock in Mandi

1. Fodder and Water Shortages

The monsoon floods of 2023 caused significant damage to maize fields, the primary fodder crop in Mandi, leading to acute shortages. Erratic rainfall patterns further exacerbated this by reducing the quality and quantity of available fodder. Studies in other regions have shown that decreased rainfall and prolonged dry spells reduce rangeland productivity, mirroring the challenges in Mandi. Farmers reported a shift towards external feed sources, increasing production costs.

Water scarcity has emerged as another critical issue. Prolonged dry spells result in the depletion of surface and groundwater resources, essential for livestock and irrigation. Research from the Western Himalayan region aligns with local observations, highlighting the critical role of water management in sustaining livestock systems under climate stress.

2. Livestock Health and Productivity

The rising temperatures and humidity have increased the prevalence of diseases such as mastitis and parasitic infestations in Mandi. Heat stress has further exacerbated declines in milk yield, reproductive performance, and overall livestock productivity. Studies across India report that climate change reduces milk production by up to 15–20% during extreme heat periods, corroborating the experiences of farmers in Mandi.

3. Economic Consequences

Farmers in Mandi have experienced significant economic losses due to increased costs of feed, veterinary services, and reduced livestock productivity. The financial burden of replacing livestock lost during extreme weather events like floods further intensifies these challenges. Similar economic vulnerabilities have been noted globally, where climate change has disrupted livestock systems, forcing farmers into debt or distress sales.

Adaptive Strategies by KVK Mandi

KVK Mandi has implemented several adaptive strategies to mitigate the impacts of climate change on livestock systems, inspired by global best practices and tailored to local conditions:

1. Silage Production from inundated maize

To address fodder shortages, KVK Mandi introduced silage-making workshops, teaching farmers to transform waterlogged maize into high-quality feed. The process involves:

Harvesting and chopping: Preventing spoilage and ensuring uniform particle size.

Anaerobic fermentation: Using silage drums to preserve feed nutritional value.

Airtight sealing: Maintaining feed quality and extending shelf life.

This intervention ensured a consistent feed supply during the crisis, improving milk yields by 10–15% within weeks. Studies in Kenya have demonstrated that silage-making reduces feed dependency and improves livestock productivity, supporting the success of this strategy in Mandi.

2. Water Resource Management

KVK Mandi has encouraged the construction of water harvesting structures like ponds and tanks, ensuring water availability for livestock during dry periods. These efforts align with findings from Ethiopia, where water conservation techniques have proven critical for livestock resilience.

3. Disease Management and Veterinary Services

Proactive disease surveillance and health campaigns initiated by KVK Mandi have mitigated the risks of disease outbreaks. Training programs for early detection and treatment have empowered farmers to manage their herds effectively. Similar interventions in the Western Himalayan region have significantly reduced disease-induced livestock losses.

4. Diversification of Livestock Systems

KVK Mandi has promoted diversification by integrating poultry and small ruminants alongside traditional cattle and buffalo herds. Diversified systems reduce dependency on a single livestock type and improve resilience to climate-induced risks, an approach validated in studies of Indian agro-climatic zones.

Conclusion

The adaptive strategies implemented by KVK Mandi highlight the potential of localized, community-driven solutions to mitigate the impacts of climate change on livestock systems. By integrating silage production, water management, disease control, and livestock diversification into broader agricultural practices, Mandi district is building resilience against climatic shocks. Scaling these interventions through targeted policies and community participation will ensure sustainable livestock management and secure livelihoods for the region's agrarian communities.

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UID: 1729

Insect Meal: An Alternative and Sustainable Feed Ingredient for Fisheries and Livestock Enterprises

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By 2050 world population will increase by 9 billion and to meet the projected demand current food production need to be doubled. Expanding the farming area is not becoming a sustainable option as the land is scarce, oceans were already over exploited, water scarcity and climate change problems are becoming major limiting factors for increasing the food production. 'Entomophagy' is mainly influenced by social, cultural and religious status of people. Insects are common as a food source for many in different regions of the world. More than 1900 species have reportedly been used as food. In recent past research on alternative feeds such as Insect meal (Entofeed) has gained importance as price and demand for fish meal / soy has increased substantially with progression of aquaculture production. Insect meals have higher essential amino acids such as methionine compare to other animal and plant meals. In addition insect meal is also good source of fatty acids and its quantity and quality mainly depends on the species, developmental stages and the media on which it is grown. Due to their biochemical composition several issues like palatability, toxicity, anti nutritional factors, presence of inorganic compounds, microbial safety should be considered. Better understanding of inclusion and specific health implications should also be considered while feeding insects as they are grown on waste products such as slaughter house waste and manures. Insects are often used as whole and can also be processed into granular or paste forms. Extracting proteins, fats, chitin, minerals and vitamins is also possible. Use of Entofeeds in aquaculture, poultry and live stock is very encouraging and is a potential entrepreneurial or start-up model in feed industry for new nutritional approaches.

UID: 1736

Productive and Economic Performance of Dairy goats in Jaisalmer District of Rajasthan

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Rainfed farming systems, which depend on limited rainfall and irrigation, face challenges in agricultural productivity, often compounded by inadequate nutrition for livestock. Dairy goats, resilient to harsh climates, are a vital source of income and nutrition for smallholder farmers, but deficiencies in essential minerals like calcium, phosphorus, and zinc, due to poor-quality feed, hinder their growth, health, and milk production. Supplementing goat diets with mineral mixtures offers a practical solution to address these nutritional gaps, improving milk yield, reproductive performance, and overall health. Mineral supplementation is especially crucial in rainfed systems, where forage quality is limited by erratic rainfall. By enhancing livestock productivity, these strategies can contribute to better food security and income for farmers, while promoting sustainable, climate-resilient agricultural practices, as seen in initiatives like the National Innovations in Climate Resilient Agriculture (NICRA).

Methodology

The study was conducted in the Jaisalmer district of Rajasthan, focusing on two villages under the Fatehgarh block: Jogidas Ka Gaon (NICRA-adopted) and Narsingho Ki Dhani

(Non-NICRA), both selected based on farming system typology 2 (rainfed with animal husbandry). A total of 60 dairy farmers, 30 from each village, were randomly selected, all owning at least five goats. In the NICRA village, farmers supplemented their goats' diet with 40-50 grams of mineral mixture per day, while farmers in the Non-NICRA village did not. Data were collected through structured, pre-tested interviews, and analyzed using simple statistical methods (mean). Economic indicators such as feed cost per goat per lactation, average milk yield, net returns, gross returns, and benefit-cost (B:C) ratio were calculated to evaluate the productive and economic performance of dairy goats in both villages.

Mean

Mean is nothing but the average of the given set of values. It denotes the equal distribution of values for a given data set.

Lactation Milk yield

Generally, sirohi breed goat have a 4.5-5-month lactation cycle and hence to calculate average milk per lactation cycle the Avg milk production is multiplied by 5.

Results

This section of the chapter deals with comparison of NICRA and Non-NICRA dairy farmers for their effect of feeding mineral mixtures to their dairy goats. The breeds of goats in NICRA adopted village were sirohi, cross-breeds and Marwari, whereas in Non-Tribal area the breeds were mostly Marwari and cross. Hence data of the dairy animals were recorded based on the best performance among the flocks in context to their economic traits.

Performance of dairy goats in NICRA village

Table 1: Productive performance of dairy goat in NICRA and Non-NICRA Villages

Type of farmer	Average milk yield /day	Total lactation milk yield	Cost of feed/goat/ lactation cycle	Gross return/goat/ lactation cycle	Net return/ goat/ lactation cycle	B:C Ratio
NICRA Farmer	0.917	688.250	11250	135135	123885	1.11
Non - NICRA Farmer	0.751	563.375	3750	105158	101408	1.05

Data depicted in Table 1 indicated that calculated B:C Ratio was found to be greater than Non-NICRA Village dairy farmer which is 1.11 in NICRA Village and 1.05 in Non-NICRA village. The mean value of lactation length and average milk yield/day in dairy goats was 688.250 litres , 0.917 litres, respectively in NICRA Village. These values in Non-NICRA Village were 563.375 litres lactation yield and, 0.751 average milk yield, which was found to be low as compared to NICRA Village goat farmers. Also, Gross return per goat was Rs. 135135 by NICRA farmers compared to Non-NICRA where it is Rs.105158 only. The

NICRA viilage dairy goat farmers had high net return per goat i.e Rs. 123885 compared to Non-NICRA Farmer where it is Rs.101408 per goat.

Conclusion

The study clearly shows the benefits of adopting NICRA practices, particularly the use of mineral mixtures, in dairy goat farming. Goats in NICRA villages had higher milk yields and better overall productivity compared to those in Non-NICRA villages. Despite higher feed costs, NICRA farmers enjoyed better gross and net returns, along with a higher benefit-cost ratio, indicating that these practices are more profitable. The results highlight the importance of adopting such interventions to improve both the productivity and economic sustainability of dairy goat farming, benefiting farmers in rainfed regions.

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UID: 21399

Genetic Improvement of Local Goat Breeds through Cross Breeding with Bundelkhandi Buck in NICRA Villages of Jhansi District

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Bundelkhandi goats are native breed of Bundelkhand region spread across southern Uttar Pradesh including 7 districts and northern Madhya Pradesh including 6 districts. Out of 2.47 million goats in Bundelkhand region, about 70% belong to Bundelkhandi goats. Besides assured income, employment and nutrition, goat-rearing supports crop production by providing cash for the purchase of critical inputs in financial distress and risk aversion in case of crop failure (Singh et al., 2013). The purest form of bundelkhandi goats are found in Datia district of Madhya Pradesh and Jhansi district of Uttar Pradesh (Mishra et al., 2012). This breed is characterized by medium to large sized cylindrical and compact body, jet black coat colour, long legs, narrow face, roman type nose, medium horns, long hair on body, black eyelids and muzzle, long curly and pendulous ears and bushy tail. The animals are hardy and able to walk long distances, therefore, highly suitable for grazing. It is highly adapted for harsh climatic conditions and able to survive in very low and high temperature in different seasons of Jhansi district of Bundelkhand region. It can give twins and sometime triplets. Therefore, an attempt has been made by Krishi Vigyan Kendra, Jhansi to study the breed /genetic improvement of local goat breeds through bundelkhandi buck in NICRA villages.

Methodology

Bundelkhandi buck distribution for genetic improvement of local goat breed was conducted by KVK, Jhansi under NICRA (National Innovation on Climate Resilient Agriculture) Project during 2021-22 on 6 beneficiaries/ farmers comprising 1 bundelkhandi buck per beneficiary/farmers in 3 NICRA villages viz. Gandhinagar, Birgua and Bawaltada. The distribution of 1-year old bundelkhandi buck was done to 6 goatherder for breed improvement. Timely vaccination and monitoring of distributed bundelkhandi buck was carried out by KVK Jhansi.

Results

The recorded data revealed that through natural cross breeding with 6 bundelkhandi buck, local goat breed after mating gave birth to 210 kids per year. During 2022-23 and 2023-24, 423 kids were born after mating through bundelkhandi buck. Therefore, resulting in genetic improvement of 423 local goat breed through natural cross breeding through Bundelkhandi buck.

Conclusion

The genetic improvement of local goat breed through bundelkhandi buck resulted in 22-25% replacement of local goat breed with bundelkhandi breed. This goat breed can easily survive under harsh condition of Jhansi district, less prone to diseases and highly suitable for bundelkhand region.

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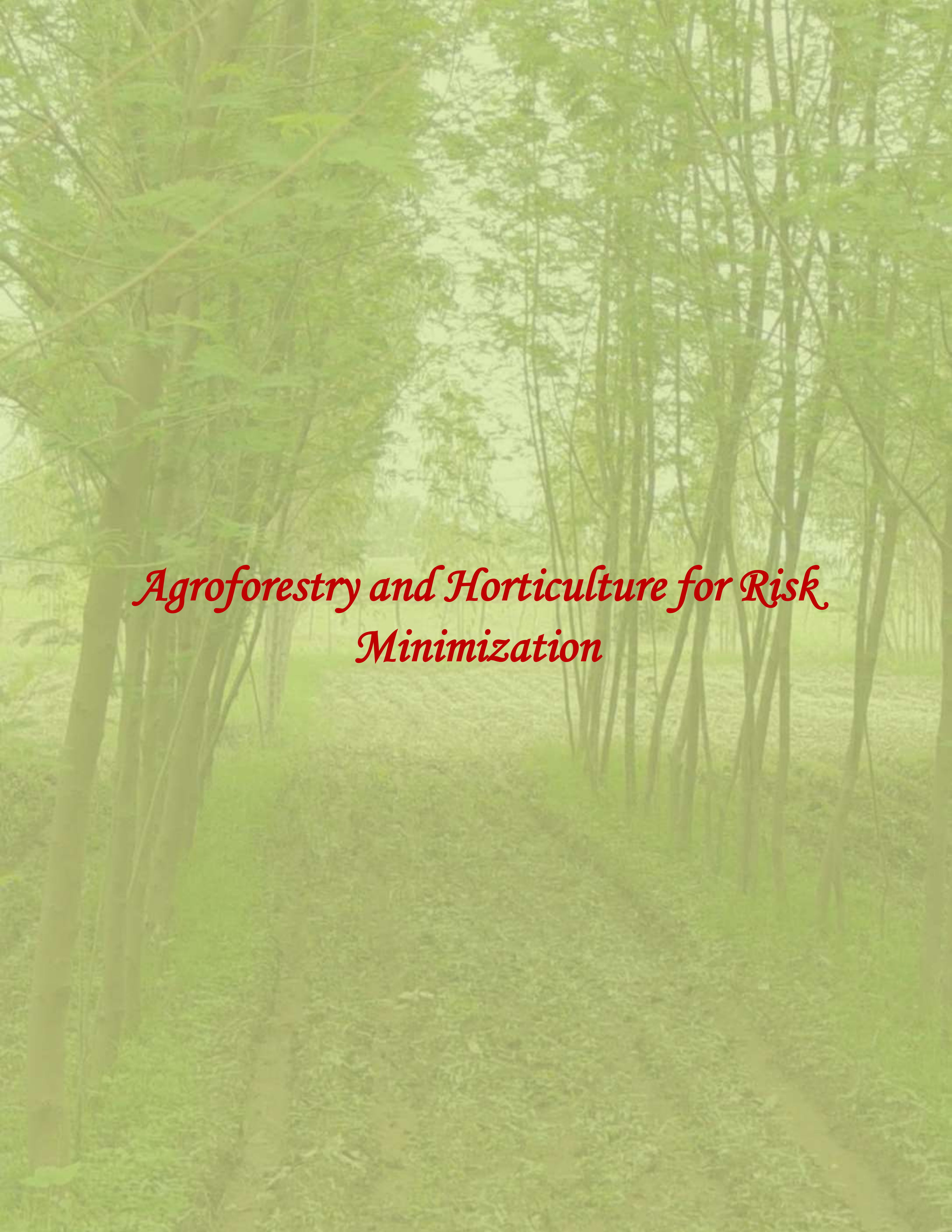

Agroforestry and Horticulture for Risk Minimization

UID: 1021

Influence of Yield and Economics of Linseed (*Linum Usitatissimum* L.) by Organic and Inorganic Sources of Nutrients Under Custard Apple (*Annona Squamosa* L.) Based Agri-Horti System

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The effectiveness of the management of nutrients in linseed cultivation more particularly under agri-horti system can be attributed to its holistic approach, which integrates various nutrient sources and management practices. For instance, the combination of organic amendments such as compost, manure or green leaf manure with chemical fertilizers helps in optimizing nutrient uptake, reducing soil degradation, and fostering sustainable agricultural practices. The application of INM techniques led to a significant increase in linseed yield, with an average enhancement of 18% compared to conventional fertilization methods (Singh *et al*. 2022). Therefore, because of the above facts, the present investigation was carried out to study the "influence of yield and economics of linseed (*Linum usitatissimum* L.) by the sources of nutrients under custard apple (*Annona squamosa* L.) based agri-horti system of *Vindhyan* region of Mirzapur" with the objectives to know the economically suitable combination of the two sources of nutrient for higher yield of linseed under the agri-horti system.

Methodology

The experiment was conducted during the winter (*rabi*) season of 2023-2024 at Agricultural Research Farm, Rajiv Gandhi South Campus, Banaras Hindu University, Barkacchha, Mirzapur (Uttar Pradesh). It is situated at 24.5833° N, 82.9167° E, 130 meters above mean sea level (msl). A randomized block design (RBD) with 3 replications comprising 10 nutrient management options as T_1: 100% Recommended Dose of NPK (RDNPK) (40, 20, 20 kg NPK/ ha), T_2: 50% RDNP through fertilizers + 50% RDN through green leaves of *Albizia lebbek* and no K, T_3: 50% RDNP through fertilizers + 50% RDN through green leaves of *Azadirachta indica* and no K, T_4: 50% RDNP through fertilizers + 50% RDN through green leaves of *Delonix rigia* and no K, T_5: 50% RDNP through fertilizers + 50% RDN through FYM and no K, T_6: 50% RDNP through fertilizers + 50% RDN through neem oil cake and no K; T_7, 50% RDNP through fertilizers + 50% RDN through green leaves of *Pongamia pinnata* and no K; T_8, 50% RDNP through fertilizers + 50% RDN through poultry manure and no K, T_9: 50% RDNP through fertilizers + 50% RDN through sheep and goat manure and no K, T_{10}: (Untreated control) were used. The crop received monthly rainfall of 66.7 mm, average daily minimum and maximum temperature was 12.49°C and 26.94°C respectively. Average daily relative humidity, wind speed (km/hr), sunshine hours and evaporation (mm) were 75.30%, 3.92, 9.63, 3.90 respectively. The experimental soil, characterized as sandy clay loam, had the following properties: a pH of 5.7, 0.36% soil organic carbon (SOC), 135.1 kg/ha of available nitrogen, 18.25 kg/ha of available phosphorus, and 215.31 kg/ha of available potassium.

Results

The maximum magnitude of growth parameters i.e. plant height, no of leaves, no of branches and dry matter accumulation were recorded by the application of 50% RDNP through fertilizers + 50% RDN through poultry manure and no potassium (T_8). A similar, trend was observed in yield attributes. The results showed that 50% RDNP-fertilizers + 50% RDN-poultry manure and no K (T_8) has increased seed, stover and biological yield of linseed by 3.62%, 2.06% & 2.52%, respectively over 100% RDF. This treatment was at par with treatment combination of 50% RDNP-fertilizers + 50% RDN -sheep and goat manure and no K, followed by 50% RDNP-fertilizers + 50% RDN-*Pongamia pinnata* and no K. The integrated nutrient management was indicated as an economically viable practice as evidenced from the maximum net returns and benefit-cost ratio of 50% RDNP through fertilizers + 50% RDN through poultry manure and no K (T_8) i.e. ₹59897 ha^{-1} and 2.09, respectively and increase in net return and the benefit-cost ratio was 1.55% and 0.43%, respectively over 100% RDF.

Conclusion

The conjunctive use of 50% RDNP (20 kg N/ ha) through fertilizers along with 50% RDN (20 kg N/ ha) through poultry manure and no potassium application gave the higher seed yield (743 kg ha^{-1}) and generating the highest net return (₹59,897 ha^{-1}) within the agri-horti system based on custard apple in the *Vindhyan* region of Mirzapur, Uttar Pradesh.

Table 1: Effect of INM practices on growth parameters, yield and economics of linseed under custard apple based agri-horti System

	Treatment	Plant height (cm) at harvest	No. of leaves/ m row length at 90 DAS	Dry matter accumulation (g)/ m row length at harvest	No. of primary branches/ m row length at harvest	Test weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Net return (₹ ha^{-1})	Benefit cost ratio
T1	100% RDF	56.1	1317	90.5	17.5	7.4	717	1697	2414	29.7	58982	2.29
T2	50% RDNP-fertilizers + 50% RDN-Albizia lebbek and no K	49.1	1022	80.5	16.5	7.05	635	1551	2187	29	54881	2.22
T3	50% RDNP-fertilizers + 50% RDN -Azadirachta indica and no K	48.3	1049	84.1	17.4	7.04	637	1552	2189	29	55491	2.25
T4	50% RDNP-fertilizers + 50% RDN -Delonix rigia and no K	47.9	1125	85.3	16.5	7.16	632	1631	2262	27.9	55281	2.24
T5	50% RDNP-fertilizers + 50% RDN-FYM and no K	53.3	1301	89.9	17.3	7.51	690	1671	2360	29.2	46545	1.82
T6	50% RDNP-fertilizers + 50% RDN- Neem oil cake and no K	50	1243	87.6	15.7	7.3	698	1706	2404	29	45986	1.80
T7	50% RDNP-fertilizers + 50% RDN -Pongamia pinnata and no K	50.6	1360	86.1	16.9	7.09	665	1658	2322	28.6	52954	2.09
T8	50% RDNP-fertilizers + 50% RDN-poultry manure and no K	58.8	1461	94.5	18.7	7.67	743	1732	2475	30	59897	2.30
T9	50% RDNP-fertilizers + 50% RDN -sheep & goat manure and no K	56.8	1301	91.6	17.6	7.43	732	1722	2453	29.8	58566	2.25
T10	Untreated control (No NPK)	41.2	1006	66.6	14.2	6.65	451	1218	1669	27	19380	1.52
	SEm±	0.69	8.78	1.14	0.36	0.32	0.32	18.6	18.9	0.57	-	-
	CD (p=0.05)	2.05	26.1	3.4	1.07	0.96	0.96	55.4	56.3	1.7	-	-

*RDF – Recommended dose of fertilizers, RDNP- Recommended dose of nitrogen & phosphorus, RDN- Recommended dose of nitrogen; included cost of production of custard apple.

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Carbon Stock Assessment and Soil Fertility Management for Risk Minimization in Horticulture and Agro-Forestry Ecosystem

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Soil carbon plays an important role in improving plant health, ability to transfer nutrients to plants, increasing water-holding capacity, maintaining biodiversity and reducing salinization of the soil. Soil carbon pool varies with different cropping system and different management practices. Soil organic matter is a vital indicator for soil quality both for agricultural functions (i.e., production and economy) and for environmental functions (e.g., C sequestration and air quality). Soil organic matter is the main determinant of biological activity. Reforestation and afforestation may have the greatest potential for sequestering carbon in soil and constitutes a major carbon sink as above and below ground biomass. Carbon sequestration is the process through which CO_2 from the atmosphere is taken by trees, crop plants and stored as carbon in biomass such as tree trunks, branches, foliage, roots and soils through photosynthesis. Agroforestry association of trees with crops or pastures, can represent a sustainable alternative to deforestation and shifting cultivation. Adopting agroforestry and horticulture cropping system can capture and store a substantial portion of atmospheric carbon in plant biomass and soils. The ability of these systems to sequester carbon is influenced by both environmental and socio-economic factors. In humid tropical regions, agroforestry systems have the potential to sequester over 70 Mg/ha in the top 20 cm of soil. Tree roots, which constitute about one-fifth to one-fourth of the total living biomass, continuously contribute organic matter to the soil as dead roots decay thereby enhancing the soil's carbon content. The tree crops cultivation and agro forestry system play a key role in the terrestrial carbon sequestration by efficiently converting the CO2 into huge biomass besides improving the soil C pools. Hence, the present study aimed to estimate carbon stock in the soil and above and below ground biomass in different types of trees maintained under different years in Northern dry zone of Karnataka.

Methodology

This experiment was conducted at MHREC, UHS main campus, Bagalkot in Northern dry zone of Karnataka. The study was carried out during December 2023. The soil samples were collected at two different depths ie. 0-15 and 15-30 cm of the soil. The collected soil samples were utilized for physicochemical analysis by following standard methods. The physicochemical properties such as bulk density by raczkowski cup method. Soil organic carbon by wet oxidation method. pH by potentiometric method, EC by conductimetric method, Available Nitrogen was estimated by alkali permanganate method. The available Phosphorous was analyzed by following colorimetric method, Available Potassium by neutral ammonium acetate method. Calcium (Ca) and Magnesium (Mg) by versenate titration method. Iron (Fe), Manganese (Mn), Zinc (Zn) and Copper (Cu) by following DTPA extract method.

The quantity of carbon stock was calculated by following the method described by Batjes (1996). It involved multiplying bulk density (Mg m^{-3}) of each layer, and thickness of each horizon (m) with the Soil organic carbon (%) in that layer.

Soil carbon stock (t ha^{-1}) = SOC (%) x Bulk density (Mg m^{-3}) x depth (m).

Results

The nitrogen content is significantly different in different ecosystem. The available nitrogen content ranging from 165.03-201.01 kg/ha in surface soil and 121.06-152.68 kg/ha in sub surface soil. At both depths highest nitrogen content was recorded in soils of teak ecosystem which was evidenced as highest carbon storage in soil. The increase in nitrogen content in the soil is due to the high litter fall and its decomposition. The available phosphorous content was decrease with increasing depth. These results were also in confirmity with the findings of Gardini *et al*. (2015) due to higher amount of organic carbon content in surface soil. Highest phosphorous was found high in pomegranate ecosystem this may be attributed to result of continues application of organic and inorganic phosphatic fertilizer. The results are fully supported by the findings of Dhaliwal *et al*. (2008). The available potassium content was increases with increasing depth due to higher kaolinite clay content in deeper layers. These results are in agreement with those of Ram *et al.* (2015). Exchangeable calcium and magnesium were greater in mango ecosystem than another ecosystem. The deep-rooted nature of mango trees allows them to access calcium and magnesium from deeper soil layers, which are then cycled to the surface soil, increasing their availability. This process is similar to the alkali pump concept by NBSS in 1976 under the Indian Council of Agricultural Research (ICAR). The available sulphur content was decrease with increasing depth. At both depths highest sulphur content was recorded in soils of teak ecosystem due to higher amount of organic matter in this ecosystem. The results are fully supported by the findings of Supriya *et al.,* 2019. Micronutrient content was lower in subsurface soil than in the surface layer might be due to their higher reactivity with soil organic matter in surface soil. Sufficiency level of available copper and zinc in pomegranate and grape ecosystem might be attributed to spraying Bordeaux mixture, regular addition of fertilizers and manures and spraying of insecticides and pesticides on plants. The similar trend was observed with the findings of Bhat *et al.* (2017). The sufficiency of available iron and manganese found high in teak ecosystem this might be due to chelation by organic compounds released during the decomposition of organic matter. These results are in accordance with the findings of Sharan *et al.,* 2020.

Estimation of Soil Organic Carbon Stock

At both depth soil organic carbon stock was found highest in teak ecosystem and decrease with increasing depth of soil. These results suggest that the added organic manures and crop residues accumulated in the surface soil layer itself and there is very little vertical movement due to fewer disturbances by tillage operations. Vinayak, 2022 also reported that decrease in soil organic carbon stock with depth in the arecanut based cropping system. Higher carbon stocks under plantation trees indicate higher organic carbon turnover through the decomposition of leaf litter. The rate of SOC stock change of deciduous broadleaved trees is significantly higher than that of sempervirent broadleaved and conifer trees in the 0– 20 cm soil depth. This is because annual aboveground litter production is greater in deciduous forests than in sempervirent forests.

Soil organic carbon, bulk density and SOC stock in surface and sub-surface soil as influenced by different land use ecosystem

Treatment	OC (g/kg)		Bulk density (g / cc)		SOC stock (t /ha)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1 : Mango	7.10	6.00	1.32	1.39	1.41	1.25
T_2 : Sapota	6.10	4.90	1.38	1.44	1.26	1.06
T_3 : Guava	5.90	5.10	1.41	1.43	1.25	1.09
T_4 : Coconut	6.50	6.20	1.35	1.38	1.32	1.28
T_5 : Grape	5.80	4.60	1.44	1.45	1.25	1.00
T_6 : Pomegranate	5.60	4.70	1.48	1.47	1.24	1.04
T_7 : Biofuel	7.60	6.70	1.29	1.32	1.47	1.33
T_8 : Teak	7.80	6.80	1.28	1.31	1.50	1.34
T_9 : Malbar neem	6.90	6.40	1.33	1.35	1.38	1.30
S. Em ±	0.05	0.04	0.02	0.01	0.02	0.01
CD (P = 0.05)	0.15	0.12	0.04	0.03	0.05	0.04

Conclusion

In the experimental study, finally concluded that the highest soil carbon stock (SOC) was recorded in teak ecosystem soils followed by biofuel and mango ecosystem soil. Along with this agro-forestry land use ecosystem contribute positively to soil health by enhancing soil organic carbon, available nutrients for sustainable agricultural ecosystems. In case of total biomass production coconut cropping system followed mango cropping system have effective compare other cropping system.

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Carbon Fractions and Biomass Dynamics in Agroforestry: Insights from Uttar Pradesh's Central Plain Zone

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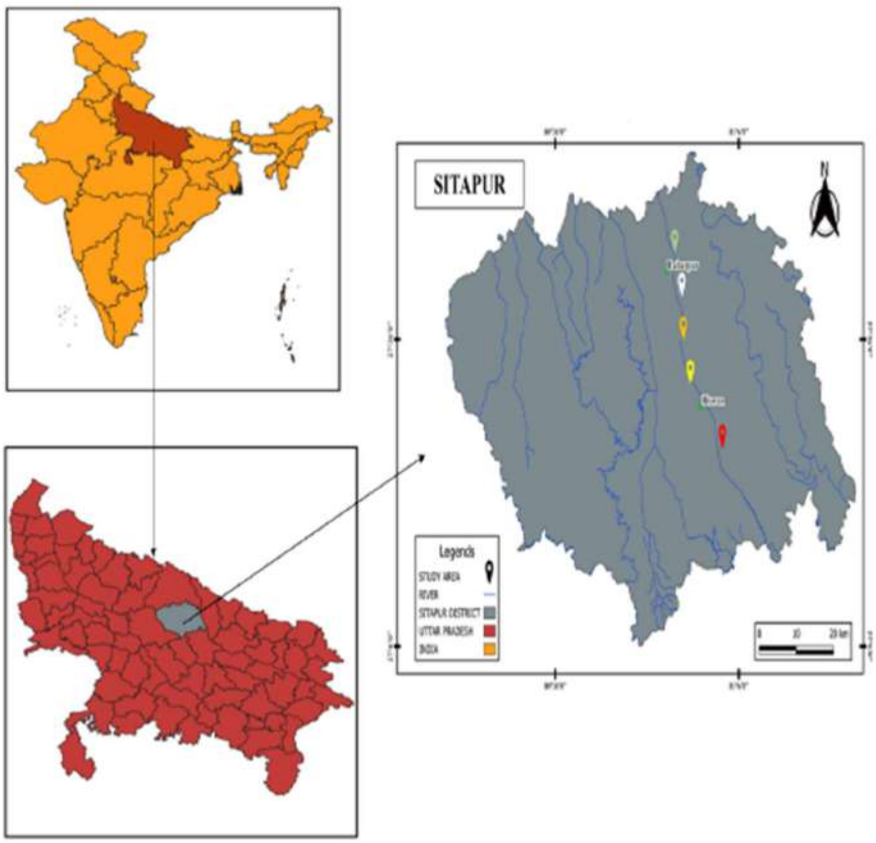
Agroforestry, a sustainable integration of trees with crops or livestock, mitigates climate challenges by sequestering carbon in biomass and soils while enhancing biodiversity and soil quality. Globally, human activities emit 36.6 billion tons of CO_2 annually, pressuring traditional carbon sinks. Agroforestry systems sequester 0.29–15.21 Mg ha^{-1} yr^{-1} of carbon in biomass and 30–300 Mg C ha^{-1} in soils, offering a viable alternative to address soil degradation and declining productivity.

This study, focused on the central plain zone of Uttar Pradesh, evaluates the carbon sequestration potential of agroforestry through biomass generation and soil organic carbon (SOC) fractions. Challenges like seasonal water stress and soil degradation hinder productivity, but agroforestry addresses these by improving soil health and diversifying incomes.

Key objectives include assessing SOC stocks, fertility, and fractions across agroforestry, horticulture, and cropland systems and identifying optimal land-use practices for maximizing carbon storage. The findings aim to guide sustainable land management and climate-resilient agricultural practices in the region.

Methodology

The experiment was conducted in the Biswan and Laharpur regions of the Sitapur district, Uttar Pradesh, India. This location lies in the Gangetic Plain between 27.5325°N latitude and 80.8987°E longitude, with an average elevation of 138 meters (452 feet). The study area encompasses approximately 1,104 hectares and is bounded by Lakhimpur Kheri district to the northwest and Lucknow district to the south. Sitapur district is agro-climatically classified as part of the Lucknow division and falls within the central plain zone (agro-climatic zone 5).



The district features elevations ranging from 150 meters above sea level in the northwest to 100 meters in the southeast. The terrain is part of the mid-plain zone, characterized by alluvial soils with normal to slightly alkaline pH. Organic matter content in the soils is generally medium to low, and drainage systems in the region are poor (Soil Survey Report, 2023). The area is predominantly rainfed, with additional water resources provided by canals, tubewells, and other groundwater sources.

Land Use Systems Studied: Samples were collected from five distinct land use systems viz., Agroforestry systems, Agri-silvipasture systems, Horticulture systems, Agri-horticulture systems. Agri-silvicultural systems. These systems reflect the diverse agricultural practices in the region, which include the cultivation of horticultural, medicinal, aromatic, and traditional agricultural crops (Agricultural Census, 2023).

Sitapur district is part of the Gangetic Plains and mid-plain zones, with soils predominantly classified as domat (loamy soils) and matiyar (clayey soils). Forested areas exist in agreeable portions, supporting the district's agricultural diversity. The district is administratively divided into seven sub-districts, 19 development blocks, and 1,599 gram sabhas encompassing 2,280 villages (District Administration Report, 2023).

Study area

The study was conducted in Laharpur and Biswan tehsils of Sitapur district, situated in the central plain zone of Uttar Pradesh, India. A total of 60 soil samples were collected from five distinct land-use systems (LUSs), with six samples taken at three soil depths (0–15 cm, 15–30 cm, and 30–45 cm) for each system, and four replications per depth. The land-use systems and sampling locations were as follows: Babul + Sugarcane (Agri-Silviculture) from Bariari village, Sakran block (54 km from Sitapur), Poplar + Sugarcane (Agri-Silviculture) from Mador village (54 km from Sitapur), Mango + Barley (Agri-Horticulture) from Salauli village (55 km from Sitapur), Banana (Horticulture) from Belva Bashahiya village (51 km from Sitapur), and Eucalyptus + Sugarcane (Agri-Silviculture) from Belva Bashahiya village (51 km from Sitapur). This design ensures comprehensive representation of different agroecosystems and facilitates a thorough analysis of soil properties across diverse land-use systems.

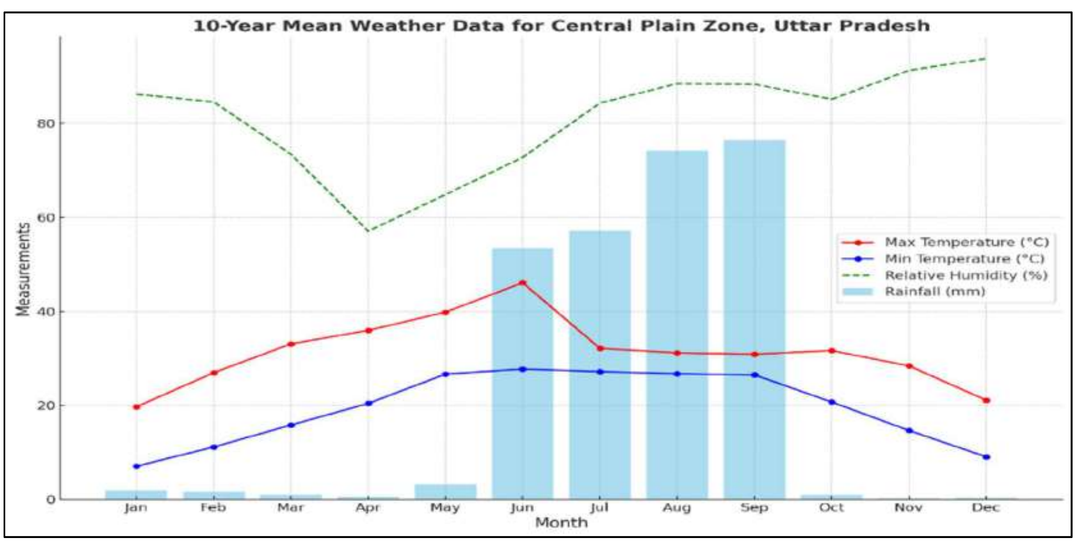


Fig 1. The average weather conditions at the experimental location for 10 years

Note: The source of the weather data is Krishi Vigyan Kendra (KVK), Kanpur

Results and Discussion

The study reveals that different agroecosystems significantly influence soil properties such as pH, electrical conductivity (EC), nutrient availability, and organic carbon content. The babool + sugarcane system consistently demonstrated superior soil quality compared to other land-use systems (LUS), including banana-based systems, which showed the least favourable results across various parameters. These findings align with previous studies highlighting the advantages of agroforestry systems in improving soil fertility and stability (Tan et al., 2020).

Soil pH varied significantly across LUSs, with the babool + sugarcane system maintaining the highest pH across all depths, ranging from 7.65 to 7.85. This can be attributed to higher buffering capacity due to organic matter decomposition and reduced acidification. Conversely, the banana system recorded the lowest pH values, likely due to acid formation from organic matter breakdown and continuous cultivation practices. Soil pH is a critical factor affecting microbial activity, nutrient availability, and the bioavailability of carbon and nitrogen (Padhubhushan et al 2020 Bahera et al., 2020).

The EC values were also higher in the babool + sugarcane system (0.59 dS m^{-1} at 0–15 cm) compared to the banana system (0.19 dS m^{-1} at 0–15 cm). This disparity may be due to the better nutrient retention and lower salt leaching in agroforestry systems. The gradual decline in EC with depth observed in all systems supports earlier findings that salt solubility and soil moisture decrease in alkaline soils with depth (Aizat et al., 2014; Meena et al., 2020).

Nitrogen availability followed a similar trend, with the babool + sugarcane system exhibiting the highest values (223.25 kg ha^{-1} at 0–15 cm) due to higher organic matter inputs and efficient decomposition. The banana system, with the lowest nitrogen levels, was impacted by intensive cultivation and reduced soil organic carbon (SOC). The role of grasses and organic inputs in agroforestry systems enhances nitrogen mineralization, as reported in earlier studies (Shivakumar et al., 2020).

Phosphorus (P) availability was also significantly higher in the babool + sugarcane system, peaking at 51.07 kg ha^{-1} at 15–30 cm depth. Higher organic carbon levels and the formation of stable organophosphate complexes contributed to this trend. In contrast, the banana system showed lower P values due to nutrient depletion and continuous cropping practices (Singh et al., 2018; Lotha et al., 2023).

Potassium (K) levels showed a similar pattern, with the highest values observed in the babool + sugarcane system (196.37 kg ha^{-1} at 0–15 cm). The banana system displayed the lowest K levels due to high nutrient uptake and reduced organic inputs. The nutrient cycling facilitated by agroforestry systems, as well as the addition of organic fertilizers, supports higher potassium availability (Nair, 2012; Bharadwal et al., 2023).

The SOC and total soil organic carbon (TSOC) content were significantly influenced by agroecosystems. The babool + sugarcane system recorded the highest SOC (1.01%) and TSOC (1.35%) at 0–15 cm, while the banana system had the lowest values (SOC: 0.32%, TSOC: 0.42%). The higher SOC in agroforestry systems is attributed to increased organic inputs, extensive root systems, and better soil structure, as observed in previous research (Gross & Glaser, 2021; Kumar et al., 2022). A similar trend was observed for soil organic matter (SOM), where the babool + sugarcane system significantly outperformed the banana system.

The superior soil quality in the babool + sugarcane agroforestry system can be attributed to its ability to enhance nutrient cycling, promote microbial activity, and maintain organic matter levels. In contrast, the intensive cultivation practices in banana-based systems led to soil degradation and nutrient depletion. These findings underscore the potential of agroforestry systems to enhance soil health, mitigate climate change impacts, and improve agricultural sustainability (Borrelli et al., 2021).

Table 1. Soil organic matter (%) under different agroforestry systems

Treatment	Soil organic matter (%) Soil depths			
	0-15 cm	15-30 cm	30-45 cm	Mean
T_1 – Banana	0.47	0.45	0.32	0.47
T_2 - Mango+Barley	1.29	0.89	0.52	1.29
T_3 - Babool+Sugarcane	1.75	1.23	0.65	1.75
T_4 - Poplar+Sugarcane	1.24	0.74	0.46	1.24
T_5 - Eucalyptus+Sugarcane	0.79	0.62	0.40	0.79
S. Em±	0.18	0.07	0.14	0.18
CD (P=0.05)	0.40	0.17	0.33	0.40

Table 2. Post-Harvest Soil Carbon Fractions Status Under Different Land Use Systems

Treatment	Soil Organic Carbon (%)				Total Soil Organic Cabon (%)				Total Soil Organic Carbon stock (Mg ha^{-1})			
	Soil depths (cm)											
	0-15	15-30	30-45	Mean	0-15	15-30	30-45	Mean	0- 15	15-30	30-45	Mean
Banana	0.32	0.26	0.16	0.25	0.42	0.35	0.22	0.42	0.09	0.08	0.05	0.09
Mango+ Barley	0.75	0.51	0.39	0.55	1.00	0.68	0.51	1.00	0.18	0.14	0.11	0.18
Babool+ Sugarcane	1.01	0.71	0.52	0.75	1.35	0.95	0.69	1.35	0.20	0.17	0.13	0.20
Poplar+ Sugarcane	0.72	0.43	0.37	0.51	0.96	0.57	0.49	0.96	0.15	0.11	0.10	0.15
Eucalyptus+ Sugarcane	0.46	0.36	0.23	0.35	0.61	0.48	0.31	0.61	0.12	0.10	0.07	0.12
S. Em±	0.10	0.04	0.05	0.07	0.14	0.06	0.07	0.14	0.020	0.012	0.013	0.020
CD (P=0.05)	0.24	0.10	0.12	0.15	0.32	0.13	0.16	0.32	0.046	0.027	0.030	0.046

Conclusion

The study concludes that agroforestry systems, particularly the babool + sugarcane-based system, offer significant advantages over traditional monoculture systems in terms of soil enrichment and sustainability. These systems not only improve soil physical and chemical properties but also contribute to higher carbon sequestration, aligning with global efforts to combat climate change. Future research should focus on optimizing agroforestry practices to maximize their environmental and economic benefits.

Table 3. Soil Nutrient Status Post-Harvest Across Various Land Use Systems

Treatment	Available Nitrogen (kg ha^{-1})				Available Phosphorus (kg ha^{-1})				Available Potassium (kg ha^{-1})			
	Soil depths (cm)											
	0-15	15-30	30-45	Mean	0-15	15-30	30-45	Mean	0-15	15-30	30-45	Mean
Banana	150.53	116.83	106.43	124.60	35.80	42.95	41.52	40.09	168.59	144.19	118.38	143.72
Mango+ Barley	163.07	126.57	113.63	134.42	38.22	44.35	42.70	41.76	173.38	149.89	122.46	148.58
Babool+ Sugarcane	223.25	173.27	148.16	181.56	49.83	51.07	48.37	49.76	196.37	177.27	142.05	171.89
Poplar+ Sugarcane	213.25	165.51	142.42	173.73	47.90	49.95	47.43	48.43	192.55	172.72	138.80	168.02
Eucalyptus+ Sugarcane	169.34	131.43	117.23	139.34	39.43	45.05	43.29	42.59	175.78	152.75	124.50	151.01
S. Em±	18.49	14.35	10.61	14.49	3.57	2.07	1.74	2.46	7.06	8.41	6.02	7.17
CD (P=0.05)	42.65	33.10	24.47	33.41	8.23	4.77	4.01	5.67	16.29	19.40	13.88	16.52

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Impact of Conservation Agriculture Pearl Millet-Based Cropping Systems on Soil Aggregation and Carbon Dynamics in Rainfed Agroecosystems

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The benefits of Conservation Agriculture (CA) in improving soil fertility and carbon sequestration under irrigated systems are well-documented, but its effects on soil aggregation and carbon dynamics in rainfed systems remain unexplored. This research evaluates the impacts of tillage practices—Zero-Tillage with residue retention (ZT+R), Zero-Tillage without residue retention (ZT-R), and Conventional Tillage (CT)—and cropping systems—Pearl Millet-Chickpea (PM-C), Pearl Millet-Chickpea-Fodder Pearl Millet (PM-C-FPM), and Pearl Millet-Chickpea-Mung bean (PM-C-M)—on soil aggregate distribution and organic carbon (SOC) at depths of 0-5, 5-15, and 15-30 cm. An undisturbed (UD) plot with natural grasses (NG) served as a control. At 0-5 cm, ZT+R had the highest percentage of small macroaggregates (19.3%), comparable to UD but 72% higher than CT, with no significant differences across cropping systems. ZT+R with PM-C-M had the highest SOC in large macroaggregates (1.45%), while UD and NG had the highest SOC in small macroaggregates (1.83%). At 5-15 cm, small macroaggregates were highest under UD (19.6%), while ZT+R with PM-C-FPM recorded the highest SOC in microaggregates (1.57%). CT increased SOC in silt+ clay fractions by 44% compared to ZT-R. At 15-30 cm, ZT+R showed the highest SOC in small macroaggregates and silt+ clay fractions, and PM-C-M had the highest SOC in large macroaggregates. The interaction between tillage and cropping systems significantly influenced SOC distribution, with ZT+R and PM-C-M outperforming other combinations. This study highlights the potential of ZT+R combined with PM-C-M to improve soil aggregation and SOC sequestration in rainfed systems, offering a pathway for sustainable soil management and enhanced soil health.

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Neem Based Agroforestry Management for Diversified Production in Central India

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Neem tree with prolific growth is naturally occurred in dry region of Bndelkhand region. However, systematic plantations do not exist with which intercropping can be taken for diversified production and to improve farmers income. Agroforestry systems based on the

principle of optimum utilization of natural resources are diversified land use options for livelihood and income generation (Yadav et al 2021).

The study on agroforestry systems were conducted at Forestry Research Farm, Bhojla of Rani Lakshmi Bai Central Agricultural University, India. Neem plantation was done in August 2019 at 5 m x 6 m spacing and it is well established with ~98% survival. Growth and yield of annual and perennial components were recorded and subjected to statistical analysis as design.

Results and Discussion

The intercropping of four legume viz., lentil (*Lens culinaris*), grass pea (*Lathyrus sativus*), broad bean (*Vicia faba*) and chick pea (*Cicer arietenum*) was done in *Rabi* season with neem and in sole cropping. It was found that there was no significant reduction in yield in intercropping compared to sole cropping and also one meter near the base of trees to middle of the trees (Fig. 1).It was found that chick pea and lentil was more promising and can be grown successfully as intercrop with comparable yield to sole cropping. Besides, neem-legume intercropping has various positive impacts on soil health (microbial fauna, structural & nutrient status) and ecological services (C sequestration).

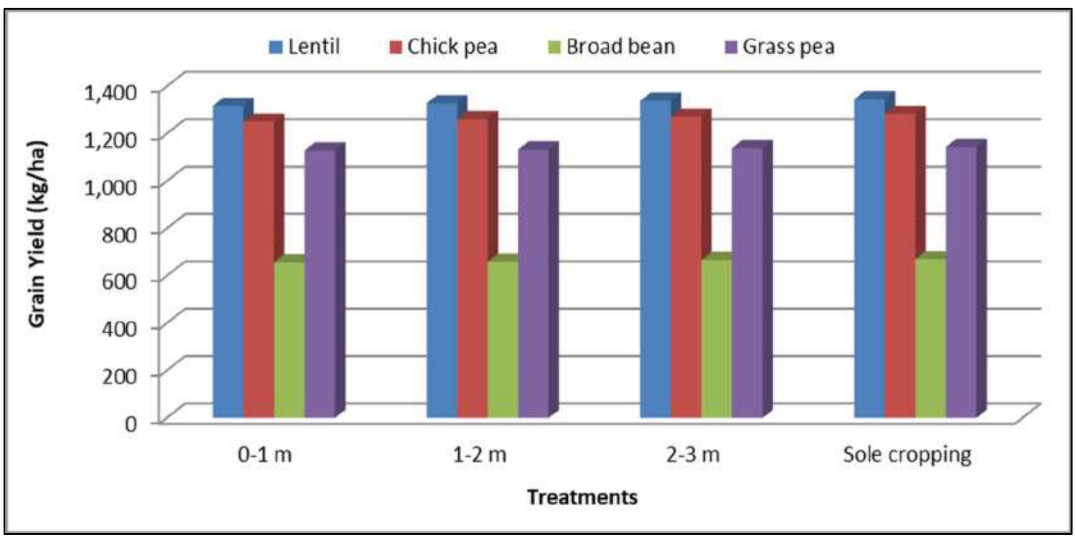

Fig 1. Grain yield (kg/ha) of different crops under neem plantation at different distance from tree base and in sole cropping

Mustard cultivar Giriraj was evaluated under neem plantation with different pruning management techniques i.e., 20% pruning, 20% pruning + Apex cut, 40% pruning, 40% pruning + Apex cut, 60% pruning and 60% pruning + Apex cut and these were compared with treatments of control (without pruning) and sole cropping (mustard). Significantly higher mustard grain yield was reported in sole cropping (1,167 kg/ha) compared to control (without pruning) (1,111 kg/ha), 20% pruning (1109 kg/ha) and 20 % pruning + Apex cut (1,114 kg/ha) only (Fig. 2).

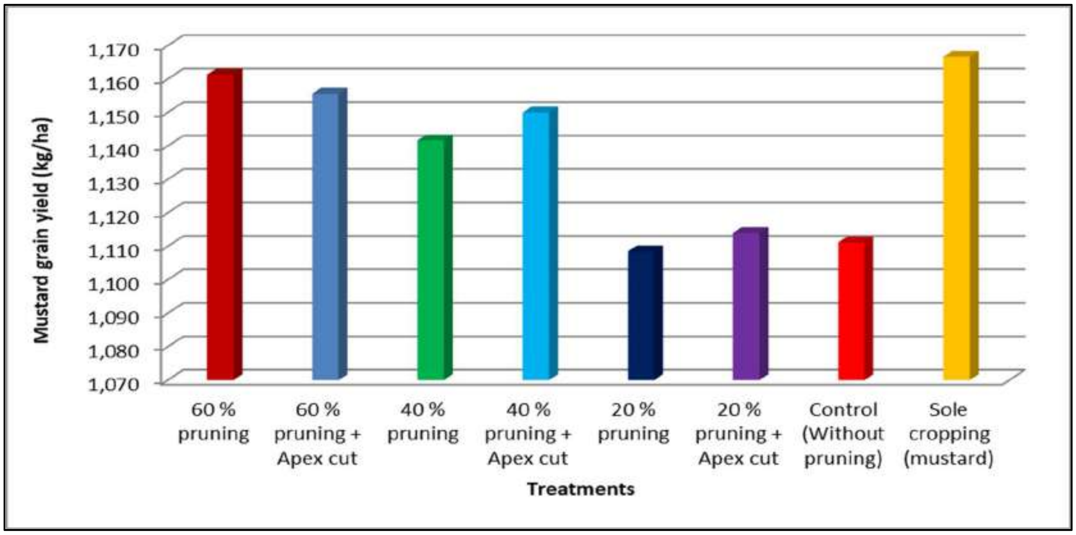

Fig 2. Grain yield (kg/ha) of mustard (cv. Giriraj) under different pruning management technique in neem plantation and in sole cropping

In another experiment nineteen mustard cultivars viz., RVM 2, KANTI, RGN 298, P VIJAY, RGN 73, VARUNA, NRCDR 2, RGN 236, NRCHB 101, RVM 3, RH 725, PM 31, RH 749, RH 406, PM 30, P BALD, VIRANTI, PM 25 and P JAGANNATH were evaluated under neem plantation and as a sole cropping.

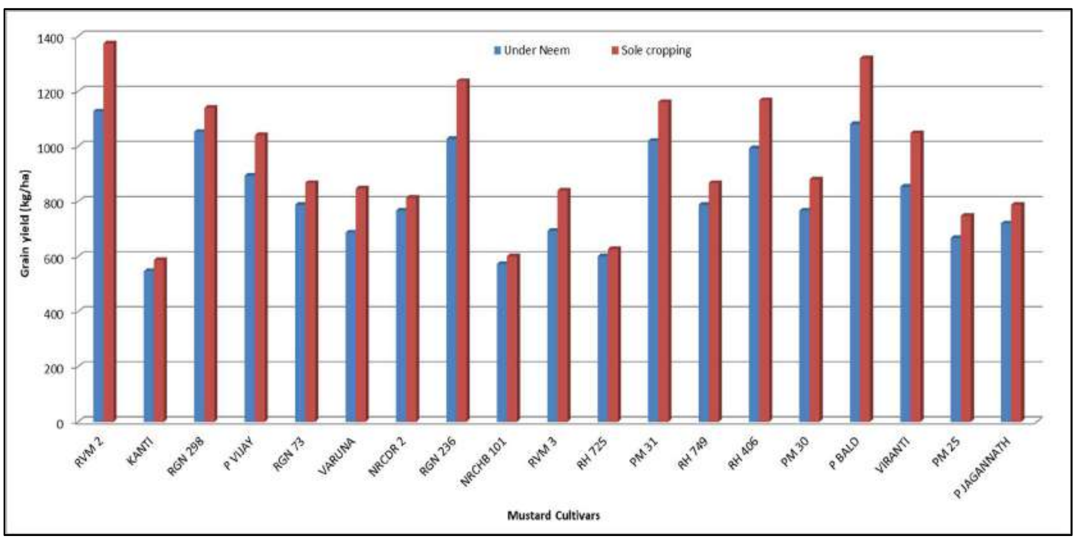

Fig 3. Grain yield (kg/ha) of different mustard cultivars under neem plantation and in sole cropping

Mustard cultivars RVM 2 gave significantly higher grain yield (1,373 & 1,127 kg/ha) compared to other cultivars in sole cropping (except RGN 298, P VIJAY, RGN 236, PM 31, RH 406 and P BALD) and under neem plantation (except RGN 298, RGN 236, PM 31, RH 406 and P BALD), respectively (Fig 3.).

Four turmeric (*Curcuma longa* L.) varieties viz., NDH-3, Pratibha, NDH 98, BSR-1 & Azad-1 under neem planation were evaluated and performance was better under neem plantations compared to sole cropping of turmeric. The growth attributes of neem trees were also recorded during the study period and it was found that mean height, girth at breast height and diameter at breast height were 4.94 m, 29.97 cm and 9.54 cm, respectively at three and one half year old age (Fig. 4). Biomass and biomass C of neem plantation was also quantified and these were recorded as 6.54 and 3.27 Mg/ha, respectively (Fig. 5).

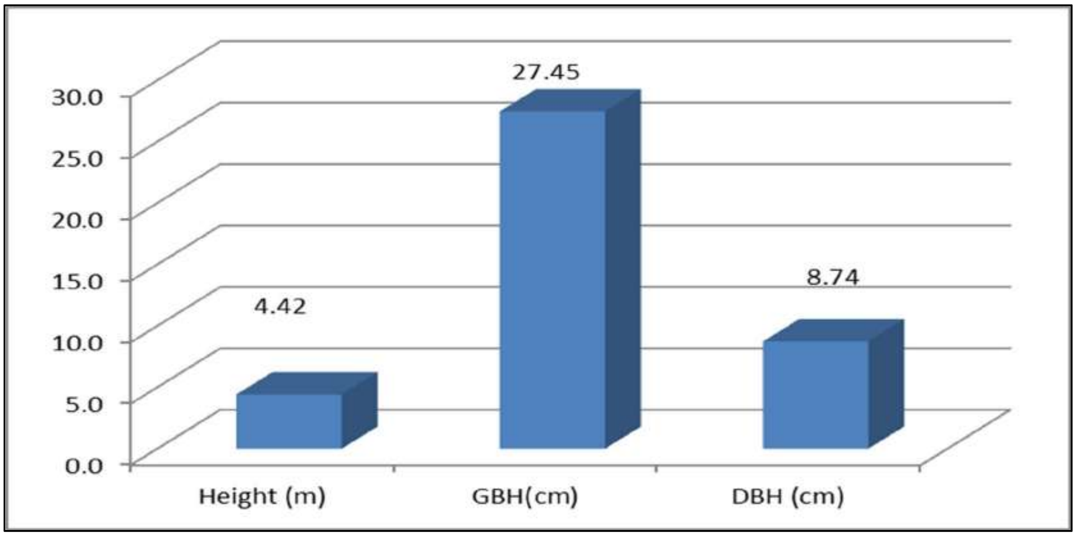

Fig 4. Height and DBH growth of neem plantation

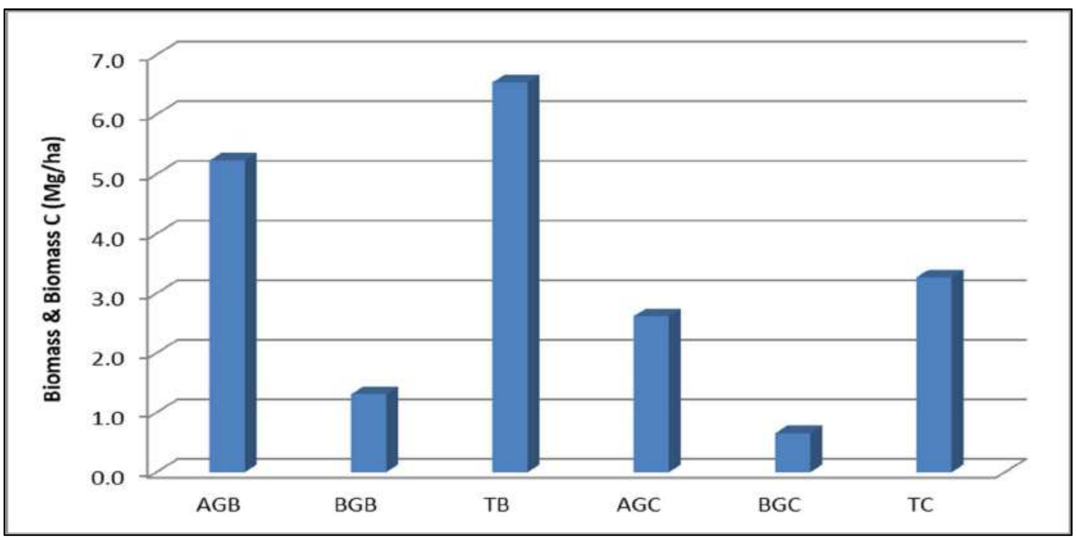

Fig 5. Biomass and biomass carbon of Neem tree (AGB- Above ground biomass, BGB- Below ground biomass, TB- Total biomass, AGC- Aboveground carbon, BGC- Belowground carbon, TC- total carbon)

Therefore, agroforestry is a set of land use alternative for resource poor farmers that can provide increased values with reduced risks in the rural areas (Yadav et al 2021). Therefore, agroforestry should be more popularized through extension programmes in the rural areas.

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UID: 1192

Total Carbon Stock and Co_2 Equivalent Potential of Multipurpose Tree Species in Rainfed Alfisols

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Agroforestry is widely recognized for its resilience role in climate change mitigation and adaptation. Total carbon stock (TCS) and Co_2 equivalent (CO2e) potential of multipurpose tree species in rainfed regions of India are poorly documented. Globally, agroforestry accounts for 1020 m ha in area. In India, it is estimated to be 28.03 m ha (Ahmad *et al.,* 2020). The area under agroforestry will expand in the near future and is estimated to be 53.32 m ha in 2050. The carbon sequestration potential of smallholder agroforestry systems ranged from 1.5 to 3.5 Mg C $ha^{-1}yr^{-1}$. A mere 30% expansion in the area of agroforestry is projected to reduce India's emissions by 2050. Therefore, it has become necessary to reorient tree farming practices in marginal landscapes of rainfed regions, providing services for storing carbon to enhance the resilience of the farming system. Therefore, the present study was carried out to quantify TCS and CO2e potential of Multipurpose Tree Species in rainfed Alfisols. It comprises 09 different Multipurpose Tree Species (MPT's), mainly established to provide multiple uses to marginal farmers.

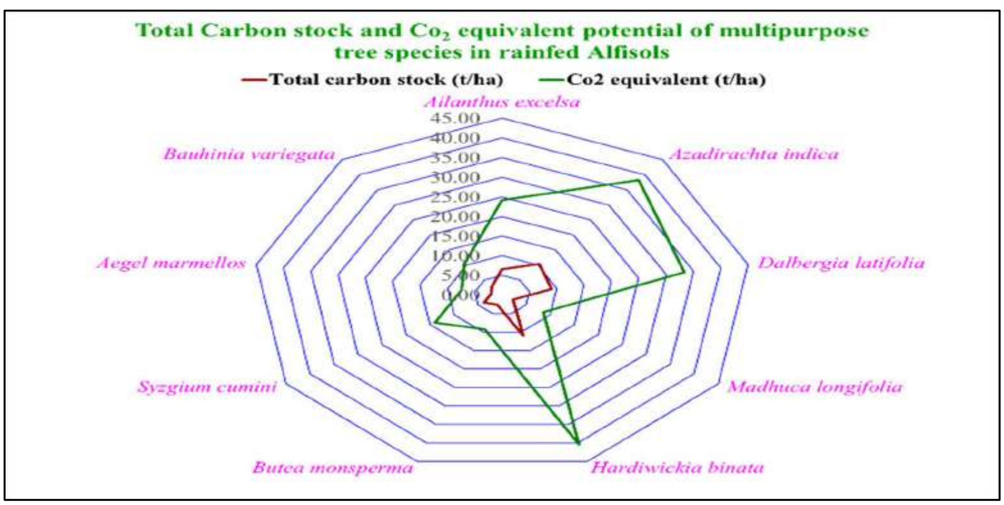
Methodology

The field study was conducted during 2019–2022 at Hayathnagar research farm of ICAR-CRIDA (17˚19′59.0" N Lat. and 78˚35′25.3″E Long.; mean sea level of 542 m), Hyderabad, Telangana, India. The Multipurpose Tree Species (MPT's) that were evaluated in the study were *Ailanthus excelsa* Roxb. (Maharukh), *Azadirachta indica* A. Juss (Neem), *Dalbergia latifolia* Roxb. (Shisham), *Madhuca longifolia* (Roxb.) A.Chev. (Mahua), *Hardiwickia binata*

Roxb. (Anjan), *Butea monosperma* (Lam.) Taub. (Dhak), *Syzygium cumini* L. (Skeels) (Jamun), *Aegel marmelos* (L.) Correa (Indian Bael) and *Bauhinia variegata* L. (Kachnar). All the selected tree species were native to the study area, which thrive well in dry forests with prolonged dry period of six to seven months. One-year old seedlings of the tree species were planted in 45 m^3 pits and refilled with soil mixed with FYM @ 5 kg pit^{-1} with onset of monsoon in August 2017. Two lifesaving irrigations for tree establishment were given in the first year. Each tree species was raised in plot of size 400 m^2 (20 m in length and 20 m in width; density of 400 trees ha^{-1}; 02 years old). Volume of the trees was estimated on the basis of field measurements of height and diameter at breast height (DBH) of the tree (Keerthika and Parthiban, 2022); above ground biomass of trees (Ravindranath and Ostwald, 2008); wood specific gravity of the tree species (Reyes *et al.,* 1992); below ground biomass of trees (IPCC, 2007) and total carbon stock (TCS) and CO_2 equivalent (CO2e) potential of trees (Keerthika and Parthiban, 2022) by following standard procedures.

Results and Discussion

The results of this study revealed significant variations in total carbon stock and CO2e potential in different Multipurpose Tree Species. Among these 09 different tree species, *Hardiwickia binata* exhibited higher TCS (t/ha) and CO2e (t/ha) potential of 11.02 and 40.43, respectively after seven years of planting in rainfed Alfisols followed by *Azadirachta indica* (TCS: 10.44 and CO2e: 38.30) and *Dalbergia latifolia* (TCS: 9.08 and CO2e: 33.32). The TCS and CO2e potential is largely influenced by the tree wood specific gravity (Keerthika and Parthiban, 2022), genetic makeup of species (Bhatt *et al.,* 2005), age and growth habit of the species and site quality and management practices (Newaj *et al.,* 2016). The TCS and CO2e potential of *Hardiwickia binata* was higher compared to other MPT's and its integration with crops in farm lands could provide improved productivity of all components *i.e.,* fodder tree, legume fodder and staple crop with additional benefits from small ruminants in rainfed regions of India.



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UID: 1211

Raising of Chilli Nursery Under Shade Nets (Pro Tray) for Better Seedling Production

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Good quality seedlings are very much essential for getting higher yield and quality of chilli crop. Cost of cultivation is constantly increasing year by year due to heavy incidence of wilt and viral diseases at initial stage of the crop. Therefore, regular supply of quality seedlings raised in pro trays is very important for plant stand and avoid early pest and disease attack. In open field nurseries with attack of sucking pests, damping off etc poor quality of seedlings were produced. Presently, the commercial chilli growers are quite aware about the importance of hybrid varieties as they are high yielding, uniform in maturity and can tolerate the effect of abiotic and biotic stresses and have better quality produce as compared to standard varieties / cultivars. Chilli is cultivated in an area of 51,391 acres in Nandyal district. KVK Yagantipalle had been raising quality nursery under shade net/polyhouse for timely distribution to the farmers.

With shade net nursery, wastage of seeds which are costly can be minimized. Nursery raising will ensure time for the main field preparation. Soil borne diseases could be prevented due to the use of sterilized media in the portray preparation and treating the seeds with recommended fungicides. Uniform establishment of seedlings and damage to the roots can be prevented along with irrigation and fertilizer use efficiency.

Methodology

The present study was conducted to investigate the effect of plug tray nursery under shade net house and open field nursery of chilli seedlings during 2020-2023 at Krishi Vigyan Kendra, Yagantipalle. in five nurseries.

The chilli seedlings (Hybrid) are ready by 40-45 days for transplanting to the main field. Thereafter, growth and development parameters were measured using twenty-five (25) randomly tagged seedlings from each nursery throughout the study. After 5 days of sowing, the number of normal seedlings germinated were counted and expressed in percentage. At the 45 DAS (days after sowing), the length of seedling was measured and the average length was calculated and expressed in centimeter. The seedling girth was measured using vernier calipers and mean girth was expressed in centimeter. The length of the root was measured and expressed in centimeter. The total number of leaves in the plants were counted and recorded. After 30 DAS the number of healthy seedlings were counted and expressed in percentage. Data on various growth parameters and insect pest was recorded.

Results

With reference to the table(1) higher germination for chilli was found to be 92.33% with pro tray nursery, while lowest germination was recorded in open field nursery (71.58 %) may be due to low water retention capacity and low nutrient availability (Meena et al., 2017). The seedling height was also influenced by shade net house in chilli. Shade net house (Pro tray nursery) had recorded the maximum height (25.80cm) then the open field nursery (16.41cm) in chilli at 45 days old seedlings. Growing media greatly influences seed germination, seedling emergence and growth of seedlings in a nursery because these media serve reservoir of moisture and plant nutrients (Mahala and Sharma 2020). The higher seedling girth and root length (0.35 cm & 7.56cm) was recorded with pro tray nursery in chilli, while the lowest girth and root growth were recorded in open field (0.29cm & 4.75cm) nursery.

The number of leaves per seedling was also influenced by shade net in chilli. The number of leaves per seedling (8.62) was higher in 45 days old seedlings grown in the shade net (pro tray) nursery and the lowest number of leaves (5.63) was found in open field nursery.

The percent of healthy seedling was one of the prime growth parameters that was significantly variable among both the nurseries. Healthy seedling was highest in shade net (94.61) nursery whereas the lowest (71.58) was recorded in open field nursery. This might be due to the using of cocopeat as growing media, 50% shade net, pro trays and very least incidence of pest and diseases in shade net house.

Chilli seedlings grown on different nurseries were critically analyzed for the incidence of any insect pest and disease (Fig.1). There was least incidence of white fly (2.14) ,thrips (3.45) and damping off (2.44) under shade net nursery. More incidences of white fly (13.26), thrips (21.42) and damping off (18.61) recorded in open field chilli nursery. It can be concluded that significant difference in incidence of insect pest occurs on these seedlings that may be attributed to different growth factors. These findings are in agreement with Islam et al. (2017), who reported that infestation behavior of the white flies could be affected by the quantity of volatile organic compounds that plant released.

Table 1. Effect of different nurseries on biometric parameters of chilli seedlings undershade net house and open field nursery (Pooled data)

Name of treatments	Germination (%)	Plant height (cm)	Seedling girth (cm)	Root length (cm)	Number of leaves/seedlings	Percentage of healthy seedling
Shade net nursery	92.33	25.80	0.35	7.56	8.62	94.61
Open filed nursery	66.20	16.41	0.29	4.75	5.63	71.58

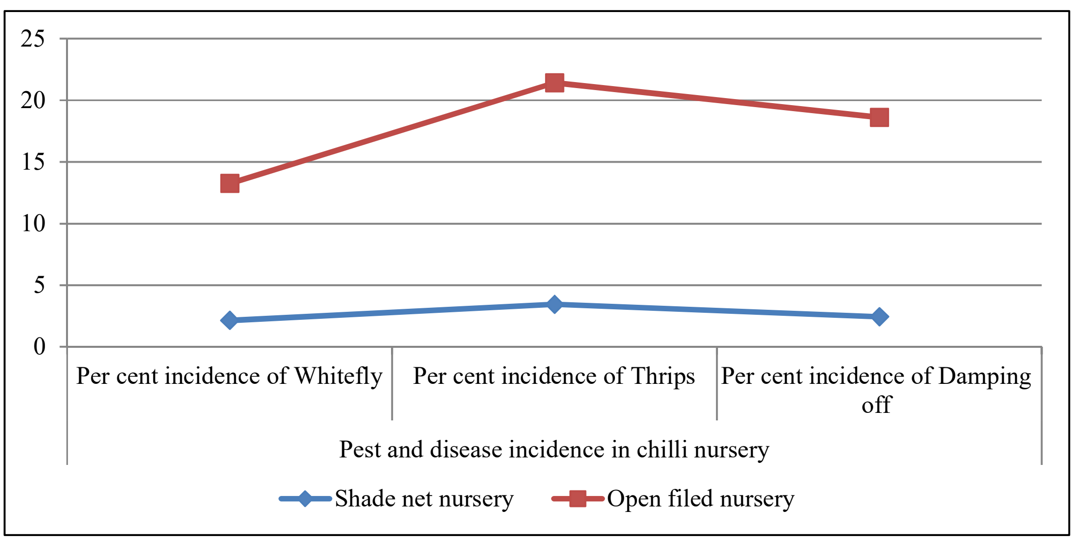

Fig 1. Effect of different nurseries on pest and disease incidence of chilli seedlings under shade net house and open field nursery (Pooled data)

Conclusion

It can be concluded that using shade nets (pro tray) for chilli nurseries can significantly improve the growth and quality of chilli plants by providing individual space for each seedling, leading to healthier root development, better uniformity in plant size, less mortality and less incidence of pest and diseases.

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UID: 1225

Influence of Pruning Intensity and Integrated Nutrient Management on Flowering Dynamics, Yield, and Quality of Custard Apple

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Custard apple, belonging to the family Annonaceae, is a hardy, drought-tolerant fruit crop valued for its high nutritional and economic significance. In India, Maharashtra is a major producer, with custard apple being grown across regions like Pune, Aurangabad, and Akola. Despite its adaptability, custard apple cultivation is often characterized by low yields and inconsistent fruit quality due to limited adoption of scientific cultivation practices.

Pruning is a vital cultural operation that regulates vegetative growth, optimizes light penetration, and promotes flowering and fruiting. Studies have shown that pruning can significantly improve the yield and quality of fruits in crops such as guava, ber, and citrus (Choudhary and Dhakare, 2018; Pilania et al., 2010).

Nutrient management is equally important in ensuring high productivity. Integrated Nutrient Management (INM) emphasizes the combined use of organic manures, biofertilizers, and inorganic nutrients to improve soil fertility and crop performance sustainably. Research in guava and other fruit crops demonstrates the benefits of INM in enhancing growth and yield attributes (Sharma et al., 2013; Binepal et al., 2013). However, little information exists on the combined effect of pruning and INM in custard apple. This study aims to address this knowledge gap by evaluating the influence of pruning and INM on flowering, yield, and quality in custard apple cv. Balanagar under semi-arid conditions.

Methodology

The experiment was conducted at the Shivar Block, Central Research Station, Akola, Maharashtra, during the 2023. The site is characterized by medium black soil with good drainage and an average annual rainfall of 802.4 mm, making it suitable for custard apple cultivation. The experiment utilized a Factorial Randomized Block Design (FRBD) with three levels of pruning and three INM regimes, resulting in nine treatment combinations replicated thrice.

Pruning was applied at three intensities: 20 cm from the tip (P_1), 15 cm from the tip (P_2), and no pruning (P_3). The INM treatments included I_1 (75% RDF with biofertilizers and neem cake), I_2 (staggered nitrogen application with full phosphorus and potassium and biofertilizers), and I_3 (control with no additional nutrients). The nutrient components in I_2 were applied in three equal doses of nitrogen, spaced one month apart, while phosphorus, potassium, and biofertilizers were applied at the onset of the monsoon.

Various parameters were recorded to evaluate the effects of treatments. Flowering and yield attributes included days to flowering, fruit set percentage, number of fruits per plant, and yield per plant. Fruit quality attributes such as average fruit weight, pulp percentage, total soluble solids (TSS), acidity, and TSS: Acidity ratio were also measured.

Results and Discussion

Effect of Pruning on Flowering and Yield Attributes

Pruning significantly influenced flowering and yield attributes. The P_1 treatment (20 cm pruning) recorded the earliest flowering (53 days after pruning), which was significantly earlier compared to P_3 (65 days) (Table 1). This can be attributed to the removal of apical dominance, which stimulated lateral bud break and flowering (Singh, 2005).

Similarly, P_1 recorded the highest fruit set percentage (62.56 %) and yield (16.40 kg/plant). Pruning enhances light penetration and aeration, improving photosynthesis and resource allocation, as reported by Choudhary and Dhakare (2018).

Table 1. Effect of Pruning and INM on Flowering and Yield Attributes

Treatment Combination	Days to Flowering	Fruit Set (%)	Number of Fruits/Plant	Yield (kg/Plant)
$P_1 \times I_1$	54	61.50	76.00	15.80
$P_1 \times I_2$	53	63.40	80.00	17.35
$P_1 \times I_3$	58	58.60	72.00	14.50
$P_2 \times I_1$	56	59.70	70.00	14.70
$P_2 \times I_2$	55	61.80	75.00	16.20
$P_2 \times I_3$	59	57.30	68.00	13.80
$P_3 \times I_1$	61	56.40	65.00	13.50
$P_3 \times I_2$	60	58.50	68.00	14.20
$P_3 \times I_3$	65	54.80	60.00	12.80
SE(m) $\pm$	1.18	1.64	2.63	0.59
CD at 5%	3.52	4.92	-	1.77

Effect of INM on Yield and Fruit Quality

The I_2 treatment (staggered nutrient application with biofertilizers) outperformed other INM regimes, recording the highest fruit set (63.40%) and yield (17.35 kg/plant) (Table 1). Biofertilizers such as AM, Azotobacter, and PSB enhance nutrient availability and uptake, leading to better plant growth and yield (Sharma *et al.,* 2013).

Conclusion

The combination of 20 cm pruning and staggered nutrient application ($P_1 \times I_2$) is highly effective in enhancing flowering, yield, and fruit quality of custard apple cv. Balanagar. Adoption of these practices can significantly improve productivity and profitability for farmers in semi-arid regions.

Table 2. Effect of Pruning and INM on Fruit Quality Parameters

Treatment Combination	Fruit Weight (g)	Pulp Percentage (%)	TSS (°Brix)	Acidity (%)	TSS:Acidity Ratio
$P_1 \times I_1$	224.50	74.2	25.5	0.18	17.8
$P_1 \times I_2$	234.34	76.5	26.8	0.15	18.5
$P_1 \times I_3$	210.80	72.3	24.1	0.20	16.9
$P_2 \times I_1$	220.40	73.4	25.2	0.18	17.5
$P_2 \times I_2$	228.10	74.8	26.0	0.16	18.2
$P_2 \times I_3$	208.50	71.8	23.8	0.21	16.7
$P_3 \times I_1$	215.60	72.9	24.6	0.19	17.1
$P_3 \times I_2$	220.20	73.8	25.4	0.18	17.7
$P_3 \times I_3$	200.40	70.5	23.2	0.22	16.3
SE(m) $\pm$	7.99	1.29	1.06	0.01	1.58
CD at 5%	23.96	3.85	3.16	-	4.73

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UID: 1345

Comparative Profile of Entrepreneurial Behavior of Agri-Horticulture Growers in Rewa District of Madhya Pradesh

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Agriculture-horticulture is a method that integrates horticulture with short-term arable crops to generate seasonal income. Agri-horticultural crops yield greater income for farmers than other monoculture crops. The district of Rewa, which possesses the largest area and production of horticultural crops in Madhya Pradesh, was intentionally chosen for the current study conducted in 2024.

Methodology

For the purpose of generating money during specific times of the year, agri-horticulture is a method that combines horticulture with short-term arable crops. Growing agri-horticultural crops results in a higher income for farmers than growing other types of monoculture crops. The district of Rewa, which is located in Madhya Pradesh and has the highest area and production of horticulture crops, was purposefully selected for the study that was carried out in the year 2024.

Results

According to the findings of the investigation, numerous factors, including educational attainment, annual average income, socio-economic status, cropping intensity, and operational land holding, were found to have a strong correlation with the degree to which individuals engaged in entrepreneurial behavior.

UID: 1387

Assessment of System Approach in Moderating the Impacts of Climate Change on Blossom Behaviour and Yield in Mango

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Climate change and its variability are posing the major challenge in mango flowering and fruiting in the recent times. In mango, early or late flowering, setting per cent and in turn fruit retention and final yield is being greatly affected by the changing times primarily due to rainfall variability and reduction in number of rainy days (Venkateswarlu and Shanker, 2012) as well the temperature variations. The issue of climate change and climate variability has thrown up greater uncertainties and risks, further imposing constraints on mango production systems. Interventions are required which are highly location-specific and knowledge-intensive for improving production in the challenged environment (Malhotra and Srivastava 2014).

The system approach is found to mitigate the climate change impacts through reducing the livelihood dependency on single crop / enterprise with diversified output and enhanced income. A close integration at farm level through production of fodder and recyclable manurial resources, extending the growing season, enhanced diversity at species, varieties and ecosystems levels were found as the advantages of the system approach. The system builds the reserves of water, fuel, biomass and was found resilient through intra system dependency by integration of perennial, semi perennial, animal, soil aquatic organisms, etc. The integration also reduces the need for external inputs through multi step resource recycling, biologicals and renewable resources and results in energy efficient systems. Inclusion of multi-functionalelements such as live fences, vermi compost and farm ponds adds to the stability. Generation of on-farm employment and build up soil fertility over the years adds to the sustainability ofthe system. The benefits of system approach is significant with the flow of intermittent cash in hand for reinvestment in input usage besides moderating micro-climate changes in the crop vicinity (Manjunath, 2021).

To assess the impact of system approach on microclimate and in turn on blossom behaviour of mango, the field experiment was initiated with the following objecives:

1. To assess the impact of weather parameters on the onset of flowering, flowering intensity, days for 50% flowering, fruit set, fruit drop, pest and diseases and mango yield

2. To assess the microclimatic resilience and the sustenance of mango based IFS under rainfed conditions with changing climatic scenario

Methdology

The experiment was conducted in RBD design involving four treatments with six

replications in a 30 years old mango (variety Totapuri) spaced at 10 m x 10m.

Treatment details:

T_1: Mango + Brinjal + Vermicompost + Farm pond

T_2: Mango + Sweet corn + Vermicompost + Farm pond

T_3: Mango + Pigeonpea + Vermicompost + Farm pond

T_4 : Mango + Vermicompost + Farm pond (Control-No intercropping)

Mango phenological data was collected in three varieties *i.e.* Totapuri, Raspuri and Arka Udaya. Data was collected on soil moisture availability in the root zone of crops after cessation of rainfall 15, 30 and 45 days after last rain and the need of protective irrigation is determined. Relative humidity and temperature measured using a digital thermo-hygrometer, in the mango basin and interspaces at ground level and at canopy level.

Results

Micro climate variations

The temperature and relative humidity were monitored at regular intervals throughout the year in inter space and mango basin both at ground level and canopy level of the intercrop.Mango + brinjal treatment maintained a comparatively lower canopy-level temperature (30.06°C), indicating a more moderated microclimate compared to other treatments.The treatment also showed the highest canopy-level relative humidity (53.67%), suggesting this intercrop combination can help retain more moisture in the surrounding microclimate. Intercropping on microclimate: treatments involving intercrops (mango + brinjal, mango + sweet corn, mango + pigeon pea) generally resulted in lower temperatures and higher humidity compared to the control indicating that intercropping systems can enhance the resilience of mango-based farming systems by modifying the microclimate.

Micro climate variations across the treatments in mango based systems

Treatments	Temperature (°C)				Relative humidity (%)			
	Ground level		Canopy level		Ground level		Canopy level	
	Mango basin	Inter space	Mango basin	Inter space	Mango basin	Inter space	Mango basin	Inter space
Mango+ brinjal	31.56	30.07	28.90	30.06	53.50	53.27	53.27	53.67
Mango+ sweet corn	32.02	30.58	29.38	30.55	52.88	52.77	52.67	53.00
Mango+ pigeon pea	31.52	31.11	29.91	31.24	52.43	52.69	52.38	52.39
Mango alone (Control)	32.14	31.61	30.59	31.78	52.77	52.65	52.60	53.09
S.Em ±	0.92	0.05	0.15	0.01	0.14	0.16	0.21	0.17
C.D (p=0.05)	NS	0.16	0.45	0.04	0.43	0.51	0.65	0.53

Blossom behaviour in mango:

Mango + brinjal system (grown under protective irrigation from farm pond) and mango + pigeonpea showed 10.5 % and 7.9 % higher flowering over sole crop of mango, respectively. The highest fruit number being in mango + pigeonpea system with over 20% higher fruits. Being a legume crop it has favoured in enhancing the main crop yield. The fruit yield in mango also improved with the pigeonpea intercropping with an increase of over 21% (144.8 kg/plant over 122.7 kg/plant in the control). The results clearly indicate the synergistic effect of leguminous intercrop in mango-based systems.

Yield and economics in mango-based systems

Treatments	Flowering %	Fruit number/plant	Fruit yield (kg/plant)
Mango + Brinjal	84.0	530.1	132.9
Mango + Sweetcorn	77.0	580.0	141.7
Mango + Pigeonpea	82.0	609.2	148.9
Mango (sole crop)	76.0	467.7	122.7
S.E m ±	4.4	48.0	10.2
C.D (p=0.05)	NS	NS	NS

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Impact of Multipurpose Tree Species on Photosynthetic Efficiency of Finger Millet (Eleusine coracana) in an Agroforestry System

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Agroforestry systems that combine annual crops with multipurpose tree species (MPTs) offer a range of ecological, environmental, and economic benefits. These systems enhance biodiversity, improve soil quality, and provide resilience to climate variability. MPTs are particularly valuable as they yield food, fuel, and fodder, contributing to economic sustainability (Cialdella et al 2023). However, the shading effect of trees can influence crop performance, particularly photosynthetic efficiency. This study focuses on the impact of various MPTs on the photosynthetic performance of finger millet (*Eleusine coracana*), an important dryland cereal crop, emphasizing the dynamics of Photosystem II (PSII).

Methodology

The experiment was conducted at ICAR-CRIDA, Hyderabad, where finger millet was cultivated as a pure crop and under the canopy of MPTs such as Swietenia macrophylla, *Hardwickia binata*, and *Tamarindus indica*. Chlorophyll fluorescence induction kinetics and a full set of chlorophyll fluorescence parameters were measured using a Handy PEA fluorometer (Hansatech Instruments Ltd, Narborough Road, Pentney, King's Lynn, Norfolk PE32 1JL, England) according to (Strasser and Govindjee 1992; Strasser et al 2000)The leaves were dark-adapted using leaf clips for 15 minutes, which was determined to be the optimal dark adaptation time. This was established by recording Fv/Fm values at increasing dark adaptation times (5, 10, 15, 20, and 25 minutes), and it was found that no increase in Fv/Fm values occurred after 15 minutes. Following dark adaptation, strong pulses of light (600 W m^{-2}) were applied to the leaf using an array of six light-emitting diodes focusing on the sample surface. The measurements were taken with high time resolution (10 µs). The primary fluorescence parameters extracted from the measurements included the minimum fluorescence yield (Fo) when all PSII reaction centers were open, the maximum fluorescence yield (Fm) when all PSII reaction centers were closed, and the variable fluorescence (Fv), which is calculated as Fv = Fm - Fo. From these primary fluorescence parameters, several derived parameters were calculated, including the maximum quantum yield of PSII photochemistry (Fv/Fm), the maximum quantum yield of primary photochemistry (ΦP0), and the quantum yield for electron transport (ΦEo). Additionally, flux ratios were calculated to provide insights into the efficiency and dynamics of energy conversion processes in PSII. Environmental variables like photosynthetic photon flux density (PPFD) were monitored across treatments to understand tree shading effects.

Results

The OJIP fluorescence transients (Fig. 1) showed that finger millet grown as a pure crop had higher chlorophyll fluorescence peaks compared to intercropped systems. Treatments under tree species like *Swietenia macrophylla* displayed suppressed fluorescence peaks, indicating photoinhibition and reduced electron transport efficiency. Conversely, treatments with *Hardwickia b*inata exhibited fluorescence patterns similar to the pure crop, suggesting better light utilization and reduced photoinhibitory stress. The maximum quantum yield of primary photochemistry (φP0) and the probability of absorbed photons driving electron transport (φEO) revealed significant differences across treatments (Fig. 2). The pure crop showed the highest φP0 and φEO values, indicating efficient PSII functioning. Among the intercropped systems, *Hardwickia binata* maintained relatively higher φP0 and φEO values, suggesting compatibility with finger millet. On the other hand, tree species such as *Swietenia macrophylla* and *Tamarindus indica* significantly reduced these parameters, reflecting photoinhibition and stress due to shading. Energy dissipation through NPQ was elevated in treatments under tree shade, particularly with *Swietenia macrophylla*, highlighting the crop's protective response to excess light. In contrast, *Hardwickia binata* allowed optimal light conditions, minimizing stress-induced energy dissipation.

Conclusion

The study demonstrates that the choice of MPTs in agroforestry systems significantly affects finger millet's photosynthetic efficiency. Species like *Hardwickia b*inata are more compatible, maintaining high PSII efficiency and reducing shading stress. Conversely, species such as *Swietenia macrophylla* and *Tamarindus indica* may hinder crop performance due to excessive shading. These findings underscore the importance of tree selection to optimize agroforestry systems for sustainable productivity and stress resilience.

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Evaluation of Different Alternate Land Use Systems for Rainfed Sub-Tropics of North-West Himalayas

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The rainfed areas are fraught with low farm productivity because of poor integration of natural resources. Just growing field crops not only results into meager net returns but also make the rainfed farmers more vulnerable to adverse weather conditions. Besides this, the farmers have the requirement for green fodder to feed cattle, timber not only to cater household needs but to supplement income by selling it out in the market and fruits to improve household nutritional security and income supplementation through sale of produce in the market. Alternate land use system involving horticulture, agroforestry, perennial grasses along with field crops holds the promise to fulfill all the aforementioned needs of the farm household besides providing income supplementation and per unit area productivity of the farm under rainfed situation. Moreover, due to increase in population the land holdings are dwindling day by day. So, a need is felt to develop a sustainable alternate land use system model for income supplementation of marginal and small farmers while meeting out their food, timber and fodder requirement.

Methodology

A field experiment was carried out at research farm of Advance Centre for Rainfed Agriculture, Rakh Dhiansar, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, UT of J & K (32° 39” N 74° 53” E, 332 m amsl) during rabi 2018-19 to 2022-23 to evaluate and develop a sustainable alternate land use system model for income supplementation of small and marginal farmers of rainfed Agro-ecosystem of Jammu region. Also to meet out the food, timber and fodder requirement of the rainfed farmers while making rational/judicious use of on-farm resources. Experiment comprised of five treatments viz. T1- Agri-Horti-Silvi-Pastoral System: Guava + Melia + Setaria Spp.+ Maize-Wheat, T2- Agri-Horti-Silvi-Pastoral System: Guava + Melia + Setaria Spp.+ Maize- Gobhi sarson, T3- Agri-Horti-Silvi-Pastoral System: Guava + Melia + SetariaSpp.+Black gram-Wheat, T4- Agri-Horti-Silvi-Pastoral System: Guava + Melia + Setaria Spp.+Black gram-Gobhi sarson and T5- Control (cereal-cereal): Maize-wheat. The soil of the experimental site was Inceptisols having sandy loam texture with low available nitrogen, medium phosphorus, low potash with pH value 6.58 and low organic carbon. Nitrogen, phosphorous and potash were applied as per package of practices through Urea, DAP and MOP. The experiment was laid out in randomized block design with four replications. Melia and Gauva were planted in rows alternately and the space in-between was covered by planting Setaria during the kharif season of 2018-19 and crops were sown in the alleys formed by Melia and Gauva.

Results

The perusal of the data revealed that the sole maize grown under maize-wheat system (Cereal-cereal) registered maximum yield of 3170 Kg/ha with highest mean B:C ratio value of 3.12. However, the maize crop recorded Maize equivalent grain yield of 2859 kg/ha and B:C ratio of 2.64, respectively in treatment Agri-Horti-Silvi-Pastoral System (Guava + Melia + Setaria Spp.+ Maize- Gobhi sarson) wherein the maize crop was sown in the alleys formed by Horti-Silvi-Pastoral component while the lowest values of mean maize equivalent yield was observed in the treatment Agri-Horti-Silvi-Pastoral System (Guava + Melia + Setaria Spp.+ Black gram – Gobhi sarson) wherein Black gram was sown in the alleys formed by Guava, Melia and Setaria species with the corresponding maize equivalent value of 1636 kg/ha.

Among the different alternate land use systems, the perusal of the data revealed that the maximum wheat equivalent yield of 4068 kg/ha was observed in treatment Agri-Horti-Silvi-Pastoral System (Guava + *Melia* + *Setaria* Spp.+ Black garm - wheat) wherein the wheat crop was sown in the alleys formed by Horti-Silvi-Pastoral component with highest mean B:C ratio of 3.73. However, the wheat equivalent yield of 3859 kg/ha was recorded in treatment Agri-Horti-Silvi-Pastoral system (Guava + *Melia* + *Setaria* Spp.+ maize- wheat) wherein the wheat crop was sown in the alleys formed by Horti-Silvi-Pastoral component while the lowest values of wheat equivalent yield of 2763 kg/ha during *rabi* was observed in the treatment Agri-Horti-Silvi-Pastoral System (Guava + *Melia* + *Setaria* Spp.+ maize - gobhi sarson) wherein gobhi sarson was sown in the alleys formed by Guava, *Melia* and *Setaria* species. However, the sole wheat crop grown during *rabi* under maize-wheat system (Cereal-cereal) system registered mean yield of 3092 kg/ha.

Conclusion

Among the different alternate land use systems, the maximum Maize equivalent grain yield of 2859 kg/ha and B:C ratio of 2.64, respectively was recorded under Agri-Horti-Silvi-Pastoral System (Guava + *Melia* + *Setaria* Spp.+ Maize- Gobhi sarson). Whereas, during *rabi*, the maximum wheat equivalent yield of 4068 kg/ha was observed in treatment Agri-Horti-Silvi-Pastoral System (Guava + *Melia* + *Setaria* Spp.+ Black garm - Wheat) with highest mean B:C ratio of 3.73.

Table 1: Evaluation of alternate land use systems for higher system productivity under rainfed subtropics of Jammu

Treatment	Maize equivalent Yield (kg/ha)					Mean MEY (kg/ha)	Mean BC ratio	Wheat equivalent Yield (kg/ha)					Mean MEY (kg/ ha)	Mean BC ratio	System productivity (t/ ha)
	2018	2019	2020	2021	2022			2018-19	2019-20	2020-21	2021-22	2022-23			
T_1	2500	2430	2517	2904	3070	2684	2.55	2780	2410	4248	5412	2780	3859	3.54	7.3
T_2	2650	2510	2595	2961	3183	2859	2.64	1700	1392	3534	3926	1700	2763	3.10	5.7
T_3	1320	1939	1730	2071	1567	1725	1.72	2830	2565	4226	5478	2830	4068	3.73	6.6
T_4	1270	1863	1640	1931	1475	1636	1.63	1826	1552	3574	4122	1826	2885	3.24	4.7
T_5	3450	3320	2650	3010	3420	3170	3.12	3170	2950	2720	2630	3170	3092	3.30	7.2
CD (5 %)	349.0	359.0	267.4	378	248.2	-	-	295.2	323.5	349.3	395.4	411.34	-	-	-

MEY: Maize equivalent yield; **WEY**: Wheat equivalent Yield

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Performance of Three Horticultural Crops Grown as Intercrops Under *Gmelina Arborea* and *Magnolea Champaca* Based Agro-Forestry System in Assam, India

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Agro-forestry is an efficient land use system where trees or shrubs are grown with arable crops seeking positive interactions in enhancing productivity on the sustainable basis. It is an important landuse system in the present scenario of climate change and sustainable food production (Subhasmita P., et al., 2023). The Agro forestry systems are not new and the traditional system of shifting cultivation. In Assam, about two third of the total land area is used for rice cultivation in low land situation and in upland situation, there is tremendous scope for introduction of region specific and viable agro forestry models for sustain production for increased social, economic and environmental benefits. Peoples of the region have traditionally developed such agroforestry to meet their local and household needs. Systematic scientific innovations to such practices are required to make such agro practices more productive and sustainable. *Gmelina arborea* based agri-horti-silvi-pastoral system has the potential to provide higher income as well as protect soil health (Swamy et al., 2003). The performance of horticultural intercrops under agroforestry systems is a significant aspect of sustainable land management, especially in regions like Assam, India, where agriculture and forestry coexist. In agroforestry systems, tree species such as *Gmelina arborea* (a fast-growing timber tree) and *Magnolia champaca* (a large evergreen tree valued for its timber) provide canopy and shade for various intercrops.

Methodology

The investigation was carried out during the period 2017-18 to 2022-23 at All India Coordinated Research Project for Dryland Agriculture, BN College of Agriculture, AAU, Assam. The dominant climate of this region is Humid Subtropical with hot and wet summer and cool and dry winter. Normal annual rainfall is 1971.8 mm with 122 days of normal rainy days. The mean air and soil temperature of the area 23.6^{O}C and 24.6^{O}C respectively. The mean summer and winter soil temperature is 25.16 ^{O}C and 19.74 ^{O}C respectively. *Gmelina arborea* and *Magnolea champaca* trees were planted at three spacing 4m x 4m, 4m x 6m and 4m x 8m. Intercrops were planted in the interspaces of *Gmelina arborea* and *Magnolea champaca* at the three spacing. The experiment was carried out in Randomized Block Design with three replications. Various growth and yield parameters were studied to assess the performance of different crops and their combinations.

Results

Different treatments (4x4, 4x6, 4x8) and conditions (Open, Gomari and Titachappa) significantly affect ginger, Colocasia and Assam Lemon yield. Six years of pulled data resulted highest ginger yield and B:C ratio under Titachappa planted at 4m x 8m spacing and lowest was recorded under Gamari planted at 4m x 4m spacing. Colocasia pooled data showed that highest yield and B: C ratio was recorded under 4m x 8m spacing Titachappa trees whereas lowest was recorded under 4m x 6m spacing Gamari tree. Simialar trend was also seen for Assam Lemon where highest yield and B:C ratio was recorded under 4m x 4m spacing Titachappa tree and lowest was recorded under 4m x 6m spacing Gamari tree.

Table 1: Yield and Benefit Cost ratio of Ginger, Colocasia and Assam Lemon under Gamari and Titachappa tree at three different spacing

Treatment	Ginger data		Colocasia data		Assam Lemon data	
	Mean yield (Kg/ha)	Mean B:C	Mean yield (Kg/ha)	Mean B:C	Mean yield (Kg/ha)	Mean B:C
4m x 4m Open	10223	4.59	23586	6.60	53124	3.56
4m x 4m Titachappa	7733	3.53	21280	5.81	39765	2.67
4m x 4m Gomari	5121	2.36	10332	3.49	3775	0.26
4 m x 6m Open	11505	5.21	23292	6.43	38975	2.63
4 m x 6m Titachappa	8300	3.79	22098	5.96	33593	2.25
4 m x 6m Gomari	5435	2.49	10164	3.47	3090	0.21
4 m x 8m Open	12467	5.63	24632	6.72	36392	2.46
4 m x 8m Titachappa	10806	4.92	23655	6.46	32330	2.16
4 m x 8m Gomari	5891	2.69	10674	3.64	3228	0.22
Mean	8609		18857		27141	
SEm	254		183		2342	
CD 5%	428		308		3934	

Conclusion

In Assam's agroforestry systems, the performance of horticultural intercrops will depend heavily on the tree species and the specific crop's shade tolerance and water needs. While *Magnolia champaca* offers moderate benefits for intercrops by providing partial shade, improving soil quality, and maintaining moisture, *Gmelina arborea* may require more specific crop management due to its dense canopy. To maximize the potential of such systems, careful planning is essential, including choosing the right intercrops, managing tree growth for optimal light conditions, and supplementing soil nutrients when necessary. In this experiment all the three intercrops perform better under *Magnolia champaca* compared to *Gmelina arborea.*

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Evaluation of High Value and Climate Smart Crops under Custard Apple Based Agri Horti System in the Vindhyan Region

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Smallholder farms have been a focal point in efforts to address food security and poverty reduction, particularly in the first two decades of the twenty-first century. Many of these small farms in developing countries are rainfed and heavily influenced by climatic conditions, which in turn affect agricultural output (Joshi and Tyagi, 2019). Climate-smart agriculture is designed to guide the transformation of agri-food systems towards environmentally sustainable and climate-resilient practices reducing GHGs for an adaptable food system in the face of changing weather patterns (LARRDIS, 2023). The US recognises that India has policy expertise and technical knowledge that are suitable for other countries, particularly in renewable energy and CSA (Ramamurthi, 2024). Agroforestry, as defined by Dr. P. K. Nair (1979), is a land use system that integrates trees, crops, and livestock in a manner that is scientifically sound, economically beneficial, practically feasible, and socially acceptable to the farmers. The agroforestry component chosen is custard apple. Custard apple

(*Annona squamosa L.),* a native of Tropical America is widely distributed throughout the tropical and sub-tropical regions. It has several synonyms such as sitaphal, sharifa, sugar apple, sweet sop etc, and there are more than 70 species which come under the genus *Annona.* India has an estimated area and production of custard apple 19,660 ha and 1,33,050 tonnes, respectively and productivity is 6.76 tonnes ha^{-1}. There is a pressing need for a second green revolution, which can be achieved through the advancement of dryland agriculture (*Vijayan*, 2016). In lieu of a second green revolution in terms of dryland agriculture, the investigation is based on (a) assessing the productivity, profitability, and resource use efficiency of diversified custard apple-based agroforestry systems; (b) identifying the most profitable agri-horti system; and (c) analysing the economic aspects of the treatments. The present study was undertaken to explore the prospects of successfully growing high value and climate smart intercrops with custard apple clones to boost the income of small holder farmers and improve the long-term productivity, sustainability and profitability of the system in Vindhyan Region of India contributing to overall sustainable development goals of the United Nations. An annual legume, cluster bean is well-suited to arid and semi-arid regions due to its drought and high-temperature tolerance. It is grown for multiple purposes, including as a vegetable, cattle feed, or green manure. Finger Millet also known as ragi, is grown for grain and fodder under various agro-climatic conditions in India. Finger millet is resilient to harsh conditions and provides higher nutritional value than rice and wheat. It is gaining popularity for its adaptability and nutritional benefits. Ashwagandha a revered herb in ayurveda is known for its wide-ranging health benefits. It enhances brain function, memory, reproductive health, and stress resilience, has potent antioxidant properties that protect against cellular damage. Cowpea helps meet nitrogen needs, controls erosion, and improves soil health supports beneficial insect populations and forms effective mycorrhizal association in low phosphorus soil. Okra is a staple food in many countries and is valued for its nutritional benefits.

Methodology

During monsoon season of 2024, on July 10, an agronomic field experiment was conducted at Rajiv Gandhi South Campus, Banaras Hindu University (25 ◦10’N latitude 82 ◦37’ E longitudes and at an altitude 365 metres above mean sea level), Barkachha , Mirzapur, Uttar Pradesh using randomized complete block design with 5 treatments and 3 replications under 17 years old custard apple agroforestry system. The pH ranged from 5.9 to 6.5 with mean of 6.14 slightly in nature, E.C. (dSm-1) ranged from 0.25-0.76 with mean of 0.53, OC ranged from 0.26-0.76% and available nitrogen, phosphorus, potassium and sulphur were ranged from 0.26-0.75% and available nitrogen, phosphorus, potassium and sulphur were ranged from 160-241.5, 8.24-11.79. 70.1-128.25 and 6.7-10.25 kg ha-1, respectively. To create a viable Custard Apple-based agroforestry system, a field experiment was carried out under ‘All India Coordinated Research Project for Dryland Agriculture’ in Rajiv Gandhi South

Campus, Banaras Hindu University, Uttar Pradesh, India. In this study, there were five treatments of okra, cowpea, cluster bean, finger millet and ashwagandha. The crops were sown on broad bed due to moisture conservation purpose.

Results

Table- 1 shows the mean crop equivalent yield of various treatments. T_1 had the largest mean crop equivalent yield (2191.42 Kg), which was significantly superior over all the treatments

Table 1: Mean crop equivalent yield of various treatments.

Treatments	CA-MCEY (Kg/ha)
T_1- Custard apple+Okra	2,191.42
T_2- Custard apple+Cowpea	1,743.57
T_3- Custard apple+Cluster bean	1,880.00
T_4- Custard apple+Finger millet	1,437.85
T_5- Custard apple+Ashwagandha	1,478.57
SE(m)	66.64
CD	207.63
CV	7.633

Table-2 shows economics of various treatments. The highest net return was found in treatment T_1 (81840), Followed by T_3 and T_4, 75040 and 72140 respectively and lowest net return was found in treatment T_2 59790.

Table 2: Economics of various treatments

Yield (Kg/ha)	Cost of Cultivation (Rs)	Gross return (Rs)	Net Return (Rs)	B:C
2,191.42	71560	153400	81840	2.14
1,743.57	62260	122050	59790	1.96
1,880.00	56560	131600	75040	2.33
1,437.85	28510	100650	72140	3.53
1,478.57	35460	103500	68040	2.92

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Assessment of Biomass and Carbon Storage in Clonal Eucalyptus Plantations: Implications for Climate Resilience in Central India

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Clonal eucalyptus is among the fast-growing species for paper and pulpwood production and serve for raw material requirement for wood-based industry in India. The present study was carried out in selected farmer's field of Shahdol district, Madhya Pradesh (MP), India to assess the biomass and carbon storage of clonal eucalyptus plantations with different plantation type, spacing regimes and age gradations. The results revealed that biomass of trees within the selected variation categories ranged from 76.18 t ha^{-1} yr^{-1} to 2444.02 t ha^{-1} yr^{-1}. The total carbon stock among the selected plantations varied from 29.33 to 916.47t ha^{-1} yr^{-1}. The trend for biomass between the components of trees followed: Bole> Bark> Branch>Leaves. Comparison analysis between the bund and block plantations of farmers' fields indicated that biomass, carbon stock and carbon dioxide (CO_2) sequestration potential was found higher in block plantations of eucalyptus than that of bund plantations. The study concluded that closer spacing lead to higher biomass, total carbon stock and CO_2 sequestration potential in eucalyptus plantations compared to wider spacing. Therefore, the study recommends that farmers of Shahdol district, MP, India should actively adopt clonal eucalyptus plantations especially in form of agroforestry that will help in doubling farmers income, livelihood opportunities and will ultimately contribute in combating climate change in present scenario.

UID: 1521

Prosopis pallida on saline-sodic soils: an agroforestry technique to be deployed for reclamation in semi-arid tropical region of south India

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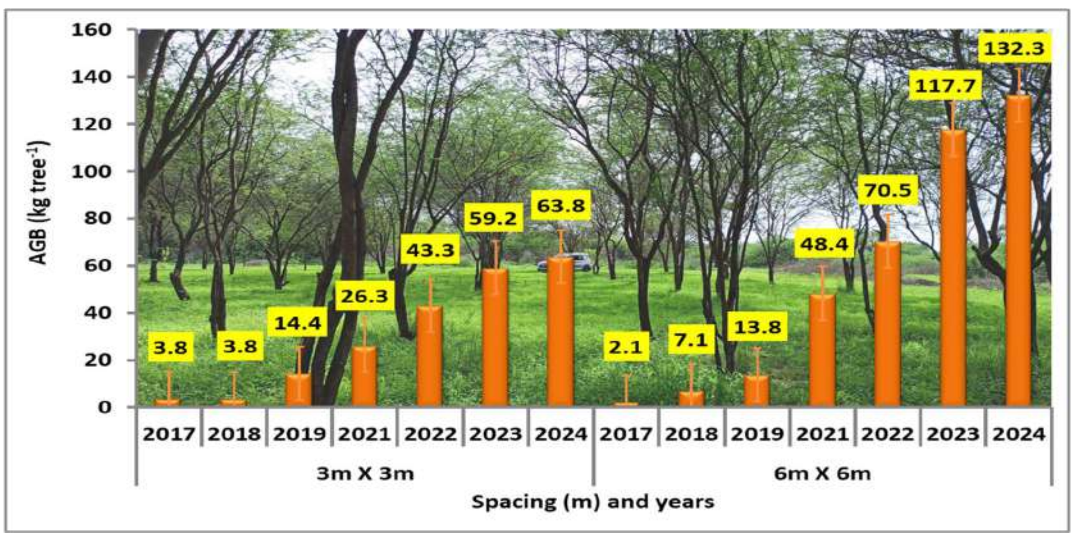
Soils are essential resource for any country to prosper and achieve the United Nation's Sustainable Developmental Goal. Contemporarily, the global soil qualities are getting deteriorated and degraded at alarming rates due to anthropogenic exploitation. The salt affected soils (SAS) occupies 1257 Mha cross the globe (Dagar et al., 2023 and their utilization is a challenge. In India about 6.73 Mha area is salt affected, which causing an economic loss of US$ ~3.0 billion annually (Kumar et al., 2022) and is projected to extend over ~16 Mha by 2050 in India.

Prosopis pallida – a thornless tree was introduced under a FAO/IBPGR programme at CAZRI, Jodhpur during 1985. Prior to that it was also evaluated on saline-sodic soils of Uttar Pradesh during 1980s and introduced into the saline-sodic soils at Karnal, Haryana during 1985 (Tiwari et al 1998). It is a nitrogen fixing, fast growing and widely distributed tree species. Highly adapted to extremely dry, wet and salinity conditions with provisions of ecological, environmental and financial benefits to the mankind (Salazar et al., 2021). Edible sweet-pods, bioethanol from mesocarp, medicinal uses and woody biomass (Grados et al., 2022). However, it was rarely evaluated in semi-arid tropical region of south India.

Therefore, we introduced *Prosopis pallida* on saline-sodic Vertisols (*SSV*) with low (6m × 6m spacing) and high-density (3m × 3m spacing) planting geometry. Since 2015, species was evaluated for its survivability, growth, biomass production, changes in soil chemical and physical properties and recovery of understory vegetation. Tree survivability on *SSV* was > 90%. The average tree height is 7.6 m and 7.0 m in high and low density stands respectively. In contrast average tree diameter at breast heigh was higher in low density stand (13.2 cm) compared to high density stand (9.2cm). Accumulation of aboveground biomass in average tree is 64 kg tree^{-1} in high density stand whereas it was 132 kg tree^{-1} in low density stand. Consequently, stand level aboveground biomass in high-density stand was 63.8 Mg ha^{-1} and 32.4 Mg ha^{-1} in low density stand with respective carbon stock of 29.6 t ha^{-1} and 15.2 t ha^{-1}. As such the direct economic benefit of ~ ₹ 16000 ha^{-1} yr^{-1} and 8100 ha^{-1} yr^{-1} would be generated by selling accumulated biomass as fire wood from high and low density stands, respectively. Harvested average aboveground grass and herbs biomass was 317g m^{-2} in low density stand and 546 m^{-2} under high density stand. Important shrubs observed on ground are *Abutilon hirtum, Desmanthus virgatus, and Corchorus trilocularis*. Herbs *Cyanthillium cinereum, Dicliptera paniculata, Parthenium hysterophorus, Alternanthera sessilis and Achyranthes aspera and c*limber *Ipomoea purpurea* occurrence were recorded. Grasses like, *Urochloa panicoides*, *Cynodon dactylon*, and *Setaria viridis* were also recorded from the experimental suite. Thus, it indicates better soil improvement under high density stand and possible pasture development on such lands which can support livestock feeding.

Chemical properties of *SSV* under *P. pallida* significantly improved over nine years and it was compared with *P. juliflora* stands and barren saline-sodic soils in the region. The recorded ECe at surface soil is ~3 dSm^{-1} which is on par with soil ECe beneath the *P. juliflora* (~3 dSm^{-1}) and significantly differed from barren saline-sodic soil in the region (19 dSm^{-1}). The ESP at surface soil was significantly lower (44%) under *P. pallida* compared 56% and 66% recorded under *P. juliflora* and barren saline-sodic land parcel, respectively. Further, appearance of herbs, shrubs and tree regeneration, indicates microhabitat improvement and initiation of plant succession. Therefore, *P. pallida* was effective natured based alternative to the thorny *P. juliflora* for re-habitation of *SSV* in the semi-arid tropics.



Average tree level aboveground biomass accumulation at high and low density stands of Prosopis pallida tree

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UID: 1524

Increasing Combined Tolerance to Drought and Heat Stress in Tomato through Grafting

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Abiotic stresses associated with edaphic and environment factors pose considerable challenge to crop production in (semi)arid regions. Considering global climate change, incidence of their impact is likely to increase. In the past decades, most studies focused on the response of crops to a single stress. However, crops are always exposed to a combination of different abiotic stresses in the field conditions such as heat stress is frequently associated with drought stress. This makes necessary to study the crops responding to combined heat and drought stress, and accordingly develop strategies to deal with the combined stress. Tomato (*Solanum lycopersicum* L.) is one of the most important vegetables with high nutritional and economic significance. Tomato plants are sensitive to high temperature as well as moisture stress. It is grown in a variety of climates and is frequently subjected to the combination of drought and heat stress during its cultivation. Considering this challenge, we screened thirty-five potential genotypes across seven species of *Solanum* by subjecting them to drought and heat stress. Based on various morphological traits related to roots, leaf, shoot, and fruits, as well as plants physiological traits such as relative water content (RWC), water potential (WP), leaf pigments, chlorophyll fluorescence (Fv/Fm), we identified five genotypes with high stress tolerance namely EC 521078, EB-4-10, IC 354557, CLN 2026 and WIR 3958. Further, the performance of selected genotypes used as root stocks for tomato grafting and tested against non-grafted control (TO 1057 F1) for combined stress by subjecting them to normal watering(control)and moisture deficit at 50% of field capacity (drought) in combination of two temperatures settings, normal (32±2°C) and high temperatures (40±2°C, heat stress) maintained under temperature gradient tunnel. Plant height, shoot dry weight (DW), root DW, mean fruit weight and fruit yield were considerably decreased in all types of plants under combined stress. However, compared to non-grafted control, grafted plants particularly on rootstocks IC 354557, CLN 2026 and WIR 3958 produced apparently higher biomass, stem girth, fruit weight, colour, and yield, showing good tolerance against combined stress. The tolerance abilities of these rootstocks were substantiated by observed higher physiological efficiency, measured in terms of crucial physiological traits like RWC, WP, Fv/Fm and chlorophyll in these grafted plants under stress conditions. The identification of IC 354557, CLN 2026 and WIR 3958genotypes for tomato grafting for their combined stress tolerance holds the potential to provide suitable rootstock material for grafting operations focused on enhancing tomato resilience to adverse climate conditions.

UID: 1541

Effect of Different Arecanut Based Cropping System on Carbon Sequestration in Eastern Himalayan Zone of West Bengal

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Climate change is putting strain on agriculture, making it difficult to achieve food, income, and ecological stability in the face of rising population rates. In this context, agricultural productivity per unit area must be increased by optimizing available vertical and horizontal space, as well as other natural resources. Arecanut-based cropping system (ABCS) is a modern and alternative approach to sustainable horticultural crop productivity for small and marginal farming communities in the country's north-east, not only providing a higher economic return but also playing a better role in sustainable land use management and climate change mitigation by sequestering atmospheric CO2 in terrestrial ecosystems. Keeping cropping systems in mind, the current study, entitled "Effect of Different Arecanut Based Cropping Systems on Carbon Sequestration in the Eastern Himalayan Zone of West Bengal," was conducted to ensure economic sustainability and mitigate the negative impact of global climate change through sequestered atmospheric CO2 in terrestrial ecosystems.

Methodology

The current study was conducted on a ten-year arecanut (cv. Mohitnagar) plantation at the Horticulture Research Station, UBKV, between 2022 and 2023. The experimental site is located at 26°19'86" latitude and 89°23'53" longitude. The sandy loam soil had approximately rough texture and reacts acidically. In order to efficiently utilise 70% of the remaining land area and 40% of the incident solar energy that penetrates the canopy of the eight-year Arecanut plantation, various annual and perennial intercrops were integrated. The study was based on following 6 Arecanut based cropping models-Model-I: Arecanut + Pineapple + Ginger + Bay leaf, Model-II: Arecanut + Turmeric+ Elephant Foot Yam + Elaichi Lemon, Model-III: Arecanut + Ginger + Asam Lemon+ Bay leaf, Model-IV: Arecanut + Pineapple + Bay leaf + Colocassia + Black Pepper + Amaranthus, Model-V: Arecanut + Bay leaf + Basella + Ipomea, Model-VI: Arecanut as sole crop.

In an arecanut-based cropping system, the biomass of various perennial crops was estimated using both destructive and non-destructive methods. To estimate stem biomass, areca palms of several models in the 40–50 cm diameter of beast height (DBH) class at 1.37 m were measured.
Using a regression equation designed specifically for palms, five palms were chosen at random from each model to determine the biomass of the stem and leaves.

Y (stem biomass): 4.5+7.5x stem height (m), Leaf biomass: 65 % of stem biomass. The root biomass was estimated by following the method developed by FAO. Root biomass = 0.30 x above ground biomass (stem biomass + leaf biomass). The bay leaf plant's DBH was measured in four models and classified as 5-10 cm or 10-15 cm in diameter. Eight plants were randomly selected from each diameter class to estimate biomass. Plant height was measured to calculate stem volume. The volume of sample trees was computed by multiplying the area of the cylindrical stem by the height of the palm to estimate stem biomass. A 5 cm-thick chunk of wood was cut at breast height 1.37 m from the tree's base. The specific gravity of wood was determined by measuring its fresh weight and drying it in an oven at 60°C. Stem biomass was determined by multiplying volume by specific gravity, then translated to per ha of each model by multiplying the total number of trees by the average diameter class. Biomass from bay leaf plant leaves, twigs, and branches was evaluated using both fresh and dried weight. Destructive sampling was conducted on three models of pine apple, lime, and lemon plants to measure both above-ground and subsurface biomass levels. carbon stock was converted into CO2 equivalent (carbon stock x 44/12) for calculating sequestration carbon Variations among the models were tested for significance using critical difference test at 5% level of significance ($p \leq 0.05$) by adopting F test.

Results

Six alternative ABCS models were quantified using the total biomass production of perennial crops (Arecanut, Bay leaf, Lemon, and Pine apple) to determine carbon sequestration. Biomass estimate was performed using both destructive and non-destructive approaches. Arecanut palms' carbon stocks were strongly impacted by their biomass reserves under different cropping approaches. The carbon stock of the palms under Model I and Model IV was significantly higher (81.78 t/ha and 79.22 t/ha, respectively), demonstrating the superiority of these Models in removing carbon from the atmosphere, whereas the carbon stock of the palms under mono-cropping was significantly lower (67.66 t/ha).

Pineapple absorbed the least amount of CO2 (1.31 t/ha), although Arecanut absorbed a comparable amount (300.12 t/ha). Arecanut palms under Models I and IV, on the other hand, sequestered much more CO2 than the other ABCS Models, with quantities of 300.12 and 290.72 t/ha, respectively, while Arecanut under the mono-cropping system recorded the lowest quantity of 248 t/ha. The component crops, with their varying carbon sequestering ability of various ABCS Models, eventually sequestered total CO2 by one-hectare Models ranging from 280.77 to 313.96 t/ha, with the lowest result under monocropping circumstances (248.31 t/ha).

Effect of different ABCS system on biomass accumulation by the main crop (Arecanut) and intercrops

Model	Arecanut (t/ha)	Bay leaf (t/ha)	Lemon (t/ha)	Pine apple (t/ha)	Total CO_2 Sequestrated (t/ha)
Model I	300.12	12.53	-	1.31	313.96
Model II	277.41	-	3.35	-	280.77
Model III	270.44	12.08	1.68	-	284.21
Model IV	290.72	12.15	-	2.81	305.68
Model V	275.75	12.11	-	-	287.86
Model VI	248.31	-	-	-	248.31
S.Em(±)	4.88	-	-	-	4.88
CD (0.05)	14.48	-	-	-	14.48

Conclusion

The study has proved that *Arecanut mono-cropping* plantations have low biomass carbon storage potential and limits its scope of terrestrial carbon sink management and climate change mitigation. Carbon sequestration potential of different woody perennials in different cropping system models varied according to the nature of plant species and biomass accumulation rate.

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UID: 1605

Response of Technology Demonstrations on High Yielding and Powdery Mildew Resistant Genotypes of Offseason Garden Pea (*Pisum Sativum* L.) To Changing Climate in Mandi District of Himachal Pradesh

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Garden Pea (*Pisum sativum* L.) is an important vegetable crop in the North-Western Himalayan region of India comprising the states of Himachal Pradesh, Jammu & Kashmir and Utrakhand (Sharma, et al, 2013). Owing to diverse agro climatic conditions in Himachal Pradesh, the crop is grown year-round, yielding lucrative returns to the growers. Garden pea has emerged as an important off-season vegetable in Himachal Pradesh in general and in mid and high hills wet-temperate region of Mandi district in particular. With the emergence of urban middle-class market having specific kitchen needs and health consciousness, the presence of garden pea in the market overall periods of a year is preferred by the consumer but due to changing climate day by day, the existing climatic condition differs and the shortage of water comes with a big constrain in its production.

Garden Pea considered as a high-value crop in the state, fetching relatively better prices compared to other agricultural commodities. The cultivation of peas not only provides a valuable source of income for the farmers but also helps in addressing food security challenges. There is a growing demand for offseason pea on large scale during summer season. However, the yields were low particularly under rainfed situations apart from high incidence of powdery mildew and pea leaf minor, have resulted in sudden fall in its production. In addition to reduction in fresh pod yield, the disease also reduces the quality of the marketable harvest significantly. Unawareness of farmers about management techniques and non-adoption of high yielding and resistant cultivars resulting in less remunerative returns which threatened livelihood security of small and marginal hill farmers. Thus, there is a dire need to scale-up off-season garden pea cultivation in the District and to solve these problems, KVK Mandi (HP) conducted two years technology demonstrations on high yielding pea genotypes with the objectives to enhancing farmers productivity and profitability in general and food & nutritional security in particular over farmers practices in mid and high hills wet-temperate region of Himachal Pradesh.

In order to fulfill above objectives and enhance quality and yield of garden pea under on farm participatory mode, ten multi location '*Front line demonstrations'* were conducted in five villages of Sundernagar, Gohar, Seraj, and Karsog development blocks of the district covering an area of about 1.60 ha under irrigated condition during Summer 2021 & 2022 (July- November) using two high yielding and powdery mildew resistant cultivars namely Him Palam Matar-1 (T1) and Him Palam Matar- 2 released by the Department of Vegetable Science and Floriculture, CSKHPKV, Palampur and PB-89 (T3) as farmers practices with recommended production technology. The yield data were determined using standard procedure, B: C ratio was computed using marketable pod yield and cost incurred towards crop management at the prevailing market price.

From the study, it was revealed that average green pea pods productivity of Him Palam Matar-2 (142.39 qt/ha) followed by Him Palam Matar-1 (137.45 qt/ha) as compared to check variety PB-89 (123.60 qt /ha) during both the years. The average yield increase was observed 15.20 % in cultivar Him Palam Matar-2 and11.20% in Him Palam Matar-1 t in spite of increase in yield of pea, technology & extension gap existed. The improved technology gave higher gross return to the tune of Rs. /- 213585 per ha in Him Palam Matar -2 followed by Rs. /- 206175 in Him Palam Matar-1 per ha, net return (141085 & 133675 Rs. /ha) with higher benefit cost ratio (2.94 & 2.84), respectively as compared to farmer's practices (Gross return to the tune of Rs. /-148320, Net returns Rs./- 75820 and B:C ratio 2.04). This was due to the poor management practices, lack of knowledge and poor socio-economic condition. The farmers were satisfied with the performance of technology demonstrations/ FLD's conducted on Him Palam Matar-2 and Him Palam Matar-1 which escape yellow rust disease, more prevalent in offseason pea growing areas and thus adopted these cultivars for future cultivation. Under sustainable agricultural practices, with this study it is concluded that Cultivar Him Palam Matar-2 and Him Palam Matar-1 in the FLD's programmes were effective and suitable cultivars with high yield potential and powdery mildew resistant whose wide spread adoption in Himachal Pradesh in general and wet temperate region in Mandi district in particular may prove as a boon to hill farmers.

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UID: 1610

Adoption of Cashew Crop as a Dryland Horticulture Practice to Combat Climate Vulnerability

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Cashew *(Anacardium Occidentale L)*, is one of the highest foreign exchanges earning perennial horticultural crops in India. Annually, India exports more than 1.1 lakh tons of cashew kernels and earns about Rs. 2,900 crores as foreign exchange. Even though India needs 12-13 lakh tons of raw cashew nuts to feed the cashew processing industries, only 6.7 lakh tons are produced and the balance is imported from Africa and other nations (Bhat, 2010).

Commercial cultivation of cashew is taken up in eight states of our country mainly in west and eastern coast viz., Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Orissa, Tamilnadu and West Bengal. In addition, cashew is also grown in few pockets of Assam, Chhattisgarh, Gujarat, Meghalaya, Nagaland and Tripura. India has an area of 10.35 lakh ha under cashew with an estimated annual production of about 6.7 lakh tons of raw cashew nut. India is the third largest producer and exporter of cashew in the world next only to Vietnam and Nigeria. It is the second largest consumer of cashew and also the biggest processor with highest acreage under the crop. The current cashew production of the country accounts for

23.0% of the global production. A large number of small and marginal farmers, especially living on the coastal belts of India, depend on cashew for their livelihood. Nearly two lakhs workers, more than 90% of whom are women, are directly employed in cashew processing factories which are concentrated mostly in Kerala, Andhra Pradesh and Maharashtra. It is estimated that nearly two million people are involved, directly and indirectly, in cashew cultivation, processing and marketing. Cashew cultivation is taken up in small and marginal holdings and as more than 70% of the cashew area is under this category (DCR, Puttur, 2017).

The current productivity of cashew in the country is as low as 0.72 t ha^{-1} against the target of 2.0 tons ha^{-1} $year^{-1}$. In order to increase the productivity of cashew in India, replacing senile/seedlings originated cashew gardens with improved varieties, identifying most suitable areas for its growth and adoption of proper management practices are very important (Rupa *et al.,* 2012).

Methedology

ICAR- KVK Hirehalli has promoted adoption of dry land horticulture crops under TDC-NICRA project of the farmers in red soil area. The KVK has introduced cashew crop cultivation in D.Nagenhalli, one of the project villages. There has been a lot of discussion between KVK Scientists and farmers regarding the adaptability and profitability of cashew cultivation under rainfed condition. Training programmes were conducted to farmers on proper cultivation practices of cashew crops.

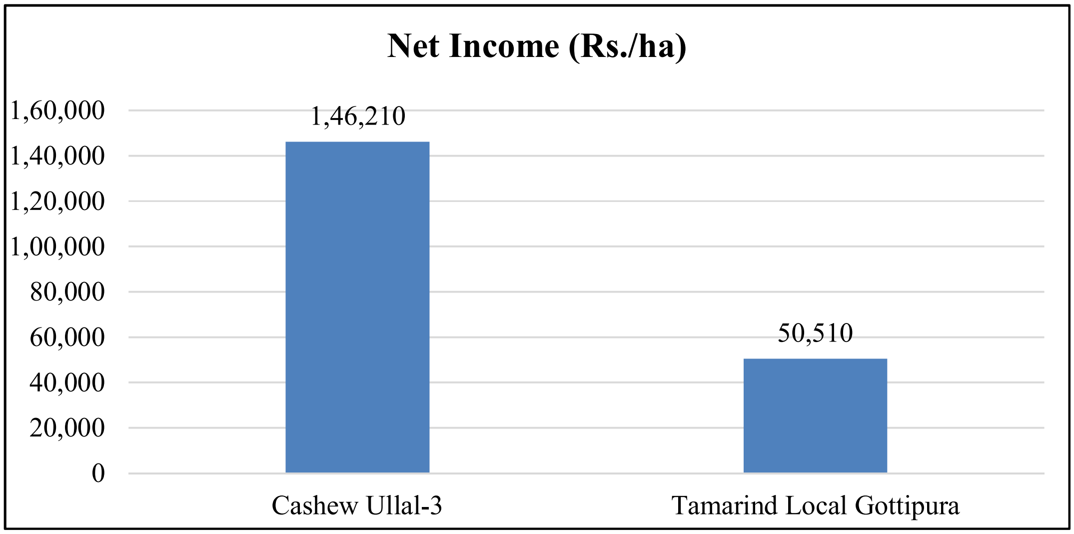
Sri. Lokesh S/o Rangappa, a progressive farmer from D Nagenahalli, has approached KVK Scientists during April, 2013 for cashew cultivation. As per their suggestion, after undergoing training, he has taken up cashew plantation with high yielding hybrids Ullal-3 and later Vengurla-7. He had procured grafts from NRC on Cashew, Puttur. He opted for normal density farming of 7 x 7 m distance that accommodated 197 trees in a 1 ha area. Cashew can grow well in well drained red soil. Farmer applied bio-fertilizer, enriched organic manures and other suitable inorganic fertilizers occasionally for the crop development. He was advised to practice other improved technological practices viz., mulching, drip irrigation, INM and IPM to combat climate vulnerability.

Results

The results, as per the below table, showed the increase in income up to 189.5%, due to improved technologies to combat climate vulnerability in comparison to Tamarind.

Comparison of yield parameters of Cashew Ullal-3 and Tamarind Local Gottipura

Details of results obtained due to the adoption of improved technologies	Improved technology Cashew Ullal-3	Traditional practices Tamarind Local Gottipura
Productivity per hectare (q/ha)	14.4	9.2
Cost of production per hectare (Rs.)	12,520	12,050
Gross income per hectare (Rs.)	1,58,730	62,560
Net income per hectare (Rs.)	1,46,210	50,510
Percent increase in net income per hectare	189.5	



Cashew Ullal-3

Cashew Vengurla-7

Conclusion

When asked about comparison of cashew nut cultivation with that of Tamarind, Mr. Lokesh said that cashew as a dryland horticulture crop is hardy, less labour intensive with minimum incidence of pest and disease. The fruiting season of both Cashew and Tamarind are similar and hence there is least maintenance cost. Further, he said that Tamarind is an irregular bearer and cashew is regular bearer. Profitability in Cashew nut cultivation is more, as prices are stable, compared to Tamarind. The profitability in cashew nut can be further enhanced if processing facilities of raw fruits are made available. The fruit which is left unutilized can be processed into different value added products. Moreover, cashew crop combats climatic vulnerabilities such as erratic rainfall, prolonged dry spells and drought. Looking into the successful cultivation of cashew nut by Mr. Lokesh, the line department officials visited his orchard and now they are motivating other farmers to cultivate cashew nut in the district.

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UID: 11397

Guava Based Alternate Land Use System under Rainfed Condition of Gujarat

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Indian agriculture predominantly relies on rainfed systems, encompassing dry farming and dryland agriculture, where crop success depends heavily on rainfall distribution and soil moisture. Integrating horticultural crops into dryland systems has been recognized as a viable strategy for sustainable agriculture. Fruit trees, like guava (*Psidium guajava* L.), with their perennial nature and deep root systems, effectively utilize deep soil moisture, adapt to marginal agro-ecological conditions, and improve degraded lands. Once established, guava trees provide a steady income through fruits, fuelwood, and fodder while addressing malnutrition with their high nutritional value.Guava is one of the most common and nutritious and hardy fruits of India, can thrive on all types of soil from alluvial to lateritic with pH value as low as 4.5 and on limestone with a value up to 8.2.India is the largest producer of guava globally, with a production of approximately 27.3 million metric tonnes in 2022, accounting for over 45% of the world's output. Major guava-producing states in India include Uttar Pradesh, Maharashtra, Tamil Nadu, and Bihar, which together contribute significantly to the national fruit economy (Anonymous, 2022).Intercropping, the practice of growing two or more crops in proximity, offers a viable strategy to overcome these challenges while improving the overall sustainability of guava orchards. For sustainable crop production in dryland conditions, growing of intercrop in fruit orchard, farmers can maximize the water use efficiency, maintain soil fertility, reduce the weed growth, minimize the soil erosion and can full utilization of interspaces left in orchard, which ultimately leads to sustainable production and doubling the farm income (Singh *et al.,* 2020). Hence, an experiment was planned to study guava based alternate land use system under rainfed condition of Gujarat

Methodolody

A field experiment was conducted during the *kharif* season of the years 2020-21 to 2023-24. at All India Coordinated Research Project for Dryland Agriculture, Main Dry Farming Research Station, Junagadh Agricultural University, Targhadia (Rajkot). The soil of the experimental field was clayey in texture, BD was 1.35 (g/cm^3) and alkaline in reaction (pH of 8.37 and EC of 0.30 dS/m). The soil had medium levels of organic carbon (0.63%), medium availability of phosphorus (45.65 kg/ha), and medium availability of potash (233 kg/ha). It was high in availability of sulphur (25.29 ppm), high in availability of iron (18.73 ppm) and copper (1.70 ppm), medium in availability of manganese (9.61 ppm) and zinc (0.63 ppm). The experiment was laid out in a randomized block design with four replications, comprising five treatment *viz.,* Guava + groundnut (T_1), Guava + black gram (T_2), Guava + sesame (T_3), Guava + cowpea (T_4), and Sole guava (T_5). Guava plantation during *Kharif* 2018 was carried out with a spacing of 6.0 m × 6.0 m. The gross and net plot size was 12.0 m X 6.0 m. The guava variety Lukhnauv-49 was grown using standard package of practices. Intercrops variety groundnut: GG-5, black gram: Guj. Uradbean-1, sesame: Guj. Til-4, cowpea: Guj. Cowpea-4 was grown using standard package of practices. The total rainfall received was 1160.4, 1100.8 and 742.4 mm in 45, 33 and 46 rainy days in the year of 2020, 2021 and 2022, respectively. Data on growth, fruit yield, intercrop yield and fruit equivalent yield as well as economic of guava based alternate land use system was pooled over 3 years.

Results

On the basis of three years pooled mean, the effect of different treatments on guava plant height was found significant (Table 1), while guava girth and canopy found non-significant. Significantly higher guava tree height (358 cm) was recorded under guava + cowpea (T_4). Similarly, effect of different treatments on guava fruit equivalent yield was found significant and recorded significantly the highest guava fruit equivalent (8123 kg/ha under guava + groundnut (T_1). Among intercrop yield, maximum yield (1955 kg/ha) was also recorded under guava + groundnut (T_1) with maximum net return (Rs.97758/ha), B:C ratio (2.18) and rainwater use efficiency (11.2 kg/ha-mm) followed by guava + cowpea. Similar results have been reported by Soni *et al.,* (2021).

Conclusion

On the basis of three years pooled results, it can conclude that maximum guava fruit equivalent yield with net returns per hectare can be secured by guava intercropped with groundnut followed by cowpea from guava based alternate land use system under raifed condition of Gujarat.

Table 1: Effect of treatments on fruit yield, intercrops yield and economics of guava based alternate land use system (Pooled mean of 3 years)

Treatments	Guava tree height (cm)	Guava fruit yield (kg/ha)	Intercrop pod/ grain yield (kg/ha)	Guava fruit equivalent yield (kg/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
T_1- Guava + groundnut	330	2777	1955	**8123**	97758	2.18	11.2
T_2- Guava + black gram	341	2913	577	4775	19061	1.24	6.6
T_3- Guava + sesame	351	2745	405	4494	14067	1.18	6.2
T_4- Guava + cowpea	358	2987	969	6052	48281	1.62	8.3
T_5- Sole Guava	293	2957	-	2957	7356	1.14	4.1
S.Em.±	13.05			572			
C.D. at 5%	37.42			1864			
C.V.%	13.50			9.66			

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Mechanization, Processing and Value chains for Rainfed Crops and Systems

UID: 1006

Optimizing Soybean (*Glycine max L.*) Yield through Precision Rotary Dibbler Sowing under Rainfed Conditions

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Field experiments were conducted during 2023-24 and 2024-25 in the NICRA-adopted village of Borgaon (N.), Latur district, Maharashtra, to assess the effect of the Precision Rotary Dibbler on the growth and yield of soybean. In this study the Precision Rotary Dibbler and conventional seed drill, were evaluated observations were recorded on seed rate, plant height, branching, flowering, and yield. Reduction in seed rate to an extent of 40-45% was observed under the Precision Rotary Dibbler, demonstrating its efficiency in resource optimization.

The Precision Rotary Dibbler recorded a significantly higher soybean yield of 2506 kg/ha as compared to 1626 kg/ha with the conventional seed drill. The higher seed yield with precision planter is due to higher growth parameters like enhanced plant height, increased number of branches, and higher flowering intensity at 50% flowering (50-55 DAS). The reduced seed rate, coupled with improved plant growth and yield, highlighted the technological advantages of the Precision Rotary Dibbler. Economic analysis further emphasized benefits, of cultivation of soybean with the Precision Rotary Dibbler A net return of ₹79,628/ha and a benefit-cost (B:C) ratio of 2.74. was recorded with precision planter. In contrast, the conventional seed drill resulted in a lower net return of ₹31,702/ha and a B:C ratio of 1.63.

These findings demonstrate the Precision Rotary Dibbler's potential in soybean cultivation by reducing seed rate, improving productivity, and maximizing profitability. Its adoption could significantly contribute to sustainable agricultural practices, particularly in resource-constrained rainfed farming systems, and enhance farmers' livelihoods in the region.

UID: 1013

Evaluation of Planter Performance under Varied Seed Rate and Nutrient Management in Chickpea

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Agriculture is the chief occupation for about one-half of the Indian population with 60 % being dependent on rainfall. With increase in labour scarcity and wages there is a dire need to switch towards mechanization (Shilpa et al., 2017). Use of appropriate machinery to conserve resources like soil, water, land, power and agricultural inputs mainly in the rainfed farming system is very much crucial for enhancing sustainable crop yield (Ghosal et al., 2019). Recent advances in agricultural machinery have made it possible to mechanize various operations in chickpea cultivation, leading to better crop management, increased efficiency, and enhanced productivity. With this objective, present study was conducted to evaluate and standardise the CIAE planter with different seed rate and nutrient management in chickpea" during rabi 2020-21 and 2021-22.

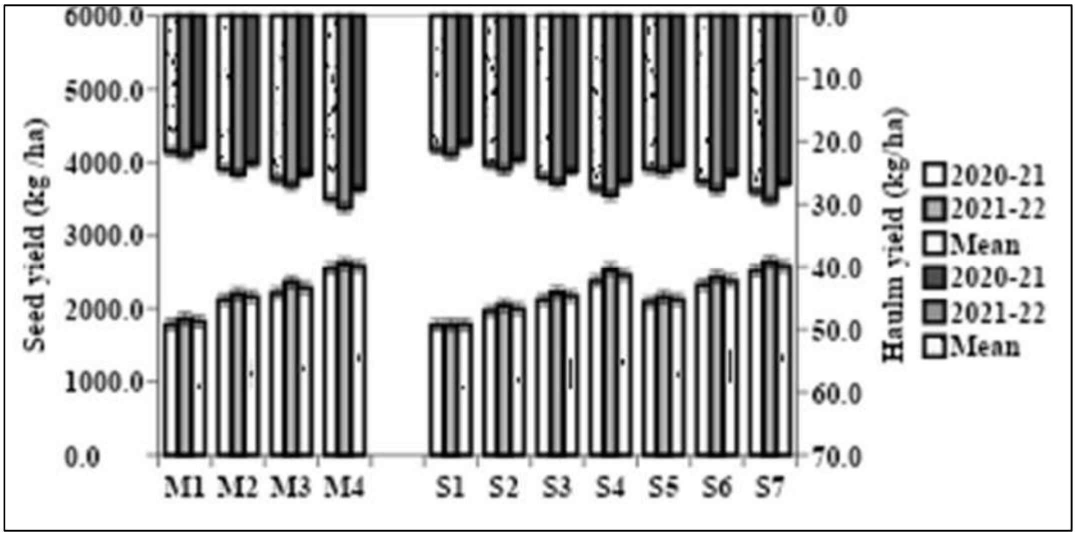
Methodology

A field experiment was conducted at Main Farm, Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University, Hyderabad to evaluate the performance of planter under varied seed rate and nutrient management in chickpea. Experiment was laid in split plot design with four seed rates (52, 70, 77 and 105 kg/ha) in main plots with corresponding planting density (2.22, 2.96, 3.33 and 4.44 lakh plants/ ha) and seven nutrient management practices as sub-plots. The nutrient management practices were S_1- Absolute control (0- N, P and K), S_2- 75 % RDF, S_3- 100 % RDF (20:50:20 N, P_2O_5 and K_2O kg/ha), S_4 -125 % RDF, S_5- 75 % RDF + Microbial consortia (MC) - *Azotobacter* + Phosphorus solubilizing bacteria + Potassium releasing bacteria+ Zinc solubilizing bacteria @ 5 kg/ ha, S_6- 100 % RDF + MC and S_7- 125 % RDF + MC and replicated thrice. Total P (Single super phosphate), K (Muriate of potash) and 50 % N (urea) were applied as basal while, remaining 50 % N was top dressed 30 days after sowing. The soil of the experimental plot was sandy clay loam. The land was prepared with disk plough. Recommended crop management practices were adopted

Results

Planter performance parameters: Mean seed spacing was measured using 16 and 18 cells seed metering plate along each planted row and was 9.4 and 7.9 cm as against theoretical spacing of 10 and 7.5 cm during 2020-21 and 9.5 and 7.5 cm during 2021-22. Mean seed spacing was within range of optimal theoretical seed spacing of 10 and 7.5 cm (Singh *et al.* 2012). Miss index was 11.31 and 10.25 % for 10 cm while, it was 7.21 and 6.00 % for 7.5 cm spacing during 2020-21 and 2021-22 respectively. This level of miss index could be due to different factors like seed metering plate, failure of metering plate to be filled with seeds, clogging of seeds in the metering plate and failure in dropping holes while multiple index ranged between 4.89 and 4.51 % for 10 cm spacing and it was 5.12 and 5.19 % for 7.5 cm during 2020-21 and 2021-22 respectively. This result might be a result of seed dropping from the metering plate or from drop tube (Kumar, 2019). Field capacity was calculated considering the productive time required for field operation and was 0.41 and 0.38 ha/ h while, the effective field efficiency was 77.35 and 71.70 % during 2020-21 and 2021-22 respectively. The effective field capacity depends on the planter operational speed and theoretical width covered by implement. The values indicate a satisfactory performance as they were within the range.

Seed and haulm yield*:* Significantly higher seed and haulm yield were registered with seed rate of 105 kg/ha (Fig.1) due to optimum plant number per unit area over corresponding lower seed rates (Patil *et al.* 2021). Among the nutrient management practices, application of 125 % RDF + MC resulted in significantly higher seed and haulm yield but, was on par with 125 and 100 % RDF + MC. Higher yields in 100% RDF and microbial consortia was due to adequate amount and available form of nutrients that favored better root growth and development and nutrient uptake (Sangma and Changde, 2020).



Seed and haulm yield of machine planted chickpea under varied seed rate and nutrient management

Conclusion

The performance of CIAE inclined planter was better with inter row spacing of 30 cm and intra row spacing of 7.5 cm with a seed rate of 105 kg/ ha. This spacing was suitable for mechanisation. Among nutrient management practices, conjunction of lower rate of inorganics along with biofertilizers realised higher yields.

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UID: 1066

Evaluation of Broad Bed and Furrow Opener on Growth and Yield of Pigeonpea in Rainfed Conditions of Karnataka

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In order to take full advantage of annual precipitation in dry land agriculture, harvesting entire runoff is essential. Farmers in dry land areas have been using traditional and outdated farm equipments which not only perform poorly but also demand a lot of energy and time and post-harvest operations. Lower number of rainfall events with high intensity storms is forecasted due to climate change effects (Kevin, 2011); Rainfall of high intensity causes excessive loss of soil through erosion which leaves the soil infertile. Farmers lack resources, tools become inefficient and ultimately productivity is low. In the arid and semiarid regions, the conservation of precipitation water for crop production is very vital. In dryland crop production areas, a major challenge is to conserve precipitation water appropriately for use during crop growth (Baumhardt and Jones, 2002).

Water harvesting and *insitu* moisture conservation at basin, area, field or micro level can bring sustainability to the water sector and, consequently, increase water availability in drought years. Hence, to increase the moisture availability to the agricultural crops in the individual farmer's field and to facilitate increased infiltration and percolation of rain water into the root profile, also to drain-out the excess runoff from the agricultural lands Broad Bed and Furrow (BBF) techniques are recommended. Maurya and Devadattam (1987) reported that the moisture availability, crop yield and cost benefit ratio were higher for the broad bed and furrow system than the flat bed system. With the above background, the present investigation was carried out to study the effect of broad bed and furrow opener on growth and yield of Pigeonpea in rainfed conditions of Vijayapur district.

Methodology

A field experiment was carried out during the *kharif* season of 2021-22 to 2023-24 under the Northern Dry Zone of Karnataka at All India Coordinated Research Project for Dryland Agriculture of Vijayapura district. The slope of experimental site is 0.75 to 1.25 per cent. The Pigeonpea variety selected for the study ware GRG 152 and TS 3R. The experiment was conducted with five treatments (Main plots: G_1: TS- 3R, G_2:GRG-152, Sub plots: S_1: 90 cm spacing with BBF planter, S_2: 120 cm spacing with BBF planter, S_3: 180 cm spacing with BBF planter, S_4: 120 cm spacing with ordinary planter, S_5: Flat bed sowing (control)). Broad bed and furrow opener was designed and developed at CRIDA Hyderabad. The experimental field was brought to optimum tilth by ploughing twice with tractor drawn mould board plough, followed by harrowing twice and ploughing. Broad bed and furrows were prepared using tractor drawn BBF opener attached with seed drill. Also the flat bed was made in the plot without forming any barrier to harvest rainwater and provision was made in the field to dispose excess surface runoff from all the treatments. The remaining cultivation practices were followed as per the package of practice of UAS, Dharwad. The soil moisture content was recorded for every 30 days interval at three depths viz., 15 cm, 30 cm and 45 cm in all the treatments.

Pigeonpea was harvested on the first week of February 2022, 2023 and 2024, respectively. Standard procedures were used to measure the yield attributes and yield parameters of Pigeonpea. Significance and non-significance difference between treatments were derived through the procedure provided for a single LSD value (Gomez and Gomez, 1984).

Results

The moisture distribution, during the *kharif* season (2021-22 to 2023-24) is presented in the following Figure 1. At the early stages of the crop growth, highest moisture was recorded at the top layer, however, in contrary, at the end of the season the highest moisture was recorded in bottom layer. Further. The soil moisture was in the range of 14–23 percent. The soil moisture was in stable/increasing trend till August, there after it starts receding.

The Pooled analysis (2021-22 to 2023-24) of the data revealed that the higher seed yield (12.05 q/ha) and BC ratio (2.83) recorded in the GRG-152 variety which is higher than the TS-3R variety. Further, among the spacing, the higher seed yield was recorded (13.33 Q/ha) in sowing at 120 cm spacing with the BBF planter, it was followed by the sowing with the BBF at 120 cm spacing with ordinary planter (12.59 q/ha), in both the cases the yield was significantly higher than the control plot (10.22 q/ha).The interaction of variety and spacing reveals that the highest yield of 13.75 q/ha was obtained in the variety GRG-152 with the spacing of 120 cm.

The highest rainwater use efficiency (RWUE) was conserved in 120 cm spacing with BBF planter (3.52 Kg/ha-mm) as compared with control and other treatments (Table.1).

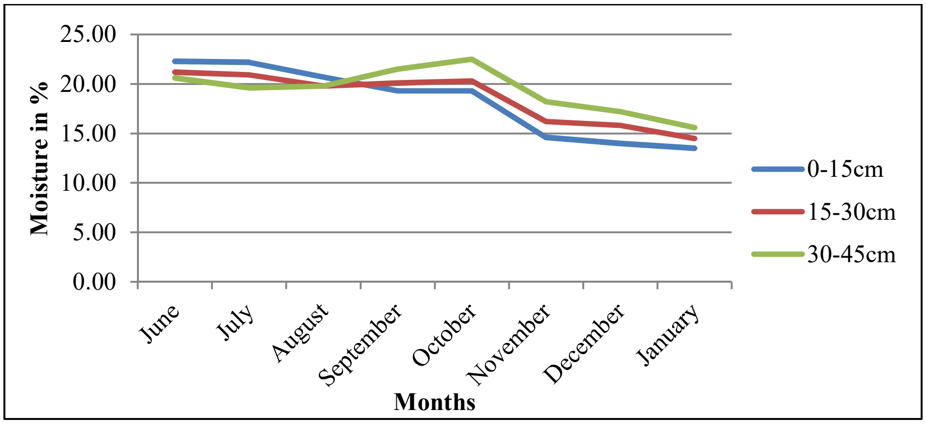

Fig.1: Soil moisture distribution in Pigeon Pea

Table 1. Variety and spacing wise yield in the pigeonpea crop in BBF

Varieties	Seed yield (kg/ha)				Mean of B:C	Mean of RWUE (kg/ha-mm)
	2021-22	2022-23	2023-24	Mean		
G_1	1229	1605	463.8	1125.2	2.60	2.89
G_2	1287	1769	579.6	1205.8	2.83	3.22
SEm±	11	27	30.29	22.73	0.45	0.27
CD	NS	163	NS	NS	NS	NS
Spacing						
S_1	1118	1588	519.3	1060.4	2.66	2.9
S_2	1429	1952	620.8	1333.3	3.19	3.6
S_3	1227	1669.5	473.5	1123.5	2.58	2.9
S_4	1388	1916	561.3	1259.4	2.95	3.4
S_5	1129	1460	433.8	1022.3	2.57	2.6
SEm±	36	43	29.651	36.14	0.19	1.31
CD	107	130	88.855	108.61	0.57	NS
Interaction						
G_1S_1	1115	1546	469.6	1036.8	2.54	2.79
G_1S_2	1396	1922	559.3	1267.1	3.08	3.38
G_1S_3	1201	1602	401.3	1068.1	2.60	2.80
G_1S_4	1359	1883	518.3	1285.7	2.92	3.35
G_1S_5	1074	1462	370.6	968.8	2.42	2.52
G_2S_1	1121	1630	569.0	1106.7	2.59	2.96
G_2S_2	1462	1982	682.3	1375.4	3.13	3.58
G_2S_3	1253	1737	545.6	1178.5	2.63	3.00
G_2S_4	1417	1949	604.3	1292.8	2.93	3.47
G_2S_5	1183	1458	497.0	1052.7	2.47	2.72
SEm±	47.2	61.6	48.213	51.91	0.20	0.15
CD	NS	NS	NS	NS	NS	NS

Conclusion

Broad bed and furrow opener is helpful in conserving soil moisture which intern increases yield. In the present study GRG 152 variety with BBF planter 120 cm spacing followed by GRG 152 variety with ordinary at 120 cm of pigeonpea recorded higher yield. Also the highest B:C and net returns were recorded in GRG 152 variety with 120 cm BBF planter.

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UID: 1070

Women Empowerment through Mechanised Seeding in Rainfed Rice Cultivation

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Rice is grown on 1.39 lakh hectares under rainfed conditions in Ramanathapuram district of Tamil Nadu, which often turn semi-dry. This district is prone to drought, marked by erratic rainfall, delayed monsoons, intermittent droughts, and terminal moisture stress. Broadcasting of seed is the major practice to complete the sowing in time one week before the onset of monsoon. Primary tillage operation is done with 5 tyne cultivator to enhance the depth of plough sole layer for water harvesting and secondary tillage operation is done after broadcasting of seeds. Around 40 to 60 per cent of seeds are placed below 7-10 cm, 10-15 percent of seed are placed above the soil surface, and only 25-50 percent of seeds are placed at right depth and support good germination and are able to tolerate moisture stress. Higher seed rate of 125 kg/ha is used; this higher seed rate results in higher plant population which leads to higher crop competition and low productivity. Alternative method is use of tractor drawn seed drill for sowing which is less than 5 percent of area in this district. This low adoption is due to lack of skilled tractor operators and lack of availability of tractor drawn seed drill during peak season.

In Ramanathapuram district in Tamil Nadu 85 % of field operations were carried out by the women in rice cultivation. Mono cropping of rice provides employment only for the women for a period of 120 to 140 man days per year in their rice cultivation. The major problems in rice cultivation were lack of mechanisation especially for timely sowing. To overcome this problem the KVK, Ramanathpuram used modified drum seeder that enables pre-monsoon sowing at right time, depth and right seed rate so that overall productivity of rainfed rice is increased and this has an additional advantage of employment generation and additional income for the women by organising training, demonstration, advisory and supply of modified drum seeder.

Methodology

The study was conducted to assess the effectiveness of modified drum seeder (T_3) and this implement was compared with broad casting (T1) and tractor drawn seed drill. The existing drum seeder, was modified. The originally designed drum seeder used in wetland conditions, includes an attachment that ensures the use of the correct quantity of seeds. and are placed at the proper depth and adequately covered, promoting better germination and support for higher yield and income.

Results and Discussion

Crop performance by the modified drum seeder

The results indicated that pre-monsoon sowing of hardened seeds using a modified dry drum seeder @ 50 kg/ha resulted in higher germination (94 %) percentage, optimum plant population of 52.00 m^2, more productive tillers (583.00m^2), and higher yield of 5214 kg/ha. and higher net income (Rs.77,122/ha) and BCR (2.80).

Employment and income generation by the women farmers:

Experience and upgraded skill on mechanized seeding, women group has been formed as clusters and three groups have been formed in two blocks (2023) and engaged for sowing under semi-dry condition during samba season and these women farmers supported other fellow farmers and earned an income of Rs.1000/acre and generated a minimum of Rs.20,000/cluster/week and earned Rs.50000/cluster with the employment of 25man days.

Effect of method of sowing with different seed rate on growth and yield characters

Treatments	Plant population (Nos/m^2)	No. of tillers/m^2	No. of productive tillers/ m^2	No. of filled grains/panicle	Grain yield (kg/ha)
T_1	68	623	428	142	3426
T_2	56	680	562	168	4719
T_3	52	657	583	196	5214
SEd	2	8	6	2	112
CD(p=0.05)	5	14	13	5	186

Two clusters achieved the economic benefits of Rs. 1,00,000 and employment generation of 50 man days. This created confidence among the women farmers to adopt drum seeder in more farmers' fields as an entrepreneurship. It will add support for the women farmers and earn higher income and employment in the year. The contribution of women is very high in the farm sector as they are involved in the majority of farm operations (Singh, 2009). Hence it is essential that the tools and implements for farm women are developed to suit their body posture (Mishra et al., 2016).

Conclusion

Using the appropriate sowing tool of modified dry drum seeder, combined with pre-monsoon sowing, the application of EPOE herbicide (Bispyribac sodium at 250 g/ha), and the recommended fertilizer dose is crucial for achieving optimal plant populations and higher yields. This approach ultimately leads to greater economic returns in rainfed rice cultivation and provides valuable support for women farmers and also provides employment opportunities for women and serves as a climate-resilient practice

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UID: 1090

Non-Invasive Seed Priming Strategies for Vegetable Seeds

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Vegetables, in addition to cereals and pulses, play a pivotal role in fulfilling the dietary requirements of human beings. The major constraints for higher productivity in vegetables include higher incidence of abiotic and biotic stresses, an inadequate availability of quality seeds and the non-affordability of expensive seeds. The attempts for sustainable production through the use of chemicals has disastrous repercussions on the environment and human health.

Seed priming is a promising strategy to provide a valuable solution to enhance the planting value of vegetable crops. During priming seeds are treated before sowing which allows their controlled hydration. Seeds undergo the first stage of germination without radical protrusion. It alleviates the stress at the germination stage and ultimately results in the successful seedling establishment under an abiotic stress environment. Primed seeds shows enhanced germination rate, early and uniform germination, improved growth attributes, faster emergence and better establishment of crop stand.

Priming Techniques

Priming techniques categorized into invasive and non-invasive based on the property of the technique to bring about changes in the seed coat and endosperm/cotyledon. Invasive techniques are wet treatments; include hydro, osmo, hormonal, halo, solid matrix, nutrient, bio and nano-priming. Invasive methods do not allow bulk seed treatment and are not environment friendly as chemical waste is generated. Nevertheless, they are cost effective treatments (Thakur *et al.,* 2022). Some of the invasive pre-sowing techniques involve the seed to be hydrated, thereby improving germination at the cost of seed storage. Such seeds cannot be stored for longer periods and have to be sown immediately after the treatment.

Non-invasive methods make use of numerous technologies such as exposure to magnetic field, UV rays, γ-rays, cold atmospheric plasma, low energy electron beam and laser beam. These

recommended in the package of practices for organic farming. The unfavourable feature of these methods is that the cost intensive installation and skilled personnel are required to operate the instruments.

Non-invasive seed priming methods

Different types of non-invasive priming methods and its mode of action tabulated and presented in Table.

Magnetopriming

Magnetopriming is a dry seed priming treatment that has been widely used to enhance seedling vigor and plant growth under various environmental cues. Ahmad *et al*. (2007) suggested that magnetic field (MF) perception/signalling in plants is mediated by the blue light photoreceptors – cryptochromes. Interesting feature of MF treatments is that they appeared to enhance tolerance to biotic or abiotic stresses as result of the antioxidant response activation.

Increased antioxidant enzyme activities of superoxide dismutase (SOD), catalase (CAT), and glutathione reductase (GR) were described in magneto-primed cucumber (*Cucumis sativus* L.) seeds (Bhardwaj *et al*., 2012). Consequently, MFs-treatments have the additional potentiality to be used for minimizing the drought- or disease-induced adverse effects on crop productivity. Environmental factors such as light, humidity and temperature are implicated in modulating seed performance but the impact of their combined application with MFs remains unclear. Poinapen *et al*., 2013 studied how the combined impact of MFs and interdependent factors affected seed viability and performance in tomato (*Solanum lycopersicum* L. var. MST/32) under laboratory conditions. Relative humidity showed to be key factor modulating seed performance in magneto-primed seeds, especially during early stages of seed germination/imbibition.

Mode of action of different types of non-invasive methods in seed priming

Non-invasive method	Mode of action
Magneto priming	Cryptochrome acts as a magnetic field receptor and generates flavin-tryptophan radical pair which alters the enzyme reactions
UV irradiation priming	Dissociates UVR8 dimer leading to expression of COP1 protein, which activates HY5 gene expression involved in photomorphogenesis
γ-radiation priming	High penetration power of rays leads to increases production of ROS which acts as signaling molecules to elicit an antioxidant response
Cold atmospheric plasma priming	Cold plasma generates ROS and RNS which interact with the seed coat and induce cracks that help in water imbibition
Low energy electron beam (LEEB) priming	Generates ions by action of accelerated electrons to remove electrons from atoms or molecules
Laser priming	Capture of light energy by the seeds which is transformed into chemical energy and is utilized for growth and development

UV irradiation priming

UV radiations are divided into three categories: UV-A (320-400 nm), UV-B (280-320 nm) and UV-C (200-280 nm). UV-C radiation is non-ionizing and it penetrates superficially into the plant tissues, supports its potential as a germicidal agent. Seed treatments with low doses of UV-C (3.6 kJ m^{-2}) were used to elicit host resistance to black rot in cabbage (*Brassica oleracea* L.). This UV-C seed treatment also improved the quality and growth response of cabbages under greenhouse conditions. In another study lettuce seeds treated with UV-C of 0.82 and 3.42 kJ m^{-2} doses, results showed that UV-C treated seedlings were able to mitigate the impact of excessive salinity, possibly as result of the enhanced free radical scavenging activity detected in their leaf tissues. Exposure to UV-B radiation shown DNA damage, proteins and membranes injury which limits photosynthesis and plant growth. Also, UV-B exposure resulted in reduction of root and shown growth. UV-A treatment stimulated germination rate as well as seedling performance reflected in the values of specific leaf area, root and shoot length and dry weight. Positive effects of UV- A and UV-C radiation have been highlighted on seed germination/seedling vigour, as well as, seed health.

γ-radiation priming

Gamma (**γ**) radiation priming involves treatment of seeds with low doses of high-energy ionizing gamma rays. These rays possess high penetration power, as a result of which they interact directly with several cell components of the living tissues. These interactions of gamma rays affect nucleic acids, cell membranes and proteins. Gamma rays act as a 'priming agent' at low doses resulting in improved germination and establishment of seedlings under optimal and suboptimal conditions. At the cellular level, low doses of gamma rays increase cell proliferation, growth, and impart stress tolerance leading to enhanced growth and crop production

Cold atmospheric plasma priming

Cold atmospheric plasma involves the mixture of ionized gas, electron, positively charged particle, and neutral gas. Cold plasma is generated when a gas molecule uses external energy to overcome the barrier of electrostatic potential so as to get ionized. Cold plasma is widely applied in biological science as it contains substantial particles with lower temperatures as compared to the electron. Cold plasma creates a variety of reactive oxygen/nitrogen species (ROS and RNS) that interact with the seed coat and induce cracks on the surface which help in water imbibition. This leads to dormancy release and more rapid process of seed germination.

Low energy electron beam priming

A low-energy electron beam (LEEB) is a form of ionizing radiation that is applied in the range of a few to approximately 300 kGy. The low-energy electron beam generates ions by the action of accelerated electrons to remove electrons from atoms or molecules. Therefore, a cathode is required in a vacuum environment so as to produce electrons which are accelerated close to the speed of light during electron beam irradiation. Hertwig *et al*. (2018) used LEEB treatment for disinfecting wheat in biological farming.

Laser priming

Seed priming with low intensity of laser light exerts a photobiomodulation effect which is based on the synergism between the photoreceptors and the polarized monochromatic laser beams. Seeds when irradiated with low-intensity laser light, result in their biostimulation that enhance seed germination, vegetative mass, photosynthesis and crop yield. Laser priming involves capture of light energy by seeds which is further transformed into chemical energy that is utilized for growth as well as development. Laser priming of seeds results in stimulation of plant growth, reduction in germination time which ultimately leads to enhanced yield. The laser irradiation may also interact with the gene associated with chlorophyll biosynthesis, mainly involved in the synthesis of protochlorophyllide. The repairing role of red laser has also been reported that enhances the physiological characters in the plants exposed to various abiotic stress conditions such as salinity, drought and UV-B induced stress.

Conclusion

Commercial vegetable production is an organized sector with/without the primary requirement of transplants for growing vegetable crops. Besides direct-seeded crops, the traditional method of raising seedlings in the nursery for transplantation of vegetables is widely used to grow the crops in the field or polyhouse. The disadvantage of the traditional method is that not all seedlings are fit to be transferred as they are non-uniform and emerge later. The effects of non-invasive priming treatments in seeds can be now addressed at multiple levels, ranging from morpho-structural aspects to changes in gene expression and protein or metabolite accumulation in comparison to traditional methods. For all mentioned non-invasive priming treatments, extensive fundamental and applied research is still needed to define the optimal dose, exposition time, genotype- and environment-dependent irradiation conditions.

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Energy Requirement for the Pre-Kharif and Kharif Crops for Upland Situation of North Bank Plain zone (NBPZ) of Assam

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The intensification of mechanization in agricultural activities is one of the most important factors for increasing the production and cropping intensity. Energy is one of the most valuable inputs in any agricultural system comprising all the farm activities from land preparation to post harvest management. The farming operations in crop production require energy inputs in various forms and in varying magnitudes. In agriculture, the input energy is categorised into direct and indirect input energy (Patel, et al., 2014). The direct energy includes the energies required to perform tasks such as land preparation, irrigation, intercultural operations, threshing, harvesting and transportation of agricultural inputs for farm produce (Singh, 2000). The efficient use of energies helps to achieve increase in production, productivity and hence contributes to the economy, profitability and competitiveness of agriculture sustainability (Ozkan et al., 2004 and Singh et al., 2002). The energy input in any crop production varies with the cropping systems (Soni et al., 2018). The energy assessment becomes an important aspect in India, where there are multiple agro-ecologies and multiple cropping systems in a single agro-ecological region (.Dey et al., 2024). The farms using higher energy input were in a better position from the viewpoint of both energy use efficiency and benefit-cost ratio than that of farms without mechanization and fertilize use (Neog et al., 2015). There is a need to determine the energy use efficiency for the upland situations of north bank plains zone of Assam. Thus, keeping in view of the above, a study was conducted with an objective to estimate and determine the total input energy requirement, total output energy obtained from the two major cropping systems of the region, i.e., pre-kharif paddy and maize, followed by kharif pulses under rainfed conditions.

Methodology

The experiment was conducted at the research farm of AICRPDA (All India Coordinated Research Project for Dryland Agriculture) Biswanath Chariali centre with a latitude of 26°43'32"N and longitude of 93°08'01"E at an altitude of 86.7 m at Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali during 2022-23 and 2023-24. The area falls under the Agro Climatic Zone (NARP) North Bank Plain Zone (NBPZ) and Agroecological subregion (NBSSLUP) Hot Humid Alluvial Plain. The experiment comprised of two cropping sequences (Ahu rice followed by green gram and Maize followed by green gram) under rainfed conditions at upland situation of Assam. The experiment was laid out in Factorial RBD (Replicated Block Design) with two treatments in three replications. The treatments were categorised as conventional method (farmer's practice) of farming and mechanization at critical operations of farming. The gross area of the experimental plot was 2500m^2 and net area of 2400 m^2 with individual treatment of 10m × 10m. The soil texture was sandy loam (30cm depth) with low water holding capacity (16.2 %). The field capacity, permanent wilting point and bulk density of the soil were 21.52 percent, 4.78 percent and 1.21 g cc^{-1}, respectively. The soil was acidic with a pH of 4.70 and EC of 0.001-0.026 dSm^{-1} and medium in available organic carbon, N, P_2O_5 and K_20 (0.66%), (313.60 kg ha^{-1}), (43.23 kg ha^{-1}) and (134.21 kg ha^{-1}) respectively.

Results

1. The farm implements used for mechanized cultivation of both rice based and maize based cropping systems were disc plough, disc harrow, cultivator, rotavator and the conventional bullock drawn plough used during land preparation only. The intercultural operations were performed mostly by wheel hoe in mechanized plots and manually in non mechanized plots and other operations (harvesting) were performed manually.

2. The energy use efficiency was highest in maize (5.344) followed by ahu paddy (2.902), greengram (2.025), potato (1.856) and lowest in toria (1.534). The highest energy productivity (Kg/MJ) was in potato (0.516) followed by maize (0.364), ahu rice (0.198), greengram (0.138) and lowest in toria (0.104) in the crops grown as pre-kharif, kharif and rabi based on the season. It was observed that the yield (Kg/ha) and output energy (MJ/ha) is directly proportional to the input energy (MJ/ha) whereas, the energy ratio and energy productivity were not directly proportional to the input energy.

Effect of treatments on energy use efficiency for 2 years (2022-23 and 2023-24)

Crops	Treatments	Input energy (MJ/ha), '000	Output energy (MJ/ha), '000	Energy ratio	Energy productivity (Kg/MJ)
Ahu rice	Farmer's practice	7.808	23.630	3.026	0.206
	Partial mechanization	9.176	25.482	2.777	0.189
Maize	Farmer's practice	7.709	43.446	5.636	0.384
	Partial mechanization	10.274	51.906	5.052	0.344
Greengram	Farmer's practice	4.667	9.186	1.969	0.134
	Partial mechanization	5.499	11.442	2.081	0.142
Potato	Farmer's practice	17.483	32.193	1.842	0.512
	Partial mechanization	20.048	37.494	1.871	0.520
Toria	Farmer's practice	7.577	10.525	1.390	0.095
	Partial mechanization	8.409	14.112	1.679	0.114

Conclusion

Mechanization of critical operations was better in terms of energy ratio and energy productivity, in all the crops except the pre-kharif ahu paddy and maize as compared to Farmers practice. This is due to the timely operation like land preparation and other intercultural operations in partial mechanisation as compared to the farmers practice. The cropping sequences (C_1: Rice-green gram-toria; C_2: Rice-green gram-potato; C_3: Maize-green gram-toria; C_4: Maize-green gram-potato) performance was better as compared to the farmers' practice.

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Millets in The Nation's Food Chain

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India is the largest producer of millets with 40% of the world's production and second-largest supplier of millets (Gowri and Shivakumar, 2020). India produces around 17.3million MT of millets annually. The millets market is set to grow from its current market value of more than $9 billion to over $12 billion by 2025. The major millet producing states in India are Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, Haryana, Gujarat, Madhya Pradesh, Tamil Nadu, Andhra Pradesh and Uttarakhand. Currently, together these ten states account for around 98 per cent in Millet's production in India during 2023-24. Millets are known as *miracle grains or crop of the future* since they are ecologically sustainable crops. FAO declared 2023 as the "International Year of Millets," with an objective to increase millet productivity and production worldwide. The Indian government also proclaimed 2018 as the "National Year of Millets."

Millets are rich in minerals, nutraceuticals and have higher dietary fibers as compared to wheat protein (9-14%), carbohydrates (70-80%) and good presence of vitamins and minerals.

Primary processing of millets:

Primary processing was carried out on the grains at producers' level or in the vicinity of the farm which improves grain quality / transforms the grain into more useful form. Cleaning, Dehulling, Sorting, Polishing/ Pearling, Grading, Size reduction/grinding, Drying are the steps involved in primary processing.

Secondary Post harvest operations:

Unit operations that are carried out on grain either directly or after primary processing, that transform the grain into products generally for direct consumption. They are done usually away from farm either in unorganized or in organized sectors. Puffing, Baking, Milling, Flaking and Value added products of millets.

Machines for processing:

Grain Pre-Cleaners, Destoner – Grain Cleaner , Jowar polisher , Ragi Pearler , Millet Rice Polisher , Flour Mills , Dehuller , Separator and sorter are required for primary processing and Twin Screw Extruder machine, Flaking machine, Grain roaster pasta machine, food blender, oven ,Kneader etc are reuired for secondary processing.

Food products of millets:

Roti with single flour or multi grain, fermented foods (idli, dosa utappa,ganji) papads are conventional foods. While millet flakes, puffing or popping, malt, noodles vermicelli, pasta, bakery products such as breads, cookies, muffins, cakes , pizzas, burgers etc are non conventional foods.

Table 1. Nutritional composition of millets

Millets	Carbohydrates(g)	Protein(g)	Fat (g)	Energy (Kcl)	Fibre (g)	Ca (mg)	P (mg)	Mg (mg)	Zn (Mg)	Fe(mg)	Thiamine (mg)	Riboflavin(mg)	Niacin (Mg)	Folic acid(mg)
Sorghum	67.7	9.97	1.7	334	10.2	27.6	274	133	1.9	3.9	0.4	0.1	2.1	
Pearl millet	61.8	10.9	5.4	347	11.5	27.4	286	124	2.8	6.4	0.3	0.2	0.9	
Finger millet	66.8	7.2	1.9	320	11.2	36.4	210	146	2.5	4.6	0.4	0.2	1.3	
Kodo millet	70.4	8.9	2.6	331	6.4	15.3	101	122	1.6	2.3	0.3	0.3	1.5	
Proso millet	60.1	12.5	1.1	341	8.5	14.0	206	153	1.4	0.8	0.4	0.1	4.5	
Foxtail millet	60.1	12.3	4.3	331	6.7	31.0	188	81	2.4	2.8	0.6	0.1	3.2	
Little millet	65.5	10.1	3.9	346	7.6	16.1	130	91	1.8	1.3	0.3	0.1	1.3	
Barnyard millet	65.5	6.2	2.2	307	12.6	20.0	280	82	3.0	5.0	0.3	0.1	4.2	

Major Initiatives by Government for production and consumption of millets

- The Government, under the Sub Mission on National Food Security Mission (NFSM) - Nutri-cereals, is creating awareness among farmers for Nutri Cereals (Millets).
- NITI Aayog signed a Statement of Intent (SoI) with United Nations World Food Program (WFP) focuses on mainstreaming millets and supporting India in taking lead globally.
- The Central Government has requested State Governments/Union Territory Administrations to explore the possibility of introducing millets under the PM POSHAN Schem**e.**
- Millet Village Scheme: The 'Millet Village Scheme,' was initiated during 2017-18 by the Government of Kerala.
- The Nutrihub-Technology Business Incubator (TBI) was established in 2017 at ICAR-IIMR, Hyderabad to strengthen and support the millet-based startup ecosystem with funding from DST and RKVY-RAFTAAR . It is currently assisting more than 200 millet-based startups.
- Three Centers of Excellence (CoE) on millets have been established, with support from the Department of Agriculture and Farmers' Welfare, at ICAR-IIMR in Hyderabad, Chaudhary Charan Singh Haryana Agricultural University, Hisar, and University of Agricultural Sciences, Bengaluru.
- The Odisha government assisted the farmers with different schemes (OMM, Mission Shakti) which are run from the time of 2017 a way back when 2023 was declared as the International year of millets.
- The Karnataka Organic Farming Policy was created to support the advancement of organic farming and the promotion of millets.

Policy Advocacy

- Minimum support price should be announced to cultivate millets and the processed millets should be available at the Public distribution system which can be facilitated by local FPO/ SHGs.
- Research funding should be enhanced on production, consumption and manufacturing simple processing units of the millets.
- Special attention should be given in establishment of millet enterprises in Pradhan mantri formalization of Micro Food Processing Enterprise.
- Launching a nationwide initiative to raise awareness about the nutritional benefits of millets.

Conclusion

Millets are nutritionally rich as compared to other cereals, so product development by processing and using millets have undisputable prospects with respect to health benefits, nutrition and quality. Simple processing techniques at the ground level by the support of the government consumption of the millets can be doubled which will have a positive impact on improving the cultivation of millets, global environment and income of rainfed farmers.

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Performance Evaluation of Tractor Drawn Planter and Intercultivation Implement in Castor

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Castor is an important non-edible oilseeds crop having multifarious industrial applications. Castor seed oil and its derivatives are used in manufacturing of several industrial products including paints, coatings, inks and lubricants. In India, castor is cultivated in an area of 0.75 million hectares, which accounts for 65% of the world's castor acreage. India produces 1.2 million tonnes of castor seed per annum contributing to more than 85% of the world's castor production (FAOSTAT, 2019). However, in the recent past farmers are diversifying to castor crop from other rainfed crops viz., groundnut, pigeonpea, and millets due to high remunerative prices to castor in the market for the last 3 years. With the increase in manpower paucity, farmers cannot take up the operations in time. To advent with the manpower scarcity in the season and to reap higher harvestable basket adoption of mechanization is the trek in rainfed areas. In recent years the area under castor is increasing in rainfed areas of Rayalaseema region of Andhra Pradesh. Cost of cultivation of castor is increasing gradually in all regions and labour shortage is acute. Based on the above conditions there is every need for development or modification of existing planter and intercultivation equipment in castor production.

Methodology

Tractor drawn three row Ananta planter and intercultivation equipment was designed and developed at AICRP for dryland Agriculture, Agricultural Research Station, Ananthapuramu. Castor crop was sown for three years from 2012-13 to 2014-15 during Kharif season. An amount of 380 , 415 and 300 mm rainfall was received in 28 , 19 and 20 rainy days from 2012 -13 to 2014-15 respectively. The components of the seed planter include seed hopper with shutter adjustment, inclined metering plate, drive (ground) wheel, guide wheel, discharge spout, furrow opener (shovel), covering device, hitching system and the handle. Ananta planter consists of a hopper box for seed, ground wheel drive mechanism, mounting frame, seed tubes and seed metering plates. The seed rate is controlled mechanically through ground wheel drive which in turn rotates the inclined plate through a set of bevel gears. A 5 cm width covering blade is also fitted behind the furrow openers to cover the furrows after seed placement. Since the row to row spacing of the castor crop is 90 cm, weeding and intercultivation was done by Tractor drawn weeder which is an extra blade attachment to the cultivator. Intercultivation was done once at 45 days after sowing.

Results

Ananta planter maintains the recommended seed rate of 5 kg/ha (Hybrids) with a spacing of 90X60 cm and required plant population. The seed damage is negligible and placement of seed is at proper depth of 4-5 cm. The field capacity is 6 to 7 ha/day and can cover large area before the soil moisture is dried up. Its cost of operation is Rs. 825 per ha. The germination and plant population was higher. The developed castor planter with inclined plate seed metering mechanism having three cells on seed plate, recorded seed rate of 5 kg/ha with mean B.C ratio of 4.85 and Rain Water Use efficiency of 2.69 kg/ha-mm (Table 1) . The tractor drawn intercultivation helps in the weed removal up to 96% and field capacity was 0.3 ha/hour with depth of operation 5–6 cm. The cost of intercultivation with tractor is Rs.400 per ha. whereas with the bullock drawn intercultivation the coverage is 2 ha per day and cost of intercultivation is Rs.1400 per ha. The percent weed removal with bullock drawn intercultivation is 90 %. By introducing this technology the field capacity is doubled and timely weeding can be completed. Women drudgery is reduced considerably. An amount of Rs.1000/ha can be saved with this technology compared to farmers' practice. Vaishnavi *et al*., (2017) developed a pull type planter with inclined plate metering mechanisms for maize, red gram and castor crops to reduce seed damage. Kumar Naik et al.(2016) reported that mechanized cultivation of castor helped in completing all field operations on time with high precision, besides saving considerable amount of time (490 hrs/ha) and labour (58 man days/ha) to perform different agronomic operations. Subba Reddy *et al*., (1999) indicated that weed control through harrowing gave additional B:C ratio of 1.5 against practice of two harrowing plus one hand weeding.

Design and development of tractor drawn castor planter

S. No	Treatment	Seed yield (kg/ha)				Mean BC Ratio	RWUE (kg/ha-mm)
		2012-13	2013-14	2014-15	Mean		
1	Castor Planter Sowing	220	1075	1026	774	4.85	2.69

Conclusion

Ananta groundnut planter metering mechanism was modified to required spacing of 60 cm for seed to seed and with row to row spacing of 90 cm for sowing castor and intercultivation with tractor drawn intercultivation implement.

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Performance Evaluation of Threshers in Rainfed Groundnut

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In Andhra Pradesh, groundnut is cultivated in an area of 5.55 lakh hectares during Kharif mainly in Rayalaseema region of Andhra Pradesh.In groundnut cultivation, after the crop is harvested, it is heaped and the stripping of pods from the plants is done manually after a period of one month or sometimes more depending upon the availability of labour, involving additional costs on heaping and stripping operations. Besides this, after heaping, the crop is subjected to oil sucking pests and damage occurs to groundnut kernels, impairing the quality of the produce. Hence, threshing/stripping of pods is time consuming, laborious and are cost intensive with traditional operations. To overcome these difficulties the performance of peg type threshers were tested at different moisture contents after harvest of groundnut crop by threshing on different dates after harvest. It was found that threshing of groundnut crop within 5 days after harvest was better in respect of threshing efficiency and capacity. Use of mechanical threshers eases the stripping operation. The costs incurred are also lesser compared to hand stripping. The early threshing operation fetched the farmer to catch highest market price during the crop season. The expenditure incurred on transport of the crop from field and heaping was avoided by use of these threshers immediately after the harvest of the crop. Farmers' income has not been able to keep pace, such as to cater to increasing costs of production including that of rising labour wages. Hence, there is a need for laboursubstituting low cost threshers in groundnut production.In view of this the available threshers were evaluated for groundnut threshing .

Methodology

An experiment was conducted in groundnutwith three varieties to evaluate the pedaloperated stripper, Tractor drawn groundnut Diesel Engine Thresher and High capacity multi crop thresher at AICRPDA, ARS, Ananthapuramu during Kharif 2022 and 2023.K6 , TCGS-1694 and Nithya Haritha varieties were tested for suitability of threshing with High capacity thresher.High capacity Multicrop thresher is a tractor driven Multicrop thresher. Tractor Operated by Multicrop threshers can be run through tractor of 35hp and above. The Multicrop thresher can be operated by coupling to the PTO shaft of any type Tractors.

Results

In manual stripping 40 to 50 kg /day/ person was stripped in groundnut. whereas with pedal operated groundnut stripper 250 to 300 kg / hr was stripped by manual feeding of groundnut plants. The groundnut diesel engine thresher recorded stripping capacity of 500 to 600 kg/hr. The cost of operation comes to Rs. 200 to 250 per quintal of pods. The thresher can be moved from one field to another on pneumatic tyres with a pair of bullock or by a tractor.Whereas, with high capacity multi crop thresher 800 to 900 kg / hr was stripped compared with other threshers. The cost of threshing was less with High capacity multi crop thresher (Rs.100 to 150 per quintal) compared other threshers This thresher is widely popular for other crops like Castor, Redgarm and Bajra. In time and energy management nutshell, the high capacity multi crop thresher is found superior when compare to other threshers for rainfed crop. Among the genotypes of groundnut the per cent broken pods were more with TCGS-1694 (9.2%) compared K6 (2.4%) and Nithya Haritha (2.5%) when threshing was done with High capacity multi crop thresher.With high capacity multi crop thresher both wet and dry pods of groundnut can be threshed in the field itself.Madhusudhana reddy *et al .,* 2020 reported that The cost of cultivation in groundnut can be reduced by Rs.3000 per hectare by using improved tools and machineryagainst traditional practices. As such 25% of cultivationexpenses could be reduced only by mechanization to thedryland farmers.Pavan Kumar Reddy *et al.,* 2022 reported that agricultural labour is 4 and 6 timesless productive than industry and service sectors, respectively and productivity increased by 25% with 65% saving on thecost of cultivation with mechanization when compared to the conventional practice.

Table 1: Performance evaluation of different threshers in groundnut

Threshing type	Engine Capacity	Threshing capacity (kg / hr)	Fuel consumption (lt. / hr)	Cost of operation (Rs/q)
Farmers Practice	-	40 to 50 kg /day/ person	-	600
Pedal operated Groundnut stripper	2 Hp	250- to 300	1 -1.5 (Petrol)	250-300
Tractor drawn diesel groundnut Thresher	8- 10 Hp Diesel Engine	500 to 600	2-3 (Diesel)	200-250
High capacity Multicrop Thresher	45 Hp Tractor	800 to 900	3.5 – 4.0 (Diesel)	100 - 150

Conclusion

In view of increasing costs of production including that of rising labour wages and also coincides with cyclonic rains (October to November) resulting heavy losses in groundnut, threshing with high capacity multi crop threshers is highly remunerative.

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Strip Cropping for Mechanization on Yield, Economic Returns and Water use Efficiency in Finger Millet under Rainfed Condition

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Rainfed farming systems face significant challenges, including irregular rainfall patterns, poor soil fertility, and low crop productivity. Finger millet (*Eleusine coracana*) is a resilient and nutrient-rich cereal crop often grown under rainfed conditions in India, but its yield can be limited when sown late in the season due to reduced soil moisture availability and nutrient uptake (Anirudh and Kumari, 2024). Strip cropping, a crop production technique for mechanization that alternates rows of different crops, has been shown to improve soil moisture retention, yield stability, and nutrient use efficiency (Sanginga & Woomer, 2009; Meena et al., 2018). Intercropping with legumes, such as field bean and cowpea, can enhance soil nitrogen through biological fixation, benefiting companion crops (Sanginga & Woomer, 2009). Additionally, oilseed crops like sunflower and niger in strip cropping systems may offer complementary root architecture and water use patterns, optimizing rainwater use efficiency (Kassam & Brammer, 2013). This study aims to evaluate the effects of various strip cropping combinations on the yield, economic returns, and water use efficiency of finger millet under late-sown conditions, with the goal of identifying resilient cropping strategies for mechanized sowing and harvest under rainfed agriculture.

Material and Methods

A field experiment was conducted at AICRP for Dryland Agriculture, UAS, GKVK, Bangalore (12° 35’ N latitude and 77° 35’ E longitude at 930 m MSL) during 2022, India. The soil at the experimental site is red sandy loam, with low in organic carbon content (0.49%) and available nitrogen (252.9 kg ha^{-1}), medium available phosphorus (84 kg ha^{-1}) and potassium (161.6 kg ha^{-1}) with a slightly acidic and pH (5.40). The experiment was conducted in RCBD design with four replications and six treatments (T1: Finger millet (FM) + Field bean; T2: FM + Sunflower; T3: FM + Rice bean; T4: FM + Cowpea; T5: FM + Niger; T6: FM + Horse gram). Stripes with 21:21 rows (FM: cover crop) were maintained. The water use efficiency was worked out in terms of grain yield/mm water. The observations recorded in these studies were statistically analyzed using analysis of variance (ANOVA) for a randomized complete block design to test the significance of treatment effects on yield, economic returns and soil moisture dynamics in finger millet based stripe-cropping systems.

Results and Discussion

Finger millet grain yield and strip crop yields:

The highest finger millet grain yield (1627 kg ha^{-1}) was recorded in fingermillet + cowpea (T4), this was closely followed by finger millet + horse gram (T6) at 1619 kg ha^{-1}. Field bean (T1) also contributed a relatively high finger millet yield of 1542 kg ha^{-1}, suggesting that leguminous crops in strip cropping might positively influence finger millet productivity. Legumes are known to improve soil fertility by fixing nitrogen, which could benefit companion crops, particularly under nutrient-limited, late-sown conditions (Sanginga & Woomer, 2009; Meena et al., 2018). In terms of strip crop yield, field bean (560 kg ha^{-1} in T1) out performed other strip crops, while niger had the lowest yield (239 kg ha^{-1} in T5). Higher strip crop yields from field bean suggest its better adaptability and productivity in the intercropping system, likely due to its efficient moisture use and complementary growth habits with finger millet (Smith et al., 2008).

Finger millet equivalent yield (FMEY):

Finger millet + sunflower (T2) achieved the highest FMEY of 2462 kg ha^{-1}, followed by finger millet + field bean (2330 kg ha^{-1} in T1). The increase in FMEY for the sunflower combination may be attributed to sunflower's efficient use of available resources under water-stressed conditions, providing a yield advantage when compared to other crops in the strip system (Kassam & Brammer, 2013). However, finger millet intercropped with niger (T5) recorded the lowest FMEY (1869 kg ha^{-1}), which reflects niger's relatively lower yield and possibly less effective resource utilization under the given conditions.

Effect of strip cropping on yield and water use efficiency in finger millet.

Treatments	Finger millet grain yield (kg ha^{-1})	Strip crop yield (kg ha^{-1})	FMEY (Finger millet equivalent yield (kg ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	RWUE (Rainwater use efficiency) (kg ha-mm^{-1})
T_1: FM (Finger millet) + Field bean	1542	560	2330	38752	2.08	4.49
T_2: FM + Sunflower	1475	526	2462	38563	1.96	4.75
T_3: FM + Rice bean	1448	481	2124	31459	1.86	4.10
T_4: FM + Cowpea	1627	445	2183	32664	1.88	4.21
T_5: FM + Niger	1422	239	1869	28046	1.88	3.60
T_6: FM + Horse gram	1619	418	2142	33930	1.98	4.13
S.Em.±	-	-	**29.90**	-	-	-
CD@5%	-	-	**90.14**	-	-	-

Economic returns and benefit-cost ratio (B:C):

The net returns were highest in T1 (FM + field bean) with Rs. 38,752 ha^{-1}, followed closely by T2 (FM + sunflower) at Rs. 38,563 ha^{-1}. These treatments also had the highest BC ratios of 2.08 and 1.96, respectively. The higher economic performance in T1 and T2 can be attributed to the combined yield benefits and market value of both finger millet and high-performing intercrops. The economic advantage of including field bean or sunflower in strip cropping is due to that diversified cropping systems can increase profitability under rainfed conditions (Smith et al., 2008). In contrast, the lowest economic returns (Rs. 28,046 ha^{-1}) and a BC ratio of 1.88 were observed in the finger millet + niger system (T5). The low yield of niger may have contributed to the reduced economic gains, suggesting that niger is less suitable as a strip crop with finger millet under these conditions.

Rainwater use efficiency (RWUE):

Rainwater use efficiency (RWUE) varied significantly among the treatments. The highest RWUE of 4.75 kg $ha\text{-}mm^{-1}$ was observed in the finger millet + sunflower system (T2), indicating that sunflower effectively used available water to produce biomass under rainfed conditions. Conversely, finger millet intercropped with niger (T5) had the lowest RWUE (3.60 kg $ha\text{-}mm^{-1}$), suggesting that niger was less effective in utilizing available water resources. Crops like sunflower, with deep rooting systems, have been reported to efficiently utilize soil moisture, especially in water-limited environments.

Conclusion

The results indicated that strip cropping of finger millet with leguminous crops like field bean and sunflower under late-sown conditions offers substantial agronomic and economic benefits. Field bean and sunflower recorded higher FMEY, net returns, and RWUE compared to other crops, demonstrating their potential to improve productivity and resource efficiency in rainfed cropping systems. Niger, however, was less effective in both yield and economic returns, suggesting limited suitability for strip cropping with finger millet under similar conditions.

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Quality Evaluation of Multipurpose Maize Instant Mix to Explore the Potential for its Commercialization

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In southern region of Rajasthan; maize based culinary items are centrally placed in the menu and there is a possibility of utilizing the charm of maize based recipe to make them popular across the boundaries of the state. Maize is mainly consumed in dry form or as flour preparations. In comparison, use of tender cobs as such or its preparations is much lower which if can be suitably utilized using simple processing techniques for developing convenience and promising products can prove to be remunerative. In turn it will enhance it's off season use. Corn instant maize boor is value added food having wide acceptability particularly in the Rajasthan region and has good shelf life. Multipurpose Maize Instant Mix was prepared by using milky corn cubes.

Materials and Methods

Procedure of Preparation

Fresh corn cobs were peeled and grated, churned, strained and were made to paste without roughages. The paste was roasted in sufficient amount of ghee to golden brown granular mixture and the mixture was packed. Multipurpose maize instant mix samples were stored in PVC bags both room (25±5ºC) and refrigerated (10±2ºC) condition for a period of six months. The nutritional, keeping and sensory quality of the products were assessed at monthly intervals using standard methods (AOAC 1965).

Results and Discussion

The study revealed that acid values and fatty acid content of the multipurpose maize instant mix show a gradual but steady increase in the sample during the entire storage period.. The magnitude of increase in acid value was less in samples stored at low temperature. This chemical change also reflected in slight deterioration of flavour, taste, scores of the dessert prepared from the multipurpose maize instant mix samples stored at room temperature for a period of six months whereas low temperature storage was proved superior in maintaining the palatability of Multipurpose Maize Instant Mix Kheer throughout the experimental period.

The dry maize flour based traditional food items are more frequently prepared during winter season where as corncobs are used for preparations such as vegetable pakoda, pulav were reported to be consumed during the season. 40% families use processed form of maize for its off season use. They prepare boor and store (40%) roast grains (30%) and prepare papdi (40%) for its off season use. Due to the tedious and cumbersome process, the farmers do not prefer to go far processing of tender maize.

Nutrient composition of multipurpose maize instant mix

Nutrient	Multipurpose Maize Instant Mix (g)	Multipurpose Maize Instant Mix Kheer (g)
Moisture	13	59
Protein	5	2
Fat	28.6	6.5
Ash	1.1	0.8
Fibre	2	0.2
Carbohydrate	48	31.0
Energy (k.cal.)	473	190

In a survey on the production, practices and mode of utilization of *mumu*- A traditional ready to eat cereal based food product, 83% of respondents indicated the use of maize as raw material for *mumu* processing and 35% ue sorgum (Ingbian and Apkapunam (2005). Ogi or Pap is local name of a popular western Nigerian semisolid food made from cereals. (Commonly sorgum, millet and maize). It is soaked in water and sugar and/or milk added optionally. It is not only used as breakfast, weaning food and nursing mother to enhance the milk secretion (A folayan et al 2010). Further inquiry from the families preparing and keeping boor reveals that 25%, 50% and 25% of them prepare 250g, 250 to 1kg and >1kg quantity of boor respectively. Here a higher ratio of the subjects keeps it for six months in steel container preferably in the refrigerator. The multipurpose maize instant mix was primarily used by subjects to prepare its kheer using either milk or water or a mixture of water and milk as a reconstitute. In the response of further query most of them expressed their willingness to purchase the product if made available in the market.

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Studies on Preparation of Annona Toffee

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Among annonaceous fruits, Custard apple (*Annona squamosa.*L), Bullock heart (*Annona reticulata*.L) and Cherimoya (*Annona cherimola* Mill.) are important fruits under cultivation (Pinto *et al.* 2005). Custard apple (Annona squamosa L.) is one of the important hardy fruit crop. Custard apple is one of the delicious and nutritionally valuable fruit meant for table purpose. Fruit has soft granular, juicy and sugary pulp with mild flavour and slight acidity. Custard apple is a climacteric fruit and ripens within 3-5 days after harvest and its shelf life is very short (Chadha, 2006). The atemoya (*Annona atemoya*) is a hybrid of two fruits sugar apple (*A.squamosa*) and Cherimoya (*A. cherimoya*). An atemoya is normally heart–shaped or rounded, with pale-green, easily bruised, bumpy skin. The flesh is not segmented like that of sugar –apple bearing more similarity to that of cherimoya. It is very juicy and smooth tasting slightly sweet and a little tart. To utilize the large quantities of the fruit produces during the glut periods, it becomes necessary to explore alternate commercial methods for its utilization

Toffee is one of the confectionery products, it is reported that pulpy fruits can be utilized for preparation of toffee, such fruit toffee naturally are very nutritious as they contain most of the constituents of the fruit from which they are prepared (Jain *et al.* 1985). However, very little work is done on *Annona sp.* toffees. The fruit are rich source of bioactive compounds along with antioxidant properties. Thus, there is enormous scope for future research and further pharmacological investigation in *Annona sp*. (Bhardwaj *et al.* 2014). It is therefore, proposed to utilize *Annona sp*. pulp for toffee making. The study was taken up to study the effect of *Annona species* pulp and different sugar concentrations on *Annona* toffee preparation for its quality and storability.

Methodology

The experiment was conducted at Post Harvest Technology laboratory, Department of Fruit Science, Dr. PDKV., Akola (MS) during the year 2019-20. The experiment comprises of 10 treatment combinations of different *Annona species* and sugar concentrations were used and conducted in FRBD on for preparation of *Annona species* toffee and stored at ambient temperature (30+2^{0}C). Evaluation of chemical changes and sensory qualities were done at 30 days interval during storage up to 150 days. For this study two factors were considered, in factor A: *Annona species* pulp wherein, A_1: *Annona squamosa* pulp and A_2: *Annona atemoya* pulp and for factor B: sugar concentrations, B_1: 30% sugar, B_1: 40% sugar, B_1: 50% sugar, B_1: 60% sugar and B_1: 70% sugar

Results and Discussion

During the year 2019-20 the Annona toffee was evaluated for its physico-chemical and sensory evaluation. The maximum values were recorded for Annona squamosa pulp (82.05^{0}B, and 82.81^{0}B, 0.26% and 0.20%, 71.55% and 72.15%, 7.92 mg/100 g and 3.04 mg/100 g and 80.16 and 58.12) for TSS, titratable acidity, total sugars, ascorbic acid and antioxidants at initial and after 150 days of storage respectively while the sugar concentration of pulp having 70% sugar was found to have maximum values for the recorded parameters at initial and after 150 days of storage. The increase in TSS content might be due to decrease in moisture content during storage. This decrease in moisture content might be due to changing atmospheric conditions (Chavan *et al*. 2016). Ascorbic acid losses may be attributed to the heat and light sensitivity of ascorbic acid during the storage period (Devidek *et al*. 1990).

Treatment	Total Soluble Solids (^{0}B)		Titratable acidity (%)		Total sugars		Ascorbic acid(mg/100g)		Antioxidants	
	Storage Days									
	Initial	150	Initial	150	Initial	150	Initial	150	Initial	150
***Annona* species**										
A_1	82.05	82.81	0.26	0.20	71.55	72.15	7.92	3.04	80.16	58.12
A_2	78.55	81.11	0.34	0.28	69.38	69.91	8.98	3.98	62.56	49.14
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m)±	0.177	0.206	0.003	0.003	0.004	0.057	0.062	0.049	0.195	0.272
CD at 5 %	0.529	0.618	0.009	0.010	0.013	0.172	0.185	0.148	0.583	0.814
Sugar Concentrations										
B_1	79.50	80.93	0.27	0.21	70.48	70.99	8.11	3.27	71.32	53.60
B_2	80.03	81.62	0.28	0.22	70.50	71.01	8.37	3.46	71.34	53.61
B_3	80.24	81.90	0.30	0.23	70.53	71.03	8.53	3.56	71.35	53.63
B_4	80.80	82.15	0.32	0.25	70.54	71.06	8.61	3.63	71.38	53.65
B_5	80.93	83.25	0.34	0.27	70.56	71.07	8.63	3.66	71.40	53.67
F test	Sig	Sig	Sig	Sig	Sig	NS	Sig	Sig	NS	NS
SE (m)±	0.279	0.326	0.005	0.005	0.007	0.091	0.097	0.078	0.308	0.430
CD at 5 %	0.837	0.977	0.015	0.016	0.020	-	0.292	0.233	-	-
Interaction (A x B)										
F test	NS	NS	NS	NS	Sig	NS	NS	NS	NS	NS
SE (m)±	0.395	0.461	0.007	0.008	0.010	0.128	0.138	0.110	0.435	0.608
CD at 5 %	-	-	-	-	0.028	-	-	-	-	-

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Harvesting Energy and Water: An Integrated Agrovoltaic and Rainwater Harvesting System for Sustainable Agriculture Development

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Water is an important input in agricultural production, the availability of which is shrinking over the years. On one hand there is water scarcity and other the streets are offend flooded during monsoon season. Rainwater harvesting is an expertise for collection and efficient storage of rainwater from different basement areas. However, one of the major constraints for rain water-harvesting structures in hilly region like Konkan is high seepage loss from storage tanks. To overcome this problem construction of the water harvesting tanks in the fields itself will drastically considerably reduce the drudgery of carrying the irrigation water. A low-cost rainwater harvesting structure called Jalkund for the hilltops has been developed. Harvested water which is used for growing horticultural as well as vegetable crops in Rabbi and summer season depending upon the availability of water. The open field production of vegetable encounter with many production constrains like heavy rain, thunderstorms, excessive solar radiation, temperatures and humidity levels above plant growth optima, high insect pest infestation pressure and fungal diseases. To overcome this problem one of the solution for that one is protected cultivation. The various types of protective cultivation practices have been adopting based upon the prevailing climatic condition. Among them, greenhouse/polyhouse is extremely useful. The production of vegetable is higher than the open field condition, but protected cultivation is energy intensive. Availability of energy in remote area is affecting

problem to overcome this problem SPV system is one the best option. By considering all the above problems there is need to develop an integrated system for water-food-energy generation at same time on same land will be beneficial. Land used for integrated system will provide ideal opportunities for triple use of lands as water-food-energy generation.

Methodology

The performance of integrated agrovoltaic and rainwater harvesting system for crop production was carried out for various crop during Winter seasons. The performance was compared with crop production structure in open field.

Rainwater Harvesting Structure: The observation was measured on daily basis during crop production. The water loss after each irrigation from inside and outside Jalkund was recorded. The various climatological parameters were measured from 9: 00 h to 17:00 h at an interval of 2 hr. on daily basis.

Solar SPV Power Plant: The observations were recorded from 9.00 h to 17.00 h at an interval of every 2 h on daily basis. The daily observation regarding variation in power output of SPV plant over crop production structure and ground mounted SPV plant, Solar Intensity, Relative Humidity, Temperature Inside the structure and outside the structure was noted down

Results

It was revealed that maximum inside and outside temperature of crop protective structure was found to be 35.98 °C and 33.34°C, respectively during 20th MW followed by 35.82 °C and 33.18 °C, respectively in 21st MW and 35.67 °C and 33.03 °C, respectively in 19th MW was observed.

It was observed that the minimum inside and outside temperature of crop protective structure was found to be 24.84°C and 23.64 °C, respectively during 28th MW followed by 25.05 °C and 23.74 °C, respectively during 27th MW and 25.09 °C and 23.89 °C, respectively during 26th MW was observed.

It was revealed that the maximum water loss due to evaporation was found to be 5.23 mm/day and 2.93 mm/day through outside and inside Jalkund during 18th MW followed by 5.23 mm/day and 2.93 mm/day during 17th MW and 5.20 mm/day and 2.91 mm/day during 11th MW.

It was observed that the minimum evaporation rate was found to be 2.80 mm/ day and 1.57 mm/day from outside and inside the Jalkund during the 41st MW followed by 2.84 mm/day and 1.59 mm/day in the 2nd MW and 2.90 mm/day and 1.62 mm/day during the 4th MW.

It was revealed that maximum energy generation from SPV panel over the crop protective structure and ground mounted SPV panel were found to be 2885.99 watt-h and 2838.16 watt-h, respectively during the month of May followed by 2801.76 watt-h and 2754.29 watt-h, respectively during the month of April.

It was observed that minimum energy generation from SPV panel over the crop protective structure and ground mounted SPV panel was found to be 1729.58 watt-h and 1676.04 watt-h, respectively during the month of October followed by 1869.75 watt-h and 1816.29 watt-h, respectively during the November.

Conclusions

1. It was recorded that the maximum water loss due to evaporation was found to be 5.23 mm/day and 2.93 mm/day, respectively through outside and inside Jalkund during 18 th MW during no load evaluation of RWHS (Jalkund) without crop.
2. It was observed that the total energy generation from SPV panel over the crop protective structure and ground mounted SPV panel were found to be 574.58 kWh and 562.41 kWh, respectively in the month of May during no load evaluation period.
3. It was observed that the temperature inside the crop protective structure is higher as compared to open field whereas the solar intensity and relative humidity is less as compared to open field during no load evaluation period of protective structure.

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Productivity and Profitability of Maize Crop at Different Levels of Mechanization Under Rainfed Subtropics of Jammu

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Maize (Zea mays L.) is one of the most versatile emerging crop shaving wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. It is cultivated on nearly 190 m ha in about 165 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 39 % in the global grain production. The United States of America (USA) is the largest producer of maize contributes nearly 36% of the total production in the world and maize is the driver of the US economy (APEDA, 2020) .India is predominantly an agricultural nation with 127.59 Mha area under agriculture i.e. 38.7 percent of the total geographical area (DES, 2020) and agriculture employs over 42.6% of the country's population (World Bank, 2019). Maize (*Zea mays*) in India ranks fifth in total area and third in total production and productivity after rice and wheat.

The net cultivated area of J&K is 7.52 lakh ha out of which about 4.38 lakh ha is under rainfed agriculture and area under Maize crop is 3.19 lakh ha. Mean Annual Rainfall in low altitude sub- tropical zone (Jammu etc.) is 1153.6 mm but about 58% crops are grown under rainfed conditions. Most of operations for cultivation of maize crops are still carried out manually in the region. The opportunities are excellent for mechanizing the maize crop in the hills of Jammu and Kashmir state by adopting the improved tools and implements for different operations suitable for the region, which can reduce the time, cost of operation and drudgery over traditional methods. A study was conducted to evaluate the impact of different machineries viz-a-viz its comparative performance of improved implements with conventional methods of maize cultivation, mechanization prospectus and to trim down the cost of cultivation under rainfed areas. Maize sowing by a maize planter ensured a proper plant stand and produced 20-25 percent increased yield over the conventional method.

Materials and Methods

A field experiment was carried out at research farm of Advanced Centre for rainfed agriculture, Rakh Dhiansar, Sher-e-Kashmir University of Agricultural Sciences and Technology of

Jammu during 2022. An experiment comprises of Three treatments viz: Farmers Practice, Partial mechanization and Complete mechanization The different machineries namely Maize Planter , Weeding cum earthing-up equipment, Power operated Maize Thresher etc were used for cultivation of maize crop. The recommended fertilizer was applied through the planter at the time of sowing in mechanized methods

Results and Discussion

Table 1. Evaluation of maize crop under different levels of mechanization during *kharif* 2022 under rainfed conditions.

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Maize grain yield in 2022	Stover/stalk yield			
Farmers Practice Sowing:Broadcasting Weeding: Manual Threshing : Manual	2130	3089	20800	30256	2.45
Partially Mechanization Sowing : Use of liner for line sowing manually Weeding : With manual hand hoe Threshing :With traditional thresher	2350	3654	21200	35869	2.69
Complete Mechanization Sowing : Use of tractor operated maize planter Weeding : Tractor operated weeder cum earthing-up equipment Threshing : With maize sheller/thresher	2740	3973	23700	41978	2.77

Among the different levels of mechanization the treatment Fully mechanization consisting of sowing with Maize Planter, Weeding and earthing-up by weeding-cum- earthingup equipment and Threshing by Power operated maize thresher shows remarkable increase in maize grain yield by28.6 %as compared to farmers practice, similarly the corresponding highest values of net returns of Rs 41978 and B:C ratio of 2.77 in treatment complete mechanization.. Khandel santosh *et al*., 2021 reported similar findings in maize crop.

Conclusion

On the basis of one year preliminarily observation, it may be concluded thatmaize crop grown under complete mechanization was found to be superior among the other treatments in terms of maize grain yield, net returns and B:C ratio under rainfed conditions of Jammu.

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Controlled Traffic Farming – a Beneficial Conservation Measure in Wheat Cultivation

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Conservation agriculture combines principles of minimal soil disturbance, permanent organic soil cover, and crop diversification, along with precision nutrient and pest management and efficient water use. No tillage and minimum tillage production with supporting machinery are proven methods of conservation agriculture. While field preparation and sowing operations, heavy machinery with tractors are operated in the field resulting in many consequences like increasing bulk density of the soil, shear stress and low infiltration. Concept of controlled traffic farming with appropriate machinery has been taken to reduce the negative effects of heavy machinery operation in the field condition. Controlled traffic movement of the tractor and implement in the research field of ICAR – CIAE Bhopal was evaluated for various crop and soil parameters. Field experiments were conducted using a randomized block design with two main treatments, CTF and random traffic farming (RTF), and five sub-treatments: 30% residue cover, 60% residue cover, 100% residue cover, residue incorporation in the soil and residue burning for two production years 2020-21 and 2022-23. In between in the year 2021-22, different crop (chickpea) was taken in the same field to commence crop rotation. However, the path of operation was defined and machinery movement was done on the same track in CTF. Tracks of the movement of tractor and machinery were defined in the field and each operation was done on the same path every year in the cropping season from 2020-21 to 2022-23.Table shows bulk density of the soil in different systems.

The average porosity for CTF samples was 43.5%, and for RTF samples, it was 40.2%, denoting that the soil under CTF had higher porosity as compared to the soil under RTF.

The shear strength of soil, measured with cone index, showed value of 269.6–1784.3 kPa in CTF compared to 764.2–1887.7 kPa in RTF at soil moisture content of 21%. The cone index values for CTF were consistently lower, indicating less resistance to penetration and improved soil structure. Table shows yield of wheat crop taken under different treatments of CTF and RTF.

Table 1. Soil bulk density under different systems

Treatments	2020-21		2022-23		Avg. BD in g/cm^3	
	CTF	RTF	CTF	RTF	CTF	RTF
30% Residue Cover	1.53	1.60	1.46	1.65	1.49	1.62
60% Residue Cover	1.56	1.58	1.40	1.58	1.48	1.58
100% Residue Cover	1.58	1.52	1.39	1.51	1.49	1.51
Residue Incorporation	1.53	1.58	1.47	1.60	1.50	1.59
Residue Burning	1.59	1.60	1.46	1.65	1.52	1.62
Total					1.50	1.58

Table 2. Yield of wheat crop in different treatments during 2020-21 and 2022-23, kg/ha

Treatments	2020-21		2022-23		Avg. yield	
	CTF	RTF	CTF	RTF	CTF	RTF
30,% Residue Cover	5064	5266	5642	5232	5353	5249
60% Residue Cover	5169	5183	5655	5761	5412	5472
100% Residue Cover	5304	4972	5778	5634	5541	5303
Residue Incorporation	5287	4788	6659	5519	5973	5153
Residue Burning	5245	4966	5258	5556	5252	5261
					5506	5287

The yield result showed that, CTF resulted in higher yields than RTF, although the differences were not statistically significant. Over the two years of the trial, the average yield for CTF was 5,495 kg/ha, while RTF yielded 5,241 kg/ha, reflecting a 4.14% higher yield under CTF. This trend was more pronounced in treatments with residue incorporation, where CTF produced 5,973 kg/ha compared to 5,153 kg/ha for RTF. These results suggest that CTF provide higher yields due to better soil structure and reduced compaction, though other factors also likely to contribute to the yield variations.

Conclusion

There were clear advantages of CTF compared to RTF because of compaction situation allevation. Bulk density values ranged from 1.48 to 1.52 g/cm³ in CTF and 1.51 to 1.62 g/cm³ in RTF. The cone index, measured to a depth of 50 cm, showed lower soil compaction in CTF systems (269.6 – 1784.3 kPa) than in RTF systems (764.2-1887.7 kPa) at a soil moisture content of 21%, indicating looser soil, which is beneficial for root growth and water infiltration. The wheat yield in CTF was 4.14% higher than RTF. Although, this yield difference was not statistically significant when analyzed over the two years of trials but depicts the improvement in a short period and it is expected to become significant in long term. The integration of CTF with zero tillage minimized soil compaction, increased porosity of soil and increased the yield.

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Development of Tractor Hydraulic System operated Weeding Machine for Horticulture Crops

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The area under horticulture crops, has increased to 27.5Mha by 2020-21. In this about 25% of area is under major fruit crops. Horticulture, contributes almost 30% to agriculture GDP (Anonymous, 2021). The yield loss due to weed infestation in India is estimated to be 10 - 60% in various crops and in horticulture crops. Due to climate change, especially under dryland conditions the weed growth increases and hence there is frequent use of implements. This frequent use is problematic since it increases risk of moisture loss and soil erosion. So, the cultivation practices should be strategically adopted as part of an integrated weed management approach to achieve optimum response. Hence effective weed management practices also change with the environment as well as type of crops.

In many horticulture crops, the field crops residues or plastic sheet mulching in multiple layers is recommended as one of the options for weed control and found effective to a considerable extent in weed suppression in seasonal crops like vegetables. But, the film laying and removal is labour intensive for basin listing, manure and nutrient application. Moreover, the continuous use of the same group of herbicides over a period of time on the same piece of land leads to weed shift, herbicide resistance in weeds and environmental pollution. Mechanical weeding improves soil quality, crop yield and resource use efficiency compared with a conventional practice. Weed seed destruction by removing seeds at maturity eliminates potential seed bank reserve from the system, thus avoiding germination in the coming season (Mohd Taufik Ahmad, 2012).

In India for normal field crops large number of self-propelled machines and limited models of tractor operated weeding equipment are available, but not for horticulture crops. The major constraints with the use of self-propelled models, is low field capacity, drudgery and memorability problems (Khandetod, 2019). In India, limited work was done on powered mechanical equipment for integrated weed management practices in fruit based horticultural crops such as pomegranate, guava and sweet orange which are predominantly grown in semiarid regions. This paper discusses newly developed machines aimed at addressing these issues.

Development of Weeding Machine

The machine basically consists of two components, the first one is an integrated hydraulic power pack of a tractor and the second component is a tool bar fitted to tractor chassis just in front of tractor rear tyres. The actuators which aid in different operational tools and sideward movement gets support through the mechanical linkages.

The tool bar developed was based on the horticulture crop weed biomass eradication and basin listing practices. It has a special provision to mount various tools such as weed trimming, weed biomass cutting, soil mechanical manipulation for weeds eradication and basin listing in a crescent shape pattern around the tree trunks. The various tools could be mounted one operation set at a time as per the field operational requirements. The tools are actuated using a hydraulic motor and jack assisted mechanism. For proper functioning of various hydraulic components mechanical linkages were developed and provided over the tool frame. (Table). The machine development and performance evaluation were done ICAR- Central Research Institute for Dryland Agriculture, Hyderabad.

Specifications of tractor hydraulic actuated weeding machine

Major Components	Specifications
Power Source	70 hp Tractor
Mode of power utility from Source	Hydraulic power, Traction power
Machine basic components	Adjustable length square shape tool bar frame supported by mechanical linkages and fixtures, working tools fitted with hydraulic actuators
Major components of hydraulic pack	70 lit integrated fluid tank, Hydro motor, Hydro Jack, Actuation Valves and Circuitry
Field operational working tools	Multi-functional; The tools can be replaceable based on operation –Rotary weed biomass trimmer, Weed biomass cutter, Rotary basin lister, Rake, Small trenching blade

Results

The developed machine was tested for its performance in two stages. The first stage involved the hydraulic system performance in actuation of various working tools and the second stage for working tool performance in various field operations.

Hydraulic Components Performance

A hydraulic pump powered by tractor draws hydraulic fluid from a reservoir in the tractor. The advantage of the remotely operated pump is its ability to maintain constant flow no matter the load condition on the actuation components like motor, jack. These types of pumps do not sense load making them the best suited for these operations. Hydraulic fluid returning from the hydraulic actuators passed through back to the reservoir provided on the tractor. Connecting hydraulic motors is important to ensure their effective functioning. Hydro motors and jacks can be connected in many ways. In this research work, three connection methods were studied ie (i). Series connection (ii). Parallel Connection and (iii). by providing valves at appropriate places. Any hydraulic actuator ie hydro motor or jack need to work at a set speed irrespective of load condition for better performance. So, flow dividers which divides flow under pressure into equal or unequal ratios were fitted in the circuits. The flow dividers made the hydraulic actuator more efficient in dividing and distributing hydraulic fluid in a system. The flow dividers used in this study maintained relatively good flow and pressure during field operations.

Machine performance:

For performance assessment, the test horticulture crop selected was mango (4 years age), tractor operating speed was kept about 1.5 kmh^{-1} and weed biomass trimming rotary head was about 1250 rpm. The machine rotary disc fitted tool bar was provided with side shift and disc lift arrangements. The tractor hydraulic system with proper components and linkages powers the working head and traction. Depending on the weed control requirement, either weed biomass mowing rotary disc or weed control soil mechanical manipulation disc could be fitted interchangeably. The weed biomass mowing rotary disc working width was 80 cm with 3 cutting devises. Whereas the soil mechanical manipulation was 45 cm in width with 2 heavy duty soil cutting blades.

The machine was tested in weed biomass shredding on weed species commonly known as such as *Joy weed, Cockscomb, Ringworm plant* and mixed weeds, whose height ranged from 25 to 125 cm. The machine performance was found satisfactory in weed biomass shredding. The moisture contents of these weeds ranged from about 90.0% (db) to 2.50 times the weed dry weight. The soil moisture content varied from 7.3 to 10.8 % (db). The machine field efficiency was about 0.25ha / hr.

Apart from weed management, the equipment developed could be also updated with additional attachments for ridging of soil under the plants or make small staggered trenches adjacent to tree row in dryland horticulture systems for natural resources conservation activities.

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Feasibility Studies on Control Traffic Agriculture using Permanent Bed System in Rainfed Agriculture ecosystem

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Farm mechanization play a key role in reducing the cost of cultivation with enhanced productivity in Indian Agriculture sector. Infact, the mechanization took early take-off in irrigated areas of Indo Gangetic Plain areas and spread across the mono cropping systems like Wheat and Paddy areas in many states of the country. Off late, the mechanization has picked up very well in rainfed ecosystem also because of labour scarcity and drudgery involved in these operations. Farmers have realized the benefits of adopting improved crop production technologies, such as precision sowing, intercropping, ridge and furrow planting, bund making, and soil preparation activities like deep ploughing using mouldboard and disc ploughs, as well as the use of rotavators for soil preparation and residue incorporation. These practices have significantly contributed to productivity gains and better management of soil health. Though it is a good sign, many times top fertile soil layer management is very much neglected because lack of awareness among the farming community which is very much prominent in the rainfed ecosystem interms of nutrient uptake and also maintaining the soil moisture at optimum levels. Use of high HP tractors even in the small farms followed by combine harvesters in addition to the use of deep ploughing machinery in light textured soils are often showing the adverse effects in terms of compaction and crusting of poorly maintained small holdings which is common phenomena. All these parameters are resulting in top soil erosion rainfed farms which does not have residue coverage during off season. Hence it is planned to conduct feasibility studies on developing a control traffic agriculture operational model in the small holding of rainfed ecosystem.

Material Methods

An experiment was conducted at Hayat Nagar Research Farm ICAR- Central Research Institute for Dryland Agriculture in which the sowing and fertilizer application was done with the help of Raised bed planter cum herbicide applicator which was earlier developed by CRIDA. The bed width was approximately 100 cm, with the adjacent furrow width adjustable in the range of 35-40 cm. The average depth of the furrow was maintained at 20 cm. These dimensions are selected by considering the tractor track width of existing tractors in the range of 35-45 hp so that the same tractor can be used for limited depth weeding and spraying operations during the crop production period to keep the soil disturbance at minimal level. The beds were maintained as permanent beds for 8 continuous years with every year reshaping during the sowing operation. The crop residues at 30 cm level were maintained to keep the bed intact during the off season to reduce the soil erosion and also for soil health improvement. The experiment was carried with Pigeonpea-Maize system and the crop geometry was accordingly changed to maintain the same plant population with allowable tolerance. Similarly control plot was also maintained for comparison.

Results

It was observed that the direct energy consumption was reduced by 30 to 50 percent in the permanent bed system when compared to the conventional system. The usage of tractor was also reduced and the path was limited in the furrows for subsequent operations, which reduced the compaction levels and helped in improving the soil fertility. It is also helped in increasing the soil moisture availability in furrows and beds when compared to the normal method of plain land cultivation.

Conclusion

Better management of precious soil can be with appropriate mechanization models for control traffic agriculture which can be suitable for different location specific areas as per the existing crop requirement in addition to the energy saving to reduce the emissions as final goal.

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Development of Solar-Cum-Battery Operated Boom Sprayer for Small Farm Holders in India

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Pesticides spraying is the most common practice to protect field crops from pests & diseases. In addition to this, pre-emergence herbicide application has its own importance to arrest weed emergence at early stage of crop growth. Including kharif & rabi crop cultivation, an area of about 146 million hectares in India is under use of pesticides, consuming about sixty thousand million tons of chemicals. Most common equipment used for chemical spraying is manually operated backpack sprayers, hand held electrostatic sprayers, power sprayers etc. The cost of pesticide application varied in the range of Rs 7000-8000/ha. including cost of chemicals, fuel and operator's charges. Existing equipment involves a lot of drudgery which affects working efficiency of the operator and ultimately increases cost of operation and energy. Battery operated sprayers which are now commercially available in India are cost effective but overall field capacity is less as most of them are backpack type. Considering the environmental issue and working efficiency of the operator it was presumed that solar-cum-battery operated sprayers may improve overall output in terms of energy and operational cost. Keeping this point in view, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad has developed solar-cum-battery operated boom sprayer for pesticide and herbicide application. This paper highlighted details of its development and performance.

Development of Solar-Cum-Battery Operated Boom Sprayer

Solar-cum-battery operated boom sprayer consists of 1.5 hp BLDC motor, motor controller, power transmission system, accelerator, solar photo voltaic (SPV) system of 3 kW, solar charge controller, spray pump (60 W) which gives flow rate @ 7-9 lit/m operating on lead acid battery of 140 W, nozzles, liquid tank (30 lit), batteries of equivalent power to operate BLDC motor and spray pump. A three tyne cultivator was used for better mixing of chemicals in the first 50-75 mm of soil layer. In total, five nozzles were fixed to the boom of 1.2 m length at a distance of 30 cm. The boom was mounted in front of the machine with ground clearance of 50 cm. Power transmission system was used having speed reduction ratio of 24:1 which translates the 3000 rpm speed of BLDC motor into a travel speed of 2-5 km using the accelerator. Motor controller facilitates forward & reverse speed. Suitable frame was fabricated to mount all the components. An SPV system was installed which was stationary and not on-the-go. Power generated from the SPV system was provided to the prime mover using suitable cable through solar charge controller which gave 48 V voltage and current as load applied. The sprayer was walk-behind-type.

Laboratory Test

Performance of the sprayer was tested in laboratory condition. Power required for the machine was recorded using digital hand-held Watt meter. Rotational speed was recorded using a digital tachometer. Each nozzle gave 0.6 lpm discharge with pressure of 2.5 kg/cm^2. Spray swath was 1.5 m. Power required to operate the machine in idle condition was 250 W. Rotational speed of the ground wheel obtained was 35 rpm and 125 rpm at low and high throttle level, respectively.

Filed performance

Performance of the developed sprayer was tested in field conditions for herbicide application. While operation, it was tried to maintain a travel speed at 2 km/hr. Ground wheel adjustment was made to obtain tyne cultivator depth at 50 cm into the soil. With these conditions, maximum field capacity of the sprayer to be obtained was 0.3 ha/hr. However, machine gave 0.2 ha/hr actual field capacity with field efficiency of seventy percent. The maximum power consumed was 750 W. Based on the flow rate and speed of the machine, the tank needs to be filled for ten times per acre considering 20% reserve of chemical in liquid tank. Study also suggested that the sprayer could be operated on solar power with conditions of solar radiation availability which provide a minimum current of 15 amps to the adopted BLDC motor. Spraying mechanism shows that there was a good control of weed germination up to three weeks after herbicide application. The operational performance is concern, there was substantial reduction in vibration and noise as compared to existing self-propelled boom sprayers.

Conclusion

Overall performance of the newly developed sprayer on battery is satisfactory and suits for small farm holders, however, its performance on direct solar power is dependent on solar radiation availability. Presently, solar power is being used for irrigation purposes in agriculture, however, adoption of solar power for mechanization may reduce the payback period of solar system by increasing utility hours of the solar power system throughout the cropping season.

UID: 1705

Custom Hiring Center: An archangel to Climate Resilient Agriculture

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The changes occurred due to the implementation of NICRA were seen in social participation, expenditure pattern, housing pattern, increased employment, occupation, material possession, annual savings, land possess, changes in cropping pattern, increase in productivity. Extension contact improved social participation, economic motivation, risk orientation, and innovativeness Under NICRA project many climate smart technologies, were demonstrated on farmers' field with their active involvement. It has provided better livelihood options to the farmers. A multi-enterprise model based on integrated farming system and multiple water-use approach involving components of crops, dairying, fisheries, horticulture, vegetables, soil health management, natural resource management, custom hiring centre etc. were developed to provide regular income, employment and livelihood to small and marginal tribal farmers with reduction in drudgery.

Intervention

The custom hiring of farm machinery provides a viable option to the small and marginal tribal farmers in timely completion of field operations and thereby reduction in total cost of cultivation and increase in profitability. • Rain water harvesting through renovation of check dams, percolation tank, farm ponds and effective use of the harvested water through MIS improved the water use efficiency and brought more area under cultivation. • Minimized fodder scarcity problems by growing a variety of fodder crops. • Farm waste is converted into manure by large scale adoption of biogas plant and making vermicompost from the slurry. • Area under rice, fruits, vegetables and fodder crops increased considerably due to increase in the availability of water and efficient utilization of water. • Capacity building of the farmers and farm women through regular on and off campus training, interactive method demonstration, exposure tour, played a significant role in increasing awareness about climate smart technologies. • Active participation of farmers at all the stages i.e. planning, implementation and execution of different activities under NICRA project resulted in success. • Increase in income per unit area by adoption of water logging resistant paddy variety and crop diversification through introduction of vegetable and spice crop. • Integrated farming system model i.e. Farming +fisheries+ Dairying + Horticulture found more remunerative instead of mono enterprise model • The problem of unavailability of seeds of water logging resistant can be overcome by seed village programme under NICRA.

Conclusion

The dominance of small and marginal holdings in Narmada district farmers majorly focus on development and designing of scale-neutral machinery suited to different geographical terrains. Facilitating the farmers and train them on above-said machines will help in their adoption at large scale and make a viable economic case for new mechanized sustainable intensification (SI) technologies in farming sector. The day-to-day hiring of machines on a rental basis would be a better option for small and marginal farmers of Narmada district.


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