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CHARACTER ASSOCIATION ANALYSIS OF YIELD, YIELD ATTRIBUTING AND KERNEL MICRONUTRIENT (IRON AND ZINC) TRAITS IN GROUNDNUT (*Arachis hypogaea* L.)

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ABSTRACT

The field experiment was carried out at Dry land farm, Regional Agricultural Research Station (RARS), Tirupati during *kharif*, 2024 to study the correlation analysis of yield, yield attributing and kernel micronutrient traits in groundnut. The plant material includes 20 diverse groundnut genotypes along with Rohini, as a check for kernel micronutrient content. Eleven traits were evaluated which include kernel yield plant^{-1}, pod yield plant^{-1}, 100 pod weight, 100 kernel weight, kernel mass, shelling percentage, sound mature kernel percentage, kernel length, kernel breadth, iron and zinc content. Character association studies revealed that pod yield plant^{-1} showed positive and significant association with kernel yield plant^{-1}, 100 pod weight, 100 kernel weight, kernel length, and sound mature kernel percent. This indicates that these traits play a crucial role in the selection of genotypes for improving pod yield.

KEYWORDS: Groundnut, character association, pod yield, yield traits.

INTRODUCTION

Groundnut, is one of the most important oilseed crop grown in India. It is commonly known as peanut, goober nut, earth nut, monkey nut *etc.,* depending on the location in which it is grown. The plant is a legume, native to South America and primarily grown in the tropical areas of Peru. The cultivated groundnut (*Arachis hypogaea* L.) is a self-pollinating, allotetraploid species with a chromosome number of 2n=4x=40. It is a member of the leguminosae family and the papilionaceae sub-family. Major groundnut-producing countries globally include India, China, the USA, West Africa, Sudan, Nigeria, and others.

Groundnut is cultivated over 32.7million hectares worldwide, resulting in the production of 53.9 million tonnes and an average productivity of 1,648 kgha^{-1} (FAOSTAT, 2023). India ranks second among groundnut producing countries with an area of 539mha, with a production of 11.3mt and productivity of 2,097 kgha^{-1} and in Andhra Pradesh, it is cultivated in an area of 0.346mha with a production of 0.360 mt and average productivity of 1041 kgha^{-1} (INDIASTAT, 2024-2025).

In groundnut, pod yield is a complex quantitative trait influenced by multiple physiological and yield-contributing components. Due to its polygenic nature and strong environmental interactions, direct selection for pod yield is often unreliable. Instead, understanding the interrelationships among yield components through correlation analysis offers a more strategic approach to selection in breeding programs. The present investigation was undertaken in this context to study the character associations between yield components and quality traits on pod yield with a view to identify effective selection criteria for higher pod yield in groundnut.

MATERIAL AND METHODS

The present investigation was carried out during *kharif*, 2024 at Dry land farm, Regional Agricultural Research Station (RARS), Tirupati, Andhra Pradesh. The experimental material utilized for the present study comprised of twenty diverse groundnut genotypes along with check Rohini for kernel iron and zinc content were raised in Randomised Block Design with two replications. Each genotype was sown in two rows of three metres length with a spacing of 30 cm between rows and 10 cm between plants within the row. All necessary cultural operations along with proper plant protection measures were undertaken to control insect pests. Observations were recorded from randomly chosen five competitive plants in each genotype for eleven characters *viz.,* kernel yield plant^{-1}, pod yield plant^{-1},100 pod weight, 100 kernel weight, kernel mass, shelling percentage, sound mature kernel percentage, kernel length, kernel breadth, iron and zinc content.

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Genotypic and phenotypic correlation coefficients between the measured traits were calculated employing R software.

RESULTS AND DISCUSSIONS

The pod yield plant^{-1} showed positive and significant correlation with kernel yield plant^{-1} (rp= 0.978, rg = 0.979) at both phenotypic and genotypic levels. Similar results were reported in findings of Pachauri and Sikarwar (2023), Patel *et al.* (2021), and Kumar *et al*. (2014).

Significant association of hundred pod weight (rp= 0.484, rg= 0.579) and hundred kernel weight (rp= 0.364, rg=0.491) with pod yield plant^{-1} were in conformity with the findings of John *et al.* (2009), Korat *et al.* (2010).

The pod yield plant^{-1} showed significantly positive correlation with kernel length at genotypic level (rg= 0.530), and significantly negative correlation with Fe content at both phenotypic and genotypic levels (rp= -0521, rg= -0.701).

Kernel yield plant^{-1}showed significantly positive correlation with 100 pod weight, 100 kernel weight (rp =0.370, rg=0.514) both at phenotypic and genotypic levels. Similar results were reported by Shoba *et al.* (2012), Mahesh *et al.* (2018).

Kernel yield per plant^{-1} showed a significantly negative correlation with Fe content both at phenotypic and genotypic levels (rp =-0.472, rg=0.621). This may be attributed to the increased kernel yield, which could lead to competition for nutrients, thereby reducing nutrient allocation to individual seeds.

100 pod weight showed significantly positive correlation with 100 kernel weight (rp= 0.513, rg= 0.935), kernel breadth (rp= 0.530, rg= 0.731), kernel mass (rp= 0.469, rg= 0.743), and showed positively significant correlation with sound mature kernel and kernel length only at genotypic level (rg= 0.592), (rg= 0.467), and also showed significantly negative correlation with Fe content (rp= -0.343, rg=- 0.507). Similar results were reported by Pachauri and Sikarwar (2022), for 100 kernel weight and with kernel breadth and kernel mass and kernel length was reported by Bhargavi *et al.* (2017) and Mitra *et al.* (2021).

100 kernel weight showed positive and significant correlation only at genotypic level with sound mature kernel percent (rg =0.490), high positive and significant correlation with kernel breadth (rp= 0.471, rg= 0.707), kernel mass (rp= 0.760, rg= 0.974) and kernel length (rp= 0.463, rg= 0.779) both at phenotypic and genotypic levels. This indicates a strong genetic linkage between SMK, kernel length, breadth, and mass with 100 kernel weight, making them key traits in selection programs (Gali *et al.,* 2023).

Shelling percentage showed negatively significant correlation with kernel length only at phenotypic level (rp= -0.420), and showed non significantly positive correlation with sound mature kernel per cent, kernel breadth and Fe content. Patil *et al.* (2006) reported a positive correlation of shelling percent with sound mature kernel percent.

Sound mature kernel percent was positively associated with kernel breadth, kernel mass and pod yield plant^{-1}. Thakur *et al*. (2013) also reported association of sound mature kernel with kernel breadth and kernel yield plant^{-1}.

Kernel length showed high positive and significant correlation with kernel mass at both phenotypic and genotypic levels (rp= 0.633, rg= 0.980). This indicates that longer kernels tend to be heavier, confirming both phenotypic (observable traits) and genotypic (inherent genetic influence) associations as hundred-kernel weight is significantly associated with related traits including kernel length, according to Gali *et al.* (2023). Kernel length showed negative non significant correlation with Fe content.

Kernel breadth showed significantly positive correlation with kernel mass at both phenotypic and genotypic levels (rp= 0.478, rg= 0.525). This indicates selection of wider kernels is an effective strategy to improve kernel weight and overall yield. Kernel breadth showed non significant negative correlation with zinc content.

Iron content showed negative non significant correlation with zinc content. Sukrutha *et al*. (2022), Ankita *et al*. (2023) reported similar results in groundnut. Zinc content showed non significant positive correlation with kernel yield plant^{-1}.

Table.1. Phenotypic and genotypic correlation analysis for yield, yield attributing and micronutrient (iron, zinc) contents in groundnut

Trait		KYP	100PWT	100KWT	SP	SMK	KL	KB	KM	IC	ZC	PYP
KYP	**p**	**1.000**	0.484**	0.370*	0.216	0.145	0.135	0.229	0.292	-0.472**	0.074	0.978**
	g	**1.000**	0.645**	0.514*	0.260	0.232	0.410	0.283	0.416	-0.621**	0.046	0.979**
100PWT	**p**		**1.000**	0.513**	0.161	0.232	0.246	0.530**	0.469**	-0.343*	-0.111	0.448**
	g		**1.000**	0.935**	0.199	0.592**	0.467*	0.731**	0.743**	-0.507*	-0.374	0.579**
100KWT	**p**			**1.000**	0.021	0.278	0.463**	0.471**	0.760**	-0.170	-0.240	0.364*
	g			**1.000**	0.032	0.490*	0.779**	0.707**	0.974**	-0.368	-0.354	0.491*
SP	**p**				**1.000**	0.266	-0.420**	0.237	-0.081	0.234	-0.134	0.038
	g				**1.000**	0.336	-0.429	0.244	-0.113	0.252	-0.214	0.035
SMK	**p**					**1.000**	-0.039	0.254	0.171	0.071	-0.188	0.105
	g					**1.000**	-0.120	0.402	0.202	-0.121	-0.424	0.162
KL	**p**						**1.000**	-0.053	0.633**	-0.220	0.116	0.204
	g						**1.000**	0.046	0.980**	-0.328	-0.009	0.530*
KB	**p**							**1.000**	0.478**	-0.244	-0.248	0.165
	g							**1.000**	0.525*	-0.430	-0.313	0.215
KM	**p**								**1.000**	-0.253	-0.054	0.309
	g								**1.000**	-0.380	-0.065	0.435
IC	**p**									**1.000**	-0.019	-0.521**
	g									**1.000**	-0.001	-0.701**
ZC	**p**										**1.000**	0.113
	g										**1.000**	0.108
PYP	**p**											**1.000**
	g											**1.000**

P*=<0.001, P**=<0.01, P*=<0.05**

PYP- Pod Yield Plant-1, 100 PW- Hundred pod weight, 100KW-Hundred kernel weight, KYP-Kernel Yield Plant-1, KM-Kernel Mass, SP-Shelling Percent, SMK- Sound Mature Kernel, KL-Kernel Length, KB-Kernel Breadth, IC- Iron content, ZC- Zinc content.

To improve the pod yield plant^{-1} the traits such as kernel yieldplant^{-1}., 100 pod weight, 100 kernel weight can be taken as selection criteria, which further helps in the development of high yielding genotypes in groundnut. Similarly, for enhancing the100 kernel weight and 100 pod weight the traits kernel mass, sound mature kernel percent, kernel length and kernel breadth should be given due importance. Thus, the genotypes that showed high 100 pod weight, 100 kernel weight, kernel mass, kernel breadth, kernel length in the study plays crucial role in the selection of genotypes for sustainable improvement of pod yield.

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VALUE CHAIN ANALYSIS OF MILLETS IN NANDURBAR DISTRICT OF MAHARASHTRA - A STUDY ON PROFILE OF STAKEHOLDERS

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ABSTRACT

Millets (Jowar and Bajra) are important climate-resilient crops cultivated in India, particularly in dryland and tribal regions of Nandurbar district of Maharashtra. The present study was conducted to study the profile characteristics of stakeholders in the millet value chains. Ninety millet farmers were selected from major millet-growing areas along with thirty other stakeholders comprising commission agents, distributors, wholesalers, processors and retailers, making a total of 120 stakeholders. Majority of the millet farmers belonged to the middle age category (48.89%), had graduation level education (27.78%), small farm size (45.56%), low farming experience (56.67%), annual income above Rs. 2,00,000 (65.56%), credit availability from own sources (61.11%), family members as the most preferred source of extension contact, medium communication pattern (68.89%), medium negotiation pattern (50.00%), no training received (72.22%), medium risk-taking ability (50.00%), medium quality management (74.44%) and medium market orientation (56.67%). Among other stakeholders, majority belonged to the middle age category (86.67%), had intermediate education (60.00%), low enterprise experience (53.33%), credit availability from own sources (43.33%), medium communication (66.67%), medium negotiation (63.33%), no training received (66.67%), medium risk-taking ability (76.67%), medium quality management (46.67%) and medium market orientation (70.00%).

KEYWORDS: Millets, value chain, stakeholders, profile characteristics, market orientation.

INTRODUCTION

Millets are gaining increasing importance in agriculture due to their nutritional value, climate resilience and suitability for cultivation under rainfed and resource-constrained conditions. As concerns over food security, malnutrition and climate change continue to rise, millets offer a sustainable solution by requiring less water, fewer inputs and exhibiting greater tolerance to drought and adverse weather conditions. However, despite their advantages, millet cultivation and consumption remain constrained by weak market linkages, inadequate processing facilities and limited value addition opportunities. A well-functioning value chain involving farmers, commission agents, distributors, wholesalers, processors and retailers plays a crucial role in enhancing the efficiency, profitability and competitiveness of millet production. Understanding the structure, stakeholder roles and performance of millet value chains can help identify bottlenecks and opportunities for improving market access, value addition and income generation for all stakeholders involved.

MATERIAL AND METHODS

The study followed a descriptive research design to assess the profile of millet farmers in Nandurbar district, Maharashtra, which was purposively selected as the researcher hails from the region. Among the 6 mandals, 3 villages with high production of millets jowar and bajra were chosen purposively. From each mandal, two villages were selected, total of six villages. 90 farmers were selected by proportionate random sampling, 30 stakeholders were selected of 120. Based on a literature review and expert input, 11 variables were identified. Data were collected through a structured interview schedule and analysed using frequency, percentage, mean, and standard deviation for meaningful interpretation.

RESULTS AND DISCUSSION

The stakeholders were distributed into different categories based on their selected profile and the results were presented in the table.

Age

The table shows that nearly half (48.89%) of the millet farmers belonged to the middle age category followed by young age (27.78%) and old age (23.33%). Whereas, a vast majority (86.67%) of the other stakeholders belonged to the middle age category followed by young age (6.67%) and old age (6.67%). The probable reason might be that middle-aged millet

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farmers are actively engaged in farming activities as they possess adequate farming experience, physical ability and decision-making skills. Majority of the other stakeholders belonged to the middle age category as value chain activities such as trading, processing and marketing require both experience and managerial skills. The above findings were in consonance with Sahil (2022).

Education

The table depicts that more than one-fourth (27.78%) of the millet farmers had graduation level education followed by secondary school (25.56%), primary school (14.44%), intermediate (14.44%), illiterate (12.22%) and functional literate (5.56%). Whereas, majority (60.00%) of the other stakeholders had intermediate level education followed by secondary school (20.00%) and graduation (20.00%). The probable reason might be that educational facilities and awareness regarding the importance of education have gradually improved in the study area, enabling farmers to attain higher levels of education. Majority of the other stakeholders possessed intermediate level education as trading, processing and marketing activities require basic literacy and record-keeping skills for efficient business management. The above findings were in line with Woldemedhin *et al.* (2016).

Unit size

The results illustrated in table stated that most (45.56%) of the millet farmers were small farmers followed by marginal farmers (33.33%), small medium farmers (14.44%), medium farmers (3.33%) and large farmers (3.33%). The probable reason might be due to fragmentation of landholdings from generation to generation, which resulted in the predominance of small and marginal farmers in the study area. Another reason might be the division of agricultural lands among family members over time. Similar results were reported by Deepthi (2013).

Experience

The results shown in table revealed that majority (56.67%) of the millet farmers had low level of farming experience followed by medium (31.11%) and high (12.22%) levels of farming experience. Whereas, majority (53.33%) of the other stakeholders had low level of enterprise experience followed by medium (33.33%) and high (13.33%) levels of experience. The predominance of middle-aged respondents among both farmers and other stakeholders might have also contributed to the low to medium levels of experience observed in the study area. Results were in conformity with Keerthana (2013).

Credit availability

Table shows that majority (61.11%) of the millet farmers availed credit from their own sources followed by formal sources (23.33%) and informal sources (15.56%). Whereas, majority (43.33%) of the other stakeholders availed credit from their own sources followed by informal sources (30.00%) and formal sources (26.67%). The probable reason might be that most of the respondents preferred utilizing their own savings and resources to meet the financial requirements of farming and business activities, thereby avoiding repayment obligations and interest burden. The results were in consonance with Luan and Kingsbury (2019).

Communication pattern between partners

Table provides evidence which shows majority (68.89%) of the millet farmers had medium level of communication pattern between partners followed by high (16.67%) and low (14.44%). Whereas, majority (66.67%) of the other stakeholders had medium level of communication pattern followed by high (16.67%) and low (16.67%). The probable reason might be that stakeholders maintained regular communication with one another for exchange of information related to production, processing and marketing activities, resulting in a medium level of communication pattern. The above findings were in line with Parveen (2021).

Training received

The findings reported in table suggested majority (72.22%) of the millet farmers had not received any training, while only 27.78 per cent had received training. Whereas, majority (66.67%) of the other stakeholders had not received any training, while 33.33 per cent had received training. The probable reason might be the limited availability of training programmes related to millet cultivation, value addition and marketing in the study area. The above findings were in conformity with Sultana *et al.* (2015).

Risk taking ability

In the table half (50.00%) of the millet farmers had medium level of risk taking ability followed by high

Table 1. Distribution of farmers according to their profile (n=120)

S. No.	Category	Groundnut farmers (n=90)		Other stakeholders (n=30)	
		Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
1.	**Age**				
1	Young (<35)	25	27.78	2	6.67
2	Middle (35 – 50)	44	48.89	26	86.67
3	Old (>50)	21	23.33	2	6.67
	Total	**90**	**100.00**	**30**	**100.00**
2.	**Education**				
1	Illiterate	11	12.22	0	0
2	Function alliterate	5	5.56	0	0
3	Primary school	13	14.44	0	0
4	Secondary school	23	25.56	6	20.00
5	Intermediate	13	14.44	18	60.00
6	Graduation	25	27.78	6	20.00
	Total	**90**	**100.00**	**30**	**100.00**
3.	**Unit size**				
1	Marginal (up to 2.5 acres)	30	33.33		
2	Small (2.5 to 5 acres)	41	45.56		
3	Small medium (5 to 7.5 acres)	13	14.44		
4	Medium (7.5 to 10 acres)	3	3.33		
5	Large (above 10 acres)	3	3.33		
	Total	**90**	**100.00**		
4.	**Experience**				
1	Low (3-26 Years)	51	56.67	16	53.33
2	Medium (16-29 Years)	28	31.11	10	33.33
3	High (29 – 42 Years)	11	12.22	4	13.33
	Total	**90**	**100.00**	**30**	**100.00**
	Mean= 119083.3 SD=72679.75				
5.	**Credit availability**				
1	Informal Sources	14	15.56	9	30.00
2	Formal Sources	21	23.33	8	26.67
3	Own Sources	55	61.11	13	43.33
	Total	**90**	**100.00**	**30**	**100.00**
6.	**Communication pattern between partners**				
1	Low (3-6)	13	14.44	5	16.67
2	Medium (6-9)	62	68.89	20	66.67
3	High (9-12)	15	16.67	5	16.67
	Total	**90**	**100.00**	**30**	**100.00**
	Mean= 9.87 SD=1.48				

Cont...

Table 1. Distribution of farmers according to their profile (n=120)

S. No.	Category	Groundnut farmers (n=90)		Other stakeholders (n=30)	Groundnut farmers (n=90)
		Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
1.	**Negotiation pattern between partners**				
1	Low (5-8)	30	33.33	5	16.67
2	Medium (8-12)	45	50.00	19	63.33
3	High (11-14)	15	16.67	6	20.00
	Total	**90**	**100.00**	**30**	**100.00**
		Mean=28.11 SD=2.48			
2.	**Training received**				
1	Training received	25	27.78	10	33.33
2	Training not received	65	72.22	20	66.67
	Total	**90**	**100.00**	**30**	**100.00**
3.	**Risk taking ability**				
1	Low	15	16.67	3	10.00
2	Medium	45	50.00	23	76.67
3	High	30	33.33	4	13.33
	Total	**90**	**100.00**	**30**	**100.00**
		Mean=5.55 SD=0.76			
4.	**Quality management**				
1	Low	13	14.44	6	20.00
2	Medium	67	74.44	14	46.67
3	High	10	11.11	10	33.33
	Total	**90**	**100.00**	**30**	**100.00**
		Mean=26.26 SD=2.74			
5.	**Market orientation**				
1	Low	15	16.67	6	20.00
2	Medium	51	56.67	21	70.00
3	High	24	26.67	3	10.00
	Total	**90**	**100.00**	**30**	**100.00**
		Mean=26.26 SD=2.74			

(33.33%) and low (16.67%). Whereas, majority (76.67%) of the other stakeholders had medium level of risk taking ability followed by high (13.33%) and low (10.00%). The probable reason might be that both farmers and other stakeholders preferred adopting practices and decisions with moderate levels of uncertainty to avoid potential losses while ensuring stable returns. The above findings were in line with Harini (2021).

Quality management

The findings presented in table indicated that majority (74.44%) of the millet farmers had medium level of quality management followed by low (14.44%) and high (11.11%). Whereas, majority (46.67%) of the other stakeholders had medium level of quality management followed by high (33.33%) and low (20.00%). The probable reason might be that both farmers and other stakeholders followed basic quality management practices, but lacked advanced knowledge and infrastructure for maintaining higher quality standards. The above findings were in line with Shelke and Bapat (2022).

Market Orientation

As shown in table, the results depicted that majority (56.67%) of the millet farmers had medium level of market orientation followed by high (26.67%) and low (16.67%). Whereas, majority (70.00%) of the other stakeholders had medium level of market orientation followed by low (20.00%) and high (10.00%). The probable reason might be that both farmers and other stakeholders possessed moderate awareness regarding market information, price fluctuations and marketing opportunities, which resulted in a medium level of market orientation. The above findings were in line with Lairenjam (2020).

The study revealed that millet value chain stakeholders in Nandurbar district were predominantly middle-aged and possessed moderate educational attainment. Most millet farmers had small landholdings, low farming experience, and relied on their own financial resources for agricultural activities. The majority of farmers and other stakeholders exhibited medium levels of communication pattern, negotiation pattern, risk-taking ability, quality management, and market orientation. Training exposure among stakeholders was found to be inadequate, indicating a need for focused capacity-building programmes. Informal information sources played a major role in disseminating agricultural knowledge among farmers. market linkages, training opportunities, and stakeholder coordination can significantly improve the effectiveness of millet value chains.

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SCREENING OF FINGER MILLET (*Eleusine coracana* L. Gaertn) GENOTYPES FOR DROUGHT TOLERANCE USING PEG-INDUCED OSMOTIC STRESS AT SEEDLING STAGE

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ABSTRACT

Drought stress limits finger millet (*Eleusine coracana* L.) production, particularly during germination and early seedling growth. Thirty genotypes were screened for drought tolerance using polyethylene glycol (PEG-6000) induced osmotic stress under five PEG concentrations. Substantial genotypic variability was observed. PPR-1279 recorded the highest germination (92.8 %) and shoot length (5.18 cm), while PPR-1332 showed the highest root length (6.06 cm). Lowest germination was observed in PPR-1330 (56.0 %) and PPR-1285 (57.0 %). Shoot length was lowest in PPR-1330 and PPR-1329 (1.80 cm), and root length in PPR-1206 (3.06 cm). PPR-1279 and PPR-1211 were drought tolerant, whereas PPR-1112 and PPR-1096 were susceptible.

KEYWORDS: Drought, finger millet, germination percentage, PEG-6000, shoot length, root length.

INTRODUCTION

Finger millet (*Eleusine coracana* L. Gaertn.) is an important small millet cultivated predominantly in the semi-arid and arid regions of India, where it plays a vital role in food and nutritional security (Upadhyaya *et al.,* 2007). The crop is valued for its superior nutritional composition, particularly its high calcium content, dietary fibre, iron and essential amino acids, making it an important component of climate-resilient agriculture (Antony Ceasar *et al.*, 2018). Despite its adaptability to marginal environments, finger millet productivity remains constrained by abiotic stresses, among which drought stress is the most widespread and severe under rainfed conditions (Boyer, 1982).

Drought stress limits water availability to plants and disrupts key physiological, biochemical and metabolic processes, leading to reduced growth, poor establishment and yield losses. Boyer (1982) reported that drought reduces plant productivity by restricting water availability and associated physiological processes, while Passioura (2007) emphasized that drought induced environmental constraints adversely affect plant growth and yield through complex physical and biological interactions. The germination and early seedling stages are particularly sensitive to moisture deficit, as inadequate water supply during these phases results in poor germination, reduced seedling vigour and weak crop stand establishment (Naveena and Mehta, 2015). Therefore, identification of drought-tolerant genotypes at early growth stages is essential for enhancing crop resilience and stabilizing productivity in water-limited environments (Mukami *et al.,* 2019).

Laboratory based screening techniques are widely employed for preliminary evaluation of large numbers of genotypes under controlled conditions. Among these methods, polyethylene glycol (PEG) induced osmotic stress is a well-established approach to simulate drought stress during germination by reducing the osmotic potential of the germination medium (Michel and Kaufmann, 1973).

Polyethylene glycol, particularly PEG-6000, is a high molecular weight, inert and non-ionic compound that does not penetrate plant tissues, thereby inducing water deficit conditions similar to soil drought without causing toxic effects (Michel and Kaufmann, 1973). PEG-induced drought stress has been effectively used to evaluate germination and seedling growth responses in finger millet, enabling the classification of genotypes into drought-tolerant and drought-susceptible categories (Gupta *et al.,* 2014; Naveena and Mehta, 2015).

In the present study, thirty finger millet genotypes were screened for drought tolerance at the germination stage using PEG-induced osmotic stress. The objectives were to assess genotypic variability for germination percentage, shoot length and root length under different PEG stress levels, and to identify contrasting drought-tolerant and drought-susceptible genotypes. Such contrasting material is valuable for further physiological, molecular and field-level evaluation and can serve as

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potential parental lines in breeding programmes aimed at improving drought tolerance in finger millet (Gupta *et al.,* 2014; Mukami *et al.,* 2019).

MATERIAL AND METHODS

The experiment was conducted at the Department of crop physiology, Tirupati, using polyethylene glycol (PEG) induced drought stress technique. Thirty finger millet (*Eleusine coracana* L.) genotypes, were obtained from the Millet Breeder, Agricultural Research Station, Perumallapalle, Tirupati, Andhra Pradesh, and were screened to identify contrasting genotypes for drought tolerance. The genotypes used in the experiment included (1) Vakula, (2) KOPN-942, (3) Tirumala, (4) KMR-206, (5) PPR-1170, (6) PPR-1296, (7) PPR-1329, (8) PPR-1279, (9) PPR-1211, (10) PPR-1300, (11) PPR-2187, (12) PPR-1330, (13) GPU-67, (14) PPR-1332, (15) PPR-1333, (16) PPR-1205, (17) PPR-1160, (18) PPR-1222, (19) PPR-1206, (20) PPR-1209, (21) PPR-1339, (22) PPR-1216, (23) PPR-1170 (24) PPR-1252, (25) PPR-2773, (26) PPR-1112, (27) PPR-1096, (28) PPR-1152, (29) PPR-1285 and (30) PPR-1280.

Seed Sterilization and Germination

Healthy and uniform seeds of each finger millet genotype were selected for the experiment. The seeds were surface sterilized by treating them with 1 per cent sodium hypochlorite solution for three minutes, followed by rinsing with 70 per cent ethanol. Subsequently, the seeds were thoroughly washed several times with distilled water to remove any traces of sterilants, and then surface-dried using Whatman filter paper. Twenty seeds of each genotype for each treatment were placed for germination on filter paper lined in nine-centimetre-diameter Petri dishes.

PEG Induced Drought Stress Treatment

PEG-6000 was used to impose drought stress at the germination stage by creating osmotic stress conditions, following the procedure described by Naveena and Mehta (2015). Five levels of PEG concentration were maintained, namely distilled water as control, and 5 per cent, 10 per cent, 12 per cent and 15 per cent PEG solutions. A quantity of 10ml of the respective PEG solution was added to each petri dish to moisten the filter paper uniformly.

Experimental Design and Growth Conditions

The experiment was laid out in a completely randomized design (CRD) with five replications for each treatment and genotype. Germination was carried out under controlled laboratory conditions by maintaining the temperature at 25 ± 1 °C and relative humidity at approximately 70 per cent. The petri dishes were regularly monitored, and the respective PEG solutions were added as required to compensate for moisture loss due to evaporation and to maintain consistent osmotic stress levels throughout the experimental period.

Observations Recorded

Seeds were considered germinated when the radicle protrusion reached a minimum length of two milli metres. Observations on germination and seedling growth were recorded at four and nine days after treatment application. Shoot length and root length were measured in centi metres from randomly selected seedlings in each replication using a standard measuring scale.

Germination Percentage

After the final count, the final germination percentage (FGP) was calculated by dividing the number of seeds germinated by the total number of seeds sown and expressing the value as a percentage. This methodology was employed to assess the relative drought tolerance of finger millet genotypes under PEG-induced osmotic stress conditions.

$$\text{FGP (\%)} = \frac{\text{Number of final germinated seeds}}{\text{Total number of seeds tested}} \text{ X } 100$$

RESULTS AND DISCUSSION

Polyethylene glycol (PEG)-induced drought stress proved to be an effective laboratory screening method for evaluating drought tolerance in finger millet genotypes, as it simulates soil moisture deficit by reducing the osmotic potential of the germination medium. This approach enabled uniform and controlled imposition of drought stress across treatments and facilitated rapid discrimination among genotypes based on germination and early seedling growth responses. Similar effectiveness of PEG as an osmotic agent has been earlier reported by Michel and Kaufmann (1973), who demonstrated clear physiological differences among seedlings exposed to PEG-induced stress. These results were included in Table.1.

Table 1. Mean response of finger millet genotypes under varying concentrations of PEG stress

Genotype	Germination (%)						Shoot Length (cm)						Root Length (cm)					
	Control	5%	10%	12%	15%	Mean	Control	5%	10%	12%	15%	Mean	Control	5%	10%	12%	15%	Mean
PPR-1333	80.00	80.00	70.00	65.00	60.00	79.00	4.55	2.82	2.74	2.66	2.18	2.99	5.34	4.26	4.10	3.76	2.93	4.08
PPR-2187	100.00	70.00	60.00	60.00	50.00	68.00	3.80	3.60	2.58	1.56	1.02	2.51	5.6	3.93	3.69	2.42	2.1	3.54
PPR-1205	90.00	80.00	75.00	50.00	10.00	61.00	2.74	2.54	2.52	2.34	0.70	2.17	6.20	3.56	3.49	2.86	2.16	3.45
PPR-1216	100.00	95.00	95.00	70.00	50.00	82.00	3.20	3.14	3.05	2.54	1.84	2.75	5.47	4.85	4.53	3.74	2.96	4.31
PPR-1285	95.00	80.00	80.00	10.00	20.00	57.00	2.72	2.20	2.10	2.00	1.70	2.14	6.20	5.00	3.60	3.40	1.90	4.02
PPR-1339	90.00	90.00	80.00	75.00	40.00	75.00	2.66	2.47	2.48	2.16	1.86	2.33	5.84	5.10	5.04	3.74	3.38	4.62
PPR-1211	100.00	100.00	85.00	80.00	70.00	87.00	5.43	4.39	4.28	4.04	4.98	4.62	6.40	5.80	3.86	3.84	3.62	4.70
PPR-1279	100.00	93.00	91.00	90.00	90.00	92.80	5.40	5.30	5.20	5.00	5.00	5.18	6.90	4.60	4.60	4.40	4.00	4.90
Tirumala	100.00	100.00	85.00	75.00	70.00	86.00	4.94	4.46	3.24	3.28	1.86	3.56	6.54	6.51	4.46	2.52	1.78	4.36
PPR-1094	90.00	90.00	90.00	80.00	60.00	82.00	2.55	2.48	2.36	2.14	1.76	2.26	5.90	5.10	5.06	3.84	1.42	4.26
PPR-1296	100.00	100.00	90.00	75.00	60.00	85.00	4.84	3.70	3.69	3.25	2.71	3.85	7.31	7.29	6.42	4.50	1.54	5.41
KMR-206	100.00	95.00	80.00	80.00	50.00	81.00	3.38	3.23	3.16	3.10	2.31	3.04	5.31	3.72	3.64	3.20	2.08	3.59
Vakula	100.00	90.00	90.00	70.00	60.00	82.00	5.40	5.38	3.30	2.90	2.20	3.74	4.62	4.30	3.92	3.54	2.63	3.80
PPR-1330	100.00	95.00	35.00	35.00	15.00	56.00	2.52	2.16	1.98	1.18	1.15	1.80	4.84	4.12	3.74	3.21	2.74	3.73
PPR-1252	90.00	70.00	70.00	40.00	25.00	59.00	2.23	2.15	2.00	1.70	1.45	1.91	4.30	4.14	3.58	2.86	2.14	3.40
GPU-67	100.00	95.00	80.00	70.00	50.00	79.00	3.32	2.78	2.64	2.26	1.35	2.47	6.00	5.98	3.23	3.65	1.96	4.16
KOPN-942	100.00	85.00	85.00	80.00	70.00	74.00	5.60	5.30	4.00	3.10	3.90	3.38	5.20	4.84	3.80	3.50	3.30	3.86
PPR-1332	100.00	100.00	95.00	90.00	60.00	89.00	3.10	2.86	2.76	1.76	1.84	2.46	8.78	6.40	6.10	4.56	4.48	6.06
PPR-1333	90.00	85.00	75.00	60.00	40.00	70.00	2.54	2.18	2.10	2.09	1.95	2.17	5.54	5.32	5.00	3.29	3.14	4.46
PPR-1112	100.00	80.00	70.00	30.00	15.00	59.00	2.42	2.39	2.34	2.22	1.12	2.10	5.24	3.82	3.00	2.92	1.80	3.36
PPR-1222	95.00	85.00	80.00	75.00	20.00	71.00	2.90	2.40	2.10	2.00	1.40	2.16	6.30	5.10	3.46	3.40	1.90	4.03
PPR-1152	100.00	100.00	100.00	75.00	50.00	85.00	2.80	2.56	2.52	2.48	1.60	2.39	6.14	5.50	5.48	5.28	3.64	5.21
PPR-1280	100.00	80.00	80.00	50.00	30.00	68.00	2.87	2.18	1.65	1.52	1.40	1.92	4.50	3.74	3.44	3.12	2.84	3.53
PPR-1329	90.00	85.00	70.00	60.00	50.00	71.00	2.22	2.13	2.00	1.90	1.30	1.91	4.50	4.24	3.54	2.92	2.21	3.48
PPR-1096	90.00	70.00	70.00	50.00	25.00	61.00	2.63	2.60	2.10	1.86	1.10	2.06	5.70	3.62	3.20	3.00	2.24	3.55
PPR-1170	90.00	90.00	85.00	75.00	20.00	72.00	3.56	3.45	3.24	3.10	2.62	3.23	5.40	5.38	4.46	4.12	3.26	4.52
PPR-2773	97.00	92.00	89.00	85.00	80.00	88.60	5.20	5.00	4.30	3.80	3.56	4.37	6.50	4.50	4.30	4.30	3.00	4.52
PPR-1217	100.00	100.00	80.00	60.00	40.00	76.00	5.74	2.46	2.09	1.94	0.50	2.55	5.66	4.46	4.14	3.50	3.10	4.17
PPR-1206	90.00	85.00	80.00	60.00	30.00	69.00	5.30	5.20	4.50	2.60	2.10	3.94	3.60	3.60	3.20	3.10	1.80	3.06
PPR-1209	100.00	95.00	90.00	80.00	60.00	85.00	3.10	2.62	2.54	2.32	1.54	2.42	6.20	5.98	5.22	4.76	3.44	5.12
Mean	95.90	89.50	82.00	66.83	47.00	76.25	3.56	3.14	2.80	2.50	2.03	2.80	5.73	4.93	4.24	3.68	2.72	4.25
SE(m)±	**3.29**	**2.01**	**3.27**	**3.19**	**2.99**		**0.87**	**0.57**	**0.55**	**0.54**	**0.47**		**0.98**	**1.17**	**0.84**	**1.01**	**0.72**	
CD (P=0.05)	**9.53**	**5.78**	**9.46**	**9.23**	**8.63**		**2.51**	**1.62**	**1.61**	**1.57**	**1.35**		**2.83**	**3.38**	**2.45**	**2.93**	**2.08**	

Final Germination Percentage

Polyethylene glycol (PEG)-induced drought stress effectively differentiated finger millet genotypes based on their germination response under moisture stress. Substantial genotypic variability was observed for final germination percentage across PEG concentrations. Under control conditions, several genotypes recorded 100 per cent germination, indicating good seed viability. With increasing PEG concentration, germination declined progressively, indicating a clear osmotic stress effect. At 5 per cent PEG, germination was relatively high (70 - 100%). At 10 per cent PEG, it decreased sharply, while at 12 per cent PEG a further reduction was observed, reaching as low as 10 per cent in some cases. At the highest stress level of 15 per cent PEG, germination was most severely affected, with values ranging from 10 per cent to 90 per cent. Among all genotypes, PPR-1279 (92.80 %), PPR-2773 (88.60 %) recorded the highest mean germination percentage across PEG levels, whereas PPR-1330 (56.00 %), PPR-1285 (57.00 %) recorded the lowest. The decline in germination with increasing osmotic stress agrees with earlier reports in finger millet and other crops under PEG-6000 induced drought conditions. Sreelatha *et al*. (2019) and Gupta *et al.* (2015) reported similar reduction in germination percentage, shoot length, root length, and seedling vigor with higher PEG concentration in finger millet. Comparable findings were also observed in maize (Majid *et al.,* 2020), barley (Davidson-Willis *et al.,* 2024), where higher PEG-induced osmotic stress significantly inhibited seed germination and early seedling growth. These studies support the present findings that increasing PEG-6000 concentration adversely affects germination and seedling traits, while tolerant genotypes maintain better growth under stress conditions.

Shoot Length

Shoot length showed a consistent and progressive reduction with increasing PEG concentration, indicating the inhibitory effect of drought stress on seedling growth. Under control conditions, the highest shoot length was recorded in PPR-1217 (5.74 cm), followed by KOPN-942 (5.60 cm) and PPR-1279 (5.40 cm), whereas the lowest values were observed in PPR-1329 (2.22 cm), PPR-1252 (2.23 cm). At 5 per cent PEG, Vakula (5.38 cm), maintained maximum shoot length, while PPR-1329 recorded minimum values. Under 10% PEG, PPR-1279 (5.20 cm), PPR-1206 (4.50 cm) showed superior shoot elongation, whereas PPR-1280 (1.65 cm), PPR-1330 (1.98 cm) and PPR-1329 (2.00 cm) exhibited poor growth. At 15 per cent PEG, PPR-1279 (5.00 cm) and PPR-1211 (4.98 cm) consistently retained higher shoot length, while PPR-1217 (0.50 cm), PPR-1205 (0.70 cm) and PPR-1330 (1.18 cm) showed severe growth inhibition. The mean shoot length across PEG levels was highest in PPR-1279 (5.18 cm), followed by PPR-1211 (4.62 cm), whereas PPR-1330 (1.80 cm) and PPR-1329 recorded the lowest mean shoot length (1.91 cm). The decrease in shoot length shows that cell expansion is limited by osmotic pressure, along with reduced leaf turgor and lower metabolic activity due to drought stress caused by PEG. (Sreelatha *et al.,* 2019; Mude *et al.,* 2022) confirming the effectiveness of PEG-6000 for screening drought-tolerant finger millet genotypes. Recent studies in barley have also confirmed similar reduction in shoot length under PEG-induced osmotic stress. They found that higher levels of PEG significantly hindered seedling shoot growth, indicating that shoot length is one of the most sensitive traits for drought screening (Davidson-Willis *et al.,* 2024).

Root Length

Root length also showed marked reduction with increasing PEG concentration, with mean values ranging from 3.06 cm to 6.06 cm; the highest mean root length was recorded in PPR-1332 (6.06 cm) followed by PPR-1296 (5.41 cm), whereas PPR-1206 (3.06 cm) and PPR-1333 (3.36 cm) recorded the lowest. This reduction in root length is consistent with the general inhibitory effect of PEG-mediated drought stress on root system development, where increasing PEG concentrations significantly restrict cell elongation, root meristem activity, and water uptake capacity. Similar results have been reported in recent studies on finger millet, where root length declined progressively with increasing PEG-6000 levels, with susceptible genotypes showing greater reductions than tolerant ones (Sreelatha *et al.,* 2019). Comparable findings in cereals such as wheat also confirm that PEG-induced osmotic stress markedly reduces primary root length and overall root architecture, making root traits reliable indicators for drought screening (Davidson-Willis *et al.,* 2024).

PEG-induced drought stress effectively distinguished finger millet genotypes for drought tolerance. The genotypes PPR-1279 and PPR-1211 showed better germination, shoot, and root growth under stress. In

contrast, PPR-1096 and PPR-1112 were very sensitive, confirming PEG-6000 as a trustworthy screening tool. These findings show the potential of using PEG-induced stress tests for early-stage selection of drought-tolerant genotypes. Utilization of these genotypes in breeding programs may enhance resilience and productivity under water-limited conditions, thereby promoting sustainable finger millet cultivation.

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PRODUCTIVITY AND PROFITABILITY OF FODDER COWPEA AS INFLUENCED BY GRADED LEVELS OF PHOSPHORUS AND ZINC

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ABSTRACT

A field experiment was conducted during *rabi*, 2024–25 on dryland farm of S.V. Agricultural College, Tirupati, to evaluate the effect of graded levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) and zinc (0, 25 and 50 kg $ZnSO_4$ ha^{-1}) on green fodder yield and economics of fodder cowpea (*Vigna unguiculata* L.). Present study revealed that higher green and dry fodder yield of fodder cowpea was recorded with the soil application of 60 kg P_2O_5 ha^{-1} along with 25 $ZnSO_4$ ha^{-1} with remunerative returns.

KEYWORDS: Fodder cowpea, green fodder, phosphorus nutrition and zinc nutrition.

INTRODUCTION

Fodder cowpea (*Vigna unguiculata* L.) is a vital leguminous forage crop valued for its high biomass and protein content under dryland conditions. Phosphorus is critical for energy transfer, root development and reproductive growth, while zinc acts as a cofactor for key enzymes like tryptophan synthetase and superoxide dismutase influences auxin synthesis, photosynthesis and stress tolerance. Integrated phosphorus and zinc fertilization can enhance green fodder yield, nutrient uptake and soil fertility, yet optimal rates remain under-studied. The present investigates the combined effects of phosphorus and zinc application on the productivity and profitability of fodder cowpea.

MATERIAL AND METHODS

A field experiment was conducted during *rabi*, 2024-25 at dryland farm of S.V. Agricultural College, Tirupati. The experimental soil was sandy loam in texture, neutral in soil reaction (pH 7.0), low in organic carbon (0.27 per cent), available nitrogen (230 kg ha^{-1}), medium in available phosphorus (22.7 kg ha^{-1}) and medium in available potassium (235 kg ha^{-1}) and medium in available zinc (2.2 mg kg^{-1}). The experiment was laid out in randomized block design with factorial concept with four levels of Factor-I and three levels of Factor-II and replicated thrice.

The treatments comprise of four phosphors levels *viz.,* 0 kg P_2O_5 ha^{-1} (P0), 20 kg P_2O_5 ha^{-1} (P_1), 40 kg P_2O_5 ha^{-1} (P_2) and 60 kg P_2O_5 ha^{-1} (P_3) allotted to Factor-I and three zinc levels *viz.,* 0 kg $ZnSO_4$ ha^{-1} (Z_0), 25 kg $ZnSO_4$ ha^{-1} (Z_1) and 50 kg $ZnSO_4$ ha^{-1} (Z_2) allotted to Factor-II. The test variety of fodder cowpea used in the present experiment was MFC-09, released from Mandya Research Station, Karnataka, India. The recommended basal dose of 25 kg N ha^{-1}, 20 kg K_2O ha^{-1} was applied uniformly as common dose to all the treatments and P_2O_5 was applied as per the treatments. Fertilizer nitrogen was applied in two equal splits *i.e.,* 50 per cent as basal and 50 per cent at 30 DAS. Entire dose of phosphorus and potassium were applied as basal at the time of sowing. Soil application of zinc sulphate at 20 kg ha^{-1} was done at 10 DAS as per the treatments. The crop was harvested for green fodder purpose by cutting the plants close to the ground at 50 per cent flowering. The total cost of cultivation of fodder cowpea (₹ ha^{-1}) was calculated for each treatment on the basis of inputs used. Gross returns (₹ ha^{-1}) were computed by considering the prevailing market price of the output. Net returns (₹ ha^{-1}) were arrived at by deducting the cost of cultivation of respective treatments from gross returns for the corresponding treatments. Benefit-cost ratio was calculated by using the following formula.

$$\text{Benefit-Cost ratio} = \frac{\text{Gross returns } (ha^{-1})}{\text{Cost of cultivation } (ha^{-1})}$$

RESULTS AND DISCUSSIONS

Green and dry fodder yield of cowpea was significantly influenced by different levels of phosphorus and zinc, but interaction effect was found to be non-significant (Table 1).

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Table 1. Green and dry yield (kg ha^{-1}) of fodder cowpea as influenced by phosphorus and zinc levels

Treatments	Green fodder yield	Dry fodder yield
Phosphorus levels		
P_0 - 0 kg ha^{-1}	10728	3155
P_1 - 20 kg ha^{-1}	13033	4707
P_2 - 40 kg ha^{-1}	13681	5179
P_3 - 60 kg ha^{-1}	14991	6291
SEm±	316	151
CD (P=0.05)	932	447
Zinc levels		
Z_0 - 0 kg ha^{-1}	11143	4066
Z_1 - 25 kg ha^{-1}	13734	5129
Z_2 - 50 kg ha^{-1}	14448	5304
SEm±	273	131
CD (P=0.05)	807	387
Phosphorus (P) × Zinc levels (P)		
SEm±	547	256
CD (P=0.05)	NS	NS

Application of phosphorus significantly influenced the green and dry fodder yield. Higher green (14991 kg ha^{-1}) and dry fodder (6291 kg ha^{-1}) yields were recorded with application of 60 kg P_2O_5 ha^{-1} (P_3), which was followed by 40 kg P_2O_5 ha^{-1} (P_2) and it was on par with 20 kg P_2O_5 ha^{-1} (P_1). Lower green (10728 kg ha^{-1}) and dry (3155 kg ha^{-1}) yields were observed in control (P_0). The improvement in green and dry fodder yield with increasing levels of phosphorus can be attributed to better root development, leading to improved uptake and utilization of nutrients. Phosphorus plays a crucial role in root growth, energy transfer and overall plant vigour, which likely contributed to increased plant height, leaf area, number of leaves plant^{-1} and number of branches plant^{-1}. These findings were in accordance with the results reported by Bhilare (2003), Shekara *et al*. (2012), Dixit *et al.* (2014) and Mobeena *et al.* (2020).

Application of 50 kg $ZnSO_4$ ha^{-1} (Z_2) recorded significantly higher green (14448 kg ha^{-1}) and dry fodder (5304 kg ha^{-1}) yields of cowpea compared to control (Z_0) and 25 kg $ZnSO_4$ ha^{-1}. Which was statistically on par with 25 kg ha^{-1} (Z_1). Significantly lower green (11143 kg ha^{-1}) and dry fodder (4066 kg ha^{-1}) yields were recorded in control (Z_0). This enhancement in green and dry fodder yield with application of zinc can be attributed to several physiological and biochemical roles of zinc in plant growth and development. Zinc acts as a cofactor for enzymes and proteins involved in cell division, nucleic acid metabolism and protein synthesis (Marschner, 1986). It also plays a critical role in carbohydrate metabolism and is essential for the biosynthesis of tryptophan, a precursor to indole-3-acetic acid (IAA), which regulates plant growth and development (Oosterhuis *et al.,* 1996). Positive responses of cowpea yield to zinc application have also been reported by Mohan and Singh (2014), Pandey *et al.* (2019) and Manisha (2021).

The higher gross returns (59966 ₹ ha^{-1}), net returns (34920 ₹ ha^{-1}) and benefit-cost ratio (2.38) of fodder

Table 2. Economics (₹ ha^{-1}) of fodder cowpea as influenced by phosphorus and zinc levels

Treatments	Green fodder yield	Dry fodder yield
Phosphorus levels		
P_0 - 0 kg ha^{-1}	10728	3155
P_1 - 20 kg ha^{-1}	13033	4707
P_2 - 40 kg ha^{-1}	13681	5179
P_3 - 60 kg ha^{-1}	14991	6291
SEm±	316	151
CD (P=0.05)	932	447
Zinc levels		
Z_0 - 0 kg ha^{-1}	11143	4066
Z_1 - 25 kg ha^{-1}	13734	5129
Z_2 - 50 kg ha^{-1}	14448	5304
SEm±	273	131
CD (P=0.05)	807	387
Phosphorus (P) × Zinc levels (P)		
SEm±	547	256
CD (P=0.05)	NS	NS

cowpea were obtained with the application of 60 kg P_2O_5 ha^{-1} (P_3), which was significantly superior to those obtained with 40 kg P_2O_5 ha^{-1} (P_2) and 20 kg P_2O_5 ha^{-1} (P_1), while the lower gross returns (42910 ₹ ha^{-1}) and net returns (18551 ₹ ha^{-1}) and benefit-cost ratio (1.76) were noticed under the control (P_0). Higher economic returns with application of 60 kg P_2O_5 ha^{-1} was due to higher yield. These results were in agreed with the findings of Kumawat and Khinchi (2017), Mobeena *et al.* (2020) and Nanda *et al.* (2023).

Cowpea supplied with 50 kg $ZnSO_4$ ha^{-1} (Z_2) recorded the maximum gross (57794 ₹ ha^{-1}), net returns (31341 ₹ ha^{-1}), which was statistically on par to 25 kg $ZnSO_4$ ha^{-1} (Z_1), lower net returns (21617 ₹ ha^{-1}) were obtained from control (Z_0). Maximum benefit-cost ratio was recorded with 25 kg $ZnSO_4$ ha^{-1} (2.22), which was statistically at par with 50 kg $ZnSO_4$ ha^{-1} (2.18), while the lowest benefit-cost ratio was recorded under control (Z_0). These results were supported by Arvind *et al.* (2020) and Manisha (2021).

The present study concluded that higher green and dry fodder yield with remunerative returns in fodder cowpea can be realized with the soil application of 60 kg P_2O_5 ha^{-1} along with 25 kg $ZnSO_4$ ha^{-1} on sandy loam soils of Tirupati during *rabi*.

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PESTICIDE USE PATTERNS AND FARMER PRACTICES IN RICE PRODUCTION ACROSS THE KRISHNA AND GODAVARI AGRO - CLIMATIC ZONES OF ANDHRA PRADESH

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ABSTRACT

Rice farmers in Andhra Pradesh rely substantially on chemical pesticides for management of insect pests and diseases. A survey of 120 farmers from 24 villages across Krishna, NTR, Kakinada and East Godavari districts during *rabi* 2025–26 documented pesticide-use patterns, application practices and farmers' knowledge. Pymetrozine (91.66%), triflumezopyrim (83.33%), tetraniliprole (79.16%), bifenthrin (74.16%) and acephate (70.83%) were the major insecticides, while azoxystrobin + tebuconazole (91.66%), tricyclazole (83.33%) and thifluzamide (80.66%) were the dominant fungicides. Calendar-based spraying and pesticide mixtures were common. Awareness of recommended pesticides, safe handling, residue management and personal protective equipment was limited. The study highlights the need for stronger extension services and integrated pest management.

KEYWORDS: Farmers' knowledge, pesticide use, perception, pesticide safety, rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is a major staple crop of Andhra Pradesh and is cultivated extensively under intensive production systems. The occurrence of insect pests and diseases has resulted in considerable dependence on chemical pesticides for crop protection. The present study was conducted to document pesticide-use patterns and farmer practices in rice production across the Krishna and Godavari Agro-climatic Zones of Andhra Pradesh.

Indiscriminate and improper pesticide use can lead to environmental contamination, health risks and unnecessary chemical applications. Repeated use of pesticides may also contribute to the development of pesticide resistance, reducing their effectiveness and increasing dependence on chemical control. In the present survey, calendar-based spraying was common, with about 70 per cent of farmers following fixed spray schedules rather than applying pesticides based on pest or disease incidence.

Pesticide residues in harvested rice are another important concern associated with improper pesticide use. However, farmer awareness regarding residue regulations and safe pesticide practices was limited. Only 26.60 per cent of respondents were aware of pesticide residue regulations and export standards, while only 12.50 per cent were aware of the recommended waiting period before milling.

The survey recorded extensive use of pesticides, with 20 insecticides and 14 fungicides belonging to different chemical groups. Pymetrozine (91.66%), triflumezopyrim (83.33%), tetraniliprole (79.16%), bifenthrin (74.16%) and acephate (70.83%) were the major insecticides, while azoxystrobin + tebuconazole (91.66%), tricyclazole (83.33%) and thifluzamide (80.66%) were the prominent fungicides.

Despite extensive pesticide use, farmers showed limited knowledge of recommended and safe pesticide practices. Only 25 per cent were aware of registered pesticides recommended for rice, while knowledge of correct pesticide measurement, spray preparation, safe storage and container disposal was low. Only 38.33 per cent adopted minimum protective measures during spraying. Therefore, the present study was undertaken to document pesticide-use patterns, pesticide-selection practices, application frequency, residue awareness and occupational safety among rice farmers, with the aim of supporting improved extension services, integrated pest management, resistance management and safer pesticide use.

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MATERIAL AND METHODS

Study Area and Survey Design

A roving survey was conducted during *rabi* 2025–26 to document pesticide use patterns in rice cultivation across the Krishna and Godavari Agro-climatic Zones of Andhra Pradesh, India. The survey covered four major rice-growing districts *viz.,* Krishna, NTR, Kakinada and East Godavari selected based on their extensive rice cultivation and intensive pesticide use. Two mandals were selected from each district, followed by three villages from each mandal, resulting in a total of 24 villages. From each village, five rice farmers were selected through direct field visits, giving a total sample size of 120 farmers. Each farmer was considered an independent sampling unit. The study area represents one of the major irrigated rice ecosystems of Andhra Pradesh, characterized by fertile alluvial soils, favorable climatic conditions and intensive crop production.

Data Collection

Information was collected through personal interviews using a structured and pre-tested questionnaire covering information on farmer name, village, mandal, district, GPS location, rice variety, agronomic practices, major insect pests and diseases, pesticide usage, type of formulation, dosage, spray volume, no. of sprays, crop growth stage, source of technical information and pesticide combinations. Particular emphasis was placed on documenting the use of recently introduced insecticides and fungicides, spray frequency and pesticide selection criteria.

Documentation of Pesticide Use Pattern

The survey documented the insecticides and fungicides used by farmers, frequency of pesticide application, commonly used pesticide mixtures, target pests and diseases and the major sources of technical advice influencing pesticide selection. The recorded pesticides were classified according to their chemical groups and mode of action to facilitate interpretation of pesticide-use trends under field conditions.

Data analysis

Frequency, percentage and mean were used as simple statistical tools for analysis. The data were processed using Microsoft Excel 2010 spreadsheet.

RESULTS AND DISCUSSION

Pesticide Use Pattern in Rice Cultivation

A total of 120 farmers were surveyed. A total of 20 insecticides and 14 fungicides belonging to different chemical groups were recorded during the survey conducted in the Krishna and Godavari Agro-climatic Zones during *rabi* 2025–26. (Fig.1) The insecticides belonged to organophosphates, neonicotinoids, pyrethroids, diamides, pyridine azomethines, mesoionic insecticides, phenylpyrazoles, isoxazolines, spinosyns, insect growth regulators and nereistoxin analogues, whereas the fungicides comprised triazoles, strobilurins, dithiocarbamates, benzimidazoles, carboxanilides and inorganic multi-site fungicides. The results indicated extensive use of multiple pesticide groups for the management of major insect pests and diseases in rice.

The use of diverse pesticide groups reflects the increasing dependence on chemical crop protection in intensive rice ecosystems. Adoption of newer pesticide molecules may be attributed to their higher efficacy and broader spectrum of activity against economically important pests and diseases.

Major Insecticides Used by Rice Farmers

Farmers used several insecticides for insect pest management, with pymetrozine (91.66%) being the most frequently adopted, followed by triflumezopyrim (83.33%), tetraniliprole (79.16%), bifenthrin (74.16%), acephate (70.83%), isocycloseram (66.66%) and profenofos (65.83%). Moderate adoption was observed for buprofezin, chlorantraniliprole, fipronil and imidacloprid, whereas fenpyroximate and temephos were comparatively less used.

The higher adoption of pymetrozine and triflumezopyrim indicates farmers' preference for effective management of brown planthopper, while tetraniliprole and bifenthrin were mainly preferred for stem borer control. Similar trends have been reported in recent rice production systems where newer insecticides have gradually replaced conventional molecules because of their improved efficacy.

Fungicide Use Pattern

Among the fungicides, azoxystrobin + tebuconazole (91.66%) were the most widely used formulation, followed by tricyclazole (83.33%), thifluzamide

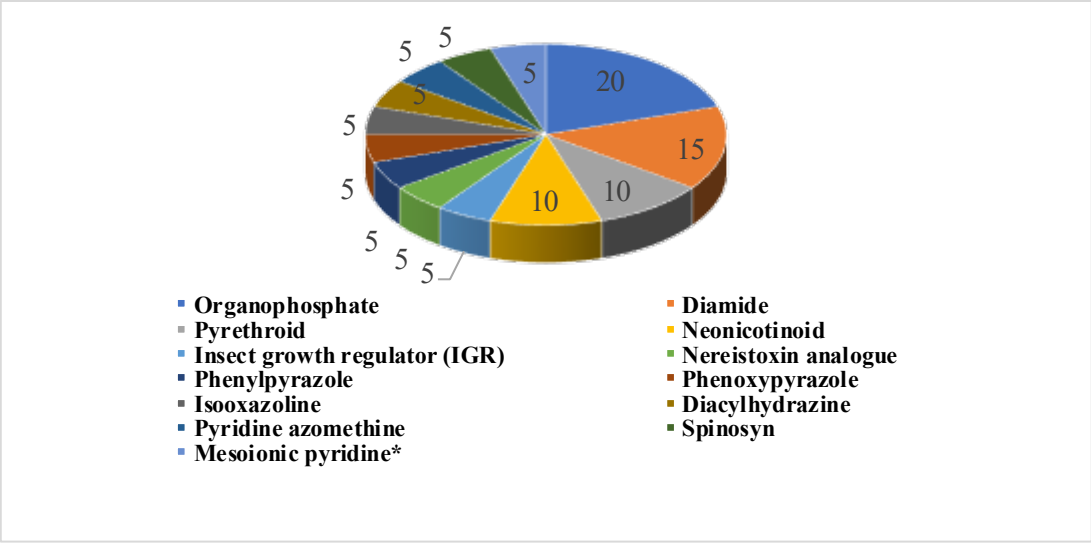


Fig. 1. Distribution of insecticides by chemical groups

(80.66%) and propiconazole (61.66%). Carbendazim and copper oxychloride showed moderate adoption, whereas propineb, isoprothiolane and hexaconazole were less frequently used.

The greater adoption of azoxystrobin + tebuconazole indicates farmers' preference for broad-spectrum fungicides capable of controlling multiple diseases. Tricyclazole and thifluzamide continue to be important fungicides for blast and sheath blight management, respectively.

Pesticide Application, Information Sources, Disposal and Occupational Safety

Approximately 70 per cent of the respondents followed calendar-based pesticide application, whereas 30 per cent adopted need-based spraying based on pest or disease incidence. Similarly, 70.83 per cent of farmers applied pesticides based on recommendations from agricultural officers, pesticide dealers or fellow farmers, while 29.17 per cent relied mainly on field observations. The predominance of calendar-based spraying indicates that preventive pesticide application was widely practiced, highlighting the need to promote economic threshold-based spraying through extension programmes to optimize pesticide use and reduce unnecessary applications. Pesticide dealers were the primary source of technical information for nearly half of the surveyed farmers, while agricultural extension personnel, progressive farmers, fellow farmers, training programmes and mass media contributed to a lesser extent. More than half of the respondents discarded empty pesticide containers in agricultural fields, whereas others disposed of them in waste collection sites or by burning; only 10.00 per cent followed recommended disposal practices. Regarding occupational safety, only 38.33 per cent of farmers used minimum protective measures during pesticide application. Most farmers did not use adequate protective equipment because of discomfort, limited availability or additional cost. Although 70.00 per cent were aware of the adverse health effects of pesticides, this awareness was not consistently reflected in their field practices.

The present investigation revealed considerable dependence on chemical pesticides among rice farmers, with calendar-based spraying and reliance on recommendations from pesticide dealers, agricultural officers and fellow farmers being common practices. These findings are comparable with Reddy *et al*. (2023), who reported that all surveyed rice farmers in Andhra Pradesh used insecticides and fungicides for managing yellow stem borer and blast, while more than 71 per cent applied pesticides above the recommended dose. Similarly, Yogeshwari (2002) reported an average of 18 pesticide applications during the rice crop period, exceeding the recommended 11 applications, indicating a tendency towards frequent pesticide use.

The dependence on pesticide dealers and inadequate technical knowledge observed in the present study is consistent with Joshi *et al.* (2022), who reported that rice farmers in Nepal commonly relied on traditional

knowledge and local dealers rather than scientific recommendations. Likewise, Shetty *et al.* (2010) found that 71 per cent of 1,039 farmers did not follow recommended pesticide dosages and frequently relied on pesticide dealers, resulting in inappropriate use of pesticide mixtures. Reddy *et al.* (2023) also reported that pesticide dealers were the major source of recommendations, with many farmers using approximate quantities while preparing spray solutions.

The present findings further indicate inadequate adoption of pesticide-safety measures. This agrees with Kumari and Reddy (2013), who observed a considerable gap between farmers' knowledge and their actual implementation of recommended safety practices. Similarly, Sharifzadeh *et al.* (2018) reported that 84.9 per cent of farmers did not use protective clothing or safety equipment during pesticide handling and application. Sai *et al.* (2019) also reported that although 61 per cent of farmers were aware of the harmful effects of pesticides, 22 per cent mixed pesticides with bare hands and 26 per cent did not use protective clothing during spraying.

Unsafe pesticide handling and disposal practices observed in the present study are also supported by previous findings. Reddy *et al*. (2023) reported that most farmers disposed of empty pesticide containers in common trash, while Sai *et al.* (2019) found that 67 per cent of farmers disposed of left over pesticides carelessly in open fields. Ntow *et al.* (2006) similarly documented inadequate protective clothing, unsafe pesticide handling and disposal and indiscriminate pesticide mixing, which increased the potential risks to human health and the environment.

Limited understanding of pesticide labels and instructions may further contribute to these unsafe practices. Mekonnen and Agonafir (2002) reported that language barriers and low literacy levels affected farmers' ability to understand pesticide labels and instructions.

The present investigation documented the pesticide-use pattern among rice farmers in the Krishna and Godavari Agro-climatic Zones of Andhra Pradesh. The survey revealed extensive dependence on chemical pesticides, with 20 insecticides and 14 fungicides belonging to different chemical groups being reported. Pymetrozine, triflumezopyrim, tetraniliprole, bifenthrin and acephate were among the commonly used insecticides, while azoxystrobin + tebuconazole, tricyclazole and thifluzamide were the major fungicides. The frequent use of pesticide combinations and calendar-based spraying indicated a tendency towards preventive and repeated pesticide application rather than need-based management.

The study also revealed considerable gaps in farmers' knowledge and adoption of recommended pesticide-use practices. Dependence on pesticide dealers and other informal sources of information was common. Awareness regarding correct pesticide measurement, preparation of spray solutions, safe storage, container disposal, pesticide residues and recommended waiting periods was limited. Although many farmers were aware of the harmful effects of pesticides, adoption of personal protective measures during spraying remained inadequate. Improper disposal of empty containers and insufficient attention to residue-related precautions further indicated weaknesses in safe pesticide management.

These findings emphasize the need to strengthen farmer-oriented extension programmes, economic threshold-based pesticide application, safe handling practices, appropriate pesticide selection, resistance-management strategies and awareness regarding pesticide residues. Improved technical guidance and regular training can help reduce unnecessary pesticide applications while promoting safer and more sustainable pest-management practices in rice cultivation.

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Research Note

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GENETIC VARIABILITY STUDIES FOR YIELD AND YIELD ATTRIBUTES IN LARGE SEEDED GENOTYPES OF GROUNDNUT (*Arachis hypogaea* L.)

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ABSTRACT

The genetic parameters namely, variability, heritability and genetic advance as per cent of mean, were estimated for 32 groundnut genotypes during *Kharif*, 2025. Among the 15 characters studied, the number of mature pods plant^{-1} and pod yield plant^{-1} exhibited high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), indicating the presence of substantial genetic variability for these traits. High heritability coupled with high genetic advance as percent of mean was observed for dry haulm yield plant^{-1}, number of mature pods plant^{-1}, pod yield plant^{-1}, kernel yield plant^{-1}, number of primary branches plant^{-1} and harvest index. This suggests the predominance of additive gene action in the inheritance of these traits. Therefore, direct selection for these characters would be effective in improving pod yield plant^{-1} in groundnut.

KEYWORDS: Genetic variability, groundnut, heritability, large-seeded and oilseed.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed-cum-food legume crops cultivated in tropical and subtropical regions of the world. It is valued for its high nutritional content, with kernels containing approximately 45-50 per cent oil and 25-30 per cent protein, making it an important source of edible oil, food and livestock feed. In India, groundnut crop occupies about an area of 53.51 lakh hectares and a production of about 120.91 lakh tonnes, productivity of about 2260 kg hectare^{-1} (Indiastat 2026). Large seeded groundnut genotypes have gained considerable importance due to their superior market preference, higher kernel recovery and suitability for confectionery purposes. These genotypes generally possess greater 100-kernel weight and attractive pod characteristics, which fetch premium prices in domestic and international markets. Large-seeded varieties are particularly preferred by the food processing industry because of their better roasting quality, uniform kernel size, and enhanced consumer acceptability. Furthermore, the incorporation of large seed size into high-yielding cultivars has become an important objective in groundnut breeding programmes aimed at improving both productivity and market value.

The present investigation was carried out with the objective to estimate the genetic variability, heritability coupled with genetic advance as percent of mean for yield and yield component traits which can support the ongoing and future groundnut breeding programs.

MATERIAL AND METHODS

The material used for the present investigation comprised of 32 groundnut genotypes. This was evaluated in randomized block design with two replications at dryland farm of S.V. Agricultural college, Tirupati during rainy season (*Kharif* 2025). Each genotype was grown in three rows of 5 m length, with a spacing of 30 cm between rows and 10 cm between plants. Standard agronomic and plant protection practices were uniformly followed throughout the crop season to ensure a healthy crop. The five plants were randomly selected from each genotype in both replications. The randomly selected plants were used for recording the plant height, number of primary branches plant^{-1}, number of mature pods plant^{-1}, hundred pod weight, hundred kernel weight, shelling percentage, sound mature kernel per cent, dry haulms yield plant^{-1}, harvest index, kernel yield plant^{-1}, pod yield plant^{-1}. Oil and protein content were estimated using the Near Infrared Spectroscopy. The analysis of variance (Panse and Sukhatme, 1967) was estimated using R software. The mean, range, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) were calculated by the formula given by Burton (1952); heritability (%) in broad sense was worked out by using the formula of Lush (1940) and genetic advance as per cent of mean was estimated by the procedure given by Johnson *et al.* (1955).

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Table 1. Estimation of genetic parameters for yield and yield attributes in large seeded genotypes of groundnut

S. No.	Characters	Mean	Range		Variance		Coefficient of variation		Heritability (Braod sense) (%)	Genetic advance (GA)	Genetic advance as percent of mean (%)
			Min.	Max.	Genotypic	Phenotypic	Genotypic	Phenotypic			
1.	DFF	32.03	27.00	36.00	4.29	7.00	6.47	8.26	61.31	3.34	10.43
2.	DM	111.97	104.00	117.00	15.25	16.57	3.49	3.64	92.04	7.72	6.89
3.	PH	45.48	31.62	50.00	13.03	17.74	7.94	9.26	73.48	6.37	14.01
4.	NPB	5.93	4.20	8.25	0.90	1.27	16.05	19.03	71.07	1.65	27.89
5.	NMP	14.69	9.90	25.23	11.75	14.11	23.34	25.58	83.21	6.44	43.88
6.	HPW	132.39	164.39	113.50	96.63	166.66	7.42	9.75	57.98	15.41	11.64
7.	HKW	47.48	39.41	55.59	8.47	25.00	6.19	10.54	33.86	3.48	7.37
8.	SP	60.51	51.45	76.68	15.15	36.35	6.43	9.96	41.68	5.17	8.55
9.	SMK	88.88	78.25	95.16	12.72	17.50	4.01	4.70	72.67	6.23	7.04
10.	DHY	29.01	28.77	44.59	28.77	33.68	18.49	20.00	85.42	10.21	35.20
11.	HI	39.32	29.04	55.52	31.00	44.60	14.16	16.98	69.52	9.56	24.33
12.	KYP	11.32	7.05	17.41	5.09	6.95	19.94	23.30	73.27	3.98	35.17
13.	OIL	48.27	46.48	50.65	1.06	1.14	2.13	2.21	92.62	2.04	4.22
14.	PRO	25.24	23.00	27.28	0.88	1.86	3.72	5.40	47.37	1.33	5.27
15.	PYP	18.82	12.54	30.70	15.80	20.65	21.12	24.14	76.53	7.16	38.07

DFF : Days to 50 % flowering
DM : Days to maturity
PH : Plant height
NPB : Number of primary branches plant^{-1}
NMP : Number of mature pods plant^{-1}

HPW : Hundred pod weight
HKW : Hundred kernel weight
SP : Shelling percentage
SMK% : Sound mature kernel percent
DHY : Dry haulms yield plant^{-1}

HI : Harvest index
KYP : Kernel yield plant^{-1}
OIL : Oil content
PRO : Protein content
PYP : Pod yield plant^{-1}

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant differences among genotypes for all the traits, indicating the presence of sufficient variability in the genotypes studied.

The phenotypic coefficient of variation (PCV) exceeded the genotypic coefficient of variation (GCV) for all the characters studied, suggesting that environmental factors contributed to the observed variation in the expression of these traits. High GCV and PCV estuimates were observed for the traits number of mature pods plant^{-1} and pod yield plant^{-1}. These results were similar with the findings of Mane *et al*. (2024), Ragiri *et al*. (2023) and Bindu Sree *et al*. (2026). It indicates a good scope for yield improvement through phenotypic selection. Low GCV and PCV were recorded for days to 50 per cent flowering, days to maturity, hundred pod weight, shelling percentage, plant height, sound mature kernel percent, oil and protein content indicating the larger influence of environment on these traits.

High heritability coupled with genetic advance as percent of mean gives a very good indication of nature of inheritance and effectiveness of selection for a particular trait (Johnson *et al.* 1955). In present study, high heritability (>60%) and high genetic advance as percent of mean (>20%) were recorded for dry haulms yield plant^{-1}, number of mature pods plant-1, pod yield plant^{-1}, kernel yield plant^{-1}, number of primary branches plant^{-1}and harvest index. These results were in accordance with the findings of Chavadhari *et al*. (2017), Mahesh *et al.* (2018), Bugati *et al.* (2020), Mane *et al.* (2024), Yami *et al.* (2025). The high heritability and genetic advance indicated the dominance of additive gene action, indicating that selection would be effective for these traits.

High heritability with moderate genetic advance as per cent of mean was exhibited by the characters *viz.,* plant height, days to 50 per cent flowering. Moderate heritability coupled with moderate genetic advance as per cent of mean were recorded for hundred pod weight. Similar results for hundred pod weight were reported by Shinde *et al.* (2019). Hundred kernel weight, shelling percentage and protein content exhibited moderate heritability with low genetic advance as per cent of mean. Hampannavar *et al.* (2018) reported the same results for shelling percentage. Moderate heritability with low genetic advance for protein content and hundred kernel weight are in accordance with the findings of Patidar and Nadaf (2017) and Aruna kumari *et al*. (2019).

The study revealed the presence of considerable genetic variability among the 32 groundnut genotypes for yield and yield related traits. High GCV and PCV were observed for number of mature pods plant^{-1} and pod yield plant^{-1}, indicating ample scope for improvement through selection. High heritability coupled with high genetic advance as per cent of mean was recorded for number of mature pods plant^{-1}, dry haulm yield plant^{-1}, kernel yield plant^{-1}, pod yield plant^{-1}, number of primary branches plant^{-1}and harvest index, suggesting the predominance of additive gene action and the effectiveness of direct selection for these traits. Therefore, these characters can be considered as an important selection criterion for enhancing pod yield in groundnut breeding programmes.

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CONSUMER AWARENESS AND PREFERENCES TOWARDS COLD-PRESSED OILS: A STUDY IN GUNTUR DISTRICT OF ANDHRA PRADESH

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ABSTRACT

India's edible oil sector has seen a paradigm shift in consumer preferences, particularly with increasing awareness about the health implications of chemically refined oils. Cold-pressed oils, retaining natural nutrients and processed without heat or chemicals are gaining popularity. This study examines the awareness levels and consumer preferences towards cold-pressed oils in Guntur district of Andhra Pradesh. Based on a primary survey of 120 respondents from Guntur and Tenali, the study analyzes socio-economic profiles, awareness sources, oil preferences and willingness to recommend or shift to cold-pressed oils. Results show that while awareness is high (100%), actual adoption remains limited (20.83%). Preferences are driven by perceived health benefits (70%), taste (41.67%) and traditional beliefs (35%). Key awareness sources include family (43.33%) and social media (21.66%). The study concludes that strategic awareness campaigns and affordable pricing could significantly improve consumer adoption of cold-pressed oils in semi-urban markets.

KEYWORDS: Cold-pressed oils, consumer awareness, preferences, health benefits, guntur, traditional oil use.

INTRODUCTION

India is one of the major producers and consumers of edible oils, with a rich tradition of cultivating diverse oilseed crops and utilizing traditional extraction techniques Sridevi and Ranjani, (2022). In recent years, there has been a notable shift in consumer preferences from chemically refined oils to healthier alternatives such as cold-pressed oils Kanimozhi and Hariharan, (2023). Cold-pressed oils are extracted mechanically without the application of heat or chemicals, thereby retaining natural nutrients, antioxidants and the original aroma and flavor of the oil Krishnaveni *et al.,* (2022). This has led to increasing consumer interest, especially among health-conscious individuals.

Despite the growing awareness regarding the nutritional benefits of cold-pressed oils, their consumption remains limited in many regions due to factors such as high price, limited availability, low brand visibility and lack of trust in unbranded products Devi and Rao, (2021); Kethavath *et al.,* (2021). The Indian edible oil market is largely dominated by refined oils owing to their affordability, longer shelf life and strong market penetration Santhoshi and Kodali, (2022). Nevertheless, the demand for traditional, chemical free products is on the rise, especially in the post-pandemic period where food safety and immunity have gained importance Simhasanam *et al.,* (2024).

Andhra Pradesh, particularly Guntur district, holds significant potential for the promotion of cold-pressed oils due to its substantial production of oilseeds such as groundnut and sesame. Government initiatives like the PMFME (Pradhan Mantri Formalisation of Micro Food Processing Enterprises Scheme) scheme and NABARD (National Bank for Agriculture and Rural Development) -supported processing units have encouraged cold-pressed oil production in this region. However, the consumer base is still evolving and their preferences, awareness levels and behavioural patterns remain underexplored Kethavath *et al.,* (2021).

Given this background, the present study was undertaken to assess consumer awareness and preferences, adoption behaviour and understand the barriers limiting the adoption of cold-pressed edible oils in Guntur district of Andhra Pradesh.

METHODOLOGY

The study followed a descriptive research design to assess consumer awareness, preferences, adoption behaviour and constraints related to the adoption of cold-pressed edible oils in Guntur district of Andhra Pradesh.

The study was conducted in Guntur district, focusing on Guntur city and Tenali due to their active edible oil markets and presence of cold-pressed oil units under the PMFME scheme. Using simple random

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sampling, 120 respondents were selected 60 from each town, based on their role in household oil purchases. Data were collected through structured, pre-tested interviews using a questionnaire with closed ended and Likert scale items. Secondary data from official sources supported the analysis Devi and Rao, (2021; Kanimozhi and Hariharan, (2023). Frequencies and percentages described socio-economic traits, while the Likert scale assessed consumer attitudes. Garrett's ranking method identified key adoption barriers. Data were analyzed using Microsoft Excel.

RESULTS AND DISCUSSION

Socio-Economic Profile of Respondents

Table 1 presents the socioeconomic profile of respondents in Guntur district of Andhra Pradesh Santhoshi and Kodali, (2022); Simhasanam *et al.,* (2024). Among the 120 respondents surveyed, the majority (33.33%) were aged between 36–45 years, followed by those aged 26–35 years (29.16%). Women comprised 62.5 per cent of the sample and most participants were married (82.5%). Educationally, 46.66 per cent were graduates and 12.51 per cent held postgraduate degrees, indicating a moderately educated consumer group.

Regarding occupation, 31.66 per cent were homemakers, followed by private employees (27.51%). The dominant family structure was nuclear (65.83%) and most households had 3–4 members (44.16%). In terms of income, 44.16 per cent of the respondents earned between ₹4–5 lakhs annually. These findings suggest that middle-income, educated women in nuclear families are central to household food decisions, making them key targets for health-oriented products like cold-pressed oils.

Awareness and Preferences Toward Cold-Pressed Oils

The details of awareness and preference levels of the respondents toward cold pressed oils are depicted in Table 2. It can be observed that all respondents were aware of cold-pressed oils, with family members (43.33%) and social media (21.66%) being the leading sources of information. However, only 20.83 per cent were current users. Awareness levels varied, with 33.33 per cent fully aware of the differences between refined and cold-pressed oils, 45.01 per cent somewhat aware and 21.66 per cent having only heard about them. The most commonly used cooking oil was refined sunflower oil (45.84%), followed by refined groundnut oil (33.33%). Among cold-pressed oil users, groundnut (42.5%) and sunflower (33.33%) were preferred, reflecting strong regional and cultural preferences. Health benefits (70%) emerged as the primary reason for choosing cold-pressed oils, followed by taste (41.67%) and belief in traditional processing methods (35%). Perceived benefits included natural taste (67.5%) and chemical-free composition (64.17%), while digestion improvement and disease control were also noted. These findings are consistent with those reported by Krishnaveni *et al.* (2022) and Simhasanam *et al.* (2024), who observed health and tradition as primary drivers for cold-pressed oil usage.

Adoption Behaviour and Willingness to Pay

While 39.17 per cent had already shifted to cold-pressed oils, 50 per cent were planning to shift, indicating strong future potential as shown in Table 3. These results clearly suggest a positive consumer mindset and growing inclination towards adopting cold-pressed oils in the near future Simhasanam *et al.,* (2024).

Additionally, 60 per cent of the respondents expressed a willingness to pay more for genuine, high-quality cold-pressed oils as in Table 4, reflecting a positive perception of the product's health benefits and authenticity. Furthermore, 80 per cent were likely or very likely to recommend cold-pressed oils to others in Table 5, indicating a strong potential for word-of-mouth promotion. However, price remained a key concern, as indicated by its top rank in the Garrett ranking of adoption barriers in Table 6, suggesting it is perceived as the most significant constraint by consumers. These findings point to the need for pricing strategies, consumer education and smaller, affordable packaging to drive wider adoption.

Barriers to Adoption

Using Garrett's ranking technique, ten key barriers were identified. High price emerged as the most significant constraint with a mean score of 73.15, followed by lack of awareness about health benefits (68.92) and low trust in product authenticity (60.08) Devi and Rao (2021) and Santhoshi and Kodali (2022). Other constraints included inadequate promotion, limited availability in local stores and lack of expert recommendations. Interestingly, factors such as taste, aroma and shorter shelf life were ranked lower, suggesting that consumers are more concerned with price, trust and information access than with product characteristics. This highlights the need for consumer education, affordable pricing strategies and quality assurance mechanisms to enhance adoption.

Table 1. Socio-economic profile of respondents (n = 120)

Variable	Categories	%
Age	26–35 years	29.16
	36–45 years	33.33
Gender	Male	37.50
	Female	62.50
Marital Status	Married	82.50
Education Level	Graduate	46.66
Occupation	Homemaker	31.66
Family Type	Nuclear	65.83
Family Size	3–4 Members	44.16
Annual Income	₹4–5 lakhs	44.16

Table 2. Awareness and preferences toward cold-pressed oils

Indicator	Category	Percentage
Awareness of Cold-Pressed Oils	Yes	100.00
Source of Awareness	Family	43.33
	Social media	21.66
	Health Expert	15.01
Awareness Difference (Fully Aware)	Fully Aware	33.33
	Somewhat Aware	45.01
	Heard Only	21.66
Type of Cooking Oil Used	Refined Sunflower	45.84
	Refined Groundnut	33.33
	Cold-Pressed Oil	20.83
Type of Cold-Pressed Oil Preferred	Groundnut	42.50
	Sunflower	33.33
	Coconut	16.67
	Sesame	7.50
Reasons for Preference (Multiple)	Health	70.00
	Taste	41.67
	Traditional Processing	35.00
Perceived Benefits (Multiple)	Natural Taste	67.50
	Chemical-Free	64.17
	Disease Control	43.33
	Better Digestion	32.50

Table 3. Intention to shift from refined to cold-pressed oils among sample consumers (n = 120)

S. No.	Shift	Frequency	Percentage
1.	Already shifted	47	39.17
2.	Planning	60	50.00
3.	Not planning	13	10.83
	Total	**120**	**100**

Table 4. Willingness to pay more for genuine cold-pressed oil among sample consumers (n = 120)

S. No.	Willingness to pay	Frequency	Percentage
1.	Yes	72	60.00
2.	No	48	40.00
	Total	**120**	**100.00**

Table 5. Recommendation of cold-pressed oils to others among sample consumers (n = 120)

S. No.	Recommendation	Frequency	Percentage
1.	Very Unlikely	0	0
2.	Unlikely	0	0
3.	Neutral	21	17.51
4.	Likely	44	36.66
5.	Very Likely	55	45.83
	Total	**120**	**100.00**

The study revealed that consumers in Guntur district have a fair level of awareness about cold-pressed oils, primarily influenced by family networks and social media. Despite this awareness, actual usage remains limited due to price sensitivity, partial knowledge of health benefits and doubts regarding product authenticity Devi and Rao, (2021; Kethavath *et al.,* (2021). Educated, middle-income women in nuclear families emerged as the key decision-makers in edible oil purchases, indicating a focused target segment for market expansion.

Health consciousness and traditional processing methods were the major factors influencing preference towards cold-pressed oils. However, the high cost, inadequate promotion and limited market access continue to hinder wider adoption. The contradiction between perceived value and price resistance reflects the need for strategic interventions.

Table 6. Barriers to adoption of cold-pressed oils

S. No.	Barrier	Mean Score	Rank
1.	High price of cold-pressed oils compared to refined oils	73.15	I
2.	Lack of awareness about the health benefits	68.92	II
3.	Lack of trust in product authenticity or purity	60.08	III
4.	Low promotional efforts or advertisements	57.54	IV
5.	Lack of recommendation from doctors or nutritionists	52.54	V
6.	Limited availability in local markets or stores	50.80	VI
7.	Limited brand options in the market	44.75	VII
8.	Taste and aroma are different from refined oils	35.25	VIII
9.	Unfamiliarity with how to use it in daily cooking	33.04	IX
10.	Shorter shelf life compared to refined oils	19.42	X

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YIELD AND NUTRIENT UPTAKE BY TRANSPLANTED FINGER MILLET AS INFLUENCED BY WEED MANAGEMENT PRACTICES

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ABSTRACT

A field experiment was conducted during *rabi*, 2024-25 at Wetland Farm, S.V. Agricultural College, Tirupati campus of Acharya N. G. Ranga Agricultural University, Andhra Pradesh, India to identify a suitable post-emergence herbicide for managing weeds and enhancing productivity of transplanted finger millet. Among the different weed management practices tried higher yield of transplanted finger millet and lower nutrient uptake by weeds was noticed with hand weeding twice at 15 and 30 DAT (T_9), which was at par with post-emergence application of penoxsulam 20 g ha^{-1} (T_7). Lower yield of transplanted finger millet and higher nutrient uptake by weeds was observed with post-emergence application of fenoxaprop-p-ethyl 42 g ha^{-1} (T_6), which was at par with post-emergence application of penoxsulam + cyhalofop-butyl 67.6 g ha^{-1} (T_4).

KEYWORDS: Herbicides, nutrient uptake, pre-emergence, post-emergence, transplanted finger millet.

INTRODUCTION

Finger millet (*Eleusine coracana* L.) commonly known as ragi, holds a prominent position as a staple food crop in South India. India is the world's leading producer of millets and the year 2023 was declared as the International year of millets, with major focus on enhancing the production and productivity of millets (Government of India, 2022). Out of all major millets produced, ragi accounts for about 85 per cent of the production in India (Sakamma *et al.,* 2017). It is predominantly cultivated under rainfed situations. Due to its climate-resilient characteristics, it can be grown under limited irrigation conditions and poor soils, which makes it a leader among the millet family with high nutritional value and hence it is considered as nutri-cereal. It has a multi-dimensional utility as food for people and fodder for animals. In India ragi was cultivated in 1.16 M ha, with a production of 1.69 M t and productivity of 1450 kg ha^{-1} (Directorate of Millets Development, 2022-23). Pre-emergence herbicides, typically applied 0-3 days after sowing provide effective weed control for a certain period depending on the weed flora. However, since finger millet is a long-duration crop, pre-emergence herbicides alone may not offer complete weed control. New flushes of weeds often emerge after 20-25 days, particularly under irrigated conditions. To manage these late-emerging weeds, post-emergence herbicide application should be employed. In recent years, the development of new herbicide molecules has led to products that are highly effective even at low doses. These modern herbicides offer broad-spectrum weed control, shorter environmental persistence, low toxicity to mammals and significantly reduced chemical load due to their application in grams rather than kg ha^{-1}. This makes them more environmentally sustainable. There is a need to have alternative herbicides with different modes of action for obtaining broad-spectrum weed control coupled with low dose and higher efficacy for control of mixed weed flora in transplanted finger millet. Hence, the present study was undertaken to assess the yield and nutrient uptake by transplanted finger millet as influenced by different weed management practices.

MATERIAL AND METHODS

A field experiment was conducted during *rabi*, 2024-25 at wetland farm of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The soil of experimental site was sandy clay loam in texture, neutral in reaction, low in available nitrogen, medium in organic carbon and potassium and high in available phosphorus. The experiment was laid out in a randomized block design with ten treatments and replicated thrice. The treatments consisted of early post-emergence application of bensulfuron methyl

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+ pretilachlor 500 g ha^{-1} (T_1), early post-emergence application of pretilachlor + pyrazosulfuron ethyl 460 g ha^{-1} (T_2), post-emergence application of bispyribac-sodium + pyrazosulfuron ethyl 52.5 g ha^{-1} (T_3), post-emergence application of penoxsulam + cyhalofop-butyl 67.6 g ha^{-1} (T_4), post-emergence application of triafamone + ethoxysulfuron 30 g ha^{-1} (T_5), post-emergence application of fenoxaprop-p-ethyl 42 g ha^{-1} (T_6), post-emergence application of penoxsulam 20 g ha^{-1} (T_7), post-emergence application of 2,4-D sodium salt 800 g ha^{-1} (T_8), hand weeding twice at 15 and 30 DAT (T_9) and weedy check (T_{10}). Finger millet was transplanted at 22.5 cm x 10 cm spacing on 23th November, 2024. Early post-emergence and post-emergence herbicides were applied to transplanted finger millet at 8-10 DAT and 20 DAT respectively by using power operated knapsack sprayer fitted with flat fan nozzle and spray volume of 500 l ha^{-1}. The crop was fertilized with 60 kg N, 30 kg P and 30 kg K ha^{-1}. Nitrogen was applied in two splits, *viz.,* half as basal and the remaining half as top dressing at 30 DAT and entire dose of phosphorous and potassium was applied as basal at the time of transplanting itself. Yield attributes, *viz*. productive tillers m^2, weight of ear head and test weight were recorded at harvest from the randomly selected plants from net plot area. Grain and straw yield of transplanted finger millet were recorded based on the yield obtained from net plot.

Nitrogen content in dried plant was determined by Microkjeldahl distillation method after destroying the organic matter with H_2SO_4 and H_2O_2 (Piper, 1966). Nitrogen uptake by crop was calculated by multiplying the nitrogen content with the respective dry matter production and expressed in kg ha^{-1}. Di-acid digested plant samples were analyzed for phosphorus content using vanado-molybdo phosphoric acid method (Piper,1966). The intensity of yellow colour developed was measured by using spectrophotometer. The uptake of phosphorus by crop was worked out by multiplying the phosphorus content with the respective dry matter production and expressed as kg ha^{-1}. Potassium content was determined by using flame photometer (Piper, 1966) and the uptake of potassium by crop was estimated by multiplying the potassium content with the respective dry matter production and expressed as kg ha^{-1}.

RESULTS AND DISCUSSION

Among the weed management practices investigated, higher number of productive tillers m^{-2} was observed in hand weeding twice at 15 and 30 DAT (T_9) (Table 1), which was at par with post-emergence application of penoxsulam 20 g ha^{-1} (T_7) and both were significantly superior over post-emergence application of 2,4-D sodium salt 800 g ha^{-1} (T_8). The higher number of productive tillers m^{-2} in the above treatments might be due to effective control of all categories of weeds during critical stages of crop, which in turn enhanced the availability of growth resources to crop and thereby produced higher number of productive tillers m^{-2}. These results were in concord with findings of Ramadevi *et al.* (2021) and Guru *et al.* (2020).

The next best treatment was early post-emergence application of pretilachlor + pyrazosulfuron ethyl 460 g ha^{-1} (T_2), which was in parity with early post-emergence application of bensulfuron methyl + pretilachlor 500 g ha^{-1} (T_1) in the order of descent. Post-emergence application of triafamone + ethoxysulfuron 30 g ha^{-1} (T_5) was comparable with post-emergence application of bispyribac-sodium + pyrazosulfuron ethyl 52.5 g ha^{-1} (T_3) and significantly superior over weedy check (T_{10}). Significantly lower number of productive tillers m^{-2} was observed with post-emergence application of fenoxaprop-p-ethyl 42 g ha^{-1} (T_6), which was at par with post-emergence application of penoxsulam + cyhalofop-butyl 67.6 g ha^{-1} (T_4). This is due to severe phytotoxicity of fenoxaprop-p-ethyl and cyhalofop-butyl on transplanted finger millet. Similar results were also documented by Pandey *et al.* (2018).

The highest test weight of transplanted finger millet was noticed with hand weeding twice at 15 and 30 DAT (T_9), which was comparable with post-emergence application of penoxsulam 20 g ha^{-1} (T_7), post-emergence application of 2,4-D sodium salt 800 g ha^{-1} (T_8), early post-emergence application of pretilachlor + pyrazosulfuron ethyl 460 g ha^{-1} (T_2), early post-emergence application of bensulfuron methyl + pretilachlor 500 g ha^{-1} (T_1), post-emergence application of bispyribac-sodium + pyrazosulfuron ethyl 52.5 g ha^{-1} (T_3), post-emergence application of triafamone + ethoxysulfuron 30 g ha^{-1} (T_5) and weedy check (T_{10}), in the order of descent. The test weight of finger millet mostly influenced by genetic makeup of the crop and less by the agronomic interactions. Significantly lower test weight was recorded with post-emergence application of fenoxaprop-p-ethyl 42 g ha^{-1} (T_6), which was at par with post-emergence application of penoxsulam + cyhalofop-butyl 67.6 g ha^{-1}

Table 1. Yield attributes and yield of transplanted finger millet as influenced by weed management practices

Treatment	Number of productive tillers m^{-2}	1000-grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T_1 : Early post-emergence (EPoE) application of bensulfuron methyl 0.6 % + pretilachlor 6.0 % GR @ 500 g ha^{-1}	106	3.61	2110	3075	40.7
T_2 : EPoE application of pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 460 g ha^{-1}	110	3.60	2203	3154	41.1
T_3 : Post-emergence (PoE) application of bispyribac-sodium 20% + pyrazosulfuron ethyl 15 % WDG @ 52.5 g ha^{-1}	79	3.58	1750	2640	39.9
T_4 : PoE application of penoxsulam 1.02 % + cyhalofop-butyl 5.1 % OD @ 67.6 g ha^{-1}	35	2.34	516	1114	31.7
T_5 : PoE application of triafamone 20 % + ethoxysulfuron 10 % WG @ 30 g ha^{-1}	80	3.57	1765	2664	39.9
T_6 : PoE application of fenoxaprop-p-ethyl 6.7 % EC @ 42 g 00ha^{-1}	28	2.22	428	950	31.1
T_7 : PoE application of penoxsulam 21.7 % SC @ 20 g ha^{-1}	139	3.73	2899	4058	41.7
T_8 : PoE application of 2,4-D sodium salt @ 800 g ha^{-1}	124	3.64	2553	3534	41.9
T_9 : Hand weeding twice at 15 and 30 DAT	143	3.83	3083	4316	41.7
T_{10} : Weedy check	66	3.57	1410	2260	38.4
SEm ±	3.6	0.137	113.8	126.6	1.42
CD (P=0.05)	11	0.41	338	376	4.2

(T_4), this is mainly due to severe phytotoxicity effect of herbicides on crop.

Among the weed management practices investigated, higher grain and straw yield was observed in hand weeding twice at 15 and 30 DAT (T_9), which was in parity with post-emergence application of penoxsulam 20 g ha^{-1} (T_7) and both were significantly superior over post-emergence application of 2,4-D sodium salt 800 g ha^{-1} (T_8). This was mainly due to effective removal of weeds at critical period of crop-weed competition that led to increased availability of growth resources to crop, which in turn created favourable conditions for increased stature of vegetative growth and reproductive potential of the crop leading to increased grain yield. These results were in conformity with findings Shubhashree *et al.* (2023) and Ramadevi *et al.* (2021).

The next best treatment was early post-emergence application of pretilachlor + pyrazosulfuron ethyl 460 g ha^{-1} (T_2), which was comparable with early post-emergence application of bensulfuron methyl + pretilachlor 500 g ha^{-1} (T_1) in the order of descent. Post-emergence application of triafamone + ethoxysulfuron 30 g ha^{-1} (T_5), which was in parity with post-emergence application of bispyribac-sodium + pyrazosulfuron ethyl 52.5 g ha^{-1} (T_3) and significantly superior over weedy check (T_{10}). This was mainly due to poor performance of transplanted finger millet as a result of mild phytotoxicity effect in (T_5) and (T_3) and heavy weed infestation in weedy check treatment. Significantly lowest grain yield of transplanted finger millet was obtained in post-emergence application of fenoxaprop-p-ethyl 42 g ha^{-1} (T_6), which was at par with post-emergence application of penoxsulam + cyhalofop-butyl 67.6 g ha^{-1} (T_4). This was mainly due to severe phytotoxicity effect of these herbicides on crop and also due to greater competition for the growth resources among the crop and weeds as evident by the lowest crop stature, yield attributes and yield of transplanted finger millet. These results were in line with Thanmai *et al.* (2018).

Higher harvest index was registered with post-emergence application of 2,4-D sodium salt 800 g ha^{-1} (T_8), however it was statistically in parity with, post-emergence application of penoxsulam 20 g ha^{-1} (T_7), hand weeding at 15 and 30 DAT (T_9), early post-emergence application of pretilachlor + pyrazosulfuron ethyl 460 g ha^{-1} (T_2), early post-emergence application of bensulfuron methyl + pretilachlor 500 g ha^{-1} (T_1), post-emergence application of bispyribac-sodium + pyrazosulfuron ethyl 52.5 g ha^{-1} (T_3), post-emergence application of triafamone + ethoxysulfuron 30 g ha^{-1} (T_5) and weedy check (T_{10}) in the order of descent.

Significantly lower harvest index was recorded with post-emergence application of fenoxaprop-p-ethyl 42 g ha^{-1} (T_6), which was at par with post-emergence application of penoxsulam + cyhalofop-butyl 67.6 g ha^{-1} (T_4), this was due to reduced grain and straw yields due to severe crop stand loss by severe phytotoxicity effect on crop plants.

Nutrient uptake *viz.,* nitrogen, phosphorous and potassium by transplanted finger millet at harvest was significantly influenced by different weed management practices (Table 2). N, P and K uptake by plant followed similar trend.

Hand weeding twice at 15 and 30 DAT (T_9), registered higher nutrient uptake, which was at par with post-emergence application of penoxsulam 20 g ha^{-1} (T_7). The next best treatment was post-emergence application of 2,4-D sodium salt 800 g ha^{-1} (T_8). This might be due to decreased crop weed competition, which concurrently increased the nutrient availability, better crop growth and higher crop biomass production coupled with more nutrient. These results were closely conformity with that of Sneha *et al.* (2024) and Ramadevi *et al.* (2021).

Early post-emergence application of pretilachlor + pyrazosulfuron ethyl 460 g ha^{-1} (T_2), which was significantly comparable with early post-emergence application of bensulfuron methyl + pretilachlor 500 g ha^{-1} (T_1).

Post-emergence application of triafamone + ethoxysulfuron 30 g ha^{-1} (T_5), which was in parity with post-emergence application of bispyribac-sodium + pyrazosulfuron ethyl 52.5 g ha^{-1} (T_3) and significantly superior over weedy check (T_{10}).

Significantly lower nutrient *i.e.,* nitrogen, phosphorous and potassium uptake was observed with post-emergence application of fenoxaprop-p-ethyl 42 g ha^{-1} (T_6), which was at par with post-emergence application of penoxsulam + cyhalofop-butyl 67.6 g ha^{-1} (T_4), due to phytotoxicity effect of fenoxaprop-p-ethyl and cyhalofop-butyl on crop, resulted in stunted growth coupled with reduced stature leading to decreased dry matter production and nutrient accumulation in the crop.

Table 2. Nutrient uptake by transplanted finger millet and weeds (kg ha^{-1}) at harvest as influenced by weed management practices

Treatment	Finger millet			Weeds	
	Nitrogen	**Phosphorus**	**Potassium**	**Nitrogen**	**Phosphorus**
T_1 : Early post-emergence (EPoE) application of bensulfuron methyl 0.6 % + pretilachlor 6.0 % GR @ 500 g ha^{-1}	48.00	27.54	38.65	11.89	5.20
T_2 : EPoE application of pretilachlor 6.0 % + pyrazosulfuron ethyl 0.15 % GR @ 460 g ha^{-1}	48.23	27.84	39.65	9.54	4.98
T_3 : Post-emergence (PoE) application of bispyribac-sodium 20% + pyrazosulfuron ethyl 15 % WDG @ 52.5 g ha^{-1}	40.87	24.76	33.78	18.65	8.16
T_4 : PoE application of penoxsulam 1.02 % + cyhalofop-butyl 5.1 % OD @ 67.6 g ha^{-1}	24.54	20.54	23.56	31.65	18.87
T_5 : PoE application of triafamone 20 % + ethoxysulfuron 10 % WG @ 30 g ha^{-1}	41.78	25.08	33.78	17.34	7.34
T_6 : PoE application of fenoxaprop-p-ethyl 6.7 % EC @ 42 g 00ha^{-1}	22.50	19.54	21.44	34.08	19.54
T_7 : PoE application of penoxsulam 21.7 % SC @ 20 g ha^{-1}	62.65	31.76	49.76	4.32	2.97
T_8 : PoE application of 2,4-D sodium salt @ 800 g ha^{-1}	55.74	29.65	44.78	8.87	4.27
T_9 : Hand weeding twice at 15 and 30 DAT	63.78	32.89	51.78	3.55	2.44
T_{10} : Weedy check	34.76	22.65	28.45	26.7	14.56
SEm ±	1.872	0.393	1.378	1.280	0.381
CD (P=0.05)	5.61	1.27	4.13	3.84	1.14

Nutrient uptake *viz.,* nitrogen, phosphorous and potassium by weeds in transplanted finger millet at harvest was significantly altered by weed management practices (Table 1 and Fig. 2). N, P and K uptake by weeds followed similar trend.

Lower uptake of nutrients by weeds was reported with hand weeding twice at 15 and 30 DAT (T_9), which was at par with post-emergence application of penoxsulam 20 g ha^{-1} (T_7), due to effective control of all the categories of weeds, leading to reduced dry matter accumulation by weeds. It was evident that with effective control of weeds, significant loss of nutrients can be avoided and thereby increased the availability of nutrients to the crop. The results were corroborates with the findings of Ashok, (2024).

The next best treatment with lower nutrient uptake by weeds was noticed with post-emergence application of 2,4-D sodium salt 800 g ha^{-1} (T_8), which was in parity with early post-emergence application of pretilachlor + pyrazosulfuron ethyl 460 g ha^{-1} (T_2) and early post-emergence application of bensulfuron methyl + pretilachlor 500 g ha^{-1} (T_1), in the order of ascent. Post-emergence application of triafamone + ethoxysulfuron 30 g ha^{-1} (T_5) and post-emergence application of bispyribac-sodium + pyrazosulfuron ethyl 52.5 g ha^{-1} (T_3) were comparable with each other and in turn superior over weedy check (T_{10}).

Significantly higher nutrient uptake by weeds was reported with post-emergence application of fenoxaprop-p-ethyl 42 g ha^{-1} (T_6), which was at par with post-emergence application of penoxsulam + cyhalofop-butyl 67.6 g ha^{-1} (T_4). This was due to phytotoxicity of the herbicides on crop, the growth of finger millet was reduced which favoured the weeds to increase their number as well as biomass leading to higher nutrient uptake by weeds.

Among the treatments, hand weeding twice at 15 and 30 DAT (T_9) and post-emergence application of penoxsulam 20 g ha^{-1} (T_7) consistently resulted in higher nutrient uptake (N, P, K), reduced nutrient loss through weeds, improved productive tillers, higher test weight, grain, straw yield and better harvest index. These treatments effectively suppressed weed growth and minimized competition. Post-emergence application of fenoxaprop-p-ethyl (T_6) and penoxsulam + cyhalofop-butyl (T_4) showed phytotoxic effects on the crop, resulting in severe loss of crop stand, poor nutrient accumulation in the plant and the lowest yield.

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AN ANALYTICAL STUDY ON FARMERS' SATISFACTION AND DETERMINANTS INFLUENCING ADOPTION OF TISSUE CULTURE BANANA (TCB) CULTIVATION IN ANNAMAYA AND NANDYALA DISTRICTS OF ANDHRA PRADESH

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ABSTRACT

This study examined the satisfaction levels and adoption factors of tissue culture banana (TCB) cultivation among farmers in Annamaya and Nandyala districts of Andhra Pradesh. TCB is favored for its disease-free planting material, uniform growth and higher yield potential. Most farmers expressed high satisfaction with yield performance and fruit quality, though concerns remained regarding pest resistance and limited access to subsidies. Satisfaction was measured using a 5-point Likert scale and Principal Component Analysis (PCA) was applied to 20 key statements. The analysis revealed seven major components influencing adoption, accounting for (64.72%) of the total variance. Key factors included uniform harvest, disease resistance, economic viability and institutional facilitation. The findings indicate that while the technical benefits of TCB are strong motivators, adoption decisions are also significantly shaped by structural aspects such as training, market linkages and subsidy delivery. Farmers are more likely to continue with TCB when both agronomic and institutional supports are present. Therefore, a balanced approach combining technology with robust support systems is essential for the sustainable success of TCB cultivation.

KEYWORDS: Tissue culture banana, farmers satisfaction, adoption factors, likert scale, principal component analysis.

INTRODUCTION

Banana (*Musa* spp.) is one of the most important fruit crops in India, contributing significantly to food security, nutrition and rural livelihoods. Andhra Pradesh is among the leading banana-growing states, where the crop serves as a major source of income for farming households. Traditionally, banana cultivation has relied on sucker propagation; however, this method often results in non-uniform growth, disease transmission and lower productivity.

Tissue culture banana (TCB) technology has emerged as an effective alternative by providing disease-free, genetically uniform and high-yielding planting material. Studies by (Anyango *et al.,* 2010) and (Kabunga *et al.,* 2012) reported that tissue culture banana cultivation improves productivity, fruit quality and farm income. Similarly, (Flarian *et al.,* 2018) highlighted the role of tissue culture technology in enhancing banana production and profitability. Due to these advantages, the adoption of tissue culture banana has increased in several banana growing regions.

Despite its benefits, adoption of tissue culture banana is influenced by various socio-economic, institutional and technical factors. (Thuo *et al.,* 2017) and (Omari *et al.,* 2023) reported that education, extension support, market access and access to credit significantly affect adoption decisions. (Wanyama *et al.,* 2016) emphasized the importance of quality planting material and institutional support, while (Mulugo *et al.,* 2019) found that social influence and farmer innovativeness positively influence technology adoption. However, constraints such as high plantlet costs, inadequate technical knowledge and limited support services continue to hinder wider adoption (Shukla *et al.,* 2018; Bairwa *et al.,* 2015).

Although tissue culture banana cultivation is gaining popularity in Andhra Pradesh, limited information is available regarding farmers' satisfaction and the factors influencing its adoption in the Rayalaseema region. Therefore, the present study was undertaken in Annamaya and Nandyala districts of Andhra Pradesh to assess farmers' satisfaction with tissue culture banana cultivation and identify the key factors influencing its adoption.

MATERIAL AND METHODS

The study was conducted in Annamaya and Nandyal districts of Andhra Pradesh, targeting 120 purposively

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selected farmers with experience in tissue culture banana (TCB) cultivation.

Data were collected through a structured interview schedule covering satisfaction levels and factors influencing TCB adoption. Satisfaction was measured using a 5-point Likert scale across seven key areas and Chi-square test was conducted to examine the association between the source of plantlets and satisfaction with the availability of plantlets

To identify adoption factors, Principal Component Analysis (PCA) was performed on 20 statements. KMO and Bartlett's tests ensured data suitability and components with eigenvalues over 1 were retained using Varimax rotation.

Chi-Square Test

This non-parametric test helps to determine whether a statistically significant relationship exists between two variables.

$$\chi^2 = \sum \frac{(O-E)^2}{E} \sim \chi^2_{(r-1)(c-1)df}$$

Where:

χ^2 = Chi-Square statistic

O = Observed frequency (from your actual data)

E = Expected frequency

r = number of rows

c = number of columns

df = degrees of freedom

Factor Analysis

To identify the underlying various factors that impact farmers decisions to cultivate tissue culture banana, exploratory factor analysis was conducted. This technique grouped related variables into a smaller set of independent factors using Principal Component Analysis (PCA) with Varimax rotation. Only factors with eigenvalues greater than 1 were retained. Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity were used to verify the adequacy of the sample for factor analysis.

Basic Factor Analysis Equation

Let

$x_1,x_2,\ldots,x_p$ = observed variables

$F_1,F_2,\ldots..,F_m$ = common factors (latent)

$u_1,u_2,\ldots\ldots,u_p$ = unique (error) factors

Then the Factor Model is:

$$x_i = \lambda_{i1}F_1 + \lambda_{i2}F_2 + \cdots\cdots + \lambda_{im}F_m + u_i$$

Where:

λ_{ij} = factor loading of variable x_i on factor F_j

u_i = unique variance for variable x_i

Definitions and Terms Used in the Factor Analysis

Factor

A factor is a linear combination of the original observed variables. It represents an underlying dimension that helps to summarize and explain the patterns of correlations among a set of variables.

Factor Loadings

Factor loadings indicate the correlation between each observed variable and the underlying factor. Higher loadings suggest a stronger association of the variable with the respective factor.

Eigenvalues

Eigenvalues reflect the amount of variance in the data explained by each factor. Only factors with eigenvalues greater than 1 are usually retained for further analysis, as they represent substantial underlying patterns.

Factor Rotation

Factor rotation is the process of adjusting the factor axes to achieve a simpler and more interpretable structure. In this study, Varimax rotation, an orthogonal method, was used to obtain uncorrelated and distinct factors.

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy

KMO measures the adequacy of the sample size for factor analysis. It ranges from 0 to 1, with values above 0.6 generally considered acceptable for proceeding with factor extraction.

Table 1. Satisfaction level towards tissue culture banana plantlets

S. No.	Particulars	Mean Score	Mean (±) SD	Satisfaction Level
1.	TCB Satisfaction plantlet quality and Growth performance	3.85	3.85 (±) 0.97	Satisfied
2.	TCB Satisfaction Yield	4.44	4.44 (±) 0.51	Highly Satisfied
3.	TCB Satisfaction Resistant for pest, disease and wind velocity	2.29	2.29 (±) 0.89	Dissatisfied
4.	TCB Satisfaction Fruit quality	3.90	3.90 (±) 0.90	Satisfied
5.	TCB Satisfaction Service facility in door delivery of plantlets	3.51	3.51 (±) 1.18	Satisfied
6.	TCB Satisfaction Availability of Plantlets	3.81	3.81 (±) 0.86	Satisfied
7.	TCB Satisfaction Subsidy for TCB	1.69	1.69 (±) 0.48	Highly Dissatisfied

Table 2. Association between availability of plantlets vs source of purchase

S. No.	Source of Plantlets	Satisfaction level			Total	Chi-square statistic (χ^2)	p-value
		Not Satisfied	Neutral	Satisfied			
1.	Private	5 (4.17%)	27 (22.5%)	51 (42.5%)	83 (69.1%)	11.936	0.0178*
2.	Dealer	1 (0.83%)	10 (8.33%)	17 (14.17%)	28 (23.3%)		
3.	Ratoon	3 (2.5%)	0 (0%)	6 (5%)	9 (7.5%)		
	Total	9 (7.5%)	37 (30.8%)	74 (61.6%)	120 (100%)		

*Significance at 0.05 level of significance

Table 3. Kaiser-meyer-olkin and bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.761**
Bartlett's Test, of Sphericity	Approx. Chi-Square	678.342
	DF	190
	P-value	<0.001

Bartlett,s Teat of Sphericity

This test checks whether the correlation matrix is significantly different from an identity matrix, which would imply that the variables are related and suitable for factor analysis. A significance level (p-value) less than 0.05 indicates that factor analysis is appropriate.

Communality (Common Variance)

Communality refers to the proportion of each variable's variance that can be explained by the extracted factors.

Correlation Matrix

A correlation matrix shows the pairwise correlations between all the observed variables used in the analysis. It is the basis for identifying variables that can be grouped together under common factors.

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a multivariate statistical technique used for reducing the dimensionality of large datasets while preserving as much variability as possible.

Scree Plot

A scree plot visually represents the eigenvalues of each factor in descending order. It helps in determining the number of factors to retain by identifying the point where the curve flattens (the "elbow").

RESULTS AND DISCUSSION

Satisfaction Level of Farmers with Tissue Culture Banana

The respondents were asked to express their level of satisfaction on various aspects of tissue culture banana (TCB) plantlets using a 5-point Likert scale, Ranging from Highly Dissatisfied (1) to Highly Satisfied (5). The satisfaction scores were then averaged to determine the overall perception of farmers. The results were presented in Table 1. These findings are similar to the results of (Omari *et al.,* 2024)

The results of the satisfaction analysis revealed a generally positive perception of TCB technology among the respondents. The highest satisfaction was recorded for yield performance (Mean score = 4.44), followed by fruit quality (3.90), plantlet quality and Growth performance (3.85), availability of plantlets (3.81), Service facility in door delivery of plantlets (3.51), Resistant for pest, disease and wind velocity (2.29), Subsidy for TCB (1.69).

The chi-square test result showed in Table 2 indicated that p-value 0.0178 at 5 per cent level of significance suggest that satisfaction scores were significantly associated with variables such as availability of plantlets and source of plantlets, suggesting that external support mechanisms influence user experience.

Factor Analysis on Adoption Influencers

From Table 3 The KMO value of 0.761 confirmed the adequacy of the sample for PCA. Bartlett's Test of Sphericity was significant at 1 per cent level of significance, indicating that correlations among items were sufficient for dimensional reduction.

Rotated Component Matrix

The rotated component matrix displays the loading values for each variable related to the factors influencing farmers' decisions to grow tissue culture banana. Based on these factor loadings, the variables were grouped into seven distinct decision-driving categories, as illustrated in Table 4.

Grouping of Extracted Factors

The variables extracted from each benefit column were grouped according to their factor loadings in Table 5.

Benefits derived by farmers by growing Tissue culture Banana

From The extracted seven factors benefits that are driven by farmers are ranked and listed in Table 6.

A total of seven principal components were extracted, explaining 64.72 per cent of the total cumulative variance.

Uniform and Early Harvest, with a mean score of 4.01 was identified as a major perceived benefit, indicating that farmers highly value the consistency in crop maturity and the ability to plan harvests and market sales more efficiently.

Crop Protection and Year-round Production, with a mean score of 3.79 emerged as another key benefit, highlighting farmers' appreciation for stress tolerance, disease resistance, and the capability of the crop to produce across all seasons.

Table 4. Rotated component matrix

Rotated Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
Quality of the plantlets	0.559						
High yield	0.232						
Drought Tolerant	0.790						
Disease resistance	0.721						
Tissue culture plants will be of same age and same variety	0.674						
Resistant to wind velocity		0.785					
Due to the adoption of drip irrigation technology		0.604					
Subsidy for planting Tissue culture Banana		0.718					
Good value in exporting of G9 Banana fruit		0.696					
Attractive yellow colour for local marketing			0.402				
Good keeping quality / shelf life			0.611				
Best in ratoon cropping			0.481				
Low cost of irrigation			0.539				
Weight of the finger is higher than the other variety				0.737			
Good taste, most preferable by consumers				0.668			
Insect resistance					0.748		
Year around cropping season/ year around yield					0.546		
Low cost of labour						0.479	
Preferable by marketers						0.767	
Early maturity/Uniform maturity							0.848

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]

According to Table 4, the rotated component matrix reveals seven key factors influencing farmers' decisions to grow tissue culture banana.

Table 5. Grouping of factors

S. No.	Benefits	Variables	Factor loadings	Mean score
1.	Plant Resilience and Uniformity	Quality of the plantlets	0.559	4.20
		High yield	0.232	4.08
		Drought Tolerant	0.790	3.60
		Disease resistance	0.721	3.50
		Tissue culture plants will be of same age and same variety	0.674	3.15
2.	Technological and Economic Support	Resistant to wind velocity	0.785	3.52
		Due to the adoption of drip irrigation technology	0.604	3.20
		Subsidy for planting Tissue culture Banana	0.718	3.08
		Good value in exporting of G9 Banana fruit	0.696	3.49
3.	Market and Resource Efficiency	Attractive yellow colour for local marketing	0.402	4.02
		Good keeping quality / shelf life	0.611	3.44
		Best in ratoon cropping	0.481	3.73
		Low cost of irrigation	0.539	3.39
4.	Fruit Quality and Consumer Preference	Weight of the finger is higher than the other variety	0.737	3.53
		Good taste, most preferable by consumers	0.668	3.77
5.	Crop Protection and Production Continuity	Insect resistance	0.748	3.58
		Year around cropping season/ year around yield	0.546	4.01
6.	Labour and Market Convenience	Low cost of labour	0.479	3.10
		Preferable by marketers	0.767	3.12
7.	Uniform and Early Harvest	Early maturity/Uniform maturity	0.848	4.01

Table 6. Benefits derived by farmers by growing tissue culture banana

S. No.	Factors	Mean score	Rank
1.	Uniform and Early Harvest	4.01	I
2.	Crop Protection and Production Continuity	3.79	II
3.	Plant Resilience and Uniformity	3.70	III
4.	Fruit Quality and Consumer Preference	3.65	IV
5.	Market and Resource Efficiency	3.64	V
6.	Technological and Economic Support	3.32	VI
7.	Labour and Market convenience	3.11	VII

Table 7. Principal component analysis

Total variance explained									
Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Per cent of variance	Cumulative per cent	Total	Per cent of variance	Cumulative per cent	Total	Per cent of variance	Cumulative per cent
1	4.96	24.831	24.831	4.966	24.831	24.831	2.687	13.435	13.435
2	2.25	11.294	36.125	2.259	11.294	36.125	2.323	11.614	25.049
3	1.39	6.991	43.116	1.398	6.991	43.116	2.225	11.124	36.173
4	1.15	5.757	48.873	1.151	5.757	48.873	1.698	8.488	44.660
5	1.10	5.536	54.409	1.107	5.536	54.409	1.386	6.931	51.592
6	1.05	5.289	59.697	1.058	5.289	59.697	1.355	6.766	58.367
7	1.00	5.028	64.725	1.006	5.028	64.725	1.272	6.358	64.725
8	0.893	4.466	69.191						
9	0.847	4.233	73.424						
10	0.757	3.783	77.207						
11	0.736	3.679	80.886						
12	0.621	3.107	83.993						
13	0.561	2.804	86.797						
14	0.525	2.623	89.420						
15	0.501	2.504	91.924						
16	0.443	2.214	94.137						
17	0.406	2.031	96.168						
18	0.307	1.536	97.704						
19	0.278	1.390	99.095						
20	0.181	0.905	100.00						

Extraction Method: Principal Component Analysis.
From this extraction method of principal component analysis revealed seven key factors influencing adoption.

Plant Resilience and Consistency, with a mean score of 3.70 reflects farmers' recognition of the high quality of tissue culture plantlets, uniform growth patterns, and improved crop stand in the field.

Fruit Quality and Market Preference, which recorded a mean score of 3.65 captures the importance given to desirable physical traits such as fruit appearance, size, and overall consumer acceptability in the market.

Economic Viability and Input Efficiency, with a mean score of 3.64 highlights the perceived benefits related to reduced input needs, extended shelf life, potential for ratoon cropping, and enhanced overall profitability.

Institutional Support and Market Opportunities, scoring a mean of 3.32 represents the influence of factors such as access to government subsidies, linkage to export markets, integration with drip irrigation, and training support.

Labour and Distribution Ease, which had a mean score of 3.11 points to benefits related to reduced harvest labour, improved transportability, and better access to distribution and logistics channels.

Principal Component Analysis

Using SPSS software, Principal Component Analysis (PCA) was applied to extract underlying factors from 20 statements intended to identify key influences on the farmers decision to grow tissue culture banana. As shown in the Component Matrix, SPSS initially extracted all variables however, based on the eigenvalue criterion (greater than one), seven components were ultimately retained. The Extraction Sums of Squared Loadings column indicated that these seven components together explained around (64.72%) of the total variance values are presented in Table 7.

Scree plot

Scree plot was, used to determine the appropriate number of factors to retain. It serves as a visual representation eigenvalue versus all the benefits. The point of interest is a place where the curve begins to flatten and the graph plotted is explained in Fig.1.

It was clear from Fig.1. that the curve begins to flatten from seventh factor were 20 variables extracted were analyzed for further research.

The above findings show that while agronomic and economic factors play a dominant role in TCB adoption, institutional and logistical parameters are also crucial. Particularly, the factor "Institutional Support and Market Opportunities" scored lower, signalling a weak linkage between farmers and enabling institutions.

The study shows that farmers generally accept tissue culture banana (TCB) for its consistent yields, early harvests and good fruit quality. While most were satisfied with its agronomic benefits, challenges like pest issues, limited subsidies and weak extension support especially for marginal farmers remain concerns.

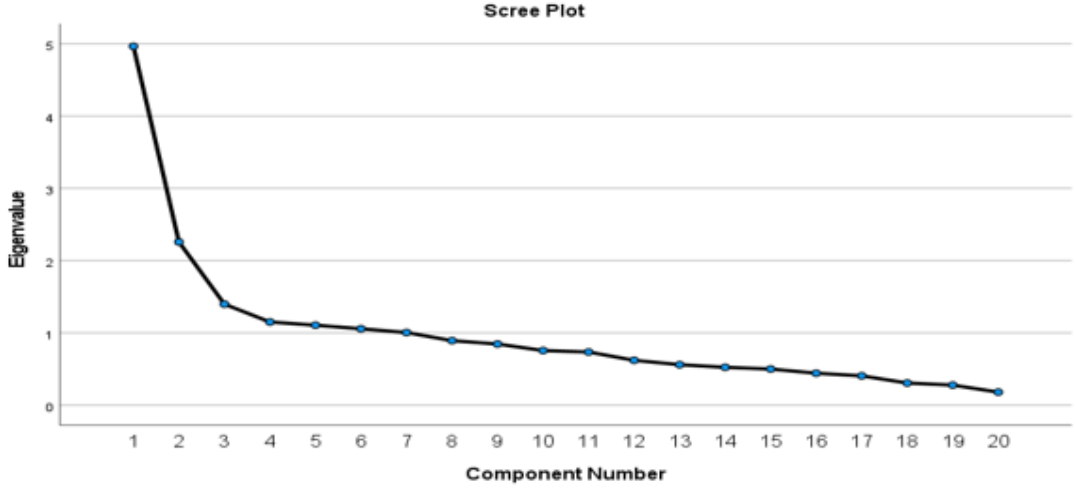


Fig. 1. Screen plot

Principal Component Analysis revealed seven key factors influencing adoption, highlighting both biological performance and institutional support. For wider and sustained adoption, it's essential to strengthen areas like pest management, timely input delivery and policy support. A balanced approach combining technology, infrastructure and government backing is crucial to expand TCB adoption across diverse regions.

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SPATIAL HETEROGENEITY IN LONG-TERM DIURNAL TEMPERATURE RANGE TRENDS ACROSS KARNATAKA, INDIA (1958–2024)

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ABSTRACT

Diurnal temperature range (DTR), the difference between daily maximum and minimum temperature, is an important indicator of asymmetric warming. This study analyses long-term spatial variability in DTR across Karnataka, India, using district-level temperature series derived from the TerraClimate dataset for 1958–2024. Annual DTR trends were evaluated using the non-parametric Mann–Kendall test and Sen's slope estimator. Results indicate pronounced spatial heterogeneity across districts. Increasing DTR trends occur primarily in southern Karnataka, whereas decreasing trends dominate northern semi-arid regions. Several coastal districts exhibit weak or non-significant trends. These findings demonstrate that aggregated temperature indicators mask substantial regional variability in diurnal thermal behaviour.

KEYWORDS: Climate variability; diurnal temperature range; Karnataka; mann–kendall test; spatial analysis.

INTRODUCTION

Diurnal temperature range (DTR), the difference between daily maximum (Tmax) and minimum (Tmin) temperatures, captures changes in the relative behaviour of daytime and nighttime temperatures that are not evident from mean temperature alone. DTR is influenced by cloud cover, atmospheric moisture, surface radiation, soil moisture and land-surface characteristics, making its long-term variation useful for examining regional differences in warming.

Changes in DTR have been observed across many regions, often reflecting unequal rates of change in Tmax and Tmin. Karl *et al.* (1993) reported faster increases in minimum than maximum temperatures across many locations, resulting in a decline in DTR. Subsequent studies have related DTR variability to precipitation, cloud cover and associated changes in surface radiation (Zhou *et al.,* 2009). In India, Roy and Balling (2005) reported an inverse association between DTR and cloud cover, indicating the importance of cloudiness in modifying daytime and nighttime temperature differences.

Long-term temperature records for India also show marked spatial variation in the behaviour of Tmax and Tmin (Kumar *et al.,* 1994; Kothawale and Rupa Kumar, 2005; Mall *et al.,* 2021). Dhorde *et al*. (2017) identified spatial differences in temperature trends across Maharashtra and Karnataka, while Mohapatra (2002) reported changes in DTR over Bengaluru in association with urbanisation and local environmental change. At the district scale, Simpson *et al.* (2024) documented spatial variation in temperature and rainfall trends across Karnataka. Their analysis, however, did not specifically examine DTR. District-level evidence on long-term DTR trends across Karnataka therefore remains limited.

This gap is important because Karnataka contains markedly different climatic regions, ranging from the humid coast and Western Ghats to the semi-arid interior. State-level averages may therefore conceal differences in the relative rates of daytime and nighttime warming. Gridded climate data make it possible to examine these differences consistently across districts and over long periods, including areas where station coverage may be uneven.

The present study examines long-term DTR trends across Karnataka using district-level Tmax and Tmin series derived from TerraClimate for 1958–2024. The Mann–Kendall test and Sen's slope estimator are used to assess the direction, statistical significance and magnitude of trends. The analysis focuses on whether the relatively stable statewide DTR pattern masks contrasting trends

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among districts and on the spatial distribution of these changes across Karnataka.

MATERIAL AND METHODS

Study Area

Karnataka is located in southern India between approximately 11°–18° N latitude and 74°–78° E longitude. The state encompasses diverse climatic and physiographic regions, including the humid coastal belt along the Arabian Sea, the elevated Western Ghats mountain range, and the semi-arid interior plateau. These regions differ substantially in rainfall, temperature regimes, elevation, and land-surface characteristics. Annual rainfall exceeds 3,000 mm in parts of the Western Ghats but falls below 600 mm in northern interior districts. Temperature conditions also vary considerably across these zones due to differences in altitude, continentality, and proximity to maritime influences. This pronounced environmental heterogeneity makes Karnataka an appropriate region for examining spatial patterns and long-term variability in diurnal temperature range.

Climate Data

Monthly maximum temperature (Tmax) and minimum temperature (Tmin) data were obtained from the TerraClimate dataset, a high-resolution global climate dataset providing monthly climate and water balance variables at approximately 1/24° spatial resolution (~4 km). TerraClimate integrates high-resolution climatology with global reanalysis data and station observations to generate spatially consistent climate fields (Abatzoglou *et al.,* 2018). The dataset covers the period from 1958 onward and is widely used for long-term climate analyses.

District-level temperature series were derived by overlaying Karnataka district boundary polygons on the TerraClimate grid. Monthly Tmax and Tmin values were calculated as spatial averages of all grid cells intersecting each district boundary. Diurnal temperature range (DTR) was then computed as the difference between Tmax and Tmin for each district and month. The monthly district-level series spanning 1958–2024 were subsequently aggregated to annual averages to construct long-term time series for trend analysis.

Trend Detection: Mann–Kendall Test

Long-term trends in annual DTR were evaluated using the non-parametric Mann–Kendall (MK) test. The MK test is widely used in climatological studies because it does not require the data to follow a specific distribution and is robust to outliers. The method assesses whether a monotonic upward or downward trend exists in a time series.

For a time series $x_1,x_2,\ldots,x_n$, the MK test statistic Sis calculated as:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}(x_j - x_i)$$

where the sign function is defined as:

$$\operatorname{sgn}(x_j - x_i) = \begin{cases} 1, & \text{if } x_j - x_i > 0 \\ 0, & \text{if } x_j - x_i = 0 \\ -1, & \text{if } x_j - x_i < 0 \end{cases}$$

Under the null hypothesis of no trend, the variance of Sis given by:

$$Var(S) = \frac{n(n-1)(2n+5)}{18}$$

The standardized test statistic Zis then computed as:

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}}, & S > 0 \\ 0, & S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}}, & S < 0 \end{cases}$$

A positive value of Zindicates an increasing trend, whereas a negative value indicates a decreasing trend. Statistical significance was assessed at the 5 per cent significance level ($p<0.05$).

Estimation of Trend Magnitude: Sen's Slope

The magnitude of the monotonic trend in DTR was estimated using Sen's slope estimator. This method calculates the median slope of all possible pairs of observations in the time series and provides a robust estimate of the rate of change over time.

For all pairs of observations (x_i,x_j) where $j>i$, the slope is calculated as:

$$Q_i = \frac{x_j - x_i}{j - i}$$

Table 1. District-wise Mann–Kendall (MK) test statistics and Sen's slope estimates for diurnal temperature range (DTR) across Karnataka for the period 1958–2024. Positive (negative) Z values and Sen's slopes indicate increasing (decreasing) DTR trends. Statistically significant trends are identified at the 5% significance level.

District	Z	S	Var(S)	p_value	Trend	Sen_slope	Intercept
Bagalkote	-3.5177	-651	34143	0.0004	decreasing	-0.0057	11.3170
Ballari	-0.5358	-100	34144	0.5921	no trend	0.0000	11.0121
Bengaluru	3.6477	675	34141	0.0003	increasing	0.0058	11.1542
Belagavi	-3.5987	-666	34146.67	0.0003	decreasing	-0.0065	11.5871
Bengaluru Rural	3.8911	720	34144	0.0001	increasing	0.0058	11.1441
Bidar	-3.8803	-718	34144	0.0001	decreasing	-0.0078	11.6921
Chamarajanagara	3.1495	583	34147.67	0.0016	increasing	0.0056	10.2054
Chikkaballapura	3.7559	695	34143	0.0002	increasing	0.0059	11.0051
Chikkamagaluru	2.1268	394	34144	0.0334	increasing	0.0034	9.9914
Chitradurga	2.1051	390	34146.67	0.0353	increasing	0.0026	10.9394
Dakshina Kannada	2.4569	455	34145.67	0.0140	increasing	0.0041	7.9399
Davanagere	0.8605	160	34144	0.3895	no trend	0.0001	11.0914
Dharwad	-2.5922	-480	34146.67	0.0095	decreasing	-0.0038	11.1348
Gadag	-2.2837	-423	34145.67	0.0224	decreasing	-0.0032	11.3598
Hassan	3.2253	597	34147.67	0.0013	increasing	0.0051	10.0233
Haveri	-0.9092	-169	34145.67	0.3633	no trend	-0.0003	10.8915
Kalaburagi	-3.8153	-706	34144	0.0001	decreasing	-0.0074	12.1091
Kodagu	3.2254	597	34145.67	0.0013	increasing	0.0051	8.3120
Kolar	3.3283	616	34144	0.0009	increasing	0.0057	10.7992
Koppal	-2.1160	-392	34144.67	0.0343	decreasing	-0.0026	11.2027
Mandya	3.4310	635	34145.67	0.0006	increasing	0.0057	10.6334
Mysuru	3.4798	644	34144.67	0.0005	increasing	0.0056	9.6164
Raichur	-2.0131	-373	34147.67	0.0441	decreasing	-0.0030	11.2624
Ramanagara	3.4041	630	34142	0.0007	increasing	0.0057	11.0397
Shivamogga	1.0228	190	34146.67	0.3064	no trend	0.0002	10.0901
Tumakuru	3.4580	640	34146.67	0.0005	increasing	0.0055	11.0396
Udupi	1.3150	244	34146.67	0.1885	no trend	0.0018	8.2091
Uttara Kannada	-1.8021	-334	34146.67	0.0715	no trend	-0.0025	9.4733
Vijayapura	-3.8368	-710	34146.67	0.0001	decreasing	-0.0066	12.0402
Yadgir	-2.3921	-443	34143	0.0168	decreasing	-0.0049	11.6097

The Sen's slope estimate is the median of all calculated slopes: Q="median"(Q_i)

Positive values of Qindicate increasing trends, while negative values indicate decreasing trends. The slope values represent the annual rate of change in diurnal temperature range for each district.

Data Processing and Analysis

All data processing and statistical analyses were conducted using Python within the Spyder integrated development environment. Spatial aggregation of TerraClimate data to district boundaries was performed using geospatial libraries, and statistical analyses were implemented using standard scientific computing packages. Trend statistics and slope estimates were computed for each district-level DTR time series covering the period 1958–2024.

RESULTS AND DISCUSSION

Temporal Evolution of Statewide Diurnal Temperature Range

The annual mean diurnal temperature range (DTR) averaged across Karnataka exhibits moderate inter-annual variability over the period 1958–2024 (Fig. 6). Statewide mean DTR values generally fluctuate between approximately 10 and 11.3 °C, indicating relatively stable long-term thermal variability at the aggregated scale. Although both maximum temperature (Tmax) and minimum temperature (Tmin) show gradual increases over time (Fig. 1), their broadly concurrent behaviour results in limited long-term change in the state-averaged DTR series.

Temporal fluctuations are nevertheless evident across different decades. Higher DTR values occur during parts of the 1960s, followed by relatively lower averages during the 1970s. Subsequent decades show gradual recovery and stabilization, with moderate year-to-year variability persisting through the most recent period. These results suggest that while long-term warming has occurred across Karnataka, the relative balance between daytime and nighttime temperatures has remained broadly stable when averaged across the entire state. However, aggregated averages may conceal important spatial differences in temperature behaviour across districts.

Spatial Distribution of District-Level DTR

Substantial spatial variability in DTR is observed across Karnataka districts (Fig. 7). Coastal districts such as Dakshina Kannada, Udupi, and Uttara Kannada exhibit relatively low median DTR values, typically around 8 °C, with comparatively narrow distributions. These patterns are consistent with the moderating influence of maritime air masses, higher humidity, and persistent cloud cover, which tend to reduce daytime heating and limit diurnal thermal contrasts.

In contrast, interior semi-arid districts including Kalaburagi, Vijayapura, Bagalkote, Gadag, and Ballari display higher median DTR values, often exceeding 11–12 °C. These districts also exhibit wider interquartile ranges, reflecting greater inter-annual variability in diurnal thermal conditions. The larger DTR values observed in these regions are consistent with lower humidity, reduced cloud cover, and stronger daytime heating typical of continental semi-arid climates.

Districts located within transitional or topographically complex regions, including Belagavi, Shivamogga, and Chikkamagaluru, show broader distributions and occasional outliers in DTR values. These patterns suggest greater sensitivity to inter-annual climatic variability in areas influenced by both coastal and interior climatic regimes.

Relationship between daytime and nighttime Temperatures

The spatial distribution of long-term mean Tmax and Tmin across districts is shown in Fig. 4. The relationship between annual mean Tmax and Tmin across Karnataka demonstrates a strong positive association (Fig. 5), indicating that warming trends generally involve concurrent increases in both daytime and nighttime temperatures. However, the dispersion of Tmin values varies across the Tmax range. Lower Tmax values, typically associated with higher-elevation or coastal districts, correspond to relatively narrow Tmin ranges. In contrast, intermediate Tmax values display a wider spread in Tmin, reflecting greater variability in nighttime temperatures across districts.

At higher Tmax levels, Tmin tends to increase more rapidly, suggesting stronger nighttime warming in warmer interior districts. Such behaviour may be associated with regional differences in atmospheric moisture, land-surface conditions, or radiative processes

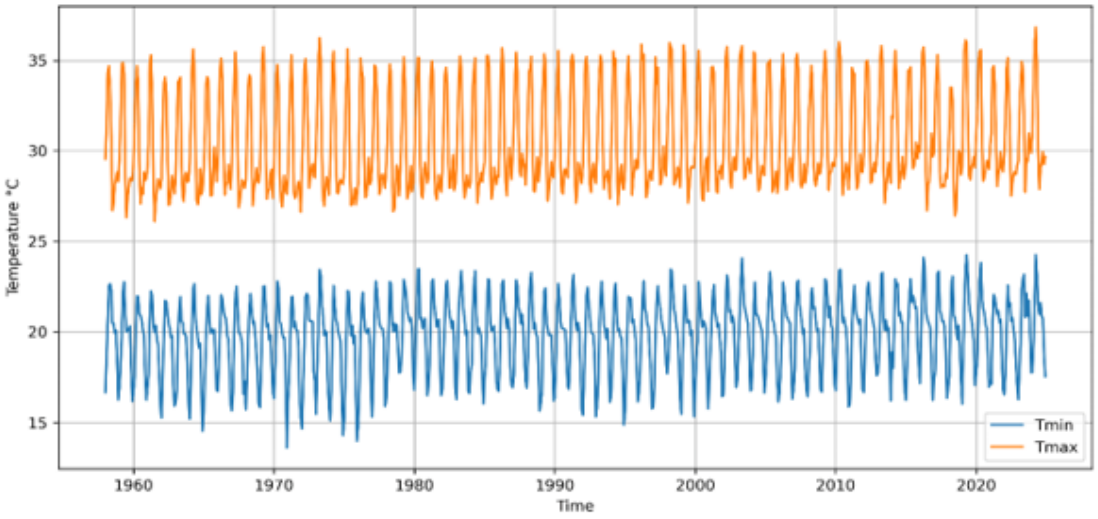


Fig. 1. Temporal evolution of annual mean maximum temperature (Tmax) and minimum temperature (Tmin) averaged across Karnataka for the period 1958–2024, illustrating concurrent warming behaviour

that influence nighttime heat retention. These variations in the relative behaviour of Tmax and Tmin contribute to spatial differences in DTR trends across the state.

Decadal Changes in Tmax and Tmin

Decadal averages of Tmax indicate a consistent increase across most districts from the earlier period (1960–1980) to the more recent period (2000–2024) (Fig. 2). Northern and north-eastern districts maintain the highest daytime temperatures throughout the study period, while districts in the Western Ghats and southern regions remain comparatively cooler due to elevation and maritime influences. Nevertheless, the overall pattern suggests widespread warming across Karnataka in recent decades.

Minimum temperature trends show a broadly similar pattern of long-term increase (Fig. 3). Coastal and Western Ghats districts consistently exhibit higher Tmin values relative to interior regions, reflecting the moderating effects of humidity and cloud cover. However, interior districts display notable increases in Tmin over time, indicating progressive nighttime warming across much of the state.

Spatial Patterns of DTR Trends

Results from the Mann–Kendall trend analysis and Sen's slope estimation reveal pronounced spatial heterogeneity in long-term DTR trends across Karnataka (Table 1; Fig. 8). Of the 30 districts analysed, 14 exhibit statistically significant increasing trends, 10 display statistically significant decreasing trends, and 6 show no statistically significant monotonic trend.

Increasing DTR trends are primarily concentrated in southern and south-eastern districts, including Bengaluru, Bengaluru Rural, Chikkaballapura, Mandya, Mysuru, Tumakuru, Kolar, Hassan, Kodagu, Ramanagara, Dakshina Kannada, and Chamarajanagara. Sen's slope estimates for these districts range from approximately 0.0026 to 0.0059 °C yr^{-1}, indicating persistent long-term increases in diurnal temperature range.

In contrast, decreasing DTR trends dominate northern and north-eastern semi-arid districts such as Bidar, Kalaburagi, Vijayapura, Bagalkote, Belagavi, and Yadgir. These districts exhibit Sen's slope values ranging from approximately −0.0026 to −0.0078 °C yr^{-1}, indicating gradual compression of diurnal temperature range over time.

Districts without statistically significant trends show near-zero Sen's slope estimates, suggesting relatively stable long-term DTR conditions or offsetting inter-annual fluctuations. Baseline DTR levels also vary substantially across districts, with lower intercept values observed in coastal and Western Ghats regions and higher values in interior semi-arid districts.

Interpretation of Spatial Trends

The contrasting spatial patterns observed in this study highlight the importance of regional climatic and environmental factors in shaping diurnal thermal

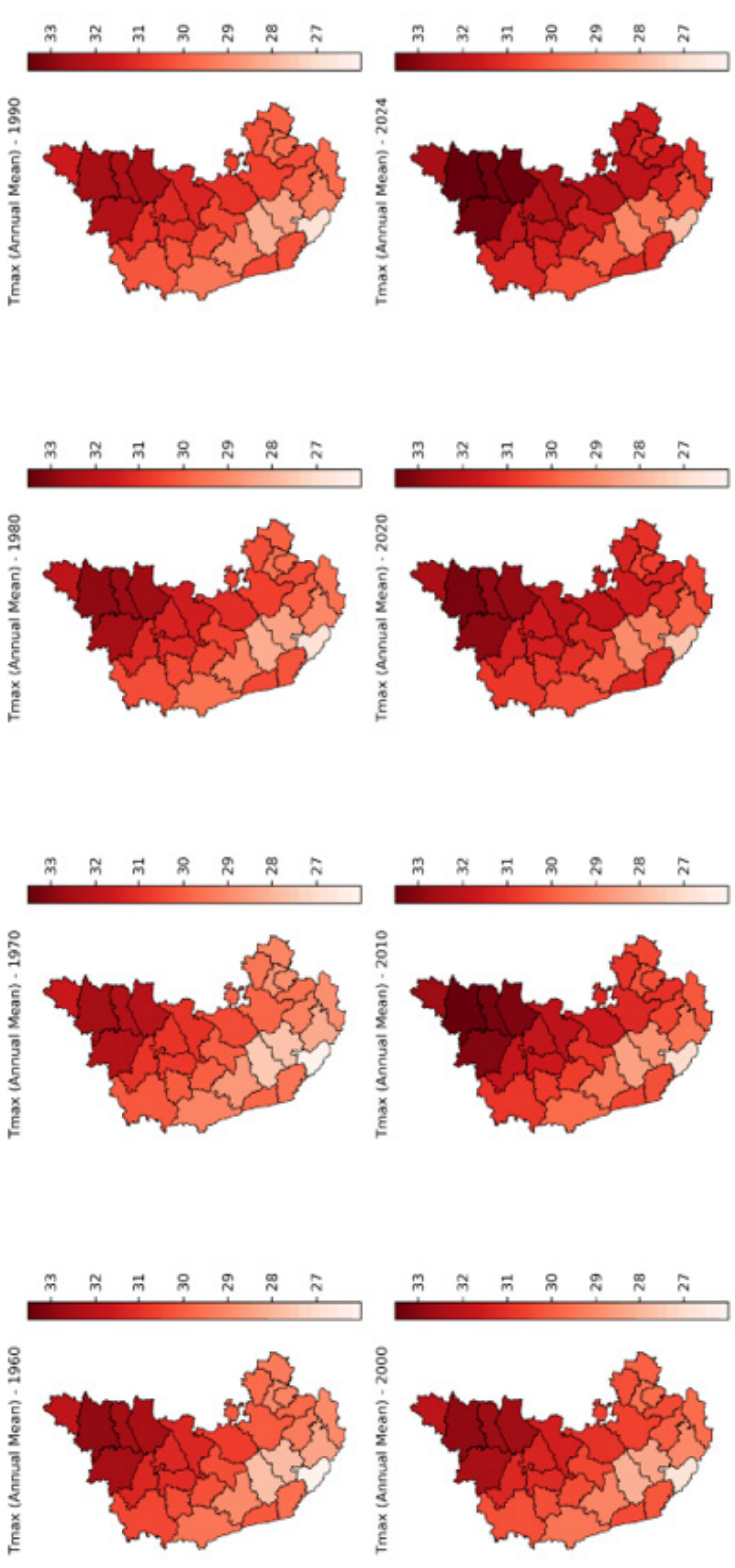


Fig. 2. Decadal averages of annual mean maximum temperature (Tmax) across Karnataka districts for selected periods between 1960–1980, 1980–2000, and 2000–2024, illustrating spatial patterns and temporal evolution of daytime temperature

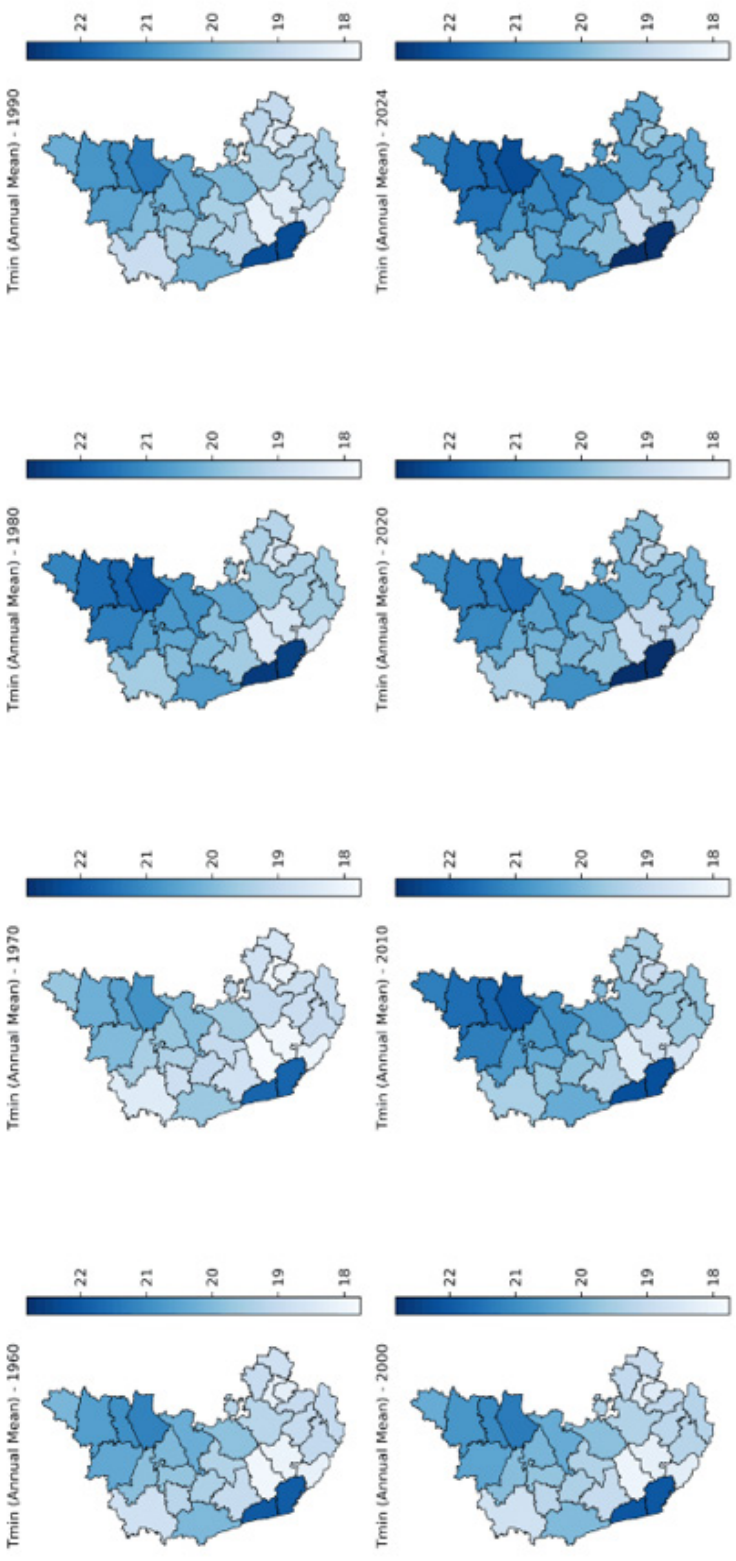


Fig. 3. Decadal averages of annual mean minimum temperature (Tmin) across Karnataka districts for selected periods between 1960–1980, 1980–2000, and 2000–2024, highlighting spatial variation and long-term nighttime warming patterns

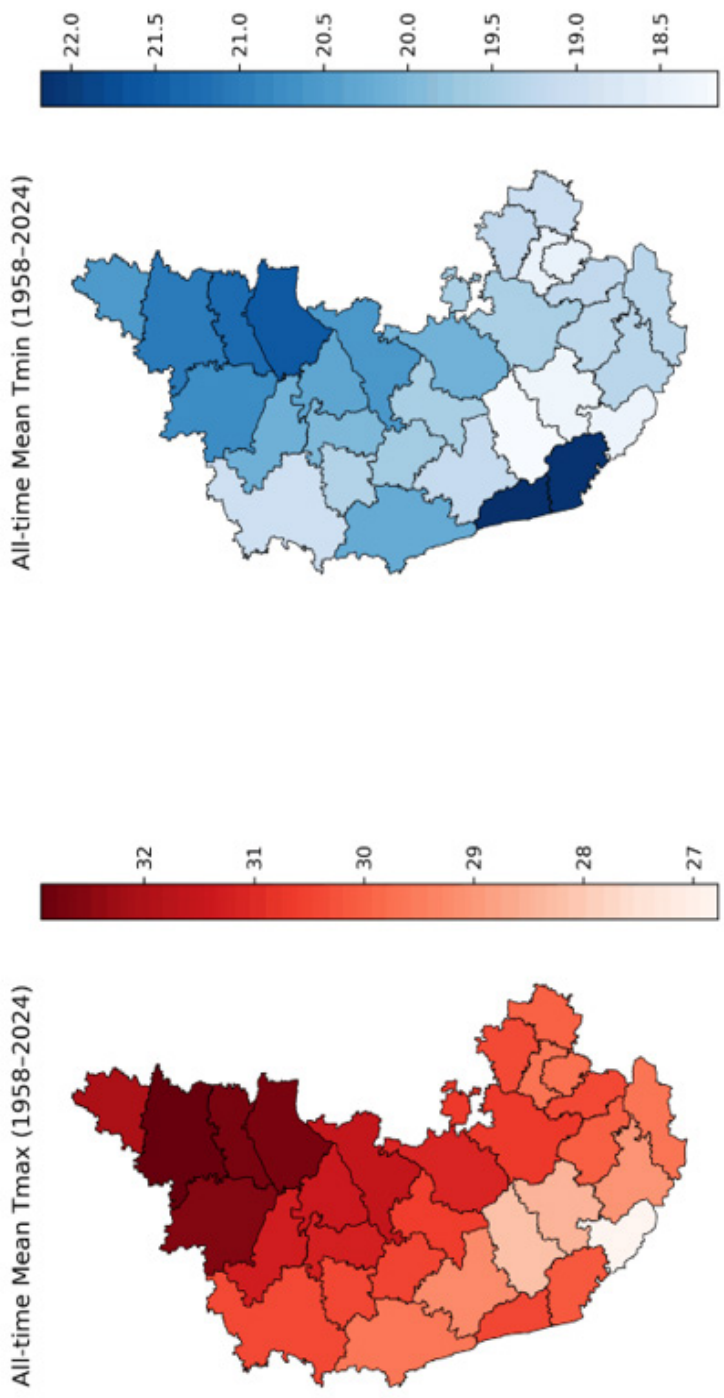


Fig. 4. Spatial distribution of long-term mean annual maximum temperature (Tmax) and minimum temperature (Tmin) across Karnataka districts for the period 1958–2024, illustrating baseline thermal contrasts across the state

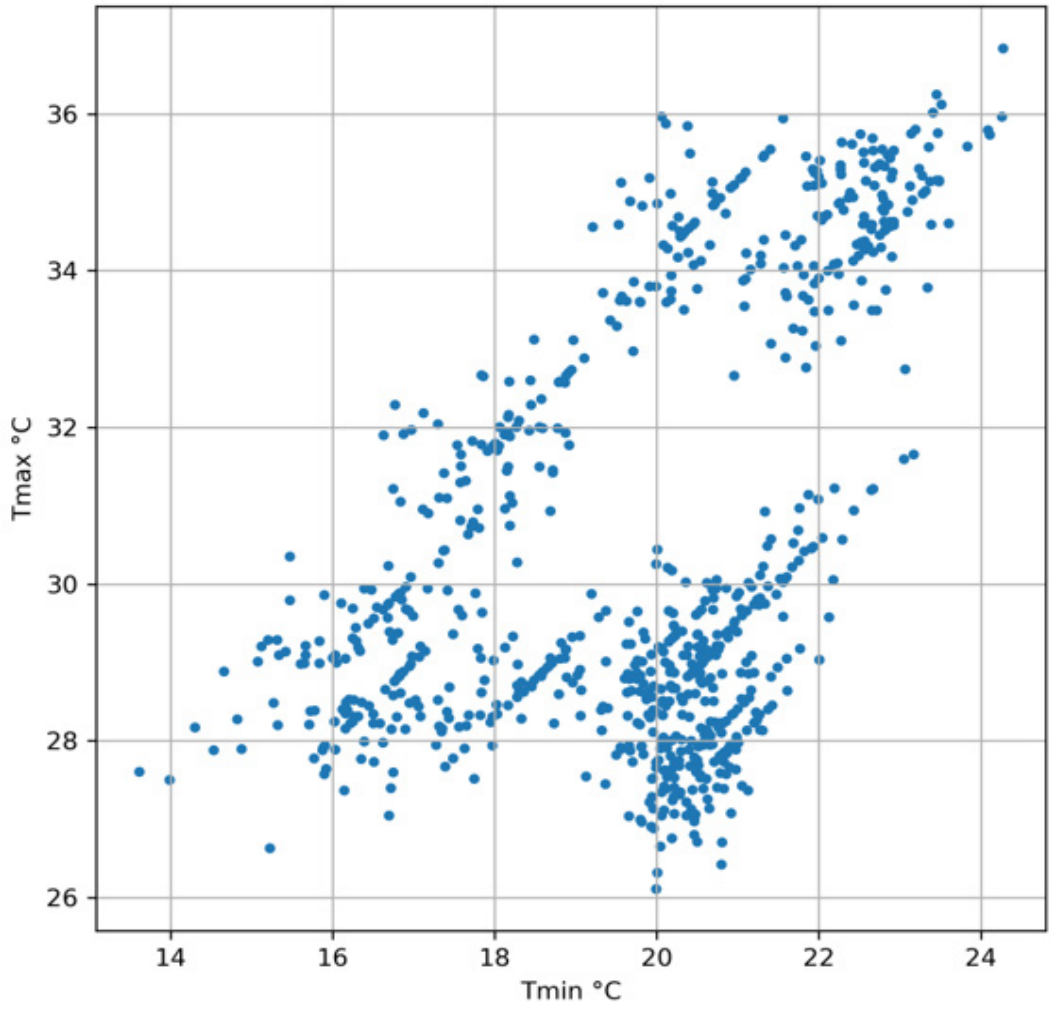


Fig. 5. Relationship between annual mean maximum temperature (Tmax) and minimum temperature (Tmin) across Karnataka for 1958–2024. Colour-coded points illustrate different temperature ranges and associated thermal conditions

behaviour. Increasing DTR trends in southern districts suggest that daytime warming has exceeded nighttime warming in these regions. Such patterns may be associated with reduced cloud cover, land-surface changes, or enhanced solar radiation that increases daytime heating.

Conversely, decreasing DTR trends in northern semi-arid districts indicate relatively stronger nighttime warming compared with daytime temperatures. This behaviour may reflect increased atmospheric moisture, irrigation expansion, or other land-surface processes that limit nocturnal cooling. Similar mechanisms have been proposed in earlier studies examining regional variations in diurnal temperature trends.

Coastal and Western Ghats districts generally display weaker or non-monotonic trends. The relatively stable DTR behaviour in these regions likely reflects the moderating influence of maritime climate, higher humidity, persistent cloud cover, and complex topography.

The spatial contrast in DTR trends across Karnataka may reflect differences in regional climate regimes and land–atmosphere interactions. Northern districts of the state lie within semi-arid interior zones that experience stronger continental influences and greater sensitivity to changes in surface moisture conditions. Expansion of irrigation, increasing atmospheric humidity, and enhanced cloud cover can reduce nocturnal cooling and elevate minimum temperatures, thereby contributing to declining DTR. In contrast, southern districts influenced

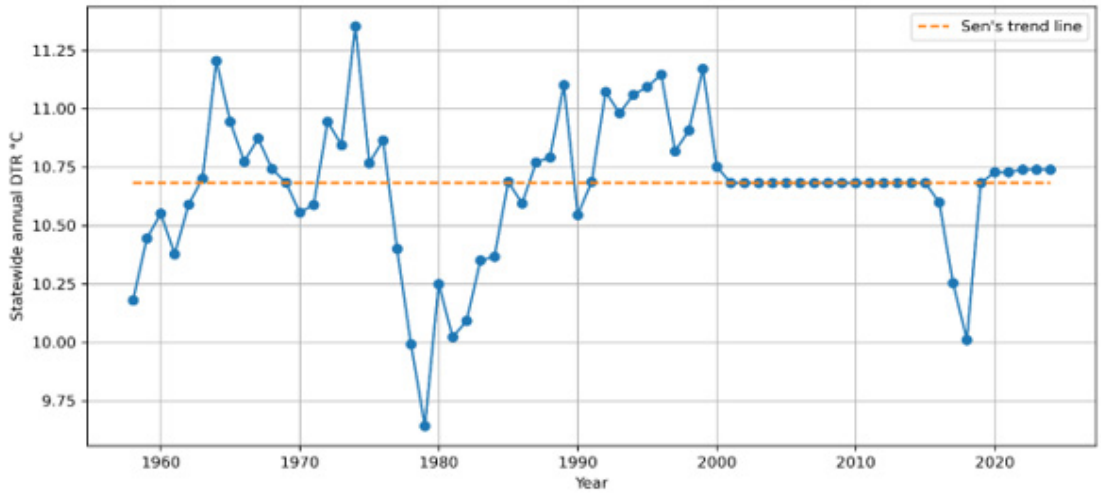


Fig. 6. Time series of annual mean diurnal temperature range (DTR) averaged over Karnataka for the period 1958–2024. The series highlights inter-annual variability and overall temporal evolution of DTR at the state scale

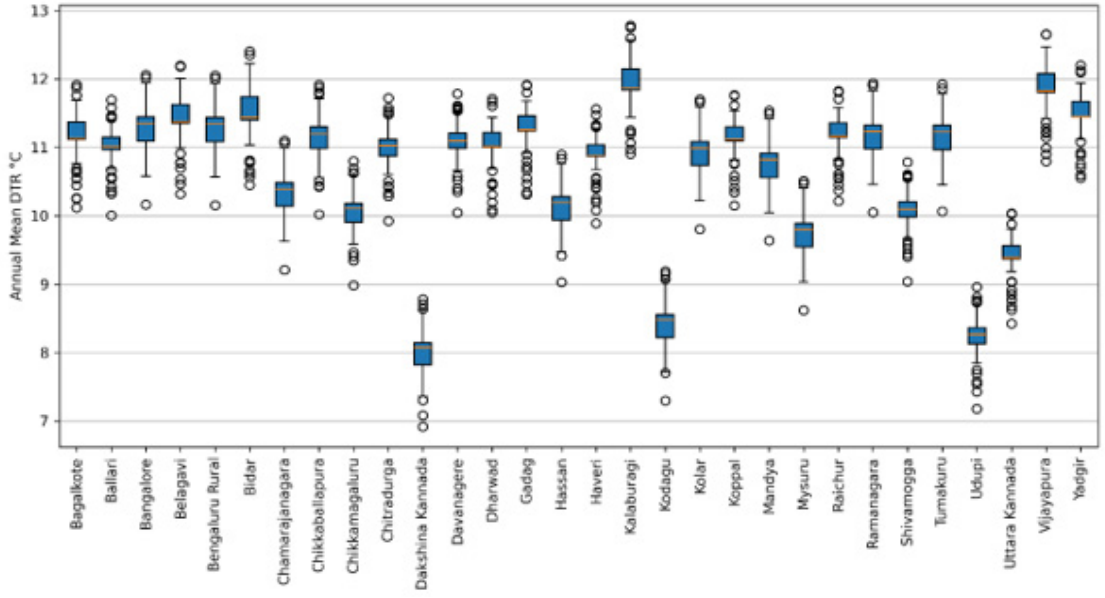


Fig. 7. Boxplot showing the distribution of annual diurnal temperature range (DTR) across Karnataka districts for the period 1958–2024. The plot highlights inter-district differences in median values, dispersion, and outliers

by higher elevation and relatively lower moisture variability may experience stronger daytime heating relative to nighttime warming, resulting in increasing DTR. Coastal and Western Ghats districts remain strongly influenced by maritime air masses, persistent cloud cover, and orographic effects associated with the southwest monsoon, which moderate both daytime heating and nighttime cooling. These regional climatic controls likely contribute to the heterogeneous spatial patterns of DTR trends observed across the state.

Overall, these findings demonstrate that statewide averages obscure significant spatial contrasts in the evolution of diurnal thermal regimes. District-level analysis reveals divergent warming pathways within the state, emphasizing the importance of spatially resolved temperature indicators for understanding regional climate variability.

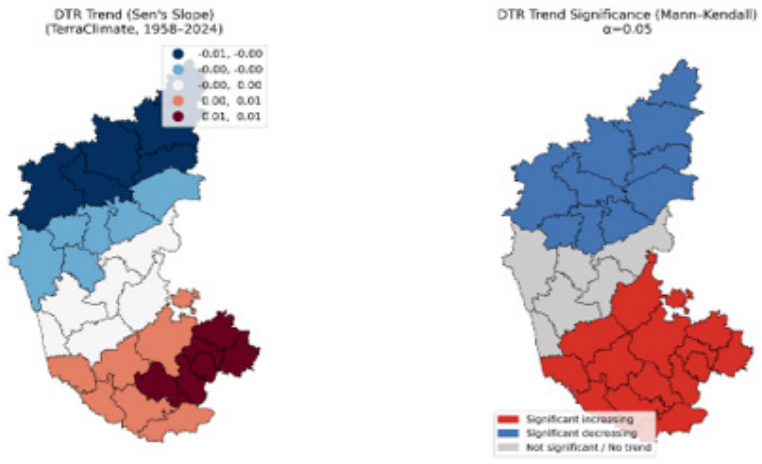


Fig. 8. Spatial distribution of district-level diurnal temperature range (DTR) trends across Karnataka based on Mann–Kendall (MK) test results and Sen's slope estimates for 1958–2024. Positive (negative) values indicate increasing (decreasing) DTR trends, while non-significant districts are indicated separately

This study examined long-term spatial patterns in diurnal temperature range (DTR) across Karnataka using district-level temperature series derived from the TerraClimate dataset for the period 1958–2024. Trend analysis using the Mann–Kendall test and Sen's slope estimator reveals pronounced spatial heterogeneity in DTR behaviour across the state. While statewide averages indicate relatively stable long-term DTR conditions, district-level analysis shows contrasting regional trends.

Increasing DTR trends are primarily observed in southern and south-eastern districts, suggesting that daytime warming has exceeded nighttime warming in these regions. In contrast, decreasing DTR trends dominate northern semi-arid districts, reflecting relatively stronger increases in minimum temperatures and a gradual compression of the diurnal temperature range. Coastal and Western Ghats districts generally exhibit weak or statistically insignificant trends, likely due to the moderating influence of maritime conditions and higher humidity.

These findings demonstrate that aggregated temperature indicators can obscure important regional differences in thermal behaviour. Spatially resolved assessments of diurnal temperature range provide valuable insight into regional climate variability and may help inform environmental monitoring and climate adaptation strategies in climatically heterogeneous regions.

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STUDY OF GENETIC PARAMETERS INFLUENCING YIELD AND YIELD COMPONENT TRAITS IN SESAME (*Sesamum indicum* L.)

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ABSTRACT

Fifty-five sesame genotypes were evaluated in a Randomized Block Design during *rabi* 2025–26 at S.V. Agricultural College, Tirupati to estimate genetic variability, heritability and genetic advance for seventeen yield and yield component traits. Significant genotypic differences were observed for all traits. PCV slightly exceeded GCV, indicating limited environmental influence. High GCV and PCV were recorded for secondary branches, primary branches, internodes, capsules per plant and seed yield per plant. These traits, along with harvest index, first capsule axis height and plant height, showed high heritability with high genetic advance, indicating additive gene action and suitability for direct selection. Oil content, capsule length and 1000-seed weight showed high heritability with moderate genetic advance, suggesting hybridization followed by pedigree selection.

KEYWORDS: Sesame, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance.

INTRODUCTION

Sesamum indicum L., commonly known as sesame or gingelly, is one of the oldest domesticated oilseed crops with archaeological evidence tracing its cultivation back more than 5,000 years in the Indus Valley and African regions. It belongs to the family Pedaliaceae with a chromosome number of 2n = 26 and is predominantly a self-pollinated species, though limited cross-pollination by insects can occur. Sesame often referred to as the 'Queen of Oilseeds,' and it occupies a prominent position in dryland farming systems globally owing to its nutritional, medicinal and economic significance (Arpitha *et al.,* 2025). The crop exhibits remarkable genetic diversity and ecological adaptability, enabling successful cultivation across over 70 countries worldwide. Despite its economic importance, sesame is often cultivated on marginal lands with minimal management, leading to low productivity. The lack of suitable high-yielding varieties adapted to different agro-climatic conditions remains a major constraint.

A clear understanding of genetic variability, heritability and genetic advance is essential for effective crop improvement. These parameters reveal the extent of heritable variation and the potential response to selection. Therefore, the present study was undertaken to estimate GCV, PCV, heritability, and genetic advance as percent of mean for seventeen yield and yield component traits in 55 sesame genotypes.

MATERIAL AND METHODS

A field experiment was conducted during rabi, 2025–26 at the Dryland Farm, S.V. Agricultural College, Tirupati, Andhra Pradesh. Fifty-five sesame genotypes along with three checks (YLM 146, YLM 66, Swetha til) were evaluated in a Randomized Block Design (RBD) with three replications. Each genotype was grown in two rows of 3 m length at a spacing of 30 × 15 cm, following recommended agronomic practices. Observations were recorded on five randomly selected plants for seventeen quantitative traits, except days to 50 per cent flowering and days to maturity, which were recorded on a plot basis. The mean data were subjected to statistical analysis to assess genetic variability, heritability, and genetic advance.

Statistical Analysis

Analysis of variance was carried out following the method described by Panse and Sukhatme (1961) to test significance of genotypic differences. Genotypic and phenotypic variances were estimated following Johnson *et al.,* (1955a). GCV and PCV were computed as per Burton (1953). Heritability in broad sense (h^2) and genetic advance (GA) at 5 per cent selection intensity and genetic advance as percent of mean were calculated as per Johnson *et al.,* (1955b). The GCV and PCV

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values were interpreted following the classification of Sivasubramanian and Menon (1973): low (<10%), moderate (10-20%) and high (>20%). Heritability estimates were categorized as low (<30%), moderate (30-60%) or high (>60%), and genetic advance as percent of mean as low (<10%), moderate (10-20%) or high (>20%).

RESULTS AND DISCUSSION

Analysis of Variance

Analysis of variance revealed highly significant differences among genotypes for all 17 traits studied, confirming the existence of substantial genetic variability in the experimental material. This wide genetic variation provides a strong foundation for identifying superior genotypes and for planning effective selection and hybridization-based breeding strategies. Similar significant genotypic differences among sesame genotypes have been reported by Swapna *et al.,* (2024) and Khuntia *et al.,* (2024).

Genotypic and Phenotypic Coefficients of Variation

The GCV and PCV estimates for all traits are presented in Table 2. PCV values were higher than the corresponding GCV values for all traits, indicating the influence of environmental factors on trait expression. The relatively small difference between PCV and GCV for most traits suggests that genetic factors played a major role and selection based on phenotype would be effective. The results were in consistent with reports by Swapna *et al.,* (2024).

High GCV and PCV (>20%) were recorded for number of secondary branches per plant (GCV: 77.36%; PCV: 77.97%), number of primary branches per plant (GCV: 31.20%; PCV: 32.19%), number of internodes (GCV: 28.15%; PCV: 28.70%), number of capsules per plant (GCV: 29.37%; PCV: 29.84%) and seed yield per plant (GCV: 24.21%; PCV: 24.78%). Similar high GCV and PCV for capsules per plant and seed yield per plant were reported by Rahna *et al.,* (2023), Roy *et al.,* (2022).

Moderate GCV (10-20%) was observed for harvest index (19.86%), first capsule axis height (19.25%), specific leaf area (11.54%), plant height (12.94%), capsule length (12.45%), 1000-seed weight (12.90%) and number of seeds per capsule (14.13%). Low GCV (<10%) was recorded for oil content (9.25 %), internodal length (9.80%), days to 50% flowering (4.43%), days to maturity (3.57%) and SCMR (3.49%). The low GCV and PCV values are observed for days to maturity, days to 50% flowering and SCMR.

Heritability and Genetic Advance as Percentage of Mean

Heritability estimates in broad sense (h^2 bs) and genetic advance as percent of mean values for all traits are presented in Table 1. Heritability ranged from a low of 18.38 per cent for SCMR to a high of 99.07 per cent for capsule length. High heritability (>60%) was recorded for all traits except SCMR (18.38%), underlining the predominantly genetic nature of trait expression in the present experimental material.

Traits that exhibited high heritability coupled with high genetic advance as percent of mean (>20%) included: number of secondary branches per plant (h^2: 98.45%; genetic advance as percent of mean: 158.13%), number of primary branches per plant (h^2: 93.97%; genetic advance as percent of mean: 62.31%), number of internodes (h^2: 96.24%; genetic advance as percent of mean: 56.89%), number of capsules per plant (h^2: 96.88%; genetic advance as percent of mean: 59.56%), seed yield per plant (h^2: 95.50%; genetic advance as percent of mean: 48.74%), harvest index (h^2: 82.64%; genetic advance as percent of mean: 37.19%), first capsule axis height (h^2: 88.27%; genetic advance as percent of mean: 37.25%), number of seeds per capsule h^2: 89.82%; genetic advance as percent of mean: 27.58%),plant height (h^2: 62.03%; genetic advance as percent of mean: 20.99%) and specific leaf area (h^2: 73.81%; genetic advance as percent of mean: 20.43%).The combination of high heritability with high genetic advance as percent of mean confirms the predominance of additive gene effects for these traits, indicating that simple phenotypic selection would be highly effective. These findings are in close agreement with the observations of Divya *et al.,* (2018) for seed yield per plant, number of capsules per plant and number of branches per plant, and with Mohanty *et al.,* (2020) for plant height and seed yield.

High heritability combined with moderate genetic advance as percent of mean (10-20%) was observed for capsule length (h^2: 99.07%; genetic advance as percent of mean: 25.54%), 1000-seed weight (h^2: 91.96%; genetic advance as percent of mean: 25.49%), oil content (h^2: 98.47%; genetic advance as percent of mean: 20.47%), internodal length (h^2: 83.03%; genetic advance as percent of mean: 18.40%) and specific leaf area (h^2:

Table 1. Analysis of variance for 17 yield and yield attributing traits in 55 sesame genotypes

S. No.	Characters	Mean sum of squares		
		Replication (df = 2)	Genotype (df = 54)	Error (df = 108)
1.	Days to 50 % flowering	17.49	9.27**	0.32
2.	Days to maturity	21.02	27.98**	0.15
3.	SPAD chlorophyll meter reading	55.7	20.90*	12.47
4.	Specific leaf area ($cm^2\ g^{-1}$)	1439.47	782.53**	82.78
5.	Plant height (cm)	226.9	571.6**	96.88
6.	First capsule axis height (cm)	10.76	63.93**	2.71
7.	Number of primary branches per plant	0.044	1.77**	0.037
8.	Number of secondary branches per plant	0.005	0.46**	0.002
9.	Number of internodes	1.45	37.72**	0.48
10.	Internodal length(cm)	0.01	0.87**	0.06
11.	Number of capsules per plant	32.11	1450.16**	15.38
12.	Capsule length (cm)	0.001	0.41**	0.001
13.	Number of seeds per capsule	3.62	272.17**	9.91
14.	1000-seed weight (g)	0.01	0.45**	0.01
15.	Oil content (%)	0.06	73.15**	0.38
16.	Harvest index	510.59	110.19**	7.21
17.	Seed yield per plant (g)	113.2	29.37**	0.45

** Significant at 1 % level, * Significant at 5 % level

Table 2. Genetic parameters for yield and yield component traits in 55 sesame genotypes

S. No.	Trait	Mean	Range		Variance		C.V		Heritability (Broad Sense) %	GA	Genetic advance as percent of mean (%)
			Min	Max	Genotypic	Phenotypic	GCV	PCV			
1.	DF	39.03	32.00	44.00	2.98	3.31	4.43	4.66	90.20	3.38	8.66
2.	DM	85.38	75.00	90.00	9.28	9.43	3.57	3.60	98.43	6.23	7.29
3.	SCMR	48.08	38.34	56.48	2.81	15.28	3.49	8.13	18.38	1.48	3.08
4.	SLA	132.30	75.78	175.17	233.25	316.03	11.54	13.44	73.81	27.03	20.43
5.	PH	97.22	56.80	139.60	158.24	255.12	12.94	16.43	62.03	20.41	20.99
6.	FCH	23.47	13.70	35.70	20.41	23.12	19.25	20.48	88.27	8.74	37.25
7.	NPB	2.44	0.00	4.00	0.58	0.62	31.20	32.19	93.97	1.52	62.31
8.	NSB	0.51	0.00	1.40	0.15	0.16	77.36	77.97	98.45	0.80	158.13
9.	NI	12.51	6.60	20.39	12.41	12.90	28.15	28.70	96.24	7.12	56.89
10.	IL	5.30	3.76	6.82	0.27	0.33	9.80	10.76	83.03	0.98	18.40
11.	NCP	74.45	36.40	152.30	478.26	493.64	29.37	29.84	96.88	44.34	59.56
12.	CL	2.98	2.04	3.76	0.14	0.14	12.45	12.51	99.07	0.76	25.54
13.	NSC	66.19	46.49	97.84	87.42	97.33	14.13	14.90	89.82	18.25	27.58
14.	TW	2.97	2.15	3.95	0.15	0.16	12.90	13.45	91.96	0.76	25.49
15.	OC	49.19	33.94	57.61	24.26	24.63	9.25	10.01	98.47	10.07	20.47
16.	HI	29.50	13.46	53.77	34.33	41.54	19.86	21.85	82.64	10.97	37.19
17.	SYP	12.82	4.50	20.53	9.64	10.09	24.21	24.78	95.50	6.25	48.74

DFF: Days to 50% flowering (days); DM: Days to maturity (days); SCMR: SPAD chlorophyll meter reading; SLA: Specific leaf area (cm^2 g^{-1}); PH: Plant height (cm); FCH: First capsule axis height (cm); NPB: No. of primary branches/plant; NSB: No. of secondary branches/plant; NI: No. of internodes; IL: Internodal length (cm); NCP: No. of capsules/plant; CL: Capsule length (cm); NSC: No. of seeds/capsule; TW: 1000-seed weight (g); OC: Oil content (%); HI: Harvest index (%); SYP: Seed yield/plant (g); GCV: Genotypic coefficient of variation; PCV: Phenotypic coefficient of variation; h_2: Heritability broad sense; GA: Genetic advance at 5% selection intensity; GENETIC ADVANCE AS PERCENT OF MEAN: Genetic advance as percentage of mean.

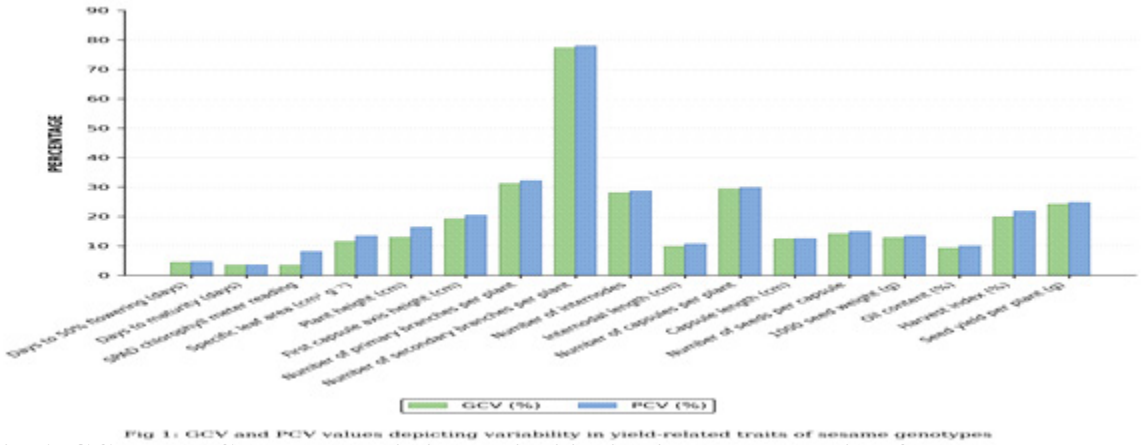


Fig. 1. GCV and PCV values depicting variability in yield-related traits of sesame genotypes

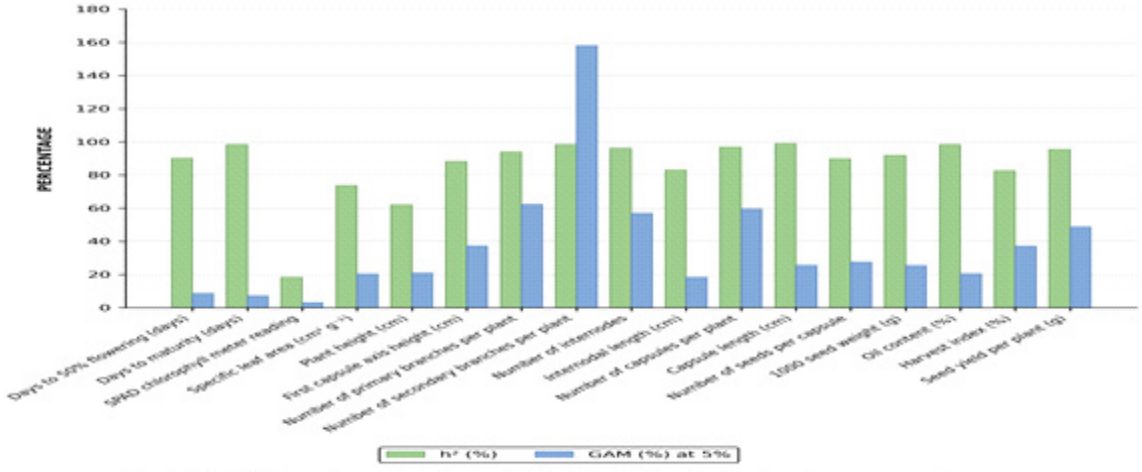


Fig. 2. Heritability and GAM for yield-related traits of sesame genotypes

73.81%; genetic advance as percent of mean: 20.43%). Despite high heritability, the moderate genetic advance for these traits suggests possible involvement of non-additive gene action. Similar findings were reported by Kehie *et al.,* (2020) for oil content and 1000-seed weight and capsule length by Kant *et al.,* (2021).

High heritability with low genetic advance as percent of mean (<10%) was recorded for days to 50 per cent flowering (h^2: 90.20%; genetic advance as percent of mean: 8.66%) and days to maturity (h^2: 98.43%; genetic advance as percent of mean: 7.29%) which indicates dominance and epistatic gene effects.

The present study revealed considerable genetic variability among existing 55 sesame genotypes for all the seventeen traits. The narrow differences between PCV and GCV for most traits indicated limited environmental influence and predominance of genetic control. High heritability coupled with high genetic advance as per cent of mean was observed for number of secondary branches per plant, number of primary branches per plant, number of internodes, number of capsules per plant, seed yield per plant, harvest index, first capsule height and plant height indicating additive gene action. Therefore, these traits can be effectively improved through direct selection. Selection can be practiced in early segregating generations as the phenotypic performance of individual plants is expected to reliably reflect their genetic potential. Oil content, capsule length and 1000-seed weight exhibited high heritability with moderate genetic advance, indicating the involvement of both additive and non-additive gene action. Hence, hybridization followed by pedigree selection would be an appropriate breeding strategy for improving these traits.

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PERFORMANCE ASSESSMENT OF FARMER PRODUCER ORGANIZATIONS IN ALLURI SITARAMA RAJU DISTRICT OF ANDHRA PRADESH

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ABSTRACT

This study evaluated the performance assessment of Farmer Producer Organizations (FPOs) in the Alluri Sita Rama Raju (ASR) district of Andhra Pradesh. A total sample size of 160 coffee growers were surveyed among which 80 are FPO beneficiaries and other 80 are FPO non-beneficiaries. The perception of coffee growers towards FPO services like technical, financial, marketing, processing and value addition are analyzed using weighted average score method. The results revealed that credit facilities were rated the most relevant, with a weighted mean score of 3.01. Market information services emerged as the most appreciated, with a weighted mean score of 3.06, indicating that timely and relevant information on prices and demand is valued highly by farmers. Procurement of produce from members stood out as the most appreciated service with a weighted mean score of 3.41, reflecting the importance farmers place on having a reliable channel to sell their produce followed by value addition (3.23) and branding (3.13), indicating that farmers recognize the role of FPOs in enhancing the marketability of their products.

KEYWORDS: Coffee growers, input services, farmer producer organizations, farmers perception, weighted mean score method.

INTRODUCTION

Andhra Pradesh has emerged as a high-growth region for coffee cultivation. The area expanded significantly from 71.96 to 97.53 thousand hectares between 2013–14 and 2022–23, registering a robust CAGR of 3.44 per cent, showing higher than the national average. This was increased by a remarkable 25.12 per cent annual growth in 2017–18, attributed to government schemes. Production showed an even more impressive CAGR of 5.32 per cent, though it was marked by extreme fluctuations, including a 101.59 per cent surge in 2015–16 and sharp declines in other years. Productivity improved at a CAGR of 1.84 per cent, yet the absolute yield (0.099 MT/ha) remains significantly lower than the national average. Alluri Sita Rama Raju district has 40 sanctioned and 32 operational FPOs, playing a key role in the region's agricultural economy, primarily focusing on coffee, turmeric and pepper. Analysis of three selected coffee-centric FPOs, Maa Thota, Paderu and Dhimsa revealed varying levels of performance (Keerthana, K 2026). All three have established basic governance structures (Board of Directors, CEO, rented office). However, Maa Thota FPO, being the oldest (7 years), outperformed the others. It boasts a larger membership (1000 farmers), higher share capital (Rs8.5 lakhs) and a greater annual turnover (Rs 25-27 lakhs). FPOs in the ASR district have successfully established foundational governance and operational structures. However, their performance and impact are directly correlated with their age, scale of operations and financial mobilization. Maa Thota's relative success highlights the importance of maturity and a larger member base. These FPOs are playing a crucial role in improving the livelihoods of tribal farmers (Hema, B 2025) by providing better access to inputs, markets and support services. This study evaluated the performance assessment of Farmer Producer Organizations (FPOs) in relation to the input services provided by FPOs in Alluri Sita Rama Raju (ASR) district of Andhra Pradesh.

MATERIAL AND METHODS

Three mandals Araku Valley, Chinthapalli and Paderu were selected purposively based on their large area under coffee cultivation, high production volumes and significant membership of coffee farmers in FPOs. Coffee farmers with FPO membership were selected purposively, while non-beneficiary farmers were chosen randomly from the same clusters. This resulted in a total sample of 160 farmers, comprising 80 FPO beneficiaries and 80 non-beneficiaries, who were interviewed for the study. Further, data also collected from FPOs, Velugu

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samastha and from Coffee Board in Chinthapalli.

weighted average score method: This method was used to rank the preference of different statements by the FPO coffee growers in the study area.

Weighted average score = ∑W X /W X

W = Weighted factor

X = No of factors

RESULTS AND DISCUSSION

Farmers perception towards Input services

Table 1 presents how farmer members rated various input services offered by their FPOs. The findings show that Quality of inputs stood out as the top service with the highest weighted mean score (3.60). Most farmers felt that FPOs are doing a great job in providing reliable, high-quality inputs, which is essential for better yields and lower risks (Ravikishore, M.,2024) . Next in line was the Regular supply of inputs (score: 3.525), followed by Seed (3.45). Farmers appreciated not just the quality but also the consistent and timely availability of inputs which helps them plan their farm work more efficiently. The variable like Timely supply of inputs and Fertilizers were ranked fourth and fifth, respectively which is highlighting farmers value timing when it comes to input delivery.

Farmers perception towards technical services

Need-based training programs were rated the most helpful which is showing that farmers value practical, relevant learning opportunities (Table 2). Support in production activities and Agro-advisory services followed closely, reflecting the importance of timely guidance and on-ground assistance (Ravikishore, M, 2026). Services like information on improved crop varieties and post-harvest management also ranked well, indicating that FPOs are playing a key role in sharing useful knowledge. Meanwhile, areas like production technology, skill improvement and crop diversification received average ratings, suggesting there's still room for improvement.

Table 1. Farmers perception towards input services

Input services	Response Category					Weighted mean	Rank
	5 (E)	4 (G)	3 (A)	2 (P)	1 (VP)		
Seeds	5	38	25	12	-	3.45	3
Fertilizers	5	32	34	9	-	3.41	5
Bio-fertilizers	6	27	38	5	4	3.32	9
Micronutrients	3	29	36	10	2	3.26	10
Plant protection chemicals	4	34	20	22		3.25	11
Equipment and machinery	2	36	33	6	3	3.35	8
Other accessories (pump sets, drip and pipe lines)	2	33	38	7	-	3.37	7
Timely supply of inputs	4	38	26	12	-	3.42	4
Reasonable cost of inputs	1	35	38	6	-	3.38	6
Quality of inputs	6	40	30	4	-	3.60	1
Regular supply of inputs	2	45	26	7	-	3.525	2

Frequency and percentage in parenthesis; E: Excellent; G: Good; A: Average; P: Poor; VP: Very poor

Table 2. Farmers perception towards technical services

Technical services	Response Category					Weighted mean	Rank
	5(E)	4(G)	3(A)	2(P)	1(VP)		
Information on crops/improved varieties	1	25	42	12	-	3.18	4
Production technology	2	25	35	15	3	3.10	6
Resource conservation technology	0	17	37	17	9	2.77	10
Crop diversification	0	17	41	18	4	2.88	8
Seed production	1	10	41	20	8	2.70	11
Facilitation of production activities	1	34	34	11	-	3.31	2
Production clusters development	-	6	44	20	10	2.57	13
Alternative farming system development	-	1	37	24	18	2.26	15
Post-harvest management	2	28	30	20	-	3.15	5
By-product utilization	5	13	35	16	11	2.81	9
Need based training programs for members	2	33	34	11	-	3.325	1
Skill improvement activities	5	19	34	18	4	3.03	7
Facilitation of kisan melas, exposure visits, field trips	-	13	36	21	10	2.65	12
Farm publication support	-	1	37	26	16	2.28	14
Agro-advisory services	3	33	30	12	2	3.28	3

Frequency and percentage in parenthesis; E: Excellent; G: Good; A: Average; P: Poor; VP: Very poor

Farmers perception towards financial services

Table 3 highlights the farmers' perception of various financial services offered by FPOs. Among the listed services, credit facilities were rated the most relevant, with a weighted mean score of 3.01. This indicates that farmers view access to credit as the most beneficial financial support provided by their FPOs, though the moderate score also suggests there's room for improvement in outreach or ease of access (Ravikishore, M). Subsidies ranked second (2.53), followed by assistance in obtaining grants (2.16), which were seen as somewhat useful but inconsistently accessed.

These findings imply that while credit-related services are relatively better perceived, many other financial services are underutilized or poorly communicated. Strengthening financial literacy, simplifying access procedures and active liaison with government departments could enhance the effectiveness of financial service delivery by FPOs. Marketing Services like direct marketing (1.70) and assured buyback (1.58) were rated poorly, possibly due to weak institutional linkages or limited capacity of FPOs to secure consistent buyers. Technical services like alternative farming systems, farm publications and cluster development didn't resonate much with members, likely due to limited outreach or awareness. Overall, while FPOs are making progress in providing market-related support, improvements in infrastructure, partnerships and buyer engagement are essential to enhance their role as effective market intermediaries.

Table 3. Farmers perception towards financial services

Financial services	Response Category					Weighted mean
	5(E)	4(G)	3(A)	2(P)	1(VP)	
Credit facilities	3	20	35	19	3	3.01
Providing subsidies	2	7	30	34	7	2.53
Crop insurance facilities	1	3	18	38	20	2.08
Convergence of funds	0	2	8	40	30	1.77
Ways of raising funds	0	1	3	41	35	1.62
Obtaining grants from various sources	1	3	20	40	16	2.16
Dovetailing of Govt. Schemes	0	2	13	35	30	1.83

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ISOLATION OF BACTERIAL AND ACTINOBACTERIAL ANTAGONISTS FROM RHIZOSPHERE SOIL OF GROUNDNUT (*Arachis hypogaea*) AGAINST STEM ROT PATHOGEN (*Sclerotium rolfsii sacc.*) FROM RAYALASEEMA DISTRICTS OF ANDHRA PRADESH, INDIA

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ABSTRACT

Groundnut (*Arachis hypogaea* L.) Stem rot disease of groundnut (*Arachis hypogaea*), caused by the fungus Sclerotium rolfsii Sacc., is one of the most destructive soilborne diseases affecting groundnut cultivation in the Rayalaseema region of Andhra Pradesh, India. A survey conducted across eight districts *viz* Tirupati, Kadapa, Chittoor, Annamayya, Kurnool, Nandyal, Ananthapur, and Sathya Sai revealed disease incidence ranging from 19.7 per cent to 31.2 per cent, with Kurnool recording the highest incidence (31.2%). In the present investigation, a total of 40 bacterial antagonists (GB1–GB40) and 14 actinobacterial isolates (GA1–GA14) were isolated from rhizospheric soil of healthy groundnut plants grown in these districts using serial dilution plating technique on Nutrient Agar (NA) medium and Starch Casein Agar (SCA) medium, respectively. All isolates were purified using the streak plate method. The pathogenicity of *S. rolfsii* was confirmed by proving Koch's postulates, where in *S. rolfsii* inoculum grown on sorghum grains were used to artificially infest soil. After 10 days of inoculation, typical stem rot symptoms that includes yellowing, wilting and rotting of collar region along with occurrence of white cottony mycelial growth and brown sclerotia in inoculated plants, while uninoculated control plants remained healthy. The fungal pathogen was successfully re-isolated from infected plants, thereby satisfying Koch's postulates. The collection of diverse antagonistic microorganisms from the rhizosphere of groundnut plants grown in Rayalaseema establishes a foundation for biocontrol-based integrated disease management strategies against groundnut stem rot.

KEYWORDS: Groundnut, stem rot, *Sclerotium rolfsii*, rhizosphere, bacterial antagonists, actinobacteria, biocontrol, rayalaseema, Andhra Pradesh.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops in India, contributing significantly to food security, rural livelihoods, and edible oil production. India ranks second in global groundnut production, with Andhra Pradesh being one of the leading producing states. The Rayalaseema region of Andhra Pradesh - encompassing the districts of Tirupati, Kadapa, Chittoor, Annamayya, Kurnool, Nandyal, Ananthapur, and Sathya Sai - is a major groundnut-growing belt characterized by semi-arid climate and red sandy loam soils highly conducive to groundnut cultivation.

Despite its agronomic importance, groundnut production is severely limited by a wide array of fungal diseases. Among these, stem rot caused by the soilborne fungus *Sclerotium rolfsii* Sacc. is considered one of the most devastating diseases, capable of causing yield losses ranging from 25 per cent to 80 per cent under favorable environmental conditions (Kokalis-Burelle *et al.,* 1997). The pathogen produces numerous sclerotia that can persist in soil for extended periods, making chemical management difficult and often economically unviable for small-scale farmers in dryland areas.

Biological control using rhizosphere-associated bacteria and actinobacteria has emerged as a promising, eco-friendly alternative for managing soilborne pathogens. The narrow soil zone of rhizosphere influenced by root exudates harbors a rich diversity of microorganisms with antagonistic potential against plant pathogens. Genera of bacteria such as *Bacillus, Pseudomonas* and actinobacterial genera including Streptomyces are well-documented for their efficacy against *S. rolfsii* through mechanisms like antibiosis, mycoparasitism, induced systemic resistance and competition for nutrients and space (Compant *et al.,* 2005; Emmert and Handelsman, 1999).

The present study was therefore undertaken with the following objectives: (i) to assess the incidence of

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stem rot disease in groundnut fields across Rayalaseema districts; (ii) to isolate and enumerate bacterial and actinobacterial antagonists from the rhizospheric soil of healthy groundnut plants; and (iii) to confirm the pathogenicity of *S. rolfsii* through Koch's postulate experiments.

MATERIAL AND METHODS

Survey of Stem Rot Disease Incidence

A roving survey was conducted during the *kharif* cropping season (2025–2026) across eight major groundnut-growing districts of Rayalaseema: Tirupati (Sanambatla), Kadapa (Pulivendula), Chittoor (Dornakambala), Annamayya (Pileru), Kurnool (Chinna Tekur), Nandyal (Velugoda), Ananthapur (Uravakonda), and Sathya Sai (Kadiri). In each district, five fields were randomly selected and disease incidence was assessed at the flowering to pegging stage. Five sampling points per field were chosen following the diagonal method, and 20 plants per sampling point were observed for visible stem rot symptoms (yellowing of foliage, wilting, rotting of collar region, white mycelial growth, and brown sclerotia). Disease incidence (%) was calculated as:

Disease Incidence (%) = (Number of infected plants / Total number of plants observed) × 100

Collection of Rhizosphere Soil Samples

Rhizospheric soil samples were collected from healthy groundnut plants from the same fields surveyed. Samples were taken from a soil depth of 5–15 cm around the root zone of healthy plants. Approximately 200 g of rhizospheric soil was collected per site by gently uprooting plants and shaking off loosely adhered soil; the tightly adhering soil was then carefully removed and pooled. Samples were placed in sterile polythene bags, labeled, and transported to the laboratory under ice-packed conditions for further processing within 24 hours of collection.

Isolation of Bacterial and Actinobacterial Antagonists

Bacterial antagonists were isolated from rhizosphere soil using the serial dilution plating technique. One gram of rhizosphere soil was suspended in 9 mL of sterile distilled water and vortexed for 2 minutes to prepare a 10-1 suspension. Serial dilutions were prepared up to 10-7. Aliquots of 0.1 mL from dilutions 10-4, 10-5, and 10-6 were plated on Nutrient Agar (NA) medium and Starch Casein Agar (SCA) medium, incubated at 28 ± 2°C for 24–72 hours. After incubation, morphologically distinct bacterial colonies were selected based on colony characteristics such as size, shape, color, margin, surface texture, and elevation. Representative colonies were sub-cultured and purified by the streak plate method on fresh NA medium. Pure cultures were maintained on NA slants at 4°C for further studies.

Isolation and Maintenance of the Pathogen (*S. rolfsii*)

Stem rot-infected groundnut plants exhibiting characteristic symptoms such as yellowing, wilting, collar region rotting, white fluffy mycelial growth, and brown sclerotia were collected from surveyed fields. Surface sterilization of infected stem tissue was performed with 0.1 per cent sodium hypochlorite for 1 minute followed by three washes in sterile distilled water. Tissue segments (4–5 mm) were placed on Potato Dextrose Agar (PDA) medium in Petri dishes and incubated at 28 ± 2°C. The white mycelial growth was identified as *S. rolfsii* based on morphological characteristics *i.e.,* white cottony mycelium, and round to oval sclerotia measuring 0.5–2.0 mm in diameter, initially white and turning to light brown on maturity. The pure cultures were maintained on PDA slants at 4°C for further use.

The pathogenicity of the isolated *S. rolfsii* was confirmed following Koch's postulates. Sorghum grain inoculum was prepared by autoclaving pre-soaked sorghum grains (at 121°C, 15 psi for 20 minutes) and inoculating with actively growing mycelial discs (5 mm diameter) of *S. rolfsii*. The inoculated grains were incubated at 28°C for 15 days until fully colonized. Plastic pots (30 cm diameter) were filled with sterile sandy loam soil. The colonized sorghum grain inoculum was mixed thoroughly with the soil at the rate of 10 g/kg of soil at the time of sowing.

Five Plants per pot were sown and maintained under shade net conditions. Disease symptom development was observed daily from 7 days after sowing. At 10 days after inoculation, the inoculated plants were assessed for stem rot symptoms. The pathogen was re-isolated from symptomatic collar tissue and its identity was confirmed by morphological characteristics, thus completing Koch's postulates.

Table 1. Incidence of stem rot disease in groundnut across rayalaseema districts of Andhra Pradesh

District	Village / Locality	Disease Incidence (%)
Tirupati	Sanambatla	23.5
Kadapa	Pulivendula	27.8
Chittoor	Dornakambala	21.3
Annamayya	Pileru	25.6
Kurnool	Chinna Tekur	31.2
Nandyal	Velugoda	28.4
Ananthapur	Uravakonda	19.7
Sathya Sai	Kadiri	22.9

Table 2. Details of Bacterial and Actinobacterial Isolates Collected from Rhizospheric Soil of Groundnut in Rayalaseema Districts

District	Village	Bacterial Isolates	Actinobacteria Isolates
Tirupati	Sanambatla	GB_1, GB_2, GB_3, GB_4, GB_5	GA_1, GA_2
Kadapa	Pulivendula	GB_6, GB_7, GB_8, GB_9, GB_{10}	GA_3, GA_4
Chittoor	Dornakambala	GB_{11}, GB_{12}, GB_{13}, GB_{14}, GB_{15}	GA_5
Annamayya	Pileru	GB_{16}, GB_{17}, GB_{18}, GB_{19}, GB_{20}, GB_{21}	GA_6, GA_7
Kurnool	Chinna Tekur	GB_{22}, GB_{23}, GB_{24}, GB_{25}, GB_{26}, GB_{27}	GA_8, GA_9
Nandyal	Velugoda	GB_{28}, GB_{29}, GB_{30}, GB_{31}, GB_{32}	GA_{10}, GA_{11}
Ananthapur	Uravakonda	GB_{33}, GB_{34}, GB_{35}, GB_{36}	GA_{12}
Sathya Sai	Kadiri	GB_{37}, GB_{38}, GB_{39}, GB_{40}	GA_{13}, GA_{14}

RESULTS

Incidence of Stem Rot Disease in Rayalaseema Districts

The survey for groundnut stem rot disease across the eight districts of Rayalaseema region of A.P revealed considerable variation in disease incidence (Table 1). The disease was recorded in all surveyed locations, confirming its widespread occurrence throughout the region. Kurnool district (Chinna Tekur village) recorded the highest disease incidence of 31.2 per cent, followed by Nandyal (Velugoda) at 28.4 per cent and Kadapa (Pulivendula) at 27.8 per cent. Annamayya (Pileru) recorded 25.6 per cent incidence, while Tirupati (Sanambatla), Sathya Sai (Kadiri), Chittoor (Dornakambala), and Ananthapur (Uravakonda) recorded incidences of 23.5 per cent, 22.9 per cent, 21.3 per cent and 19.7 per cent respectively.

Isolation of Bacterial and Actinobacterial Antagonists

A total of 40 bacterial isolates (GB1–GB40) were obtained from samples across the eight districts of Rayalaseema region of A.P. Colonies with characteristic actinobacterial morphology like chalky white, grey, or earthy-smelling colonies with powdery texture and substrate mycelia were selected, purified by the streak plate method, and maintained on SCA slants at 4°C. A total of 14 actinobacterial isolates (GA1–GA14) were obtained from the eight districts. Colonies of actinobacteria on SCA medium appeared after 7–14 days of incubation.

The pathogenicity test was conducted to confirm that the isolated fungus *S. rolfsii* was the causal organism of stem rot in groundnut. The fungus was multiplied on PDA medium and inoculated into soil using sorghum grain inoculum colonized by *S. rolfsii*. After 10 days of inoculation, inoculated plants exhibited typical stem rot symptoms, including yellowing and interveinal chlorosis of lower leaves, wilting of the entire plant, and browning and rotting of the collar region at the soil surface level. White cottony mycelial growth characteristic of *S. rolfsii* was clearly observed along the infected stem portions, along with brown to tan round sclerotia on the mycelial mass and soil surface adjacent to the plant base.

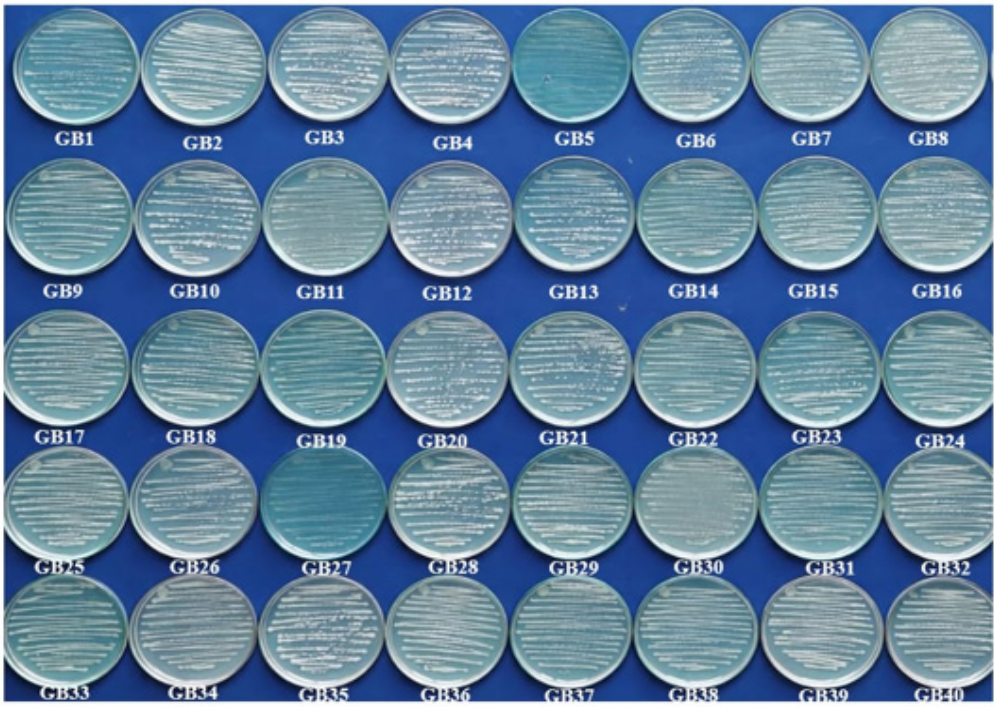
In sharp contrast, uninoculated control plants remained completely healthy throughout the observation period with no visible disease symptoms.The pathogen was successfully re-isolated; the re-isolated cultures exhibited identical morphological characteristics on PDA medium. The pathogenicity test confirmed that *S. rolfsii* was the causal organism of groundnut stem rot.

DISCUSSION

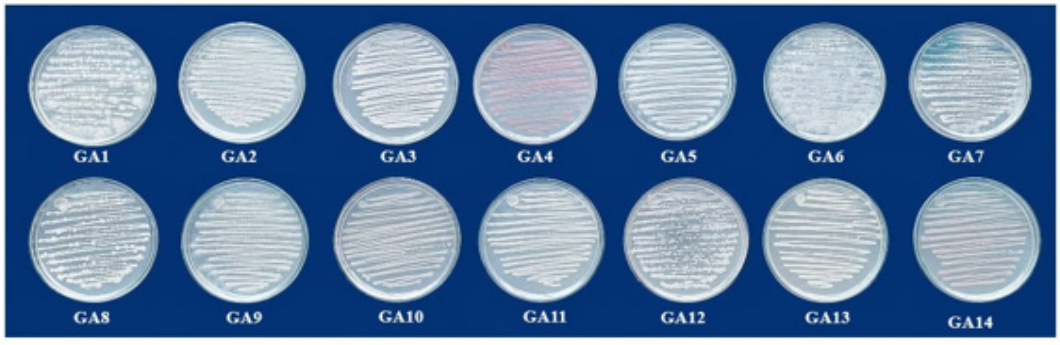
The results of the present survey confirm that stem rot disease caused by S. rolfsii is a serious and widespread constraint for groundnut cultivation in the Rayalaseema region of Andhra Pradesh. The overall mean disease incidence of 25.1 per cent recorded in the present study is consistent with earlier reports from different groundnut-growing regions of India. Kolte (1984) reported stem rot incidence ranging from 20–80 per cent in susceptible cultivars under favorable conditions, while Subrahmanyam *et al.* (1990) documented heavy losses in Andhra Pradesh due to soilborne pathogens. Kurnool district recording the highest incidence (31.2%) may be related to its black cotton soil with higher water retention capacity and slightly alkaline pH, both of which are known to favor sclerotia germination and mycelial growth of *S. rolfsii* (Purdy, 1979).

The pathogenicity test results conclusively established *S. rolfsii* as the causal organism of stem rot in groundnut in the Rayalaseema region. The appearance of symptoms at 10 days after inoculation is consistent with the typical incubation period of S. rolfsii under greenhouse conditions (Aycock, 1966). The use of sorghum grain inoculum has been widely validated as an effective method for soil infestation studies with S. rolfsii (Patel *et al.,* 2008), as colonized grains provide both viable mycelium and sclerotia for efficient disease establishment. The complete absence of symptoms in uninoculated control plants confirmed the specificity of symptoms to the inoculated pathogen. Re-isolation of morphologically identical fungal cultures from inoculated plants completed Koch's postulates. The characteristic white cottony mycelium and brown sclerotia observed on inoculated plants were identical to symptoms recorded in field surveys.The collection of 54 diverse antagonistic microbial isolates (40 bacterial and 14 actinobacterial) from the groundnut rhizosphere of Rayalaseema districts provides a valuable resource for subsequent *in vitro* and *in vivo* biocontrol screening against *S. rolfsii*.

The present study documented substantial incidence of *S. rolfsii* incited stem rot disease in groundnut across eight Rayalaseema districts of Andhra Pradesh, with overall mean incidence of 25.1 per cent (range: 19.7-31.2%). A total of 54 antagonistic microorganisms - 40 bacterial isolates (GB1–GB40) and 14 actinobacterial



Pure cultures of rhizosphere bacteria of groundnut



Pure cultures of rhizosphere actinobacteria of groundnut

isolates (GA1–GA14) - were successfully isolated from the rhizospheric soil of healthy groundnut plants using NA and SCA selective media. Pathogenicity of the isolated *S. rolfsii* was confirmed by satisfying Koch's postulates under shade net conditions, with clear stem rot symptoms appearing in inoculated plants (yellowing, wilting, collar rot, white mycelium, and sclerotia) while uninoculated controls remained healthy.

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POTENTIAL OF VARIOUS NATURAL FARMING PRACTICES FOR AUGMENTING THE GROWTH AND YIELD OF FINGER MILLET (*Eleusine coracana* L.)

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ABSTRACT

A field experiment was conducted during *rabi*, 2025-26 on sandy loam soils of S.V Agriculture College, Dry land farm, Tirupati, Andhra Pradesh to study the "Sustainable cultivation of finger millet (*Eleusine coracana* L.) through natural farming". The experiment was laid out in a randomized block design and replicated thrice. The findings of the experiment revealed that significantly highest growth parameters and yield of finger millet were recorded with application of Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyankura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage (T_{10}), which was however comparable with Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyankura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage (T_8) and Organic Package - Enriched FYM @ 5 t ha^{-1} + Foliar spray of Panchagavya 5 per cent @ 30 & 45 DAT (T_{11}). Application of Ghanajeevamrutham @ 500 kg ha^{-1} (T_1) recorded the lowest stature of growth parameters and yield. However, considering the comparable yield performance and economic returns with a lower quantity of Ghanajeevamrutham than application of Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyankura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage (T_{10}), application of Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyakura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stages (T_8) was found to be promising and economically viable natural farming practices on sandy loam soils of Southern Agro-Climatic Zone of Andhra Pradesh.

KEYWORDS: Natural farming practices, ghanajeevamrutham, dravajeevamrutham, panchagavya, fish amino acid, sapthadhanyankura kashyam, yield and finger millet.

INTRODUCTION

Modern agriculture has led to the excessive use of chemical fertilizers and pesticides, raising serious concerns in recent years. Although these inputs have contributed to enhanced crop productivity, their continuous and indiscriminate use has resulted in declining soil fertility, soil degradation, erosion and contamination of surface and groundwater resources. Furthermore, the rising cost of chemical inputs has increased the financial burden on farmers, reducing the profitability of cultivation. These challenges have emphasized the need for sustainable and environmentally friendly farming practices.

In this context, natural farming has emerged as a promising alternative that reduces dependence on external inputs while restoring and strengthening the ecological processes and functions of the farm ecosystem. It is gaining widespread recognition as a chemical-free production system that utilizes locally available resources, protects soil health, conserves biodiversity and promotes sustainable crop production. By minimizing the use of synthetic fertilizers and pesticides, natural farming also helps reduce the cost of cultivation.

Millets are gaining tremendous attention as climate-resilient and nutrient-rich crops that contribute to food and nutritional security, particularly in rainfed and resource-poor regions (Brahmachari *et al.,* 2019). India is the world's largest producer of millets, accounting for about 44 per cent of global production (USDA, 2026). Among them, finger millet (*Eleusine coracana* L.) is an important millet crop valued for its high calcium, iron, protein content and low glycaemic index, making it a nutritious food for health-conscious consumers. In India, it is cultivated over 12.29 lakh hectares with a production of 18.34 lakh tonnes and a productivity of 1,492 kg ha^{-1} (Indiastat, 2024–25). Its nutritional richness and adaptability to diverse agro-climatic conditions make finger millet a promising crop for sustainable agriculture and future food security.

However, the production potential of finger millet is constrained by several agronomic factors, among which nutrient management plays a crucial role. Although natural farming has gained considerable attention as a

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sustainable production system, scientific information on the validation of different natural farming inputs and their combinations for finger millet cultivation is still limited. This knowledge gap highlights the need for systematic evaluation of natural farming nutrient management practices to improve crop growth, productivity and soil health.

MATERIAL AND METHODS

A field experiment entitled "Sustainable cultivation of finger millet (*Eleusine coracana* L.) through natural farming" was conducted during *rabi,* 2025-26 at S. V. Agricultural College, Dry land Farm, Tirupati. It is geographically situated at 13.6o N latitude and 79.3o E longitude and at an altitude of 182.9 m above mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh. The soil of experimental field was sandy loam in texture, neutral in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and available potassium content. The experiment was laid out in a randomized block design and replicated thrice.

The experiment consisted of eleven treatments *viz.,* Ghanajeevamrutham@500kgha^{-1}(T_1),Ghanajeevamrutham @ 1000 kg ha^{-1} (T_2), Ghanajeevamrutham @ 1500 kg ha^{-1} (T_3), Ghanajeevamrutham @ 500 kg ha-1 + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 per cent at 30 and 45 DAT (T_4), Ghanajeevamrutham @ 500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Fish amino acid 1 per cent at 30 and 45 DAT (T_5), Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 per cent at 30 and 45 DAT (T_6), Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Fish amino acid 1 per cent at 30 and 45 DAT (T_7), Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyankura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage (T_8), Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 per cent at 30 and 45 DAT (T_9), Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyankura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage (T_{10}) and Organic Package - Enriched FYM @ 5 t ha^{-1} + Foliar spray of Panchagavya 5 per cent @ 30 & 45 DAT (T_{11}). Seedlings were treated with beejamrutham and groundnut shell was used as mulch, ghanajeevamrutham is applied 50 per cent at basal and 50 per cent as topdressing at 30 DAT. Dravajeevamrutham applied through irrigation water at 20, 40 and 60 DAT according to the treatments *i.e* 500 l ha^{-1} and 1000 l ha^{-1}. Fish amino acid and Sapthadhanyankura kashayam applied as foliar spray and plant protection measures are carried out by natural inputs through neemastra.

Preparations

Jeevamrutham

Fresh cow dung (25 kg), cow urine (25 L), jaggery (5 kg), Bengalgram flour (5 kg) and fertile soil (2 handfuls) were mixed in 500 L water, kept under shade for 2 days and stirred three times daily.

Ghanajeevamrutham

For 200 kg FYM, Drava Jeevamrutham (20 L) was uniformly mixed, covered with a jute bag and fermented for 48 hours, followed by spreading and sun-drying completely.

Fish Amino Acid

Fish Amino Acid (FAA): Fish waste and jaggery were taken in a 1:1 ratio, mixed layer by layer and stored in a cool, dry place away from sunlight for 30 days. The fermented liquid was then filtered to obtain the FAA stock solution.

Sapthadhanyankura kashayam

Sesame, greengram, blackgram, cowpea, horsegram, chickpea and wheat seeds (100 g each) were soaked overnight, sprouted to about 1 cm and ground into a fine paste. The paste was mixed with 200 L water and 10 L cow urine, stirred, kept for 2 hours and filtered to obtain the stock solution.

Panchagavya Fresh cow dung (7 kg) and cow ghee (1 kg) were mixed thoroughly and kept for 2 days, followed by addition of cow urine (10 L) and water (10 L) and kept for 15 days. Milk (2 L), curd (2 L), jaggery (250 g), ripe bananas (12 nos.) and tender coconut water (3 L) were then added and the mixture was stirred twice daily and kept under shade for 15 days.

RESULTS AND DISCUSSION

Growth Parameters

All the growth parameters differed significantly with the application of various natural farming practices (Table 1 and Table 2).

Table 1. Growth parameters of finger millet at 50 DAT as influenced by various natural farming practices

Treatment	Plant height (cm)	Leaf area index	Dry matter production (kg ha^{-1})	Number of tillers m^{-2}	Plant height (cm)
T_1 : Ghanajeevamrutham @ 500 kg ha^{-1}	41.7	0.96	768	48.5	41.7
T_2 : Ghanajeevamrutham @ 1000 kg ha^{-1}	43.2	1.02	811	51.1	43.2
T_3 : Ghanajeevamrutham @ 1500 kg ha^{-1}	44.8	1.07	837	52.4	44.8
T_4 : Ghanajeevamrutham @ 500 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	49.1	1.21	963	54.2	49.1
T_5 : Ghanajeevamrutham @ 500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	56.5	1.35	1142	60.0	56.5
T_6 : Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	49.2	1.23	978	55.8	49.2
T_7 : Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	56.9	1.47	1217	60.4	56.9
T_8 : Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyakura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage	50.6	1.30	1007	56.4	50.6
T_9 : Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	49.8	1.26	992	56.2	49.8
T_{10} : Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyakura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage	52.7	1.33	1028	57.3	52.7
T_{11} : Organic Package - Enriched FYM @ 5 t ha^{-1} + foliar spray of Panchagavya 5 % @ 30 & 45 DAT	59.8	1.52	1296	63.4	59.8
SEm ±	1.19	0.034	37.2	1.05	1.19
CD (P=0.05)	3.6	0.10	110	3.1	3.6

Table 2. Growth parameters of finger millet at harvest as influenced by various natural farming practices

Treatment	Plant height (cm)	Leaf area index	Dry matter production (kg ha^{-1})	Number of tillers m^{-2}
T_1 : Ghanajeevamrutham @ 500 kg ha^{-1}	55.0	1.18	1955	50.6
T_2 : Ghanajeevamrutham @ 1000 kg ha^{-1}	57.9	1.24	2012	53.7
T_3 : Ghanajeevamrutham @ 1500 kg ha^{-1}	58.5	1.31	2046	54.5
T_4 : Ghanajeevamrutham @ 500 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	63.2	1.55	2393	56.2
T_5 : Ghanajeevamrutham @ 500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	66.2	1.62	2434	62.4
T_6 : Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	64.5	1.56	2408	58.2
T_7 : Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 1ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	67.5	1.68	2470	62.7
T_8 : Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 1ha^{-1} + Sapthadhanyakura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage	73.0	1.87	2812	67.7
T_9 : Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	65.9	1.60	2422	61.3
T_{10} : Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 1000 1ha^{-1} + Sapthadhanyakura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage	75.8	1.94	2849	68.1
T_{11} : Organic Package - Enriched FYM @ 5 t ha^{-1} + foliar spray of Panchagavya 5 % @ 30 & 45 DAT	72.3	1.83	2796	67.3
SEm ±	1.48	0.044	101.3	1.50
CD (P=0.05)	4.4	0.13	301	4.5

Table 3. Grain and straw yield of finger millet as influenced by various natural farming practices

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 : Ghanajeevamrutham @ 500 kg ha^{-1}	650	1127
T_2 : Ghanajeevamrutham @ 1000 kg ha^{-1}	685	1144
T_3 : Ghanajeevamrutham @ 1500 kg ha^{-1}	710	1150
T_4 : Ghanajeevamrutham @ 500 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	843	1332
T_5 : Ghanajeevamrutham @ 500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	868	1345
T_6 : Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	852	1337
T_7 : Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	886	1360
T_8 : Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyakura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage	1016	1540
T_9 : Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 500 l ha^{-1} + Fish amino acid 1 % at 30 and 45 DAT	857	1345
T_{10} : Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyakura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage	1032	1558
T_{11} : Organic Package - Enriched FYM @ 5 t ha^{-1} + foliar spray of Panchagavya 5 % @ 30 & 45 DAT	1009	1533
SEm ±	35.4	57.2
CD (P=0.05)	105	170

Among the different natural farming treatments tried, application of Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyankura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage (T_{10}) recorded significantly higher growth parameters (plant height, LAI, dry matter production) at harvest, which was however, comparable with Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyankura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage (T_8) and Organic Package - Enriched FYM @ 5 t ha^{-1} + foliar spray of Panchagavya 5 per cent @ 30 & 45 DAT (T_{11}), which were superior over rest of the treatments. Wheareas the lowest growth parameters were recorded with Ghanajeevamrutham @ 500 kg ha^{-1} (T_1) which was in turn on par with Ghanajeevamrutham @ 1000 kg ha^{-1} (T_2) and Ghanajeevamrutham @ 1500 kg ha^{-1} (T_3). The increased plant height, leaf area and dry matter production at harvest might be attributed to the combined application of higher doses of Ghanajeevamrutham and Dravajeevamrutham along with Sapthadhanyankura kashayam, which enhanced soil biological activity, nutrient mineralization and the production of growth-promoting substances. The increased availability and uptake of nutrients throughout the crop growth period might have promoted root proliferation, cell division, leaf expansion and photosynthetic efficiency, thereby enhancing biomass accumulation and overall crop growth. Similar findings were reported by Kumbar and Devakumar (2016), Chaithra and Sujith (2021), Mahapatra *et al.* (2020) and Kumari *et al.* (2025).

Yield

Application of different natural farming practices exerted significant influence on grain and straw yield of finger millet (Table 3).

Application of Ghanajeevamrutham @ 1500 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyankura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage (T_{10}) recorded higher grain and straw yield, which was however, comparable with application of Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Sapthadhanyankura kashayam @ 25 l ha^{-1} at flower bud initiation and grain filling stage (T_8) and Organic Package - Enriched FYM @ 5 t ha^{-1} + Foliar spray of Panchagavya 5 per cent @ 30 & 45 DAT (T_{11}) followed by Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + Fish amino acid 1 per cent at 30 and 45 DAT (T_7) and these treatments are significantly superior over rest of the treatments tried. The lowest grain and straw yield of finger millet was recorded with Ghanajeevamrutham @ 500 kg ha^{-1} (T_1) and these are comparable with Ghanajeevamrutham @ 1000 kg ha^{-1} (T_2) and Ghanajeevamrutham @ 1500 kg ha^{-1} (T_3).

The higher yield might be attributed to enhanced microbial activity and sustained availability of nutrients throughout the crop growth period. Sapthadhanyankura kashayam, being a fermented formulation prepared from sprouted grains, might have supplied readily available macro and micronutrients, enzymes, amino acids and growth-promoting substances, thereby favourably influencing crop growth and development. The combined application of these natural farming inputs might have enhanced nutrient mobilization and uptake, resulting in improved photosynthetic efficiency and efficient translocation of photosynthates to the developing sinks. Moreover, the presence of growth-promoting hormones such as IAA and GA_3 (Mahapatra *et al.* 2020) might have stimulated physiological and metabolic activities, leading to improved source–sink relationships, greater biomass accumulation and ultimately higher grain and straw yield of finger millet. These results were in confirmity with the findings of Choudhary *et al.* (2022), Kumar *et al.* (2023), Veeranna *et al.* (2023) and Devakumar *et al.* (2018).

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PROFILE CHARACTERISTICS OF ANNADATHA SUKHIBHAVA SCHEME FARMERS IN ANANTHAPURAMU DISTRICT OF ANDHRA PRADESH

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ABSTRACT

The present study was conducted in Ananthapuramu district of Andhra Pradesh with a sample of 120 beneficiaries of Annadatha Sukhibhava scheme selected through random sampling. The findings revealed that a majority of the beneficiaries belonged to the middle-aged category (53.33%), had high school education (29.17%), medium landholding (44.16%), medium farming experience (65.83%), medium annual income (43.33%), medium extension contact (60.83%), medium social participation (65.00%), medium achievement motivation (67.50%), medium economic motivation (80.00%), medium credit orientation (50.83%) and medium awareness regarding government schemes (75.83%).

KEYWORDS: Annadatha Sukhibhava Scheme, PM- KISAN, farmer welfare.

INTRODUCTION

The Annadatha Sukhibhava Scheme was a farmer welfare and income support programme implemented by the Government of Andhra Pradesh to provide financial assistance to farmers. The scheme was originally introduced in 2019 and was later continued as YSR Rythu Bharosa–PM KISAN (https://pmkisan.gov.in/PM kissan). In 2025, it was relaunched as Annadatha Sukhibhava with enhanced financial support. Under the scheme, eligible farmer families receive ₹20,000 annually, including ₹14,000 from the State Government and ₹6,000 under PM-KISAN. The assistance was provided through Direct Benefit Transfer (DBT) in instalments to help farmers meet cultivation expenses, purchase quality inputs, reduce dependence on non-institutional credit and improve agricultural productivity and livelihood security. Annadatha Sukhibhava Scheme (https://annadathasukhibhava.ap.gov.in/). Profile characteristics play a significant role in understanding the socio-economic background of farmers benefiting from the Annadatha Sukhibhava Scheme. These characteristics include age, education, landholding, annual income, farming experience and extension contact, which help describe the beneficiaries and their farming circumstances. Studying these attributes provides insights into the diversity of farmers, their resource availability and their information needs. It also helps assess the representation of different categories of farmers among the beneficiaries and provides a basis for interpreting their experiences with the scheme. Understanding farmers' profile characteristics is therefore essential for developing appropriate extension strategies and improving the implementation of farmer welfare programmes.

MATERIAL AND METHODS

The study followed an ex-post facto research design to analyse the profile characteristics of the Annadatha Sukhibhava Scheme farmers Ananthapuramu district of Andhra Pradesh which was purposively selected. Three mandals, namely, Peddapappur, Gooty and Bukkaraya Samudram, were selected purposively and two villages from each mandal were chosen randomly making a total of six villages. Beneficiaries were selected from the identified villages using a random sampling procedure, resulting in a sample size of 120 respondents. Based on a literature review and expert input, 11 variables were selected for the study. Data were collected through a structured interview schedule and analyzed using frequency, percentage, mean and standard deviation for interpretation.

RESULTS AND DISCUSSION

The farmers were distributed into different categories based on their selected profile characteristics and the results were presented in the Table 1.

Age

The results from Table 1 revealed that half of the of Annadatha Sukhibhava Scheme beneficiary farmers belonged to the middle aged (53.33%) followed by old

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(35.00%) and young (11.67%) age. The predominance of middle-aged and older farmers indicated that the beneficiary group largely comprised farmers with established roles in agricultural activities and household management. The comparatively lower proportion of young farmers highlighted the need to encourage greater participation of younger individuals in agriculture and related extension programmes. This finding was in conformity with Nagesh (2019).

Education

The findings from Table 1 showed that 29.17 per cent had education up to high school level followed by middle (20.83%) school, college (17.50%) level education, those who could read and write (11.67%), primary education and could read only (7.50% each) and (5.83%) were illiterate. The distribution indicated that the respondents had varied educational backgrounds, with high school education being the most common. Extension programmes should therefore use clear, accessible communication methods, combining written information with verbal explanations to address the needs of farmers with different educational levels. This finding was in conformity with Choudhary (2021).

Land holding

The results furnished in Table 1 stated that, more than one-third 44.16 per cent beneficiaries belonged to the medium land holding category followed by (29.17%) semi medium farmers, (20.00%) were small farmers, (5.00%) were large farmer and only 1.67 per cent were marginal farmers. The predominance of medium and semi-medium landholders indicated that these categories formed a substantial share of the respondents. Differences in landholding size may be associated with variations in cultivation expenditure and the scale of farming operations. The result was in accordance with the finding of Hani *et al.* (2022).

Farming experience

The results from Table 1 revealed that, majority (65.83%) beneficiaries belonged to the medium farming experience category followed by (18.34%) high farming experience and (15.83%) low farming experience. The predominance of medium-experience farmers suggested that most respondents had accumulated considerable practical experience in agricultural activities. Such experience can be useful in farm management and decision-making; however, continued extension support remains important for improving awareness of new agricultural practices and government programmes. This finding was in conformity with Adhikari *et al.* (2021).

Annual income

From the Table 1, it can be inferred that, 43.33 per cent of the beneficiaries belonged to the medium annual income category followed by (16.67%) high annual income category, (15.83%) low annual income category, (12.50%) very low annual income category and (11.67%) fell under the very high annual income category. The predominance of the medium-income category indicated that this was the most common income group among the surveyed beneficiaries. Nevertheless, the presence of farmers across all five income categories demonstrated variation in their economic circumstances. This variation highlights the importance of timely financial assistance and accessible extension services to help farmers manage cultivation expenses according to their individual needs. The results were in line with the findings of Reddy (2026).

Extension Contact

The findings on extension contact from Table 1 projected that, 60.83 per cent of the beneficiaries belonged to the medium extension contact category followed by (20.00%) high extension contact and (19.17%) low extension contact. Most respondents had a moderate level of interaction with extension personnel and related information sources. However, the proportion with low extension contact suggested that some farmers might have limited opportunities to obtain timely agricultural information. Strengthening village-level extension activities and regular communication with farmers could help improve access to information about agricultural practices and welfare programmes. The result was in accordance with the finding Hani *et al.* (2022).

Social participation

It could be understood from the Table 1 that, 65.00 per cent of the beneficiaries belonged to the medium category followed by (20.00%) high social participation and (15.00%) low social participation category. The predominance of medium social participation suggested that most respondents had some level of involvement in social organisations or community activities. Such participation may provide opportunities for information

Table 1. Distribution of Annadatha Sukhibhava scheme farmers according to their profile (n=120)

S. No.	Category	Frequency (f)	Percentage (%)
1.	**Age**		
1	Young age (35 years and below)	14	11.67
2	Middle age (36 to 55 years)	64	53.33
3	Old age (56 years and above)	42	35.00
	Total	**120**	**100.00**
2.	**Education**		
1	Illiterate	70	05.83
2	Can read only	09	07.50
3	Can read and write	14	11.67
4	Primary	09	07.50
5	Middle	25	20.83
6	High school	35	29.17
7	College level	21	17.50
	Total	**120**	**100.00**
3.	**Land holding**		
1	Marginal (Up to 2.5 acres)	02	01.67
2	Small (2.5 to 5 acres)	24	20.00
3	Semi medium (5 to 7.5 acres)	35	29.17
4	Medium (7.5 to 10 acres)	53	44.16
5	Large (>10 acres)	06	05.00
	Total	**120**	**100.00**
4.	**Farming experience**		
1	Low farming experience	19	15.83
2	Medium farming experience	79	65.83
3	High farming experience	22	18.34
	Total	**120**	**100.00**
			Mean= 24.36; SD= 11.33
5.	**Annual income**		
1	Very high annual income (above 2,00,000/-)	14	11.67
2	High annual income (1,50,001/- to 2,00,000/-)	20	16.67
3	Medium annual income (1,00,001/- to 1,50,000/-)	52	43.33
4	Low annual income (50,001/- to 1,00,000/-)	19	15.83
5	Very low annual income (Up to 50,000/-)	15	12.5
	Total	**120**	**100.00**
6.	**Extension contact**		
1	Low extension contact	23	19.17
2	Medium extension contact	73	60.83
	High extension contact	24	20.00
	Total	**120**	**100.00**
			Mean= 37.98; SD= 4.60

Cont...

Table 1. Distribution of Annadatha Sukhibhava scheme farmers according to their profile (n=120)

S. No.	Category	Frequency (f)	Percentage (%)
1.	**Social participation**		
1	Low social participation	18	15.00
2	Medium social participation	78	65.00
3	High social participation	24	20.00
	Total	**120**	**100.00**
			Mean= 11.98; SD= 2.62
2.	**Achievement motivation**		
1	Low achievement Motivation	20	16.67
2	Medium achievement Motivation	81	67.50
3	High achievement Motivation	19	15.83
	Total	**120**	**100.00**
			Mean= 19.05; SD= 1.88
3.	**Economic motivation**		
1	Low economic motivation	08	06.67
2	Medium economic motivation	96	80.00
3	High economic motivation	16	13.33
	Total	**120**	**100.00**
			Mean= 23.11; SD= 2.24
4.	**Credit orientation**		
1	Low credit orientation	24	20.00
2	Medium credit orientation	61	50.83
3	High credit orientation	35	29.17
	Total	**120**	**100.00**
			Mean= 3.08; SD= 0.71
5.	**Awareness on government schemes**		
1	Low awareness on government schemes	10	8.33
2	Medium awareness on government schemes	91	75.83
3	High awareness on government schemes	19	15.84
	Total	**120**	**100.00**
			Mean= 8.46; SD= 1.61

exchange and collective learning among farmers. Encouraging participation in farmer groups, self-help groups and other relevant community organisations may further strengthen communication and awareness regarding agricultural support programmes. This finding was in conformity with Dhulgand (2020).

Achievement motivation

It could be concluded from the Table 1 that, majority (67.50%) of the beneficiaries belonged to the medium achievement motivation category followed by (16.67%) low achievement motivation category and (15.83%) high achievement motivation category. The predominance of medium achievement motivation suggested that most respondents demonstrated a moderate orientation towards achieving farming-related goals. Extension programmes that promote goal setting, exposure to successful farming practices and interaction with progressive farmers may help strengthen farmers' motivation to improve their agricultural performance. The result was in accordance with the finding Thakur *et al.* (2022).

Economic motivation

It could be observed from Table 1 that, majority (80.00%) of the beneficiaries belonged to the medium economic motivation followed by (13.33%) high and (6.67%) low economic motivation category. This distribution indicated that most beneficiary farmers demonstrated a moderate orientation towards improving their economic position through farming. Timely access to agricultural information, suitable technologies and financial support may help farmers make informed decisions regarding input use, farm investment and income improvement. The result was in accordance with the findings of Dhulgand (2020).

Credit Orientation

From the Table 1 it could be interpreted that, more than half (50.83%) of the beneficiaries belonged to the medium credit orientation category followed by the high credit orientation category (29.17%) and low credit orientation category (20.00%). This highlights the importance of providing information about institutional credit facilities, loan procedures and responsible credit management. Better access to appropriate credit information may help farmers make informed financial decisions and manage cultivation-related expenditure. The findings of the present study were similar to that of Sreedaya and Suresh (2022).

Awareness on Government Schemes

The findings from the Table 1 showed that, Majority (75.83%) of the beneficiaries belonged to the medium awareness category followed by (15.84%) high and (8.33%) low awareness category. The predominance of medium awareness suggested that most beneficiary farmers possessed a moderate level of knowledge about government support programmes. However, the presence of farmers in the low-awareness category indicated a need for continued awareness-building activities. Regular village-level meetings, farmer-oriented information materials and direct communication through extension personnel could help farmers understand scheme provisions, eligibility requirements and application procedures. The findings of the present study were similar to that of Singh and Rathore (2023).

The present study conducted in Ananthapuramu district of Andhra Pradesh revealed that the beneficiary farmers of the Annadatha Sukhibhava Scheme were predominantly middle-aged, had high school education, possessed medium landholdings and had medium farming experience. Most respondents belonged to the medium annual income, extension contact, social participation, achievement motivation, economic motivation, credit orientation and awareness of government schemes categories. These findings highlighted the diverse socio-economic and psychological characteristics of the beneficiary farmers. The profile information can serve as a useful basis for planning farmer-oriented extension programmes and improving communication regarding agricultural welfare schemes. Greater attention to farmers' educational backgrounds, information needs and awareness levels may help extension agencies provide more accessible and appropriate services to different categories of beneficiaries.

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