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SURVEY ON PESTICIDE USAGE PATTERN IN RICE CROP GROWN IN THE SOUTHERN ZONE OF ANDHRA PRADESH

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ABSTRACT

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A roving survey was conducted on pesticide usage pattern in rice crop grown in Southern Agro-climatic Zone of Andhra Pradesh during *rabi*, 2024-25. Data from 120 farmers were collected in four districts *viz.*, Kadapa, Nellore, Chittoor, Tirupati, two mandals from each district and three villages from each mandal. The data on crop management practices followed by the rice farmers, occurrence of insect pests and diseases, time of plant protection, pesticides, dose, method of application, *etc.*, was recorded. The results indicated that, stem borer, leaf folder, gall midge and brown plant hopper are the common insect pests of rice in surveyed areas and the insecticides *viz.*, chlorantraniliprole, dinotefuran, triflumezopyrim, acephate, cypermethrin, were used in the insect pest control. Diseases *viz.*, sheath blight, blast, grain discoloration were observed in common and fungicides azoxystrobin, tebuconazole, propiconazole, tricyclazole, carbendazim were the most frequently used to control the diseases. Among the insecticides, chlorantraniliprole being applied to the extent of 77 per cent against stem borers in Kadapa district followed by triflumezopyrim (70%) in Tirupati and Nellore districts against brown plant hoppers. In Chittoor district, 66.7 per cent farmers used cypermethrin against leaf folder. Among the fungicides, the combination of azoxystrobin and tebuconazole was used against sheath blight to the tune of 25.0 per cent, followed by tricyclazole (23.33%) against rice blast and propiconazole (20.8%) against sheath blight. Highest fungicide usage was observed in Tirupati district. The studies revealed that most of the farmers are using insecticides and fungicides in combination spray after tank mixing, limited to 3-5 no. of sprays with the power sprayer. This study provides an overview of the history and evolution of pesticide use in rice cultivation, explores the functions and application patterns of different types of pesticides.

KEYWORDS: Survey, rice, insecticides, fungicides, Andhra Pradesh.

INTRODUCTION

Pesticides constitute the key control tactics for management of pests and diseases and the productivity of crops depends on their effective control. As global food demand continues to grow, the use of pesticides in rice cultivation has become a common practice to ensure high yields. In India, 76 per cent of the pesticides were used as insecticides as against 44 per cent globally. The use of herbicides and fungicides were correspondingly less (Dey *et al.*, 2013). Rice crop is known to attack by more than 100 insect pest species worldwide and among them 10-12 are major in Indian context. Yellow stem borer, leaf folder, brown plant hopper, gall midge, green leaf hoppers, are the major insect pests in one and other rice growing locations of Andhra Pradesh. Rice crop is next to cotton in pesticidal application. Several new molecules with novel modes of action are applying in rice ecosystem for insect pest and disease control (Reddy *et al.*, 2023). The pesticide application in rice crop is started from nursery till maturity. In recent years end

of the season pesticide application observed in different rice growing areas of Andhra Pradesh. In view of the availability and usage of latest pesticide molecules, the present studies were planned to collect the data on pesticide usage in rice crop from Southern Agro-Climatic Zone of Andhra Pradesh.

MATERIAL AND METHODS

Roving survey was conducted in major rice growing areas of Andhra Pradesh *viz.*, Chittoor, S P S Nellore, Tirupati and Y S R Kadapa districts during early *rabi*, 2024-2025 to study the pesticide usage pattern. In each district, two mandals were selected and in each mandal, three villages were chosen randomly and 5 farmers in each village will be selected for conducting the survey. The list of districts, mandals and villages surveyed are mentioned in (Table 1). Survey was conducted as per standard proforma to access the pesticide usage pattern in rice crop by collecting the information on variety sown, seed treatment, date of sowing and transplanting, fertilizer dosage, insecticides and fungicides sprayed,

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Table 1. List of districts, mandals and villages of Andhra Pradesh surveyed for the pesticide usage pattern during *rabi*, 2024-2025

Districts	Mandals	Villages	Farmers
Chittoor	Rompicherla	3	15
	Pulicherla	3	15
Nellore	Indukurpet	3	15
	Venkatachalam	3	15
Y. S. R. Kadapa	Duvvur	3	15
	Proddatur	3	15
Tirupati	Chinnagottigallu	3	15
	Yerravaripalem	3	15
Total		24	120

stage of spraying, date of harvesting, source for pesticides, precautionary measures *etc.*,

RESULTS AND DISCUSSION

Pesticide usage pattern on rice crop against insect pests, diseases and weeds during *rabi*, 2024-25

From the Table 2, it was clear that different formulations of 19 insecticides, 10 fungicides were used by paddy farmers throughout the crop growing season during *rabi*, 2024-25. The highest number of farmers (65.00%) used chlorantraniliprole followed by triflumezopyrim (63.33%) and monocrotophos (60.00%), while the least number of farmers used bifenthrin (35.00%) for control of different insect pests, while, in case of fungicides, azoxystrobin and tebuconazole (25.00%) followed by tricyclazole (23.00%) and propiconazole (20.83%) were used by farmers against different fungal infections. In case herbicides, 10.00 and 3.33 per cent farmers used butachlor and bispyribac sodium and the remaining farmers (86.67%) followed manual method for weed control.

Among the insecticides used by the farmers, bifenthrin, cypermethrin, profenophos, phorate, deltamethrin and lambda-cyhalothrin and fungicide, copper oxychloride were not recommended on rice crop as per CIB & RC (2024). Pesticides *viz.*, trifloxystrobin fungicide

recommended in combination with other fungicides. Among the pesticides used monocrotophos belongs to class Ib which was highly toxic and likely to cause ill-effects whereas, chlorantraniliprole, azoxystrobin, mancozeb and carbendazim unlikely to cause ill-effects in normal use and belongs to class 'U' according to WHO Classification 2019.

Based on the survey during *rabi*, 2024-25, it was concluded that farmers used more insecticides followed by fungicides and herbicides to reduce the insect pests, diseases and weeds. These results were similar with the observations of Sai *et al.* (2019) who reported that insecticides (72%) were the most commonly used among pesticides, followed by fungicides and bactericides (18%) and herbicides (6%). From the obtained results it was revealed that among different pesticides, farmers used different formulations of insecticides and fungicides which were available in different trade names. The results were in conformity with the survey done by Ahmad *et al.* (2014) who reported that, most of the insecticides which were used frequently by the famers contains active ingredients of thiamethoxam, lambda-cyhalothrin, chlorpyrifos, cypermethrin, buprofezin and cartap hydrochloride and among the fungicides, difenoconazole and isoprothiolane were the active ingredients used to control fungal pathogens (*Rhizoctonia solani* and *Pyricularia oryzae*).

Table 2. Pesticide usage pattern on rice crop against insect pests, diseases and weeds during *rabi*, 2024-25

Insecticide	Type of formulation	Trade name	Chemical class	IRAC class	No. of farmers (120)	%	Rank
Acephate	75 SP	Asataf	Organophosphate	1B	67	55.83	5
Bifenthrin	10 EC, 8 SC	Talstar	Pyrethroid	3A	42	35	15
Buprofezin	25 SC	Applaud	Insect growth regulator (IGR)	16	45	37.5	14
Carbofuran	3 G	Furadan	Carbamate	1A	48	40	12
Cartap-hydrochloride	50 WP, 4G	Sanvex, Caldan	Nereistoxin analogue	1B	49	40.83	11
Chlorantraniliprole	18.5 SC, 0.4 GR	Coragen, Ferterra	Diamide	28	78	65	1
Chlorpyrifos	20 EC	Dursban	Organophosphate	1B	69	57.5	4
Cypermethrin	10 EC	Cyperkill	Pyrethroid	3A	39	32.5	16
Deltamethrin	2.5 EC	Butoflin	Pyrethroid	3A	39	32.5	16
Dinotefuran	20 SG	Dinogold	Neonicotinoid	4A	47	39.17	13
Flubendiamide	20 WDG, 480 SC	Fame	Diamide	28	53	44.17	10
Imidacloprid	17.8 SL, 600 FS	Confidor, Gaucho	Neonicotinoid	4A	56	46.67	8
Indoxacarb	14.5 SC	Avaunt	Oxadiazine	22A	64	53.33	6
Lambda-cyhalothrin	5 EC	Warrior	Pyrethroid	3A	56	46.67	8
Monocrotophos	36 SL	Monokem, Hycrophos	Organophosphate	1B	72	60	3
Phorate	10 G	Thimet	Organophosphate	1B	52	43.33	9
Profenofos	50 EC	Pivot, ProfiganS	Organophosphate	1B	62	51.67	7
Pymetrozine	50 WG	Chess	Pyridine azomethine	9B	56	46.67	8
Triflumezopyrim	10 SC	Trifluzopy	Mesonoic pyridol [1,2-a] pyrimidine	4E	76	63.33	2
Fungicide			Chemical class	IRAC class			
Azoxystrobin	23 SC	Amistar	Strobilurin (QoI)	11	30	25	1
Carbendazim	50 WP, 46.27 SC	Bavistin	Benzimidazole	1	20	16.67	5
Copper oxychloride	50 WP	Blitox	Inorganic (multi-site)	M1	14	11.67	7
Difenoconazole	25 EC	Score	Triazole (DMI)	3	7	5.83	8
Hexaconazole	5 EC	Contaf Plus, Sitara	Triazole (DMI)	3	21	17.5	4
Mancozeb	75 WP	Dithane m-45	Dithiocarbamate	M3	14	11.67	7
Propiconazole	25 EC	Tilt, Radar	Triazole (DMI)	3	25	20.83	3
Tebuconazole	25.9 EC, 430 SC	Folicur	Triazole (DMI)	3	30	25	1
Tricyclazole	75 WP	Beam, Sivic	Benzimidazole	16	28	23.33	2
Trifloxystrobin	50 WG, 25 WG	Nativo	Strobilurin (QoI)	11	16	13.33	6
Herbicide							
Butachlor	50 EC	Machete	Acetanilide		12	10	1
Bispyribac sodium	10 SC	Nominee Gold	Pyrimidinylthiobenzoate		4	3.33	2

Table 3. General awareness of farmers on usage of pesticides on paddy crop during *rabi*, 2024-25

S. No.	Particulars	<i>Rabi</i> , 2024-25 (n=120)	
		Frequency	Percentage
1.	Period of farming activity in using pesticides on paddy crop		
	<5 years	28	23.33
	>5 years	92	76.67
2.	Awareness on recommendations of pesticides		
	With awareness	17	14.17
	Without awareness	103	85.83
3.	Farmers desire to mix different pesticides		
	Insecticide + insecticide	72	60.00
	Insecticide + fungicide	34	28.33
	Fungicide + fungicide	14	11.67
4.	Measurement of pesticides		
	Bottle cap (correct dosage)	36	30.00
	Approximately (more or less dosage)	84	70.00
5.	Mixing of pesticides with water to prepare spray solution		
	Bare hands	0	0.00
	Stick	120	100.00
6.	Frequency of application		
	4 days interval	21	17.50
	5 days interval	38	31.67
	Weekly interval	61	50.83
7.	Selection of spraying equipment		
	Knapsack sprayer	19	15.83
	Power sprayer	101	84.17
8.	Time of pesticide application		
	Morning or evening hours	78	65.00
	Day light hours	42	35.00
9.	Precautions while application of pesticides		
	Face masks	0	0.00
	Hand gloves	3	2.50
	Shirts with full hands	101	84.17
	No precautions	16	13.33

General awareness of farmers on usage of pesticides on paddy crop during *rabi*, 2024-25

From the table 3, information on paddy farmers of 76.67 and 23.33 per cent have been using different chemical pesticides for more than five and less than five years respectively against different pests. Since most of the famers had an farming experience of 10-15 years

on different crops. These results were similar with the findings of Sankoh *et al.* (2016) who reported that most of the respondents used at least one type of pesticide on their farms throughout their farming experience. Only 14.17 per cent of the farmers had awareness to use recommended pesticides for different pests and 85.83 per cent of the farmers used recommended pesticides without

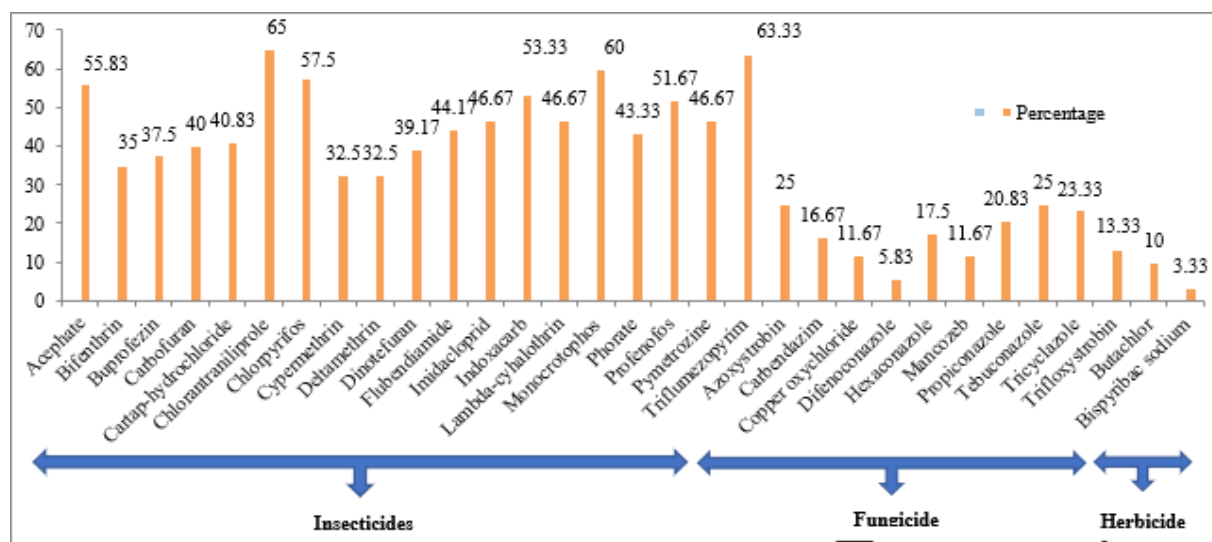


Fig 3.1 Pesticide usage pattern on rice crop against insect pests, diseases and weeds during rabi, 2024-25

awareness. The results were similar with the outcome of Deviprasad *et al.* (2015) who observed that most of the pesticide formulations which were used against different pests at various stages of crop production by the farmers were recognized. Shetty *et al.* (2010) observed that 52.49 per cent of the farmers applied combination of two to three pesticides against major pests and 48 per cent of the respondents in the study area sprayed pesticides without mixing two or more pesticides. Fajardo *et al.* (2000) observed that the pesticides were sprayed with a 15 litre capacity knapsack sprayer on paddy crop by majority of the farmers. This output was similar with the findings of Hamsan *et al.* (2017) who observed that 89.60 per cent of farmers sprayed in the morning or evening and only 4.0 per cent sprayed pesticides while it was so hot in the afternoon. The findings of Jallow *et al.* (2017) who reported that the majority (58%) of the farmers did not use any protection equipment when mixing or spraying pesticides due to lack of availability when needed.

Present surveys in Southern Agro-Climatic Zone of Andhra Pradesh revealed that the farmers were using 19 insecticides, 10 fungicides and 2 herbicides. The compounds *viz.*, bifenthrin, cypermethrin, profenophos, phorate, deltamethrin and lambda-cyhalothrin were not recommended on rice crop and fungicides; copper oxychloride also not recommended. Pesticides *viz.*, trifloxystrobin fungicide recommended in combination with other fungicides. The farmers applying tank mixture of insecticides and fungicides alone and in combination also. End season application of fungicides was resulted

for fungal diseases and grain discoloration. Hence the harvest time residues in rice also need to be studied.

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SURVEY FOR BLAST AND SEEDLING BLIGHT DISEASES OF FINGER MILLET IN ANDHRA PRADESH

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ABSTRACT

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A comprehensive roving survey was conducted during the *kharif* 2024 and *rabi* 2024–2025 seasons across seven districts of Andhra Pradesh to assess the severity of blast and seedling blight diseases in finger millet. The survey revealed that blast disease (mean PDI of Blast with 41.1%) was more prevalent and severe compared to seedling blight (mean PDI of Seedling blight with 18.7%). The highest blast incidence during *kharif* 2024 was recorded in YSR Kadapa district with a mean PDI of 63.2 per cent, followed by Satya Sai (61.0%) and Vizianagaram (55.0%). In *rabi* 2024–2025, Satya Sai district showed the highest mean PDI of 52.7 per cent, while Chittoor and Nandyal districts exhibited lower infection levels. Seedling blight incidence was comparatively lower, with a maximum mean PDI of 26 per cent in Satya Sai during *kharif* 2024 and 36 per cent in YSR Kadapa during *rabi* 2024–2025. A comparative analysis indicated that disease severity was higher during the *kharif* season, likely due to favourable environmental conditions. The findings underscore blast as the more dominant and damaging disease in finger millet, necessitating targeted disease management strategies.

KEYWORDS: Finger millet, blast, seedling blight, survey, Andhra Pradesh.

INTRODUCTION

Finger millet (*Eleusine coracana* Gaertn. L.) is a cereal crop cultivated primarily for food in parts of Africa and South Asia, especially in India across states such as Uttar Pradesh, Bihar, Tamil Nadu, Karnataka, and Andhra Pradesh. Finger millet is a major crop in the arid and semi-arid regions of developing countries across Asia and Africa (Ceasar *et al.*, 2018; Krishna *et al.*, 2020).

Among all cereals and millets, finger millet contains the highest levels of calcium (344 mg per 100 g) and potassium (408 mg per 100 g). It also provides more dietary fiber, minerals, and sulfur-containing amino acids than white rice, which is currently the major staple food in India (Shobana *et al.*, 2013). Finger millet is also a rich source of essential amino acids such as arginine, lysine, methionine, and lecithin. These compounds play vital roles in promoting health, including acting as precursors for nitric oxide synthesis and aiding in the stimulation and release of growth hormone (Pragya, 2012). Leaf blast symptoms caused by *Pyricularia grisea* typically appear as elongated, diamond-shaped lesions with gray or whitish centers and brown to reddish-brown margins (Acharya *et al.*, 2019). In severe cases, the portion of the panicle above the infected neck turns dark brown to black, often resulting in the complete death of the plant.

Brown spot, also known as seedling blight or leaf blight, caused by *Helminthosporium nodulosum* (Berk and Curt.), is the second most severe and widely distributed disease of finger millet after blast. The characteristic symptom on the leaf lamina is the appearance of brown to dark brown spots. In finger millet, *Helminthosporium* infects nursery seedlings or very young plants, attacking the coleoptile, collar or first leaves, causing rapidly spreading lesions that lead to wilting, drying and collapse of seedlings. The pathogen primarily infects leaves either from the upper surface or in the region between the leaf and the leaf sheath. Infection occurs through stomata, epidermal cells, or more commonly *via* certain epidermal outgrowths.

In the past few years, the production of finger millet has faced significant constraints due to blast and seedling blight diseases in the Vizianagaram and Rayalaseema districts of Andhra Pradesh. A survey was conducted to determine the severity of blast and seedling blight diseases.

MATERIAL AND METHODS

To assess the prevalence of blast and seedling blight diseases in finger millet, a roving survey was undertaken in one mandal was selected for each district and two villages were randomly selected across the districts of Vizianagaram, Tirupati, Sri Sathya Sai, Chittoor,

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Table 1. Finger millet Leaf blast Standard Evaluation System (SES)(Nagaraja *et al.*, 2007)

Score	Description
1	Small, brown, pinhead size specks without sporulating centre
2	Small (1-2mm) roundish to elongated, necrotic grey spots with a distinct brown margin covering up to 5% leaf area
3	Typical blast lesions (≥ 3 mm) with sporulating center, covering 6-10% of the leaf area
4	Blast lesions covering 11-20 % leaf area
5	Blast lesions covering 21-30 % leaf area
6	Blast lesions covering 31-40 % leaf area
7	Blast lesions covering 41-50 % leaf area
8	Blast lesions covering 51-75 % leaf area
9	Blast lesions covering >75 % leaf area & plant death

Table 2. Scale used for screening the varieties against brown spot (Nagaraja *et al.* 2007)

Grade	Percentage leaf area affected
0	No infection.
1	Pinhead spots less than 1% leaf area affected.
2	Pinhead spots 5-10% leaf area affected.
3	Typical brown spots with grey centre 5-25% leaf area affected.
4	25-50% leaf area affected.
5	Large brown spots with grey centre more than 50% leaf area affected.

Y.S.R. Kadapa, Ananthapuram, and Nandyala of Andhra Pradesh.

Ten representative leaves from one plant were selected from each field and evaluated using a 1–9 rating scale for blast disease (Table 1) and a 0–5 rating scale for seedling blight (Table 2). These scores were then used to calculate the percent disease index (PDI) for each surveyed field, following the method outlined by Nagaraja *et al.* (2007). Disease severity was determined based on the visible symptoms of blast and brown spot on the plants.

The per cent disease index was computed with the following formula.

Sum of all the scores

$$\text{PDI} = \frac{\text{Sum of all the scores}}{\text{Total number of scores} \times \text{Maximum score}} \times 100$$

(Total number of scores x Maximum score)

RESULTS AND DISCUSSION

Prevalence of blast in finger millet during *kharif* 2024

The results revealed considerable variation in disease PDI among the surveyed locations. The highest mean PDI was recorded in YSR Kadapa district (63.2), where the villages of Muthukur and Moillacheruvu showed very high infection levels of 67.7 per cent and 58.7 per cent, respectively. Satya Sai district followed

with a mean PDI of 61.0 per cent, as both Madakasira (64.4 %) and R. Ananthapuram (57.7%) exhibited significant disease pressure (Table 3).

Vizianagaram district reported a moderately high mean PDI of 55.0 per cent, with Kanguva (53.5%) and Tummikapalli (56.6%) showing notable infection levels. Tirupati district recorded a moderate level of disease, with a mean PDI of 49.9 per cent, ranging from 45.5 per cent in Perumallapalle to 54.4 per cent in Tirupati. In contrast, relatively lower disease incidence was observed in Ananthapuram (mean PDI of 34.4%) and Chittoor (mean PDI of 29.9%), where village-level PDIs ranged from 28.8 to 35.5 per cent. The lowest disease incidence was found in Nandyal district, which had a mean PDI of 24.4 per cent, Pandlapuram village recorded the least infection with a PDI of 20.0 per cent (Table 3).

Prevalence of blast in finger millet during *rabi* 2024-25

During *rabi* 2024-25 the highest mean PDI was recorded in Satya Sai district (52.7%), where Madakasira and R. Ananthapuram villages reported high PDIs of 59.2 and 46.3 per cent, respectively, indicating a significant blast infection. YSR Kadapa followed with a mean PDI of 50.4 per cent (Table 3), Muthukur recorded a PDI of 57.4, while Moillacheruvu had 43.5 per cent (Table 3)

In contrast, lower disease incidence was observed in Chittoor district with lowest mean PDI of 14.2 per cent,

with Puthalapattu at 17.8 per cent and Oddepalle at just 10.7 per cent, (Table 3) indicating minimal disease PDI.

A comparison of blast disease surveys from *Kharif* 2024 and *rabi* 2024–2025 in Andhra Pradesh showed that the Percent Disease Index (PDI) was higher during the *Kharif* 2024 season, with a PDI of 63.2 (table 3) recorded in YSR Kadapa district, compared to a PDI of 52.7 (table 3) in Satya Sai district during the *rabi* 2024–2025 season, likely due to more favorable conditions for disease development during *Kharif*.

Prevalence of seedling blight in finger millet during *kharif* 2024

The highest incidence was observed in the Satya Sai district, where the Madakasira and R. Ananthapuram villages exhibited a mean PDI of 26 per cent, suggesting a severe incidence. In contrast, Chittoor district (Puthalapattu mandal) recorded the lowest mean PDI of 4 per cent, indicating minimal disease index (Table 3).

Prevalence of seedling blight in finger millet during *rabi* 2024-25

The highest mean PDI of 36 per cent was reported in YSR Kadapa district (Atlur mandal), particularly in Muthukur and Moillacheruvu villages, indicating a severe outbreak of seedling blight (Table 3). In contrast, Chittoor district (Puthalapattu mandal) had the lowest mean PDI of just 10 per cent (Table 3).

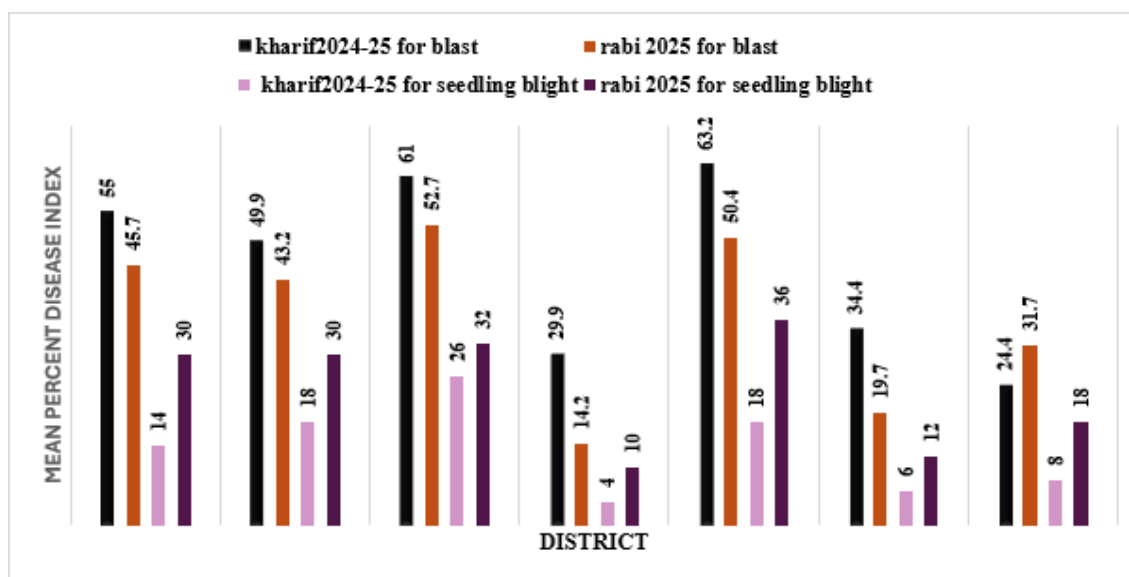


Fig 1. Survey on PDI blast and seedling blight of finger millet during *kharif* 2024-25 and *rabi* 2024-25

Table 3. Survey on PDI blast and seedling blight of finger millet during *Kharif* 2024-25 and *rabi* 2025

S. No.	District	Mandal	Village	Blast				Seedling Blight			
				<i>Kharif</i> 2024-25	Mean PDI	<i>Rabi</i> 2025	Mean PDI	<i>Kharif</i> 2024-25	Mean PDI	<i>Rabi</i> 2025	Mean PDI
1.	Vizianagaram	Gajapathinagaram	Kenguva	53.5	55.0	47.2	45.7	12	14	28	30
			Tummikapalli	56.6		44.3		16		32	
2.	Tirupati	Tirupati	Tirupati	54.4	49.9	47.6	43.2	16	18	36	30
			Perumallapalle	45.5		38.8		20		24	
3.	Satya Sai	Madakasira	Madakasira	64.4	61.0	59.2	52.7	28	26	36	32
			R. Ananthapuram	57.7		46.3		24		28	
4.	Chittoor	Puthalapattu	Puthalapattu	28.8	29.9	17.8	14.2	4	4	12	10
			Oddepalle	31.1		10.7		4		8	
5.	Y. S.R. Kadapa	Atlur	Muthukur	67.7	63.2	57.4	50.4	20	18	40	36
			Moilacheruvu	58.7		43.5		16		32	
6.	Ananthapuram	Tadipatri	Tadipatri	33.3	34.4	21.7	19.7	4	6	12	12
			Veerapuram	35.5		17.8		8		12	
7.	Nandyala	Banganapalle	Banganapalle	28.8	24.4	25.7	31.7	8	8	20	18
			Pandlapuram	20		37.8		8		16	
					45.4		36.8		13.4		24

Aravind *et al.* (2024) conducted a roving survey to gather rice samples affected by blast disease from key rice-producing regions of the Northern Telangana zone. The Percent Disease Index (PDI) showed considerable variation, ranging from 18.5 per cent in Mancherla to 79.41 per cent in Peddapalli. Likewise, disease severity fluctuated between 22.2 per cent and 85.1 per cent, reflecting the extensive and intense occurrence of blast disease in specific areas of the region. Odeph *et al.* (2020) conducted a survey on finger millet blast severity across selected counties in Kenya and reported that Busia County had the highest disease severity, with an average of 82.3 per cent, based on whole-farm observations. Bungoma and Machakos followed closely with severity levels of 67.0 per cent and 66.0 per cent, respectively, while Makueni recorded the lowest severity at 61.0 per cent.

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GENETIC VARIABILITY STUDIES ON CANE YIELD AND JUICE QUALITY IN SUGARCANE (*Saccharum* spp.)

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ABSTRACT

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Fifty one sugarcane clones were evaluated in randomized block design with two replications at ARS, Perumallapalle, Tirupati, Andhra Pradesh to study the variability for cane yield and juice quality traits. The analysis of variance (ANOVA) revealed significant differences in the mean sum of squares for all the characters. The phenotypic coefficient of variance (PCV) is greater than the genotypic coefficient of variance (GCV) for all the traits under study. High heritability coupled with high genetic advance as per cent of mean was observed for tillers at 120 DAP, number of nodes per cane, sucrose per cent and CCS per cent at 10th month, top leaf weight, reducing sugars and leaf area index. High heritability coupled with moderate genetic advance as per cent of mean was observed for number of millable canes, cane length, brix per cent at 10th and 12th month, sucrose per cent and CCS per cent at 12th month and fibre per cent. High heritability and low genetic advance were observed for germination per cent at 30 DAP, purity per cent at 10th and 12th month.

KEYWORDS: ANOVA, heritability, GCV and PCV.

INTRODUCTION

Sugarcane (*Saccharum* spp.) is an important commercial crop. Its Latin name *Saccharum* given by Carl Linne in 1753 derives from the words 'Karkara' and 'Sakkara' in Sanskrit and Prakrit. It grows as a tall perennial grass. It belongs to the order Poales, family Poaceae and sub family Panicoideae. It's chromosome number ranging between 2n=80-120. Among all the regions worldwide, India stands out as a significant player in the sugarcane production and in sugar industry with an area of 5.648 M ha, producing 446.43 M t of cane, with a productivity of 79.03 t ha⁻¹. The state of Andhra Pradesh contributes to the country's output with an area of 0.027 M ha, producing 2.10 M t of cane and a productivity rate of 76.34 t ha⁻¹. (Directorate of Sugarcane Development, 2024). In sugarcane cultivation, early and mid-late clones refer to different maturity groups. Sugarcane is a highly heterozygous and complex in terms of its genetic makeup, exhibits a tendency to give rise to significant variability. This variability is typically quantified through measures such as, PCV, GCV (phenotypic and genotypic coefficient of variation) and genetic advance as a per cent of the mean (GAM). Knowledge of the genetic variability and broad sense heritability of traits holds paramount importance to breeders, aiding them in executing effective selection among various clones.

The combination of the coefficient of variation with heritability, alongside GAM, facilitates the improvement of traits by providing insights into the attainment of specific objectives using the convenient resources.

MATERIAL AND METHODS

The experimental material consists of fifty-one clones. All material was provided by Principal scientist and Head, Agricultural Research Station, Perumallapalle. The clones were planted in a Randomized Block Design with two replications during 2024-25 at ARS, Perumallapalle, Tirupati, Andhra Pradesh. Plot size was four rows (2 pairs with an interpair spacing of 1.5 m and interrow spacing of 0.6m) of 6 m row length. Four three-budded sets were planted per metre row length. Observations were recorded by randomly selecting five canes of each clone from each replication for component traits of cane yield and quality parameters viz., germination percent at 30 DAP, tillers at 120 DAP ('000 ha⁻¹), number of millable canes ('000 ha⁻¹), cane yield (t ha⁻¹), single cane weight (kg), cane length (cm), cane diameter (cm), number of nodes per cane, top leaf weight (kg), fibre per cent, leaf area index, reducing sugars and CCS yield (t ha⁻¹) at harvest. Juice analysis was done in both 10th and 12th month which includes brix per cent, sucrose per cent, purity per cent and CCS per cent. The genetic parameters *i.e.* phenotypic coefficient of variance

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Table 1. Analysis of Variance for cane yield, yield attributing and quality characters in Sugarcane (*Saccharum spp.*)

S. No.	Characters	Mean sum of squares		
		Replications (df: 1)	Treatments (df: 50)	Error (df: 50)
1.	Germination % at 30 DAP	24.80	29.504**	6.817
2.	Tillers at 120 DAP ('000/ha)	184.55	404.4**	49.83
3.	Number of millable canes ('000/ha)	0.001	121.37**	19.6
4.	Number of nodes per cane	0.48	34.77**	6.447
5.	Cane length (cm)	518.63	2704.16**	348.63
6.	Cane diameter (cm)	0.113	0.127*	0.067
7.	Single cane weight (kg)	0.04	0.19**	0.05
8.	Brix % at 10 th month	0.0519	5.474**	0.366
9.	Sucrose % at 10 th month	0.022	4.67**	0.329
10.	Purity % at 10 th month	0.106	1.376**	0.303
11.	CCS % at 10 th month	0.006	2.363**	0.168
12.	Brix % at 12 th month	0.094	4.152**	0.472
13.	Sucrose % at 12 th month	0.176	3.8**	0.436
14.	Purity % at 12 th month	0.96	1.365**	0.266
15.	CCS % at 12 th month	0.139	1.968**	0.232
16.	Top leaf weight (kg)	0.001	0.005**	0.001
17.	Fibre %	0.047	3.826**	0.208
18.	Reducing sugars %	0.067	0.879**	0.065
19.	Leaf area index	0.281	1.182**	0.079
20.	CCS yield (t ha ⁻¹)	2.101	18.498**	4.646
21.	Cane yield (t ha ⁻¹)	284.90	1056.53**	393.714

Table 2. Mean, range, coefficient of variation, heritability (broad sense), genetic advance and genetic advance as percent of mean for cane yield, yield attributing and quality characters in sugarcane

S. No.	Characters	Mean	Range		Variance		Coefficient of variation (%)		Heritability (%)	Genetic advance	Genetic advance as percent of mean(%)
			Minimum	Maximum	Genotypic	Phenotypic	Genotypic	Phenotypic			
1.	Germination % at 30DAP	58.86	52.75	66.80	11.34	18.16	5.72	7.24	62.46	5.48	9.31
2.	Tillers at 120 DAP	119.70	93.24	155.54	177.29	227.12	11.12	12.59	78.06	24.23	20.24
3.	NMC (*000/ha)	84.08	66.86	97.41	50.88	70.49	8.48	9.98	72.19	12.48	14.85
4.	Number of nodes per cane	32.00	23	41.00	14.18	20.58	11.77	14.17	68.91	6.44	20.12
5.	Cane length (cm)	333.63	255.0	415.00	1177.76	1526.39	10.29	11.71	77.16	62.10	18.61
6.	Cane diameter (cm)	3.00	2.56	3.64	0.03	0.09	5.76	10.42	30.56	0.19	6.56
7.	Single cane weight (kg)	1.63	1.02	2.29	0.07	0.12	16.19	20.98	59.56	0.42	25.75
8.	Brix % at 10 th month	15.98	12.75	18.85	2.55	2.92	10.01	10.7	87.46	3.08	19.28
9.	Sucrose % at 10 th month	13.97	11.25	16.65	2.17	2.49	10.54	11.31	86.82	2.82	20.23
10.	Purity % at 10 th month	87.48	85.5	89.5	0.54	0.84	0.84	1.05	63.84	1.20	1.38
11.	CCS % at 10 th month	9.65	7.8	11.65	1.09	1.27	10.85	11.65	86.68	2.01	20.81
12.	Brix % at 12 th month	18.92	15.25	22.25	1.84	2.31	7.17	8.04	79.56	2.49	13.17
13.	Sucrose % at 12 th month	16.70	13.15	19.60	1.68	2.12	7.77	8.72	79.39	2.38	14.25
14.	Purity % at 12 th month	88.12	86.25	90.0	0.55	0.82	0.84	1.02	67.33	1.25	1.42
15.	CCS % at 12 th month	11.58	9.02	13.58	0.87	1.10	8.05	9.06	78.86	1.70	14.72
16.	Top leaf weight (kg)	0.21	0.12	0.37	0.002	0.003	21.08	26.46	63.46	0.07	34.59
17.	Fibre %	13.24	10.3	16.35	1.81	2.02	10.16	10.73	89.68	2.62	19.81
18.	Reducing sugars %	1.68	0.57	2.79	0.41	0.47	37.87	40.79	86.15	1.22	72.41
19.	Leaf area index	3.41	1.68	5.28	0.55	0.63	21.78	23.3	87.41	1.43	41.95
20.	CCS yield (t ha ⁻¹)	15.82	10.49	22.32	6.92	11.57	16.62	21.49	59.85	4.19	26.50
21.	Cane yield (t ha ⁻¹)	136.86	84.32	176.26	331.41	725.12	13.30	19.67	45.70	25.32	18.52

(PCV) and genotypic coefficient of variance (GCV), heritability (h^2) in a broad sense and genetic advance as a per cent of mean were calculated as suggested by Burton (1952), Allard (1960) and Johnson *et al.* (1955). The data analysis was carried out with INDOSTAT software version 9.2.

RESULTS AND DISCUSSION

The results of analysis of variance (ANOVA) revealed significant differences among the genotypes for all the characters (table 1). The highest estimates of GCV and PCV were registered for top leaf weight, leaf area index, single cane weight, commercial cane sugar yield and reducing sugars per cent indicating greater variability. Moderate estimates of PCV and GCV were recorded for tillers at 120 DAP, number of nodes per cane, cane length, CCS yield, brix per cent and sucrose per cent at 10th month, fibre per cent and cane yield. Low estimates of GCV and PCV were recorded for the germination per cent at 30 DAP, cane diameter, number of millable canes and juice quality parameters like brix per cent, sucrose per cent, purity per cent, CCS per cent for 12th month and purity at 10th month. All the traits showed higher phenotypic coefficient of variation than genotypic coefficient of variation, indicating that environmental factors played a significant role in the inheritance of characters in sugarcane. These results are in accordance with the findings of Negi *et al.* (2017), Patil *et al.* (2023) and Navya *et al.* (2025) (table 2).

High heritability coupled with high genetic advance as per cent of mean was observed for tillers at 120 DAP, number of nodes per cane, sucrose per cent and CCS per cent at 10th month, top leaf weight, reducing sugars and leaf area index. This indicates that these characters are controlled by additive gene action. It was therefore suggested that preference should be given to the above characters in the selection programme to isolate superior lines for wholistic improvement in cane yield. A similar kind of gene action was reported by Gowda *et al.* (2016), Singh *et al.* (2020) and Navya *et al.* (2025). High heritability coupled with moderate genetic advance as per cent of mean was observed for number of millable canes, cane length, brix per cent at 10th and 12th month, sucrose per cent and CCS per cent at 12th month and fibre per cent which indicates that the traits were controlled by both additive and non-additive gene action and these traits may respond favourably to selection and genetic improvement can be achieved through heterosis

breeding. A similar kind of gene action was reported by Bora *et al.* (2014), Pandey *et al.* (2018) and Sailaja (2019). High heritability and low genetic advance was observed for germination per cent at 30 DAP, purity per cent at 10th and 12th month which indicates that the traits were controlled by non-additive gene action and selection for this trait is not effective. These results are in accordance with the findings of Ahmed *et al.* (2012) and Navya *et al.* (2025) (table 2).

The results of Analysis of variance (ANOVA) revealed significant difference in the mean sum of squares for all the characters under the study which indicates the presence of ample variability among all the clones. High heritability accompanied with high genetic advance as per cent of mean recorded for traits *viz.*, tillers at 120 DAP, number of nodes per cane, sucrose per cent and CCS per cent at 10th month, top leaf weight, reducing sugars and leaf area index indicating the prevalence of additive gene action hence crop improvement could be achieved by simple selection of these traits.

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PROFILE CHARACTERISTICS AND CONSTRAINTS FACED BY FARMERS USING ICT TOOLS

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ABSTRACT

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The present investigation was conducted in Anakapalle district of Andhra Pradesh to study attitude of farmers towards use of information and communication technology on agricultural production. Three mandals from Anakapalle district of Andhra Pradesh state selected for the study. An Ex-post-facto research design was followed for the study. The constraints faced by respondents while using the ICT tools and techniques were, lack of awareness of proper functioning about ICT tools (69.33%), lack of training of the farmers towards use of different ICT tools (68.00%), inadequate internet supply (67.33%), lack of uninterrupted power supply (66.00%), difficulty in understanding the content language of ICT gadgets (66.67%), lack of local language in handling and understanding of software (66.67%), poor mobile/internet connectivity in rural areas (66.00%) and beyond this some other constraints also faced by farmers.

KEYWORDS: Utilization of ICT tools, constraints.

INTRODUCTION

Information and Communication Technology (ICT) can revolutionize Indian farming sector and can benefit all farmers including small landholders. Over the years, digital agriculture in India has evolved from basic information and communication tools to more advanced and integrated systems. Today the focus is on real time monitoring, data driven planning, modern technologies, and strong decision support systems. ICT in agriculture provides farmers with vital information pertaining to sowing, crop protection, and improving soil fertility that enables them to improve agricultural productivity. Weather-related advisories and alerts help them prepare for sporadic events such as floods, drought, or even pest and disease outbreaks, thus preventing significant crop loss.

The increasing penetration of budget-friendly mobile phones and the internet is an added advantage for farmers living in remote areas in several emerging nations. Access to inexpensive mobile devices has now made it easier for them to acquire additional information and services that enable informed decision-making. ICT helps in growing demand for new approaches. It also helps in empowering the rural people by providing better access to natural resources, improved agricultural technologies, effective production strategies, markets, banking and financial services etc. to know the awareness of farmers on ICT and its impact on marketing and economic conditions in

agriculture. The study was conducted with an objective of assessing profile characteristics of the respondents and also elicited the constraints faced and suggestions rendered by the respondents in utilization of ICT tools. (Jamdhade S.S.2015.)

MATERIAL AND METHODS

Ex-post-facto" research approach was used for study. The present study was conducted in Anakapalle district of Andhra Pradesh state during 2022-2023. Three mandals from Anakapalle district and five villages from each mandal were selected randomly for the study. From each selected village, ten respondents were selected randomly, those having mobile phones with internet facilities and engaged in agricultural operations were selected, and a total of one hundred fifty respondents were considered for the present study. Data was gathered using a structured interview schedule designed for study. The collected data was analyzed, classified and tabulated. Statistical tools such as frequency, percentage and ranking were used to interpret findings and draw conclusions.

The findings indicate that respondents face multiple constraints in the use of ICT tools across socioeconomic, infrastructural, and technical dimensions. Among socioeconomic constraints, poor economic condition (67.33%) and difficulty in understanding content language (66.67%) emerged as the most critical issues, followed by lack of skills in using ICT tools (60.00%), high cost

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Table I. Profile of respondents**1. Age**

S. No.	Age group	F	%
1.	Young (Up to 28 years)	25	16.33
2.	Middle (29 to 49 years)	100	68.34
3.	Old (50 years and above)	25	16.33
Total		150	100.00

Majority of respondents (68.34%) belong to the middle age group (29–49 years). Young and old age groups are equally represented, each contributing 16.33% of the sample.

2. Education

S. No.	Category	F	%
1.	Illiterate	15	9.3
2.	Can read and write only	20	12.6
3.	Primary school level	23	16.0
4.	Middle school level	56	38.2
5.	High school level	34	22.6
6.	Graduate	2	1.3
7.	Other	0	0
Total		150	100.00

Majority of respondents have education up to middle school (24%) and high school (22%), indicating a moderate level of education. A smaller share includes primary level (16%), read and write only (12.67%), illiterate (9.33%), and very few graduates (16%), with none in the other category.

3. Occupation

S. No.	Occupation	F	%
1.	Farming	65	43.34
2.	Dairy Farming	20	13.33
3.	Goat Farming	10	6.67
4.	Business	25	16.66
5.	Service	20	13.33
6.	Other	10	6.67
Total		150	100.00

The majority of respondents are engaged in farming (43.34%), followed by service (13.33%) and business (16.66%). Smaller proportions are involved in dairy farming (13.33%), other activities (6.67%), and goat farming (6.67%), indicating agriculture as the main occupation.

4. Family Size

S. No.	Family size	F	%
1.	Small (up to 4 members)	40	26.67
2.	Medium (5 to 7 members)	50	33.33
3.	Large (above 7 members)	60	40.00
Total		150	100.00

The majority of respondents belong to large families (40.00%), followed by medium families (33.33%). A smaller proportion comes from small families (26.67%), indicating a prevalence of bigger family sizes.

5. Farming experience

S. No.	Farming experience	F	%
1.	Low (up to 8 years)	42	28.00
2.	Medium (9 to 30 years)	31	20.66
3.	High (above 30 years)	77	51.34
Total		150	100.00

Majority (51.34%) of respondents have high experience (above 30 years) followed by low experience (28%) and medium experience (20.66%) categories.

6. Utility of ICT in extension

S. No.	Utility of ICT	F	%
1.	Occasionally	19	12.00
2.	Once in a week	17	11.33
3.	Daily	115	76.67
Total		150	100.00

Most respondents use ICT daily (76.67%), indicating high utility in extension activities followed by occasionally (12%) and once a week (11.33%).

7. Methods of learning ICT skills

S. No.	Methods of learning ICT skills	F	%
1.	Low	72	48.00
2.	Medium	54	36.00
3.	High	25	16.00
Total		150	100.00

Most respondents have a low level of ICT learning skills (48.00%), followed by a medium level (36.00%). Only a small proportion (16.00%) have high ICT skills, indicating the need for improvement in ICT training.

8. Awareness about ICT

S. No.	Level of awareness	F	%
1.	Low (up to 6)	9	6.00
2.	Medium (7-10)	116	77.33
3.	High (Above 10)	25	16.67
Total		150	100.00

Majority of respondents fall under the medium category (77.33%). A smaller proportion are in the high category (16.67%), while only 6.00% are in the low category.

9. Level of Knowledge

S. No.	Level of knowledge	F	%
1.	Low (up to 4)	50	33.33
2.	Medium (5 to 7)	91	60.67
3.	High (7 & above)	9	6.00
Total		150	100.00

Majority of respondents have a medium level of knowledge (60.67%), followed by a low level (33.33%). Only a small proportion (6.00%) possess a high level of knowledge.

Table II. Attitude of farmers towards ICT tools

S. No.	Level of attitude	F	%
1.	Less favourable (up to 60)	22	14.67
2.	Moderately favourable (60-75)	111	74.00
3.	Highly favourable (above 75)	17	11.33
Total		150	100.00

Majority of respondents have a moderately favourable attitude towards ICT tools (74.00%), followed by a less favourable attitude (14.67%). Only a small proportion (11.33%) exhibit a highly favourable attitude, indicating scope for improving perceptions towards ICT.

Table 1. Analysis of Variance for cane yield, yield attributing and quality characters in Sugarcane (*Saccharum spp.*)

S. No.	Characters	Mean sum of squares		
		Replications (df: 1)	Treatments (df: 50)	Error (df: 50)
1.	Germination % at 30 DAP	24.80	29.504**	6.817
2.	Tillers at 120 DAP ('000/ha)	184.55	404.4**	49.83
3.	Number of millable canes ('000/ha)	0.001	121.37**	19.6
4.	Number of nodes per cane	0.48	34.77**	6.447
5.	Cane length (cm)	518.63	2704.16**	348.63
6.	Cane diameter (cm)	0.113	0.127*	0.067
7.	Single cane weight (kg)	0.04	0.19**	0.05
8.	Brix % at 10 th month	0.0519	5.474**	0.366
9.	Sucrose % at 10 th month	0.022	4.67**	0.329
10.	Purity % at 10 th month	0.106	1.376**	0.303
11.	CCS % at 10 th month	0.006	2.363**	0.168
12.	Brix % at 12 th month	0.094	4.152**	0.472
13.	Sucrose % at 12 th month	0.176	3.8**	0.436
14.	Purity % at 12 th month	0.96	1.365**	0.266
15.	CCS % at 12 th month	0.139	1.968**	0.232
16.	Top leaf weight (kg)	0.001	0.005**	0.001
17.	Fibre %	0.047	3.826**	0.208
18.	Reducing sugars %	0.067	0.879**	0.065
19.	Leaf area index	0.281	1.182**	0.079
20.	CCS yield (t ha ⁻¹)	2.101	18.498**	4.646
21.	Cane yield (t ha ⁻¹)	284.90	1056.53**	393.714

of devices (58.67%), and lack of belief in e-sources (57.33%). With respect to infrastructural constraints, lack of awareness about proper functioning of ICT tools (69.33%) ranked highest, followed by inadequate internet supply (67.33%), poor connectivity and power supply (66.00%), and insufficient maintenance facilities (62.67%). In terms of technical constraints, lack of training (68.00%) and absence of local language support (66.67%) were the major challenges, along with issues such as misleading information (66.00%), communication gaps (65.33%), and untrained operators (64.00%). Overall, these findings highlight the need for improving economic access, strengthening infrastructure, and enhancing technical training to promote effective utilization of ICT tools (Syiem R, Raj S. 2015).

The study concludes that farmers in the study area have a moderate level of awareness (77.33%), knowledge (60.67%), and attitude (74.00%) towards ICT tools, with a majority using ICTs daily (76.67%) for agricultural activities. However, the overall level of ICT learning skills remains low (48.00%), indicating that although farmers are exposed to ICTs, their capacity to effectively utilize these tools is still limited. The major constraints identified include poor economic conditions, lack of awareness and training, inadequate internet and power supply, and absence of local language support, which hinder optimal utilization of ICT tools.

Based on these findings, it is evident that there is a need to strengthen capacity-building programmes through regular training, demonstrations, and extension support to enhance farmers' ICT skills. Efforts should be made to improve rural infrastructure, including reliable internet connectivity and power supply, along with promoting affordable ICT tools. Additionally, developing user-friendly and local language-based digital content, and increasing awareness about the proper use of ICT tools, can significantly improve adoption and effective utilization, thereby contributing to enhanced agricultural productivity and rural development.

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WAREHOUSE RECEIPT FINANCE IN RED CHILLI FARMING: IMPACT ASSESSMENT AND ADOPTION CHALLENGES

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ABSTRACT

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This study assessed the economic impact of Warehouse Receipt Finance (WHRF) on red chilli farmers in the Guntur district of Andhra Pradesh and identified the key constraints hindering its adoption. A purposive cum random sampling method was employed to select 144 farmers and were categorized into non-users, cold storage users and WHRF users. Primary data was collected for the agricultural year 2024–25, covering aspects such as cultivation costs, yield, storage expenses, credit access and net returns. The findings revealed that WHRF users achieved significantly higher average selling prices (₹11,857.41/quintal) and net returns (₹3,025.93/quintal) compared to non-users and cold storage users. The Benefit-Cost Ratio was also highest among WHRF users (1.34), indicating superior profitability. Constraints affecting WHRF adoption were analysed using the Garrett Ranking Technique. The most critical issues identified were insufficient quantum of finance, high interest rates from informal lenders and high warehouse storage costs. Procedural delays, inadequate storage infrastructure and lack of institutional support also emerged as notable barriers. The study concluded that while WHRF offered substantial economic benefits, its wider adoption depends on improved financial, institutional and infrastructural support for smallholder farmers.

KEYWORDS: Benefit-cost ratio, profitability, institutional support, red chilli and warehouse receipt finance.

INTRODUCTION

Agriculture remains a foundational pillar of the Indian economy, contributing 16 per cent to GDP and supporting nearly 46 per cent of the population (Economic Survey, 2024–25). However, it is dominated by small and marginal farmers who often struggle with limited resources, post-harvest losses and volatile markets. Red chilli plays a vital role in India, as it is the world's largest producer, contributing over 36 per cent to global output (Agmarknet, 2023). Andhra Pradesh leads in national production, with the Krishna-Guntur region being a key chilli-growing belt (Chilli Outlook Report, ANGRAU, 2023–24).

Red chilli cultivation is majorly done in *kharif* season, with peak harvests from December to March. This results in heavy market arrivals during a short period, causing price crashes and forcing farmers particularly those lacking access to storage and credit to sell at lower prices leading to distress sales. Price volatility, coupled with weak bargaining power and poor market access, significantly reduces farm incomes and discourages long-term sustainability in chilli farming.

A well-developed Warehouse Receipt System (WRS) is expected to provide the growers with adequate storage

conditions and liquidity allowing them to wait for higher prices rather than selling their produce at unfavourable terms right after the harvest (Shwartz, 2024). WRS can significantly enhance agricultural financing by serving as reliable and credible collateral for securing agricultural credit (Mahanta, 2012). Warehouse Receipt Finance (WHRF) has emerged as a viable institutional intervention to address these challenges. By allowing farmers to store their produce in accredited warehouses and use receipts as collateral for credit, WHRF enables them to delay sales until market conditions improve. Recognized by banks and commodity exchanges, negotiable warehouse receipts (NWRs), also called transferable warehouse receipts help to improve liquidity, reduce market risks and enhance price realization. In volatile crop markets like red chilli, WHRF holds the potential to stabilize farmer incomes (Chitra, 2014).

Despite its advantages, WHRF adoption remains limited due to structural and institutional barriers such as poor rural warehousing infrastructure, low awareness, regulatory gaps and distrust in the system. Many smallholders continue to rely on informal credit and face exploitation due to urgent post-harvest sales (Varangis and Larson, 1996). Strengthening the Warehouse Receipt System (WRS), expanding storage capacity and

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promoting trust and accessibility can enhance financial inclusion and post-harvest resilience. This article evaluated the impact of WHRF on red chilli farmers and explored the challenges and opportunities for its wider adoption in erstwhile Guntur District of Andhra Pradesh.

METHODOLOGY

The study was undertaken in the erstwhile Guntur District of Andhra Pradesh, a prominent red chilli-growing region. Purposive cum random sampling method was employed to select four major red chilli-producing mandals *viz.*, Gurazala, Dachepalle, Macherla and Medikonduru based on chilli cultivation area. From each mandal, three villages were purposively selected with high red chilli cultivation and 12 red chilli farmers were randomly chosen from each village, resulting in a total sample of 144 respondents. Primary data were collected for the agricultural year 2024–25 using a structured and pre-tested interview schedule.

The respondents were categorized into three groups: WHRF users, cold storage users and immediate sellers (non-users). Data related to socio-economic characteristics, yield, cost of cultivation, storage and finance costs, price realization, credit access and constraints related to WHRF adoption were collected. Descriptive statistics and comparative analysis were used to assess the economic impact of WHRF. To identify key constraints to avail WHRF adoption, Garrett Ranking Technique was employed, wherein farmers ranked major issues, which were then converted into scores to determine their severity. This approach enabled a comprehensive understanding of WHRF's economic implications and adoption challenges in the region.

RESULTS AND DISCUSSION

ECONOMIC IMPACT ASSESSMENT OF RED CHILLI FARMERS TOWARDS AVAILING WAREHOUSE RECEIPT FINANCE

This section aims to assess the economic impact on red chilli farmers through availing warehouse receipt finance (WHRF) in the study area. The information regarding key economic indicators such as cost of cultivation (₹ per acre), yield levels (quintal/acre), marketing expenses (₹ per bag), warehouse storage charges (₹ per bag), interest charges, selling price (₹), *etc.* were collected from sample respondents. By comparing these parameters across three categories of farmers

(immediate sellers, cold storage users and WHRF users) the financial advantages associated with availing WHRF can be studied. The details of the same were presented in Table 1.

The comparative analysis of economic parameters across three farmer categories *viz.*, immediate sellers, cold storage users without WHRF and WHRF users indicated that WHRF offered significant economic benefits. WHRF users recorded the highest average cost of cultivation at ₹1,61,520.23 per acre, compared to ₹1,51,106.87 for cold storage users and ₹1,48,939.61 for immediate sellers. Despite higher cultivation costs, WHRF users achieved better productivity (26.10 quintals/acre), slightly above that of cold storage users (25.90) and notably higher than immediate sellers (22.60).

Marketing and post-harvest expenses further distinguished the three groups. Immediate sellers incurred the highest marketing costs at ₹1,037.97 per quintal, reflecting urgent sales and lower bargaining power. WHRF users, by contrast, managed more efficient marketing at ₹892.56 per quintal, aided by access to structured financing and storage. Although WHRF users faced slightly higher storage costs (₹482.56 per quintal) than cold storage users (₹451.78), their access to formal credit reduced financial costs (₹1,267.84 per quintal) compared to the heavy burden of informal loans for cold storage users (₹1,395.20).

The financial outcomes were striking. WHRF users realized the highest average selling price of ₹11,857.41 per quintal, followed by ₹10,561.82 for cold storage users and ₹9,669.52 for non-users. As a result, WHRF users achieved the highest net return of ₹3,025.93 per quintal, significantly above the returns for cold storage users (₹2,108.44) and non-users (₹2,041.30). This improvement was further reinforced by a higher Benefit-Cost (B:C) ratio of 1.34 for WHRF users, compared to 1.24 and 1.20 for cold storage users and immediate sellers respectively. These outcomes underline the potential of WHRF in enhancing income security by reducing the need for distress sales and enabling better price realization through strategic market timing.

CONSTRAINTS OF SAMPLE RED CHILLI FARMERS IN WAREHOUSE RECEIPT FINANCE ADOPTION

To understand the constraints of red chilli farmers for the adoption of warehouse receipt finance Garrett

ranking was employed. Nine constraints were identified that include higher interest rate by informal sources, delayed loan processing, insufficient quantum of finance, inadequate storage facilities, lack of logistic facilities, higher warehouse storage cost, lack of support from lending institutions, awareness for warehouse receipt finance and fear of produce damage. And the sample respondents were asked to rank the challenges. The details were presented in the Table 2.

The outcome of garret ranking is shown in Table 2. It can be seen that the most severe constraint identified was insufficient quantum of finance, which secured the highest mean score of 63.99 and was ranked I. This indicates that the loan amount sanctioned under warehouse receipt finance schemes does not adequately meet the working capital requirements of farmers. As a result, farmers are unable to fully benefit from the scheme, particularly during post-harvest periods when liquidity needs are high. The second major constraint was higher interest rate charged by informal sources, with a mean score of 62.61 and was ranked II. This suggests that despite the availability of warehouse receipt finance, farmers continue to rely on informal credit sources due to accessibility and flexibility, even though such sources charge higher interest rates. This dependency increases their cost of borrowing and reduces net returns.

Higher warehouse storage cost was ranked III with a mean score of 57.09, indicating that the expenses associated with storage, including rent and maintenance charges, discourage farmers from storing produce for price realization. High storage costs reduce the economic advantage of postponing sales. The constraint delayed loan processing and documentation obtained a mean score of 53.09 and was ranked IV. This reflects procedural complexities, lengthy documentation requirements and administrative delays that prevent farmers from accessing timely credit, especially during urgent financial needs.

Inadequate storage facilities secured Rank V with a mean score of 50.49, highlighting infrastructural gaps such as insufficient warehouse capacity, poor quality storage infrastructure and limited accessibility in rural areas. Then, Lack of support from lending institutions was ranked V with a mean score of 47.97, indicating insufficient guidance, follow-up services and institutional encouragement for farmers to adopt WHRF.

Further, lack of logistic facilities was placed in Rank VII with a mean score of 35.03, suggesting transportation difficulties and handling constraints that add to operational challenges. And fear of produce damage ranked VIII with a mean score of 34.09, reflecting farmers' concerns about quality deterioration, pest infestation or spoilage during storage.

Finally, awareness about warehouse receipt finance was ranked IX with the lowest mean score of 31.77, implying that awareness exists to some extent among respondents and is relatively less severe compared to financial and infrastructural constraints. Thus, the Garrett ranking analysis clearly highlighted that, issues related to inadequate loan amounts, high interest rates and procedural delays significantly limited farmers' access to timely and affordable credit. Additionally, infrastructural and logistical shortcomings, coupled with limited awareness and institutional support, further constrained the adoption of WHRF. Addressing these challenges through policy interventions, would improve financial outreach and enhanced infrastructure is essential to strengthen farmers' participation in warehouse-based financing systems.

The study aligned with the results of Jairath *et al.* (2016) who in their study also identified that high interest rate, insufficient quantum of finance and delayed loan processing and documentation were constraints faced by red chilli growers.

The study evaluated the economic impact of WHRF and identified barriers to its adoption among red chilli farmers in Guntur District. The analysis revealed that WHRF users realized a significantly higher average price of ₹13,297 per quintal, compared to ₹12,365 for cold storage users and ₹10,479 for immediate sellers (non-users). Net returns per acre were also notably higher for WHRF users at ₹1,77,299, followed by ₹1,43,830 for cold storage users and ₹1,00,452 for non-users. Furthermore, the benefit-cost ratio was most favourable for WHRF users at 1.34, compared to 1.24 and 1.20 for the other groups respectively. These differences highlight the profitability and risk-mitigating potential of WHRF. The Garrett ranking analysis revealed that insufficient quantum of finance was the most critical constraint faced by red chilli farmers in adopting warehouse receipt finance (WHRF), with the highest mean score of 63.99. This indicates that the sanctioned loan amounts were often inadequate to meet actual financial requirements.

Table 1. Economic parameters for assessment of red chilli farmers towards availing warehouse receipt finance

Particulars (₹)	Immediate seller (non-user)	Cold storage user	WHRF user
Average cost of cultivation (₹ per acre)	1,48,939.61	1,51,106.87	1,61,520.23
Average yield (Quintals per acre)	22.60	25.90	26.10
Production cost (₹ per acre)	6590.24	5834.25	6188.51
Marketing costs (₹ per quintal)	1037.97	772.15	892.56
Total cost (₹ per quintal)	7628.21		
Average selling price (₹ per quintal)	9,669.52		
Average Net returns (₹ per quintal)	2041.30		
Storage costs (₹ per quintal)		451.78	482.56
Financial cost (₹ per quintal)		1,395.20	1,267.84
Total cost (₹ per quintal)		8453.37	8831.47
Average selling price (₹ per quintal)		10,561.82	11,857.41
Average Net returns (₹ per quintal)	2041.31	2108.44	3025.93
Benefit Cost Ratio	1.20	1.24	1.34

Table 2. Constraints faced by the farmers for adoption of warehouse receipt finance

S. No.	Constraints	Total score	Mean score	Rank
1.	Higher interest rate by informal sources	9017	62.61	2
2.	Delayed loan processing and documentation	7645	53.09	4
3.	Insufficient quantum of finance	9215	63.99	1
4.	Inadequate storage facilities	7271	50.49	5
5.	Lack of logistic facilities	5045	35.03	7
6.	Higher warehouse storage cost	8221	57.09	3
7.	Lack of support from lending institutions	6908	47.97	6
8.	Awareness for warehouse receipt finance	4576	31.77	9
9.	Fear of produce damage	4910	34.09	8

It was followed by the high interest rates from informal sources (62.61) and high warehouse storage costs (57.09), both of which discouraged farmers from using WHRF. Delayed loan processing and documentation ranked fourth (53.09), pointing to procedural delays. Inadequate storage facilities (50.49) and lack of support from lending institutions (47.97) reflected infrastructural and institutional gaps. Logistic challenges (35.03), fear of produce damage (34.09) and limited awareness about WHRF (31.77) were ranked lower, suggesting these were less critical but still notable concerns.

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ASSESSMENT OF YIELD AND QUALITY PARAMETERS IN ORGANIC SESAME (*Sesamum indicum* L.)

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ABSTRACT

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A field experiment was conducted during summer, 2025 on sandy loam soils of dryland farm of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University. The results of the experiment revealed that 100 per cent RDN through neem cake along with foliar spray of seaweed extract @ 2 per cent recorded significantly higher seed and stalk yield. Quality parameters like protein and oil content were also high in 100 per cent RDN through neem cake and seaweed extract @ 2 per cent.

KEYWORDS: Organic sesame, protein content, oil content, seed yield, stalk yield.

INTRODUCTION

India stands as the world's leading producer of oilseeds, contributing approximately 10 per cent of global production and utilizing 20.8 per cent of the world's cultivable land for this purpose. The country cultivates a wide range of oilseed crops, including groundnut, soybean, sunflower, sesame, mustard, and safflower. Despite this diversity, oilseed productivity remains relatively low due to the dominance of small-scale, rainfed agriculture, which accounts for about 72 per cent of the total oilseed-growing area.

Sesame (*Sesamum indicum* L.), commonly known as til, is one of the oldest cultivated oilseed crops and is highly valued for its superior oil quality, earning it the title "Queen of Oilseeds." This multipurpose crop offers significant nutritional and medicinal benefits. Sesame seeds contain 46–52 per cent oil, 20–26 per cent protein, 14–16 per cent sugar, and 5–7 per cent minerals.

Organic sesame oil is rich in natural antioxidants like sesamin, sesamol, and sesamolin, which contribute to its stability and long shelf life. The oil is widely recognized for its stress-relieving, anti-inflammatory, and antioxidant properties. It helps in managing fatigue, calming the nervous system, easing muscle spasms and promoting overall strength and vitality. These qualities make it a preferred choice in traditional therapies such as Ayurveda.

Organic sesame holds immense promise for India's sustainable agriculture and health-conscious consumer base. With its adaptability, health benefits

and export potential, it serves as a powerful crop for improving farmer income and promoting environmental sustainability. Continued focus on organic research, farmer trainings and market development will be the key aspect to realize the full potential of organic sesame in India.

MATERIAL AND METHODS

The field experiment was conducted during summer, 2025 at dryland farm of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The soil of the experimental site was sandy loam having 0.40 per cent organic carbon, 203 kg ha⁻¹, 26 kg ha⁻¹ and 245 kg ha⁻¹ of available N, P₂O₅ and K₂O respectively. A total rainfall received during the crop period was 2 mm in zero rainy days. The experiment was laid out in a factorial randomized block design with two factors, factor I comprised of 100 per cent RDN through FYM (S₁), 100 per cent RDN through neem cake (S₂) and 100 per cent RDN through pongamia cake (S₃). Factor II consisted of seaweed extract @ 2 per cent, panchagavya @ 3 per cent, water spray and fish amino acid @ 1 per cent. Sesame seeds were sown in lines, 30 cm apart with plant to plant spacing of 15 cm and adopting all the standard package of practices. The recommended 40 kg N ha⁻¹ was applied through organic manures by calculating nitrogen content in respective manures. And these manures were applied one week prior to sowing and foliar spraying was done twice at 30 and 45 DAS. The treatment wise seed and stalk yield of sesame were harvested from each net plot. The quality parameters, oil content of the seed was estimated by using

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Table 1. Seed, stalk yield (kg ha⁻¹) and quality parameters of sesame as influenced by organic manures and organic foliar sprays

Treatments	Seed yield	Stalk yield	Oil content	Protein content
Soil application of organic manures				
S ₁ : 100 % RDN through FYM	399	724	49.0	20.9
S ₂ : 100 % RDN through neem cake	798	1453	51.2	21.2
S ₃ : 100 % RDN through pongamia cake	555	1019	50.5	21.1
SEm _±	14.5	34.7	0.62	0.11
CD (P = 0.05)	43	103	NS	NS
Organic foliar sprays at 30 and 45 DAS				
F ₁ : Sea weed extract @ 2 %	764	1339	51.1	21.3
F ₂ : Panchagavya @ 3 %	554	1019	50.2	21.0
F ₃ : Water spray	426	801	49.3	20.8
F ₄ : Fish amino acid @ 1 %	593	1091	50.4	21.1
SEm _±	16.8	40.1	0.72	0.13
CD (P = 0.05)	50	118	NS	NS
Interaction				
S × F				
SEm _±	29.1	69.5	1.25	0.22
CD (P = 0.05)	86	205	NS	NS

Nuclear Magnetic Resonance (NMR) Spectrophotometer as per the procedure laid down by Tiwari *et al.* (1974) and expressed in per cent (%) and for protein content the nitrogen content of the seeds was estimated and it was multiplied by the factor 6.25 and the resultant protein content was expressed in per cent.

RESULTS AND DISCUSSION

Seed and stalk yields were significantly affected by different organic manures and foliar sprays (Table 1). Significantly higher seed and stalk yield were recorded with 100 per cent RDN through neem cake. Lower seed

and stalk yields were recorded with 100 per cent RDN through FYM. Among organic foliar sprays seaweed extract @ 2 per cent recorded higher seed and stalk yields followed by foliar application of FAA @ 1 per cent which was found non-significant with foliar spray of panchagavya @ 3 per cent and lowest was recorded in water spray at 30 and 45 DAS. Interaction between organic manures and organic foliar sprays was found significant. Combination of 100 per cent RDN through neem cake along with foliar spray of seaweed extract @ 2 per cent (S₂F₁) recorded significantly higher seed and stalk yield compared to other combinations.

Table 2. Seed yield (kg ha⁻¹) of sesamum as influenced by interaction between organic manures and organic foliar sprays

Treatments	F ₁	F ₂	F ₃	F ₄	Mean
S ₁ : 100% RDN through FYM	542	361	258	436	399
S ₂ : 100% RDN through neem cake	940	811	610	829	798
S ₃ : 100% RDN through pongamia cake	808	489	409	513	555
Mean	764	554	426	593	
SEm ±			29.1		
CD (P = 0.05)			86		

Table 3. Stalk yield (kg ha⁻¹) of sesamum as influenced by interaction between organic manures and organic foliar sprays

Treatments	F ₁	F ₂	F ₃	F ₄	Mean
S ₁ : 100% RDN through FYM	844	707	590	755	724
S ₂ : 100% RDN through neem cake	1841	1419	1040	1511	1453
S ₃ : 100% RDN through pongamia cake	1362	932	772	1008	1019
Mean	1349	1019	801	1091	
SEm ±			69.5		
CD (P = 0.05)			205		

The highest seed yield recorded with application of neem cake (S₂) might be due to higher concentration of macro and micronutrients in conjunction with steady nutrient release throughout the crop period. It also has efficient source of NPK along with beneficial micronutrients which enhance the plant activity and resulted in better plant stand, more dry matter and more grain filling ultimately resulted in more seed yield. Similar results were also reported by Lalnunpuia *et al.* (2018), Ahirwar *et al.* (2017), Kumar *et al.* (2017), Vasundhara *et al.* (2012), Duhoon *et al.* (2004). (Table 2 and 3)

Protein and oil content were found non-significant with soil application of organic manures and organic foliar sprays and the interaction affect also found to be non significant between them. However higher oil content was recorded in soil application of 100 per cent RDN through neem cake and lowest was recorded in 100 per cent RDN through FYM. Among the organic foliar spray's, seaweed extract recorded higher oil and protein content and lower was recorded in water spray.

Hence, from the present study it can be concluded that higher seed yield in summer sesame can be realized

with the soil application of 100 per cent RDN *i.e.* 40 kg N ha⁻¹ through neem cake along with foliar spray of seaweed extracts @ 2 per cent twice at 30 and 45 DAS in Southern Agro-climatic Zone of Andhra Pradesh.

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INFLUENCE OF MOISTURE LEVELS, GENOTYPES AND GROWTH REGULATING CHEMICALS ON MORPHOPHYSIOLOGICAL PARAMETERS OF GROUNDNUT (*Arachis hypogea* L.)

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ABSTRACT

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An experiment was conducted at S.V. Agricultural College, Tirupati, to evaluate the effect of moisture levels, genotypes and growth regulating chemicals on the morphophysiological parameters of groundnut (*Arachis hypogea* L.). The study revealed significant variations among moisture treatments for plant height, leaf area, total dry matter and crop growth rate (CGR). The treatment with 50 per cent above field capacity (M_3) recorded the highest values for most of the parameters, followed by field capacity (M_2), whereas the control treatment (need-based irrigation) showed comparatively lower values. However, SCMR values were not significantly influenced by moisture levels. Groundnut genotypes also differed significantly in their morphophysiological performance. Genotype (K_6) recorded higher plant height and total dry matter, genotype K_9 exhibited superior leaf area, SCMR and CGR values. Application of growth regulating chemicals at 40 and 30 days before harvest significantly influenced the growth parameters of groundnut. Among the chemicals tested, maleic hydrazide at 2000 ppm markedly reduced plant height, leaf area, total dry matter and CGR, followed by CCC at 2000ppm. The highest values for these traits were observed in the untreated control. SCMR values, however, did not show significant variation due to chemical treatments. A significant interaction effect between moisture levels and genotypes (MxG) was observed for leaf area at harvest.

KEYWORDS: Seed dormancy, field capacity, moisture level, groundnut, growth regulating chemicals.

INTRODUCTION

Groundnut (*Arachis hypogea* L.) is one of the most important oilseed crops cultivated widely in tropical and subtropical regions of the world. It plays a significant role in the agricultural economy due to its high oil and protein content and its adaptability to diverse agro-climatic conditions. In India, groundnut is cultivated extensively under rainfed as well as irrigated conditions and contributes substantially to edible oil production. However, productivity of groundnut is often affected by several environmental and physiological constraints, among which soil moisture stress and pre harvest sprouting are major concerns.

Spanish bunch type groundnut cultivars generally lack fresh seed dormancy, which results in rapid germination of seeds immediately after physiological maturity when rainfall coincides with harvest. Increased soil moisture during crop maturity leads to field sprouting, deterioration of seed quality, reduction of seed viability and poor market value. Such conditions adversely affect the post-harvest quality and storage life of seeds. Therefore, development of strategies to induce temporary seed dormancy without affecting yield and quality is highly essential. Moisture availability

is one of the most critical factors influencing plant growth and development. Soil moisture regulates several physiological and biochemical processes such as photosynthesis, nutrient uptake, translocation of assimilates, cell expansion and enzyme activity. Both excess and deficit moisture conditions can significantly alter morphophysiological characteristics including plant height, leaf area, chlorophyll content, dry matter accumulation and crop growth rate. Adequate moisture availability generally promotes vegetative growth and biomass production, whereas moisture stress restricts growth by reducing cell turgor, stomatal conductance and photosynthetic efficiency.

Apart from moisture management, genetic variability among groundnut genotypes also plays an important role in determining crop performance under varying environmental conditions. Different genotypes exhibit variations in growth pattern, physiological efficiency, dry matter partitioning and tolerance to moisture stress. Identification of suitable genotypes with superior morphophysiological traits is therefore important for improving productivity and adaptability of groundnut under different moisture regimes.

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Application of plant growth regulating chemicals has emerged as an effective approach to manipulate plant growth and induce seed dormancy. Growth retardants such as maleic hydrazide (MH), cycocel or chlormequat chloride (CCC) are known to suppress excessive vegetative growth, modify physiological activities and enhance assimilate partitioning. Maleic hydrazide acts by inhibiting cell division and elongation, while CCC reduces gibberellins biosynthesis, thereby controlling plant height and growth rate. These chemicals have also been reported to induce fresh seed dormancy and reduce pre-harvest sprouting in several crops. However, their influence on morphophysiological parameters and yield characteristics of groundnut under different moisture conditions requires further investigation.

Considering the importance of moisture management, genotype selection and growth regulating chemicals in improving groundnut productivity and seed quality, the present study was undertaken to evaluate the influence of different moisture levels. Genotypes and growth regulating chemicals on morphophysiological parameters of groundnut. The study aimed to understand their individual as well as interactive effects on plant growth, physiological efficiency and yield performance under varying soil moisture conditions.

MATERIAL AND METHODS

The experiment was laid out in a split-split design with 3 replications. Effect of three factors *viz.*, moisture levels, genotypes and growth regulating chemicals were studied on morphophysiological parameters of groundnut in *rabi* season of 2019/2020. Wherein main plot treatments comprised of moisture levels (M₁: need based irrigation, M₂: soil moisture content at field capacity and M₃: soil moisture content at 50 per cent above field capacity) measured using TDR 350 starting at 20 DBH, sub plot treatments (G₁: K₆, G₂: K₉ and G₃: TAG-24) and sub-sub plot treatments (C₁: Control, C₂: Maleic hydrazide @ 2000 ppm at 40 and 30 DBH and C₃: CCC @ 2000 ppm at 40 and 30 DBH).

Application of Chemicals

Pre harvest chemical treatment sprays were applied at 40 and 30 days before harvest. The chemicals sprayed were growth retardants Maleic Hydrazide and CCC both applied at 2000 ppm. In order to prepare 2000 ppm of Maleic hydrazide 8g of MH was diluted in NaOH to aid in dissolving the chemical. It was then added to 4L of

water. To achieve 2000 ppm of CCC solution 8g of CCC was dissolved in 4L water.

Plant height (cm)

The height in cms of the five randomly selected and tagged plants in each plot was measured at 30, 60, 90 DAS and also at harvest. The plant height was measured from the base of the plant to the growing point of the plant.

Leaf area (cm² plant⁻¹)

Leaf area was worked out for the three plants selected for destructive analysis at different stages of sampling *i.e.* at 30, 60, 90 DAS and at harvest. It was measured by using Leaf Area Meter (Li-COR model LI 3000) and the average was expressed as leaf area plant⁻¹ in cm².

Dry matter accumulation and partitioning (g plant⁻¹)

The total dry matter accumulation and its partitioning was estimated from the three randomly selected plants sampled from each treatment in three replications. They were then separated into roots, shoots and pods. The plant parts were dried to a constant weight in hot air oven at 80°C for two days and the dry weights were recorded and expressed in g plant⁻¹. The following growth characteristics were computed using the data recorded on leaf area and dry matter.

Crop growth rate (g m⁻² day⁻¹)

The CGR is the rate of dry matter production per unit ground area per unit time. It is used for the estimation of production efficiency of crop. The CGR was calculated adopting the formula as suggested by Watson *et al.* (1952).

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{P}$$

Where,

W₁ = Dry weight (g) of the plants at time T₁

W₂ = Dry weight (g) of plants at time T₂

P = Unit land area occupied by the plant (m²)

Total chlorophyll content in terms of SCMR

Chlorophyll content was measured with SPAD Chlorophyll Meter Readings (SCMR) following the method of Turner and Jund (1991) at 30 days interval up

Table 1. Effect of moisture levels, genotypes and growth regulating chemicals on plant height (cm) of groundnut

Moisture Levels	30 DAS	60 DAS	90 DAS	Harvest
M ₁ : Need based irrigation	9.6	19.0	22.1	23.5
M ₂ : Soil moisture content at field capacity	9.7	20.4	24.1	26.1
M ₃ : soil moisture content at 50% above field capacity	9.5	19.2	24.6	27.2
CD	NS	NS	1.40	1.73
SEm±	0.15	0.56	0.36	0.44
Genotypes				
G ₁ : K6	11.9	25.0	26.5	28.3
G ₂ : K9	9.9	19.9	24.8	27.3
G ₃ : TAG-24	7.0	13.7	19.4	21.2
CD	0.73	1.51	1.57	1.34
SEm±	0.23	0.49	0.51	0.43
Chemicals				
C ₁ : Control	9.6	20.0	25.0	27.2
C ₂ : Maleic hydrazide @ 2000 ppm at 40 and 30 DBH	9.7	19.1	22.7	24.2
C ₃ : CCC @ 2000 ppm at 40 and 30 DBH	9.5	19.5	23.6	25.4
CD	NS	NS	1.71	1.26
SEm±	0.19	0.31	0.59	0.44
MXG				
CD	NS	NS	NS	NS
SEm±	0.41	0.85	0.88	0.75
MXC				
CD	NS	NS	NS	NS
SEm±	0.32	0.54	1.03	0.76
GXC				
CD	NS	NS	NS	NS
SEm±	0.32	0.54	1.03	0.76
MXGXC				
CD	NS	NS	NS	NS
SEm±	0.57	0.94	1.79	1.3

Table 2. Effect of moisture levels, genotypes and growth regulating chemicals on leaf area (cm² plant⁻¹) of groundnut

Moisture Levels	30 DAS	60 DAS	90 DAS	Harvest
M ₁ : Need based irrigation	447.9	811.5	938.3	1,016.9
M ₂ : Soil moisture content at field capacity	434.0	775.8	946.9	1,090.4
M ₃ : Soil moisture content at 50% above field capacity	454.3	799.0	977.9	1,120.1
CD	NS	NS	26.9	47.14
SEm±	5.99	32.34	6.89	12.07
Genotypes				
G ₁ : K6	548.1	1,110.7	1,107.2	1,222.6
G ₂ : K9	358.1	720.4	1076.3	1305.9
G ₃ : TAG-24	430.0	555.2	679.5	699.04
CD	16.18	58.92	17.18	33.01
SEm±	5.25	19.13	5.58	10.72
Chemicals				
C ₁ : Control	437.7	791.4	1106.3	1185.4
C ₂ : Maleic hydrazide @ 2000 ppm at 40 and 30 DBH	456.1	783.2	835.0	984.1
C ₃ : CCC @ 2000 ppm at 40 and 30 DBH	442.4	811.7	921.7	1058.0
CD	NS	NS	30.56	24.75
SEm±	7.12	17.20	10.65	8.63
MXG				
CD	NS	NS	29.76	NS
SEm±	9.10	33.13	9.66	18.56
MXC				
CD	NS	NS	NS	NS
SEm±	12.33	29.80	18.45	14.94
GXC				
CD	NS	NS	NS	NS
SEm±	12.33	29.80	18.45	14.94
MXGXC				
CD	NS	NS	NS	NS
SEm±	21.36	51.61	31.95	25.88

to 90 DAS and also at harvest. SCMR data were recorded on matured exposed leaf from top of each representative plant, between 8.00 a.m. and 9.00 a.m. of the day.

RESULTS AND DISCUSSION

Plant Height (cm)

A significant difference was observed in plant height with respect to moisture levels, genotypes and growth regulating chemicals.

With respect to moisture levels, plant height did not differ significantly at 30 and 60 DAS as the imposition of the moisture treatments was given from twenty days before harvest only.

Plant height differed significantly at 90 DAS and at harvest. M₃ (50% above field capacity) recorded significantly higher plant height (24.6 cm) which was at par with M₂ (field capacity) (24.1 cm). The least plant height was observed in M₁ (need based irrigation) (22.1 cm) at 90 DAS.

A similar trend was observed at harvest. This increase could be due to the positive influence of water on turgor related growth processes. Ross (2007) reported that high moisture was directly proportional to plant height in groundnut.

A significant difference in plant height was observed among the genotypes at all the growth stages.

At 30 DAS K₆ recorded significantly higher plant height (11.9 cm) followed by K₉ (9.9 cm) and TAG-24 (7.03 cm). Almost a similar trend was observed at all growth stages. This could be due to the difference in crop phenology. Plant height is influenced by the interaction of environmental conditions and genetic constitution of the plant.

Patra *et al.* (1981) also reported that genotypes ICGV-8614, ICGS-44, JL-24 and TG-24 recorded higher plant height and dry matter accumulation due to the difference in phenologies and pattern of assimilate partitioning between vegetative and reproductive components.

As the treatments were imposed at 40 and 30 days before harvesting, plant height differences among the treatments were not observed at 30 and 60 DAS. However, plant height differed significantly at 90 DAS and at harvest with respect to growth regulating chemicals.

C2 (MH @ 2000 ppm) significantly reduced the plant height (22.7 cm) followed by C3 (CCC @ 2000 ppm) (23.6 cm) and control (25.0).

MH is involved in reduction of cell division, whereas CCC retards stem extension without any physiological aberration. Similar results of reduction in plant height with MH and CCC were also reported by Mukund (2004) in groundnut with MH treatments and Jare (1994). Wherein, application of CCC at 2000 ppm reduced the plant height of the groundnut variety ICGS-44. This was attributed to the slowdown of cell division and reduced cell elongation.

There was no interaction observed

Leaf Area

The results revealed a significant difference in leaf area with respect to moisture levels, genotypes and growth regulating chemicals.

In this study the moisture treatment was imposed 20 days before harvesting. Hence there was no significant difference on leaf area at 30 DAS and 60 DAS with respect to different levels of moisture. However, leaf area differed significantly at 90 DAS and at harvest.

Significantly higher leaf area was recorded in M₃ (50% above field capacity) (977.9 cm²) followed by M₂ (field capacity) (946.9 cm²) which was on par with M₁ (need based irrigation) (938.3 cm²) at 90 DAS. However, at harvest significantly higher leaf area was recorded in M₃ (50% above field capacity) (1120.1 cm²) which was on par with M₂ (field capacity) (1090.4 cm²) and M₁ (need based irrigation) (1016.9 cm²) recorded significantly lowest leaf area.

The results are in agreement with Hosseini *et al.* (2009) who reported that the leaf area declined with reduced moisture contents in chickpea. According to them the highest leaf area was recorded with 100 per cent field capacity while lowest was with 25 per cent field capacity.

There was significant difference observed in leaf area among genotypes in all growth stages.

At 30 DAS, K₆ recorded significantly highest leaf area (548.1 cm²) followed by TAG-24 (430.0 cm²) and significantly lowest was recorded in K₉ (358.1 cm²). At 60 and 90 DAS K₆ recorded significantly highest leaf area (1110.7 and 1107.2 cm²) followed by K₉ (720.4 and

1076.3 cm²). Whereas, the lowest leaf area was recorded with TAG-24 (555.2 and 679.5 cm²). However, at harvest, K₉ (1305.9 cm²) recorded significantly highest leaf area, followed by K₆ (1222.6 cm²) and the lowest significant leaf area was recorded by TAG-24 (699.0 cm²).

Similar results showing genotypic variation were reported by Dharanguttikar and Bokar (2014) with genotype TPG-41 maintaining higher leaf area (24.69 dm²) followed by ICG-8401 (22.19 dm²) and ICG-8444 (22.98 dm²).

Leaf area differed significantly at 90 DAS and at harvest. Among the different growth regulating chemical treatments at 90 DAS, significantly lowest leaf area was recorded in C₂ (MH @ 2000 ppm) (835.0 cm²) followed by C₃ (CCC @ 2000 ppm) with (921.7 cm²) and highest leaf area was recorded in C₁ (control) with (1106.3 cm²). A similar trend was observed at harvest.

Khandagale (2011) also reported that MH @ 1500 ppm applied at 60 and 90 DAS recorded the lowest leaf area over all treatments at various stages of growth in groundnut variety TLG-45.

A significant interaction was recorded at 90 DAS between moisture treatments and genotypes wherein K₆ (G₁) at field capacity (M₂) recorded significantly highest leaf area and significantly lowest leaf area was recorded in TAG-24 (G₃) at need-based irrigation (M₁). The short stature and comparatively less moisture content availability could be the reason for this.

SCMR VALUES

The data pertaining to the influence of moisture levels, genotypes and growth regulating chemicals on SCMR values of groundnut was presented in Fig 1.

SCMR values differed significantly with the genotypes whereas the influence of moisture levels and growth regulating chemicals was observed to be non-significant.

At 30 DAS K₉ recorded significantly highest SCMR values (48.4) followed by TAG-24 (44.8) which was at par with K₆ (43.6). A similar trend was observed throughout the crop growth stages. SCMR values increased up to 60 DAS and were observed to be more or less stable later on.

These results are in agreement with Pallas (1982) wherein significant genotypic variation for photosynthetic

rate and chlorophyll content in groundnut was reported. The mean values of SCMR among genotypes during *Kharif*, 2017 ranged from 40.13 (Narayani) to 48.48 (K₉) with a general mean of 43.98. There was no interaction observed.

Total Dry Matter (g plant⁻¹)

The data on total dry matter of groundnut as influenced by moisture levels, genotypes and growth regulating chemicals was presented in Table 3. Total dry matter showed a significant increase as the growth progressed. However, the increase was drastic between 30-60 DAS and 60-90 DAS, after that the total dry matter stabilized.

A significant difference in total dry matter was observed only at harvest. M₃ (50% above field capacity) recorded significantly highest total dry matter (26.01 g plant⁻¹) followed by M₂ (field capacity) (24.16 g plant⁻¹) which was on par with M₁ (need based irrigation) (23.04 g plant⁻¹).

The influence of moisture level on total dry matter was also suggested by Nageswara Rao *et al.* (1985). According to them the amount of dry matter accumulated by a crop was closely related to the water transpired.

Total dry matter differed significantly among all the genotypes at all the growth stages. K₆ recorded significantly highest total dry matter at 90 DAS (23.77 g plant⁻¹) which was on par with K₉ (23.23 g plant⁻¹). However, K₉ recorded significantly highest total dry matter (28.02 g plant⁻¹) followed by K₆ (26.67 g plant⁻¹) and TAG-24 (19.23 g plant⁻¹) at harvest.

The results were in line with Dharanguttikar and Bokar (2014). They reported that dry matter production and its distribution in component parts of plant increased progressively with the advancing age of the groundnut crop.

Total dry matter differed significantly at 90 DAS and harvest with respect to application of growth regulating chemicals.

At 90 DAS, C₂ (MH @ 2000 ppm) (19.61 g plant⁻¹) recorded the lowest total dry matter followed by C₃ (CCC @ 2000 ppm) (21.92 g plant⁻¹) and C₁ (control) (23.91 g plant⁻¹). A similar trend was also observed at harvest. By the time of harvesting C₂ (MH @ 2000 ppm) and C₃ (CCC @ 2000 ppm) reduced the total dry matter by 22 and 12.2 per cent respectively compared to the control.

Table. 3. Effect of moisture levels, genotypes and growth regulating chemicals on total dry matter (g plant⁻¹) of groundnut

Moisture Levels	30 DAS	60 DAS	90 DAS	Harvest
M ₁ : Need based irrigation	3.29	10.98	21.60	23.04
M ₂ : Soil moisture content at field capacity	3.22	10.92	22.02	24.16
M ₃ : Soil moisture content at 50% above field capacity	3.23	10.93	21.82	26.01
CD	NS	NS	NS	1.13
SEm±	0.09	0.36	0.31	0.29
Genotypes				
G ₁ : K6	3.98	11.40	23.77	25.95
G ₂ : K9	3.75	11.60	23.23	28.02
G ₃ : TAG-24	2.01	9.83	18.44	19.23
CD	0.17	1.24	1.23	1.35
SEm±	0.06	0.40	0.40	0.44
Chemicals				
C ₁ : Control	3.23	11.11	23.91	27.15
C ₂ : Maleic hydrazide @ 2000 ppm at 40 and 30 DBH	3.21	10.69	19.61	21.62
C ₃ : CCC @ 2000 ppm at 40 and 30 DBH	3.30	11.04	21.92	24.44
CD	NS	NS	1.25	1.54
SEm±	0.06	0.25	0.44	0.54
MXG				
CD	NS	NS	NS	NS
SEm±	0.10	0.70	0.69	0.76
MXC				
CD	NS	NS	NS	NS
SEm±	0.11	0.43	0.76	0.93
GXC				
CD	NS	NS	NS	NS
SEm±	0.11	0.43	0.76	0.93
MXGXC				
CD	NS	NS	NS	NS
SEm±	0.19	0.74	1.31	1.61

Table 4. Effect of moisture levels, genotypes and growth regulating chemicals on crop growth rate (g dm⁻² day⁻¹) of groundnut

Moisture Levels	30-60 DAS	60-90 DAS	90 DAS Harvest
M ₁ : Need based irrigation	11.38	15.71	2.11
M ₂ : Soil moisture content at field capacity	11.39	16.42	3.29
M ₃ : Soil moisture content at 50% above field capacity	11.40	16.11	6.23
CD	NS	NS	1.55
SEm±	0.56	0.39	0.40
Genotypes			
G ₁ : K6	10.98	18.30	3.22
G ₂ : K9	11.62	17.21	7.08
G ₃ : TAG-24	11.57	12.73	1.33
CD	NS	2.66	1.57
SEm±	0.60	0.86	0.51
Chemicals			
C ₁ : Control	11.65	18.90	4.90
C ₂ : Maleic hydrazide @ 2000 ppm at 40 and 30 DBH	11.07	13.20	2.99
C ₃ : CCC @ 2000 ppm at 40 and 30 DBH	11.45	16.10	3.74
CD	NS	2.25	NS
SEm±	0.37	0.79	0.66
MXG			
CD	NS	NS	NS
SEm±	1.03	1.49	0.88
MXC			
CD	NS	NS	NS
SEm±	0.65	1.36	1.15
GXC			
CD	NS	NS	NS
SEm±	0.65	1.36	1.15
MXGXC			
CD	1.59	NS	NS
SEm±	1.12	2.36	1.99

Pradhan (1993) also suggested similar results. Wherein the dry matter production showed a decline with increased number of sprays of maleic hydrazide in groundnut. There was no interaction effect observed.

Thus, the results showed that among moisture levels M₃ (50% above field capacity) (26.01 g plant⁻¹), among genotypes K₉ (28.02 g plant⁻¹) recorded highest total dry matter at harvest. Whereas C₂ (MH @ 2000 ppm) reduced the total dry matter significantly (21.62 g plant⁻¹) compared to control (27.15 g plant⁻¹) at harvest.

Crop Growth Rate (g dm⁻² day⁻¹)

The data (Table 4) revealed that the crop growth rate increased from 30-60 DAS to 60-90 DAS and later on showed a decreasing trend. Significant differences in CGR was observed at 60-90 DAS and 90 DAS to harvest period.

The effect of moisture levels on crop growth rate were found to be significant “90 DAS-Harvest” moisture levels differed significantly, wherein M₃ (50% above field capacity) recorded significantly higher CGR (6.23 g dm⁻² day⁻¹) followed by M₂ (field capacity) (3.29 g dm⁻² day⁻¹) and M₁ (need based irrigation) (2.11 g dm⁻² day⁻¹).

As the moisture treatments were imposed from 20 days before harvest the availability of higher moisture might have caused more crop growth rate. Pranusha (2011) also found out that increased CGR and NAR values were maintained up to 55-75 DAS and declined thereafter in groundnut genotypes.

CGR did not differ significantly among the genotypes at 30-60 DAS. However, at 60-90 DAS, K₆ recorded significantly highest CGR (18.3 g dm⁻² day⁻¹) which was at par with K₉ (17.2 g dm⁻² day⁻¹) followed by TAG-24 (12.7 g dm⁻² day⁻¹). However, at ‘90-harvest’ K₉ recorded significantly highest CGR (7.08 g dm⁻² day⁻¹) followed by K₆ (3.22 g dm⁻² day⁻¹) and the lowest CGR was observed with TAG-24 (1.33 g dm⁻² day⁻¹). This could be due to the differences in crop duration. The duration of K₉ was 115 days whereas TAG-24 was harvested at 95 DAS.

The results are in concurrence with Nautiyal *et al.* (2002) who reported a significant difference among the genotypes with respect to CGR at different stages of crop growth, yield and its component characters.

The data revealed that the influence of growth regulating chemicals on CGR was only at 60-90 DAS, wherein significantly highest CGR was recorded with control (18.9 g dm⁻² day⁻¹). CGR was decreased by 30.6 per cent with MH @ 2000 ppm (C₂) and by 15.3 per cent with CCC @ 2000 ppm (C₃).

The results therefore showed the influence of growth regulating chemicals in reducing the crop growth rate.

Influence of moisture levels, genotypes and growth regulating chemicals was observed in all morphophysiological parameters. Significant increase due to moisture levels was observed in plant height, leaf area, total dry matter and crop growth rate. Whereas there was no significant difference with respect to SCMR. Variation between genotypes was observed wherein K₉ recorded highest plant height, leaf area, SCMR and CGR values and Total dry matter followed by K₆ and TAG 24. Growth regulating chemicals significantly reduced morphophysiological parameters. The reduction being attributed to C₂ (MH @ 2000 ppm) and C₃ (CCC @ 2000 ppm). No drastic effect was observed due to treatments therefore it can be concluded that growth regulating chemicals can be used to arrest fresh seed dormancy without causing adverse effects.

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ISOLATION AND IDENTIFICATION OF INDIGENOUS ENTOMOPATHOGENIC FUNGI FROM BROWN PLANTHOPPER IN RICE

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ABSTRACT

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A promising alternative for insect pest control in agriculture is the use of entomopathogenic fungi. The objectives of this work were to isolate and identify strains of entomopathogenic fungi from brown plant hopper, *Nilaparvatha lugens* in rice ecosystems of Nellore and West Godavari districts of Andhra Pradesh. Two native strains of entomopathogenic fungi were isolated from the infected BPH cadavers. According to their macroscopic and microscopic traits, one isolate was identified as *Beauveria bassiana* species (coded as Bb-NLR) and another isolate was identified as *Metarhizium anisopliae* species (coded as Ma-NLR). Bb-NLR was isolated from a BPH cadaver collected from the Agricultural Research Station (ARS), Nellore, while Ma-NLR was isolated from a BPH cadaver collected from Chinnacherukuru village in T.P. Gudur mandal of Nellore district. No entomopathogenic fungi were recovered from soil samples despite multiple isolations. These native strains offer potential for development of biocontrol agents targeting major rice insect pests.

KEYWORDS: Entomopathogenic fungi, brown planthopper, *nilaparvathalugens*, morphological identification.

INTRODUCTION

Rice (*Oryzasativa* L.) is a vital food crop globally, serving as the staple diet for over half of the world's population. It plays a crucial role in ensuring food security and provides a major source of livelihood and employment, particularly in developing nations such as India. Approximately 90 per cent of global rice cultivation and consumption occurs in Asia. However, sustaining productivity amidst increasing pest pressure remains a major challenge for farmers and agricultural scientists. Despite technological advancements, rice production continues to face significant challenges from both abiotic and biotic stresses. Insect pests remain a major biotic constraint, causing substantial yield losses and threatening crop sustainability. Among the insect pests, the brown planthopper (*Nilaparvatalugens*, Hemiptera: Delphacidae) has economic importance in rice ecosystems across Asia. The brown planthopper is a monophagous herbivore is recognized as one of the most destructive insect pests of rice in Asia, capable of causing 20–80 per cent yield losses through both direct and indirect damage (Balachiranjeevi *et al.*, 2019). *N. lugens* causes damage by feeding on phloem sap and transmitting viral pathogens, including rice grassy stunt virus (RGSV) and rice ragged stunt virus (RRSV), resulting in significant physiological stress and hopperburn symptoms (Helina *et al.*, 2019). However, indiscriminate chemical use for

the control of *N. lugens* has led to adverse consequences such as pest resurgence, resistance development, non-target effects and environmental contamination. These concerns have prompted the adoption of Integrated Pest Management (IPM), with an emphasis on ecologically sustainable approaches. Among these, biological control utilizing microbial agents has gained attention as an environmentally benign and effective alternative. Entomopathogenic fungi (EPF) are promising candidates for biological control due to their ability to infect and kill a wide range of insect pests. More than 700 fungal species, mainly from Deuteromycetes and Entomophthorales, are known to be entomopathogenic (Wang *et al.*, 2020). Rice ecosystems, characterized by high humidity and a favorable microclimate, support the natural occurrence and activity of EPF. Species such as *Beauveria bassiana* and *Metarhiziumanisopliae* have demonstrated high virulence against key rice pests (Malekan *et al.*, 2015). The successful application of EPF in field conditions often depends on the selection of locally adapted and highly virulent strains. Indigenous isolates tend to perform better under native environmental conditions (Jackson *et al.*, 2000). In this context, the present study aims to isolate and identify indigenous entomopathogenic fungi associated with brown plant hopper in the rice ecosystem.

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MATERIAL AND METHODS

The study was conducted during the *rabi* season of 2024 - 2025 at the Agricultural Research Station, Nellore (14.4303°N, 79.9987°E), with the objective of Isolation, identification of indigenous entomopathogenic fungi (EPF) associated with brown plant hopper in the rice. A systematic roving survey was carried out in rice fields of Nellore and West Godavari districts, Andhra Pradesh during October 2024 – February 2025. In total, 18 villages were selected across six mandals (three mandals per district, three villages per mandal). Naturally infected insect cadavers showing external mycosis symptoms were collected using sterile fine brushes into sterile glass vials by labelling them. Rhizospheric soil samples (top 5–10 cm) were also collected near cadaver sites using a sterile spatula, placed in sterile polyethylene bags and stored at room temperature ($25 \pm 2^\circ\text{C}$) until processing.

media and incubated for 7–14 days under sterile conditions to allow colony development. To obtain pure cultures, hyphal tips were subcultured repeatedly onto fresh agar media. The purified fungal isolates were maintained on agar slants and preserved in glycerol at -19°C for long-term storage and future experimentation.

Isolation of Entomopathogenic fungi from soil

Ten soil samples were collected from surveyed fields and 1 gram from each sample was used for serial dilution. The soil was initially suspended in 10 ml of sterile distilled water (autoclaved at 121°C , 15 psi for 15 minutes) to prepare a 10^{-1} dilution, followed by successive 1 ml transfers into 9 ml sterile water to achieve dilutions up to 10^{-11} . From the 10^{-11} dilution, 1 ml was aseptically transferred into sterile Petri plates inside a Laminar Air Flow chamber. Approximately 10–20 ml of molten and cooled Sabouraud's Maltose Agar with Yeast Extract was



Fig. 1. Survey map showing collection of insect cadavers of BPH and soils from Nellore & West godavari districts of Andhrapradesh, India

Isolation of entomopathogenic fungi from insect cadavers

The insect cadavers collected during the field survey were initially surface-sterilized by immersing them in 1 per cent sodium hypochlorite solution for 1 minute. This was followed by three successive rinses in sterile distilled water to remove any residual disinfectant. Following sterilization, the cadavers were transferred aseptically onto sterile Petri plates lined with moistened filter paper to maintain humidity. The plates were incubated at $25 \pm 1^\circ\text{C}$ for 3–5 days to facilitate the outgrowth of fungal mycelia from the cadaver surface.

Emerging fungal growth was carefully transferred to Sabouraud Dextrose Agar with Yeast extract (SDAY)

poured into the plates and gently swirled for even mixing before allowing it to solidify. The inoculated plates were incubated at $25^\circ\text{C} \pm 2^\circ\text{C}$ for a duration of 10 days to facilitate fungal growth and isolation.

Morphological characterization of entomopathogenic fungi

Fungal morphology was examined based on colony texture, mycelial structure, conidiophores, phialides, and conidia. Fungal mounts were prepared using lactophenol cotton blue stain on sterile slides and observed under a Phase Contrast Microscope (OLYMPUS BX43) at 40X & 100X magnification. Identification was based on standard taxonomic keys and morphological traits.



Fig. 2. Collection of insect cadavers of BPH from rice field in Nellore and west godavari districts of Andhra Pradesh

RESULTS AND DISCUSSION

Survey efforts were focused in three mandals per district; Nellore Rural, Kodavaluru, and T.P. Gudur in Nellore district; and Penumantra, Achanta, and Palakollu in West Godavari district—covering different rice varieties and crop stages to enhance the possibility of capturing natural epizootics of entomopathogenic fungi in the field. In Nellore district brown planthopper cadavers were collected across all locations, mainly from rice varieties BPT 5204, KNM 1638, and MTU 1010 during tillering to grain filling stages. In West Godavari district, brown planthopper cadavers were predominantly found in MTU 7029 fields at the flowering stage. During the course of the survey, a total of 10 BPH cadavers suspected to be infected with entomopathogenic fungi were collected. The cadavers were collected based on visible signs of fungal infection under field conditions and brought to the laboratory for fungal isolation. Additionally, ten rhizospheric soil samples were also collected from the surveyed sites. However, none of the soil samples yielded entomopathogenic fungi despite repeated isolations using standard culturing techniques.

From the BPH cadavers collected from rice ecosystems, two fungal isolates showing typical characteristics of entomopathogenic fungi were isolated. Of these fungi, one isolate corresponded to *Beauveria bassiana* (coded as Bb-NLR) and one isolate corresponded to *Metarhizium anisopliae* (coded as Ma-NLR). Bb-NLR was isolated from a BPH cadaver collected from the Agricultural Research Station (ARS), Nellore, while Ma-NLR was identified from a BPH cadaver collected

from Chinnacherukuru village in T.P. Gudur mandal of Nellore district. Remaining eight isolates were identified as plant pathogens morphologically under microscope.

The morphological identification (employing macroscopic and microscopic information) allowed the identification of the strains to the genera and species levels. In the present work, the fungal isolations of *B. bassiana* and *M. anisopliae* presented similar shapes, sizes and dispositions of conidia with the descriptions made by Samson *et al.* (1988), Humber (2005, 2012) and Rehner *et al.* (2005). All the fungal strains obtained corresponded to microorganisms of the Phylum Ascomycota, Sordariomycetes class, and the families Cordycipitaceae for *Beauveria*, and Clavicipitaceae in the case of *Metarhizium* (Humber, 2005, 2012).

The isolate Bb-NLR exhibited white, powdery colonies with cottony to velvety aerial mycelium and a uniformly circular growth pattern. After 10–12 days of incubation at $25 \pm 1^\circ\text{C}$, colonies attained a diameter of approximately 6.5 cm. Microscopic examination showed globose, hyaline conidia borne singly on a denticulated, zig-zag rachis, a characteristic feature of *Beauveria bassiana*. The conidia were smooth-walled, hyaline and measured $2.3\text{--}3.0\ \mu\text{m}$ in length and $2.0\text{--}2.5\ \mu\text{m}$ in width. Kirubhadharsini *et al.* (2017) also recorded the macroscopic characters of *Beauveria* isolates, which exhibited a white colony colour, powdery to cottony texture and a round shape and microscopic examination of *Beauveria* isolates revealed globose to sub-globose conidia with hyaline hyphae.

Table 1. Survey Locations and details of Entomopathogenic Fungi-Infected BPH Cadavers and soil collected from Rice Ecosystems of Nellore and West Godavari Districts (rabi 2024–2025)

District	Mandal	Village	Variety	Crop stage	latitude	longitude	Pest cadaver collected	Entomopathogenic fungi isolated from soil
Nellore	Nellore rural	Nellore(ARS)	BPT5204	Tillering stage	14.430195°N	79.99867°E	BPH	Not determined
		Mullamudi	KNM 1638	Tillering stage	14.45651°N	79.98019°E	BPH	Not determined
		Magallapalem	KNM1638	Tillering stage	14.44259°N	79.98645°E		Not determined
		Northrajupalem	MTU1010	Grain filling stage	14.5531°N	79.9887°E	BPH	Not determined
	Kodavaluru	Ramannapalem	KNM733	Grain filling stage	14.54139°N	79.99723°E	--	Not determined
		Kodavaluru	KNM1638	Grain filling stage	14.5669°N	80.0034°E	--	Not determined
	T P gudur	Chinnacherukuru	MTU1010	Tillering stage	14.3833°N	80.1000°E	BPH	Not determined
		Koduru	KNM1638	Tillering stage	16.0086°N	81.03441°E	BPH	Not determined
		Varigonda	KNM1638	Flowering stage	16.60999°N	80.72144°E	BPH	Not determined
		Maruteru	MTU7029	Flowering stage	16.631162°N	81.7389°E	BPH	Not determined
West Godavari	Penumantra	Neggipudi	MTU1318	Flowering stage	16.6366°N	81.7308°E	BPH	Not determined
		Alamuru	MTU1318	Flowering stage	16.7833°N	81.9000°E	BPH	Not determined
		Koderu	MTU1061	Grain filling stage	16.60386°N	81.85659°E	---	Not determined
		Kodamanchili	MTU1064	Grain filling stage	16.60516°N	81.83343°E	---	Not determined
	Achanta	Penumanchili	MTU1061	Grain filling stage	16.58581°N	81.82376°E	---	Not determined
		Palakollu rural	MTU1318	Grain filling stage	16.5333°N	81.7333°E	BPH	Not determined
		Palamuru	MTU1282	Grain filling stage	16.5487°N	81.6515°E	---	Not determined
		Pulapalli	BPT 5204	Grain filling stage	16.5187°N	81.7062°E	---	Not determined
	Palakollu							

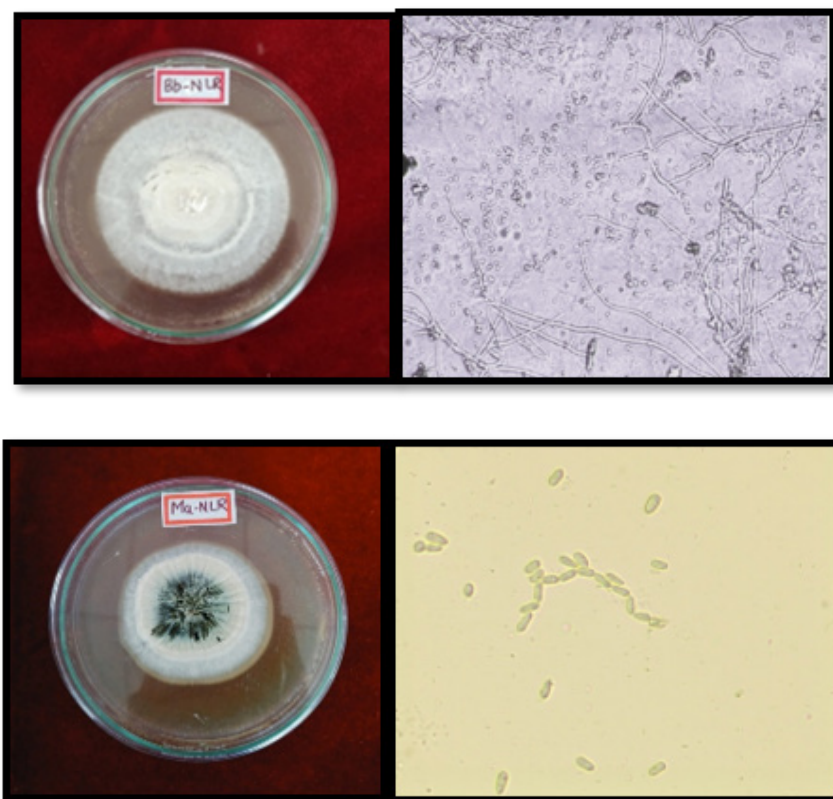


Fig. 3. Macroscopic and microscopic identification of fungal isolates (a) Morphology of *Beauveria bassiana* colony and (b) *B. bassiana* conidia (Bb-NLR) at 40X (c) Morphology of *Metarhizium anisopliae* colony (d) *M. anisopliae* conidia (Ma-NLR) at 40X

The Ma-NLR isolate displayed colonies with light to olive-green pigmentation, compact and granular in surface texture, and reached a diameter of approximately 5.8 cm after 10–12 days of incubation. Microscopic observation revealed cylindrical conidia arranged in chains on verticillate conidiophores. The conidia were smooth-walled, green and measured 6.4–7.2 μm in length and 3.4–3.6 μm in width. These morphological characteristics are consistent with previous reports for *Metarhizium anisopliae*, including the observations made by Elham *et al.* (2018), who reported similar traits on Potato Dextrose Agar. Bai *et al.* (2015) observed that colony borders of all the isolates of *M. anisopliae* were regular. During sporulation, the colour of colonies became yellow green or olivaceous green to dark green. The average spore width was 2.10– 4.10 μm , while the average spore length was 3.20– 7.69 μm . The spores were categorized as oval, round, or elongated based on their length and width.

The present work presents information of indigenous entomopathogenic fungi associated with brown plant hopper, *N. lugens* in rice ecosystem of Nellore district, Andhra Pradesh. Two native strains of entomopathogenic fungi were isolated from the infected BPH cadavers. According to their macroscopic and microscopic traits, one isolate corresponded to *B. bassiana* species and one isolate corresponded to *M. anisopliae* species. No entomopathogenic fungi were recovered from soil samples despite multiple isolations. The native isolates have potential for use in eco-friendly rice pest management strategies.

Table 2. Macroscopic characteristics of isolated entomopathogenic fungal isolates

Isolate code	Colony colour	Colony shape	Elevation	Surface texture	Colony diameter (cm)	Growth pattern
Bb- NLR	White, powdery	Round	raised	Cottony to velvety	6.5	Circular
Ma-NLR	Light to olive green	Round	Flat	Granular, compact	5.8	Circular

Table 3. Microscopic characteristics of isolated entomopathogenic fungal isolates

Isolate code	Conidial shape and colour	Conidial arrangement	Spore length (µm) (40X)	Spore width (µm)(40X)	Spore wall	Conidiogenous structure
Bb NLR	Globose, hyaline	Singly borne	2.3–3.0	2.0–2.5	Smooth, hyaline	Zig-zag rachis, denticulate
Ma-NLR	Cylindrical	Chains	6.4–7.2	3.4–3.6	Smooth, green	Verticillate conidiophores

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GROWTH TRENDS IN AREA, PRODUCTION AND PRODUCTIVITY OF ONION IN INDIA: A DECADAL ANALYSIS

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ABSTRACT

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The study was undertaken to analyse the growth trends in onion cultivation across India during the period 2014-15 to 2023-24 using secondary data sourced from the Directorate of Economics and Statistics. Compound Annual Growth Rate (CAGR), Coefficient of Variation (CV) and Cuddy Della Valle Instability Index were employed to assess long term trends and year to year fluctuations in area, production and productivity. The results revealed a positive growth in all three parameters: area expanded at a CAGR of 1.58 per cent, production increased by 2.67 per cent and productivity improved marginally at 1.05 per cent. The Coefficient of Variation was 6.84 per cent for area, 10.42 per cent for production and 8.97 per cent for productivity indicating moderate variability. Instability indices suggested relatively higher fluctuations in production compared to area and productivity. The findings reflect a consistent but moderate improvement in India's onion sector with scope for yield enhancement through improved agronomic and post harvest practices.

KEYWORDS: Onion, growth trend, CAGR, instability, India, production.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most widely cultivated and consumed vegetable crops in India, playing a vital role in the daily diet of millions as well as in the country's agricultural economy. Renowned for its pungency and flavour-enhancing properties, onion holds a significant position not only in domestic consumption but also in processing and exports (APEDA, 2024; UN COMTRADE, 2024). India ranks second in global onion production after China (FAO, 2024), with production primarily concentrated in the states of Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Rajasthan, and Andhra Pradesh (Department of Agriculture and Farmers Welfare, 2024).

Over the past decade, the onion sector has witnessed dynamic changes influenced by market fluctuations, climatic variability, policy interventions, and infrastructural developments (Baviskar *et al.*, 2022; Nalegaonkar *et al.*, 2020). Despite its importance, the sector continues to face challenges in terms of price volatility, production instability, and storage inefficiencies (DGCI&S, 2024). Hence, a comprehensive understanding of its growth performance over time is crucial for informed policymaking and supply chain improvements.

In this context, the present study was undertaken to analyse the growth trends in onion area, production, and productivity at the national level during the period 2014–15 to 2023–24. The analysis utilizes the Annual Growth Rate (AGR) to assess yearly variations, Compound Annual Growth Rate (CAGR) to evaluate long-term trends, along with the Coefficient of Variation (CV) and Cuddy Della Valle Instability Index (CDVI) to capture year-to-year fluctuations (Department of Agriculture and Farmers Welfare, 2024; FAO, 2024). The findings aim to offer insights into the pace and stability of onion production growth, thereby contributing to strategic planning for enhancing production and reducing volatility in the supply chain.

MATERIAL AND METHODS

The present study is based on secondary data for the period from 2014-15 to 2023-24 pertaining to onion cultivation in India. The data on area (hectares), production (metric tonnes) and productivity (tonnes per hectare) were collected from authentic sources including the Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare, Government of India. To analyze short term fluctuations, the Annual Growth Rate (AGR) was computed for quantity, value and unit value. The AGR indicates the year on year percentage change and was calculated using the following formula:

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Table 1. Area, production and productivity of onion in India (2014–15 to 2023–24)

Year	Area (Lakh ha)	Production (Lakh MT)	Productivity (MT ha⁻¹)
2014–15	12.16	189.17	15.56
2015–16	11.74	209.08	17.81
2016–17	12.06	224.99	18.66
2017–18	12.36	232.83	18.83
2018–19	12.91	228.19	17.68
2019–20	13.20	258.89	19.61
2020–21	13.57	266.41	19.63
2021–22	13.60	316.98	23.30
2022–23	13.85	302.08	21.81
2023–24	14.32	309.07	21.58

Table 2. Annual growth rate (AGR) for area, production and productivity

Year	Area AGR (%)	Production AGR (%)	Productivity AGR (%)
2014–15	–	–	–
2015–16	0.43	10.95	10.55
2016–17	10.18	15.26	4.55
2017–18	1.31	3.86	5.11
2018–19	1.22	0.98	2.26
2019–20	1.31	12.36	13.81
2020–21	10.84	1.14	8.75
2021–22	0.84	18.76	19.75
2022–23	8.01	0.36	7.07
2023–24	1.12	1.22	2.34

$$AGR = \left(\frac{E_t - E_{t-1}}{E_{t-1}} \right) \times 100$$

where E_t is the value in the current year and E_{t-1} is the value in the previous year.

To capture long term trends, the Compound Annual Growth Rate (CAGR) was calculated. CAGR provides the average annual rate of change over the study period by smoothing out year to year fluctuations. It was computed using the formula:

$$CAGR = \left(\frac{V_f}{V_i} \right)^{\left(\frac{1}{n} \right)} - 1$$

where V_f and V_i denote the final and initial year values respectively and n is the number of years.

To assess the variability, the Coefficient of Variation (CV) and the Cuddy Della Valle Instability Index (CDVI) were employed. While CV measures relative variability, the CDVI corrects for the presence of a time trend, offering a more realistic measure of instability. The CDVI was calculated using the formula:

$$\text{Instability Index} = C.V. \times \sqrt{1 - R^2}$$

where R^2 is the coefficient of determination from a linear trend regression and CV is the standard deviation expressed as a percentage of the mean.

RESULT AND DISCUSSION

The performance of onion cultivation in India over the period 2014-15 to 2023-24 has been analysed in terms of area, production and productivity. A decadal analysis provides insight into structural changes and growth trends in the sector. To quantify the rate of growth over time, Compound Annual Growth Rate (CAGR) and Annual Growth Rate (AGR) were computed. While CAGR captures the long term average growth on a compounded basis, AGR provides a yearly variation estimate reflecting short term changes.

These growth rates help differentiate whether increases in production are primarily driven by area expansion or improvements in productivity. Moreover, evaluating both AGR and CAGR together gives a balanced perspective on the stability and sustainability of growth patterns.

The yearly values of onion area, production and productivity across the study period are shown in Table 1 below.

As shown in Table 1 the area under onion cultivation increased from 12.16 lakh hectares in 2014-15 to 14.32 lakh hectares in 2023-24. Correspondingly, production rose from 189.17 lakh metric tonnes to 309.07 lakh metric tonnes. Productivity improved from 15.56 MT ha⁻¹ to 21.58 MT ha⁻¹ over the same period indicating technological advancements and better agronomic practices.

The AGR values exhibited inter annual fluctuations. For instance, production witnessed a sharp increase in 2021-22 due to favourable climatic conditions and government incentives followed by a decline in 2022-23. These fluctuations reflect the crop's vulnerability to weather, market shocks and storage limitations.

The CAGR for the decade was estimated at 1.87 per cent for area, 5.63 per cent for production and 3.75 per cent for productivity highlighting a stronger growth in output and efficiency than in land expansion. This suggests that productivity gains contributed significantly to overall growth.

The production of onion in India recorded a CAGR of 5.54 per cent, which is relatively higher than the CAGR of 1.85 per cent for area, indicating that the increase in output is largely attributable to gains in productivity rather than area expansion. Productivity itself showed a CAGR of 3.61 per cent, supporting the role of technological adoption and improved practices. The AGR values reflected short term fluctuations influenced by climatic conditions, policy interventions and market factors.

INSTABILITY IN AREA, PRODUCTION AND PRODUCTIVITY

The instability in area, production and productivity was estimated using Coefficient of Variation (CV) and Cuddy Della Valle Index (CDVI) to understand the consistency of growth during the study period. The findings are presented in Table 4 provided below.

Instability in area, production, and productivity was estimated using CV and CDVI (Table 4). Area exhibited low variability (CV: 5.77%; CDVI: 4.39%), reflecting stability in land allocation (Department of Agriculture and Farmers Welfare, 2024). Production (CV: 14.42%; CDVI: 11.92%) and productivity (CV: 11.98%; CDVI: 9.21%) showed moderate instability, likely influenced

Table 3. Growth rate analysis

Parameter	CAGR (%)	Average AGR (%)
Area	1.85	1.96
Production	5.54	5.30
Productivity	3.61	3.28

Table 4. Instability indices for onion area, production and productivity in India

Parameter	CV (%)	CDVI (%)
Area	5.77	4.39
Production	14.42	11.92
Productivity	11.98	9.21

by erratic rainfall, pest infestations, and market volatility (Baviskar et al., 2022; Nalegaonkar et al., 2020).

The growth trend analysis of onion in India from 2014–15 to 2023–24 shows a positive trajectory in production and productivity, with production increasing at a CAGR of 5.54 per cent outpacing area expansion. Productivity gains reflect the increasing efficiency and intensification of onion cultivation systems (FAO, 2024; Department of Agriculture and Farmers Welfare, 2024). Moderate instability in production and productivity persists due to biotic and abiotic stressors (Baviskar et al., 2022; Nalegaonkar et al., 2020). The findings underscore the importance of sustaining technological and policy interventions to further stabilize and enhance onion productivity, ensuring long-term supply security and farmer profitability (APEDA, 2024).

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ANGRAUDAATTC MOBILE APP: A DIGITAL INITIATIVE FOR AGRICULTURE

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ABSTRACT

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The application of Information and Communication Technologies (ICTs) in agriculture has revolutionized information dissemination and decision-making among farmers and extension personnel. This study explores the role of mobile applications as digital tools in modern agriculture, with a special focus on the ANGRAU-DAATTC mobile app developed to deliver crop-specific best practices in English and Telugu. The increasing penetration of smartphones and mobile internet in rural India presents an opportunity to bridge information gap and improve farm productivity and livelihoods. Mobile technology is transferring access to information by many folds. New apps are also emerging as per the need and requirements of the user. It is very important to be selective in choosing the app ensuring its credibility and information source. Development and dissemination of agriculture mobile app should provide accurate, validated content and services across the globe. So, mobile app DAATTC is considered to be one of the important app for farmer, extension functionaries, scientists etc. It contains package of practices of field crops in english and telugu in word, audio and video formats for the benefit of farmers, extension functionaries, scientists etc. The information is compiled very well organized for the clientele without wasting of time. It can be downloaded from online store from any smartphone by typing ANGRAU-DAATTC.

KEYWORDS: Smartphone, ANGRAU-DAATTC, app, agriculture.

INTRODUCTION

Agriculture, the backbone of India's economy, faces several challenges including knowledge gaps, access to timely inputs, weather uncertainties, and market price volatility. ICTs have emerged as transformative tools, helping farmers access critical information in real-time. Among ICT tools, mobile phones especially smartphones have proven to be game changers. Their capabilities extend beyond voice communication to include internet browsing, multimedia sharing, GPS-based services, and mobile applications.

This paper explores the evolution of ICTs in agriculture, the growing relevance of mobile apps, and presents a case study on ANGRAU-DAATTC, an agricultural app developed to serve the information needs of farmers and stakeholders across Andhra Pradesh.

Role of ICTs and Mobile applications in Agriculture

Information and Communication Technologies (ICTs) are playing a transformative role in agriculture, especially in disseminating timely and relevant information to farmers and extension personnel. ICTs have the potential to bridge the information gap in rural areas by providing advanced services related to inputs, weather forecasts, market trends, pest management, and

more. Tools like mobile phones, information kiosks, Kisan Call Centres (KCC), Kisan TV, Common Service Centres (CSCs), computers, and precision farming technologies have made agricultural knowledge more accessible.

Rise of Mobile Technology in Agriculture

Mobility has become the most widely used method of data transfer, offering a powerful platform for voice communication, applications, and online services. Among these, mobile applications (apps) have emerged as one of the most effective tools for delivering information directly to end users. The agriculture sector is steadily moving towards digitalization—from sowing to harvesting, and even to the post-harvest stage. Mobile phones, especially smartphones, are rapidly evolving and proving to be invaluable in improving rural livelihoods by connecting previously unconnected populations.

Benefits of Mobile applications in Agriculture

Mobile apps have become essential tools for farmers, assisting them throughout the crop production cycle. These apps offer real-time updates on weather conditions, input availability, market prices, expert consultations, pest/disease alerts, and more. As a result, farmers are empowered to make informed decisions that

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enhance crop productivity, reduce cultivation costs, and improve their overall income and livelihoods.

Initially designed for basic computing tasks such as email and weather updates, mobile apps now serve diverse sectors like commerce, banking, tourism, and health. However, agriculture still lags behind other sectors in terms of mobile app development (Costopoulou *et al.*, 2016).

Key Functionalities of Mobile Phones in Agriculture

Mobile phones are two types *viz.*, Basic phones and Smartphone. The following table illustrates the features of a mobile phone.

Technology	Mobile phone
Voice	Basic phone, Smartphone
Short Messaging service (SMS)	Basic phone, Smartphone
Interactive Voice Response (IVR)	Basic phone, Smartphone
Camera	Smartphone
Web, Apps	Smartphone
GPS	Smartphone

For effective agricultural communication, information must be accurate, timely, and reliable. While there are numerous agricultural apps, verifying the credibility and scientific validity of their content is essential.

Development of ANGRAU-DAATTC App

To cater to the growing need for reliable agricultural information, the ANGRAU-DAATTC mobile application was developed. This app serves farmers, extension workers, scientists, NGOs, and other stakeholders by providing packages of practices for various crops in both english and telugu.

The ANGRAU-DAATTC mobile app was developed as a bilingual platform (English and Telugu) containing comprehensive packages of practices for major crops cultivated in Andhra Pradesh. The app includes content in text, audio, and video formats and can be downloaded from the Google Play Store. Upon installation, the user registers by entering personal and location-specific information.

App availability and access

The ANGRAU-DAATTC app is available for free on the Google Play Store and is compatible with all Android smartphones. Upon downloading, users must register by providing their name, mobile number, village, mandal, and district. The content is offered in text, audio, and video formats, ensuring ease of access and understanding.

RESULTS AND DISCUSSION

Feature of ANGRAU-DAATTC App

The app includes content related to crop management practices, soil requirements, pest control, water and

fertilizer management, and harvesting techniques. The following table summarizes the content offered for key crops:

The app provides comprehensive information on crop management, soil and climate compatibility, rainfall patterns, and usage of farm machinery. Content is well-structured and easily accessible, ensuring farmers can retrieve the required information quickly and efficiently. Studies by Rossi *et al.* (2014) and Kirk *et al.* (2011) affirm that digital tools like ANGRAU-DAATTC facilitate evidence-based decision-making and reduce time spent searching for scattered information.

According to the Boston Consulting Group (2016), nearly 300 million rural Indian consumers were projected to be online by 2020, with more than half of them from rural areas. This highlights the importance of mobile platforms in reaching India's farming communities. Furthermore, the World Bank (2012) emphasized the advantages of mobile phones in terms of affordability, widespread ownership, voice functionality, and efficient service delivery.

Crop	Content	Language
Rice	Varieties, seed rate, seed treatment, season, fertilizer dosage, weed management, Pest management,	English and Telugu
Sugarcane	Varieties, land preparation, seed rate, sett treatment, manures, fertilizers and biofertilizers, weed management, inter cultivation, irrigation, management of sugarcane under moist stress, trash mulching, intercropping, gap filling, harvesting, pest and disease management, post harvest technology	English and Telugu
Maize	Soils, climate, land preparation, season, selection of varieties, sowing, seed treatment, nutrient management, water management, weed management, insect management. No – till maize: season, sowing, weed management, nutrient management, water management, insects and disease management, yield.	English and Telugu
Cotton	Hybrids, varieties, land preparation, seed rate, seed treatment, spacing, inter cropping, gap filling, manure and fertilizers, weed management, pest management, IPM, harvesting, post harvest handling of seed cotton	English and Telugu
Oilseeds (castor, groundnut safflower, sesame, sunflower)	Varieties, hybrids, land preparation, seed rate, spacing, seed treatment, sowing time, fertilizer application, weed management, irrigation management, pest management, harvesting, storage	English and Telugu
Pulses (redgram, blackgram, greengram, bengalgram)	Varieties, land preparation, seed rate, seed treatment, spacing, inter cropping, gap filling, manure and fertilizers, weed management, pest management, IPM, harvesting,	English and Telugu
Millets (jowar, bajra, ragi, korra, sama)	Varieties, land preparation, seed treatment, seed rate, spacing, weed control, fertilizer dose, pest management, irrigation, harvesting,	English and Telugu

Advantages

Accessibility: Easy download and registration

Content Diversity: Text, audio, and video formats for better understanding

Localization: Availability in regional language (Telugu)

User-Centric Design: Tailored for farmers, extension agents, NGOs, and scientists

Mobile applications have become a cornerstone of modern agricultural extension. ICTs, particularly mobile applications, are redefining agricultural extension and advisory services in India. Mobile apps like ANGRAU-DAATTC offer reliable, timely, and locally relevant information, empowering farmers to make data-driven

decisions. With continued smartphone penetration and government support for digital agriculture, tools like ANGRAU-DAATTC can significantly enhance farm productivity and rural livelihoods.

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IN VITRO AFFINITY OF *MACROPHOMINA PHASEOLINA* (TASSI) GOID. TO VARIOUS CROP SPECIES

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ABSTRACT

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An *in vitro* study was conducted to evaluate the affinity and relative pathogenicity of *Macrophomina phaseolina* to twenty agriculturally important crop species. Five-day-old cultures of *M. phaseolina* grown on PDA (30 ± 1 °C) were used to pre-colonize Petri plates; surface-sterilized seeds (10 seeds/plate; 4 replicates per crop, $n = 40$) were placed equidistantly around the colony and incubated in darkness at 30 ± 1 °C for six days. Seed and seedling responses were scored on a 0–5 scale and a Virulence Index (VI) was computed following. Based on virulence crops were grouped into high (VI 4.6-4.9), moderate (VI 3.0-4.4) and low (VI 2.2-2.6) virulent categories. Pulses and oilseeds (e.g., sesame, groundnut, green gram, chickpea, redgram, black gram) and some cereals (maize) showed the highest susceptibility (VI 4.6- 4.9), while tobacco, rice and tomato exhibited the least susceptibility (VI 2.2–2.6). The results demonstrate the broad host range and strong affinity of *M. phaseolina* for pulses and oilseeds under the tested *in vitro* conditions and highlight the need for crop-specific management strategies.

KEYWORDS: *Macrophomina phaseolina*, virulence index, seed infection, host affinity, *in vitro* screening.

INTRODUCTION

Macrophomina phaseolina (Tassi) Goid. is a cosmopolitan, necrotrophic soil-borne fungus that causes charcoal rot, root rot and seedling blight in a wide range of crops, leading to significant yield losses under warm and dry conditions. Its polyphagous nature and long-lived microsclerotia in soil make it a challenging pathogen to manage. Understanding host affinity across crops helps to prioritize management and breeding efforts. *In vitro* seed-colonization assays using standardized severity scales and virulence indices offer a rapid approach to compare relative susceptibility among species (Manici *et al.*, 1995; Cervantes-Garcia *et al.*, 2003; Beas-Fernandez *et al.*, 2006). The present study evaluated the affinity of *M. phaseolina* to 20 crop species representing pulses, oilseeds, cereals, cucurbits and solanaceous crops under controlled *in vitro* conditions and quantified pathogenic impact using a Virulence Index.

MATERIAL AND METHODS

The present investigation was taken at SV Agricultural College, Tirupati on *in vitro* affinity of *M. phaseolina* towards different crop species.

Fungal isolate and culture preparation

A virulent isolate of *Macrophomina phaseolina* was

maintained on Potato Dextrose Agar (PDA). Five-day-old cultures grown at 30 ± 1 °C was used for all inoculations following Manici *et al.* (1995) and Cervantes-Garcia *et al.* (2003).

Selection of plant species

Twenty crop species were selected based on reported or suspected susceptibility to *M. phaseolina*. The list (common name and scientific name) is presented in Table 1.

Surface sterilization of seeds

Seeds were surface-sterilized with 1 per cent sodium hypochlorite (NaOCl) for 1-2 min, rinsed three times with sterile distilled water and blotted dry on sterile filter paper prior to inoculation.

Inoculation procedure

PDA plates were inoculated centrally with a 5 mm disc of five-day-old *M. phaseolina* culture and incubated at 30 ± 1 °C for 48 h to allow pre-colonization. Ten surface-sterilized seeds of each species were placed equidistantly around the fungal colony on each plate. Four replicate plates per species (total $n = 40$ seeds per species) were maintained. To aid seed germination, 2 ml sterile distilled water was added to each plate prior to incubation. Plates were incubated in complete darkness

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at 30 ± 1 °C for six days (Manici *et al.*, 1995; Beas-Fernandez *et al.*, 2006).

Disease severity assessment

On day seven, seed and seedling responses were assessed using a 0–5 scale (Manici *et al.*, 1995; Cervantes-Garcia *et al.*, 2003) where: 0 = healthy seed and seedling; 1 = discoloration of seed portion in contact with mycelium; 2 = seed integuments colonized by mycelium and microsclerotia but seedling healthy; 3 = seed coat unaffected but seedling infected; 4 = both seed integuments and seedling infected; 5 = seed infected and failed to germinate.

Calculation of Virulence Index

Virulence Index (VI) for each species was calculated following Beas-Fernandez *et al.* (2006):

$$\text{Virulence Index} = \frac{\text{No. of infected seeds} \times \text{Rating scale}}{\text{Total no. of seeds}}$$

Statistical analysis

Mean VI values were computed for each species. Standard error of mean (SEm $\pm$), critical difference (CD at $P = 0.05$) and coefficient of variation (CV) were calculated.

RESULTS AND DISCUSSION

Overall affinity pattern

In vitro screening revealed marked variation in *M. phaseolina* affinity among the 20 crops tested. Based on calculated Virulence Indices, crops were classified into three groups: Highly virulent (VI 4.6-4.9), Moderately virulent (VI 3.0-4.4) and Low virulent (VI 2.2-2.6). The summary of results is presented in Table 2.

Several pulses and oilseeds like sesame, groundnut, green gram, chickpea, redgram and black gram along with maize and brassica and cucurbits displayed the highest virulence (VI 4.6-4.9). Most of these crops exhibited seed integument invasion and seedling infection or failure to germinate (scores 4-5). This strong affinity corroborates with earlier reports that *M. phaseolina* is particularly aggressive on pulses and oilseeds under favorable conditions (e.g., warm, dry environment) and is capable of causing severe seedling blight and establishment failure. Production of cell wall-degrading enzymes (CWDEs) and phytotoxins likely contribute to rapid tissue maceration and seed death in these hosts (Ramos *et al.*, 2016; Degani *et al.*, 2023).

Table 1. Crop species screened for affinity to *M. phaseolina* (n = 20)

S. No.	Crop	Scientific name	S. No.	Crop	Scientific name
1.	Sesame	<i>Sesamum indicum</i>	11.	Groundnut	<i>Arachis hypogaea</i>
2.	Sorghum	<i>Sorghum bicolor</i>	12.	Chickpea	<i>Cicer arietinum</i>
3.	Sunflower	<i>Helianthus annuus</i>	13.	Tomato	<i>Solanum lycopersicum</i>
4.	Maize	<i>Zea mays</i>	14.	Chilli	<i>Capsicum annuum</i>
5.	Cotton	<i>Gossypium hirsutum</i>	15.	Tobacco	<i>Nicotiana tabacum</i>
6.	Castor	<i>Ricinus communis</i>	16.	Rice	<i>Oryza sativa</i>
7.	Wheat	<i>Triticum aestivum</i>	17.	Ladyfinger	<i>Abelmoschus esculentus</i>
8.	Redgram	<i>Cajanus cajan</i>	18.	Mustard	<i>Brassica nigra</i>
9.	Mungbean	<i>Vigna radiata</i>	19.	Watermelon	<i>Citrullus lanatus</i>
10.	Urdbean	<i>Vigna mungo</i>	20.	Cucumber	<i>Cucumis sativus</i>

Table 2. Seed infection severity (scale and number of seeds infected) and Virulence Index (n = 40 seeds per crop)

S. No.	Crop	Disease severity scores (No. of seeds /40)	Virulence index	Virulence group
1.	Sesame	4 (4), 5 (36)	4.9	Highly virulent
2.	Groundnut	4 (8), 5 (32)	4.9	Highly virulent
3.	Maize	4 (5), 5 (35)	4.9	Highly virulent
4.	Green gram	4 (4), 5 (36)	4.9	Highly virulent
5.	Chickpea	4 (8), 5 (32)	4.8	Highly virulent
6.	Redgram	4 (8), 5 (32)	4.8	Highly virulent
7.	Brassica	4 (8), 5 (32)	4.8	Highly virulent
8.	Cucumber	4 (8), 5 (32)	4.8	Highly virulent
9.	Chilli	4 (12), 5 (28)	4.7	Highly virulent
10.	Black gram	4 (16), 5 (24)	4.6	Highly virulent
11.	Cotton	4 (13), 5 (27)	4.4	Moderately virulent
12.	Bhendi (Lady's finger)	4 (24), 5 (16)	4.4	Moderately virulent
13.	Sunflower	3 (12), 4 (16), 5 (12)	4.0	Moderately virulent
14.	Wheat	0 (9), 5 (31)	3.9	Moderately virulent
15.	Sorghum	0 (8), 4 (12), 5 (20)	3.7	Moderately virulent
16.	Castor	0 (10), 4 (10), 5 (20)	3.5	Moderately virulent
17.	Watermelon	2 (20), 3 (10), 5 (10)	3.0	Moderately virulent
18.	Tobacco	0 (19), 4 (1), 5 (20)	2.6	Low virulent
19.	Paddy (Rice)	0 (5), 1 (10), 2 (5), 3 (5), 4 (10), 5 (5)	2.5	Low virulent
20.	Tomato	0 (16), 1 (2), 3 (6), 4 (12), 5 (4)	2.2	Low virulent
SEm $\pm$		0.1		
CD (P = 0.05)		0.28		
CV		4.8%		

Cotton, bhendi, sunflower, wheat, sorghum, castor and watermelon fell into the moderate virulence category (VI 3.0-4.4). Symptoms were often less severe with partial seed coat invasion or seedling infection suggesting partial tolerance or structural/biochemical defenses reducing pathogen progress. Differences in host cell wall composition, seed coat thickness or preformed inhibitors may account for reduced colonization in these crops (Kaur *et al.*, 2019; Hameed *et al.*, 2022).

Tobacco, rice and tomato exhibited the lowest virulence indices (VI 2.2-2.6), generally showing discoloration at the seed portion in contact with mycelium or limited seedling symptoms (scores 1-2). Such low susceptibility could reflect effective early defense responses (hormonal signaling involving salicylic acid, jasmonic acid or ethylene) or physical barriers that limit fungal ingress (Radadiya *et al.*, 2021). These crops may be useful models for dissecting resistance mechanisms and identifying candidate genes for breeding.

Interactions between pathogen, host and environment

The pronounced host variation noted here is consistent with the recognized isolate-dependent pathogenicity of *M. phaseolina*. Reports from diverse regions indicate variability in aggressiveness on specific hosts (Rathore *et al.*, 2024; Lokesh *et al.*, 2020). Similarity between studies for example, reports of limited maize infection by some isolates versus high virulence on maize in the present study underline the influence of isolate genotype, host genotype and experimental conditions on observed pathogenicity (Ramos *et al.*, 2016; Rathore *et al.*, 2024).

Implications for management

High VI values for economically important crops such as sesame and groundnut underscore the need for integrated management. Due to longevity of microsclerotia in soil, crop rotation alone may reduce but not eliminate inoculum. Biological control agents (e.g., *Trichoderma* spp., *Bacillus* spp.) and the deployment of resistant genotypes appear promising components of integrated strategies (Khamari and Hashmi, 2019; Singh *et al.*, 2022). Crops categorized in the low virulence group may possess effective defense mechanisms and further investigation of these mechanisms could provide useful leads for breeding durable resistance.

In vitro affinity assay demonstrated that *Macrophomina phaseolina* shows high affinity for pulses and oilseeds (VI 4.6-4.9), moderate affinity for cereals and cucurbits (VI 3.0-4.4) and low affinity on tobacco, rice and tomato (VI 2.2-2.6) under the tested conditions. These results highlight the broad host range and aggressive potential of *M. phaseolina*, particularly on pulses and oilseeds, and provide a basis for prioritizing crops for management, surveillance and breeding for resistance.

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JOB-ORIENTED SKILL SETS POSSESSED BY AGRICULTURAL GRADUATES ACQUIRED THROUGH ACADEMIC PROGRAMME

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ABSTRACT

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This study sought to identify the job-oriented skillsets possessed by agricultural graduates acquired through academic curriculum. The study adopted exploratory research design. A total of 65 skills taken up for the study under three categories: personal, technical and other job-oriented skillsets based on the relevancy test. Data were collected from 120 agricultural graduates using a structured questionnaire. The skills were ranked based on their mean score value. Result revealed that among personal skills, learning skills (Rank I), interactive skill (Rank II), team working skill and presentation skill (Rank III) were highly acquired by graduates. Among technical skills, farm management skill (Rank I), irrigation management skill (Rank II), conservation agricultural skill, monitoring and evaluation skill (Rank III), need assessment skill and laboratory skill (Rank IV), soil health management skill and audio and video preparation skill (Rank V) were highly acquired and possessed by the agricultural graduates. In terms of other job-oriented skillsets, demonstration skill (Rank I), resource management skill (Rank II) and agri-business management skill (Rank III) were highly acquired by agricultural graduates through curriculum. The findings in this study will support universities in shaping their curriculum to better prepare the graduates in meeting the current demands of the labour market.

KEYWORDS: Agricultural graduates, job-oriented skills, personal skills, technical skills, other job-oriented skills, curriculum.

INTRODUCTION

To prepare the graduates for tomorrow workforce, universities have increased their efforts to redesign curriculum and enhance academic programs, aiming to better impart the students with the job-oriented skillsets in the modern workplace. Though these updated curricula, graduates acquire a wide range of skillsets, which was crucial for employability in today's job market (Adebakin *et al.*, 2015). As for university graduates, in the face of rapidly changing environments, internationalization and globalization, employers expect them to be fully equipped with various professional skills and knowledge to deal with complex situations effectively and solve problems quickly (Murakami *et al.*, 2009). Omar *et al.*, (2012) indicates that both technical skills and soft skills are essential for employment, as technical skills enable individuals to perform specific job tasks, while soft skills facilitate obtaining, retaining, and advancing in a career; lacking either can limit employability and career progression. Although, graduates acquire these skills while they are undergoing during the degree programs. But they often fall short in acquiring skills from curriculum, indicating less prepared for industry

demanding skills. Thus, the study aims to examine the skillsets possessed by agricultural graduates that were acquired through the undergraduate academic program in their B.Sc. (Hons) Agricultural Curriculum.

MATERIAL AND METHODS

An Exploratory survey was conducted to assess the job-oriented skillsets possessed by agricultural graduates through academic curriculum. The study was conducted in the constituent colleges of Acharya N.G. Ranga Agricultural university, Andhra Pradesh, namely, S.V. Agricultural college, Tirupati and Agricultural College, Bapatla. The study sample comprised randomly selected 120 agricultural under graduated students (60 from S.V. Agricultural College, Tirupati and 60 from Agricultural College, Bapatla who completed their degree program in the past three years (2022-23, 2023-24 and 2024-25 passed out agri-graduates). From the B.Sc. (Agri.) Hons graduate course curriculum, all the skills taught by the graduated program were listed. The listed all the skills were categorized into three groups: (1) Personal skillsets, (2) Technical skillsets and (3) Other job-oriented skillsets. These identified skills were then subjected to a relevancy

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test by a panel of judges of 60 number, using a three-point continuum *viz.*, Most Relevant-3, Relevant-2 and Less Relevant-1. Based on the result of relevancy test, a set 19 skills under personal skillsets category, 37 skills under technical skillsets category; and 9 skillsets under Other-Job oriented skills category were selected. The questionnaire was divided into three sections; (i) personal skill, (ii) technical skill (iii) other job-oriented skill acquired through undergraduate academic course curriculum. Students were asked to indicate their level of competence for each skill using a three-point continuum; *viz.*, Highly competent-3, Competent-2, Less competent-1. A questionnaire was developed to collect the responses from the B.Sc. (Agril.) Hons graduates course completed students during last three academic years. The mean value was taken to rank the skills possessed by agricultural graduates that were acquired through the curriculum.

RESULT AND DISCUSSION

The result in Table 1 and Illustration 1 shows that the calculated mean values of personal skillsets possessed by agricultural graduates which acquired by undergoing B.Sc. (Agriculture) undergraduate course curriculum. The highly acquired and possessed skills were learning skills (Rank I), interactive skill (Rank II), team working and presentation skill (Rank III), e-learning skill and leadership skill (Rank IV), self- motivated skill, independent working skill and interpersonal skill (Rank V). Followed by comparatively lower possessed skills were time management and decision-making skill (Rank VI), communication skill (Rank VII), problem solving skill (Rank VIII), critical thinking skill (Rank IX), networking skill (Rank X), analytical skill (Rank XI), risk management skill (Rank XII), computer skill (Rank XIII) and negotiation skill (Rank XIV).

The rationale behind the highly possessed skills by agricultural graduates might be those skills were given more importance within the curriculum and imparted to the students during their graduation. The active involvement of graduates in project work, field task, continuous exposure in practical component such as participation in the Rural Agricultural Work Experience Program and Experiential Learning Program during their final year might be the possible reason for possessing these essential personal skills.

The least possessed skills due to the graduates might be lack of exposure on internships and job training programs. If the graduates not received any training or internship programs during their academic period, they feel struggle to adapt to workplace demands and handle real world challenges.

The study consistent with the findings of Morgan and Rucker (2013). Sarin (2019), Colclasure (2020), Cenizia *et al.* (2021) and Olowa *et al.* (2023)

The data depicted in table 2 and Illustration 2 showed the mean score value of technical skillsets possessed by agricultural graduates, which were acquired through academic curriculum as follows: farm management skill (Rank I), irrigation management skill(Rank II), conservation agricultural and monitoring and evaluation skill (Rank III), need assessment skill and laboratory skill (Rank IV), soil health management skill and audio & video preparation skill (Rank V), project proposal writing skill (Rank VI), nurse management skill and market intelligence skill (Rank VII), biocontrol management skill and farm advisory skill (Rank VIII), pest management skill (Rank IX), disease management skill (Rank X), nutrient media preparation skill, integrated nutrient management skill and waste management skill (Rank XI), greenhouse management skill(Rank XII), plant propagation skill (Rank XIII), agroforestry system management skill(Rank XIV), seed production skill and climate smart agricultural planning skill (Rank XV), watershed management skill and landscape designing skill (Rank XVI), weather observation skill (Rank XVII), biofertilizer production skill (Rank XVIII), precision agricultural skill (Rank XIX), food nutrient analysis skill (Rank XX), food preservation technique skill (Rank XXI), bee keeping management skill (Rank XXII), Silkworm rearing skill (Rank XXIII), plant tissue culture skill and livestock management skill (Rank XXIV), crop breeding skill (Rank XXV), surveying and topography skill (Rank XXVI) and biogas production skill (Rank XXVII).

Based on the analysis, farm management skill, irrigation management skill, conservation agricultural skill, monitoring and evaluation skill, need assessment skill and laboratory skill, soil health management skill and audio and video preparation skill were highly possessed by the graduates. This reflected that the curriculum strongly focused on agricultural operation in academic program that were highly required by the

I Personal skillsets possessed by agricultural graduates acquired through academic curriculum

Table 1. Personal skillsets possessed by agricultural graduates acquired through academic curriculum (n=120)

S. No.	Personal skillsets	Mean score	Rank
1.	Learning skill	2.54	I
2.	Interactive skill	2.50	II
3.	Team working skill	2.48	III
4.	Presentation skill	2.48	III
5.	e-Learning skill	2.47	IV
6.	Leadership skill	2.47	IV
7.	Self-motivation skill	2.45	V
8.	Independent working skill	2.45	V
9.	Interpersonal skill	2.45	V
10.	Time management skill	2.42	VI
11.	Decision making skill	2.42	VI
12.	Communication skill	2.40	VII
13.	Problem solving skill	2.38	VIII
14.	Critical thinking skill	2.34	IX
15.	Networking skill	2.33	X
16.	Analytical skill	2.32	XI
17.	Risk management skill	2.28	XII
18.	Computer skill	2.27	XIII
19.	Negotiation skill	2.25	XIV

(Source: Agricultural graduates primary survey during 2025)

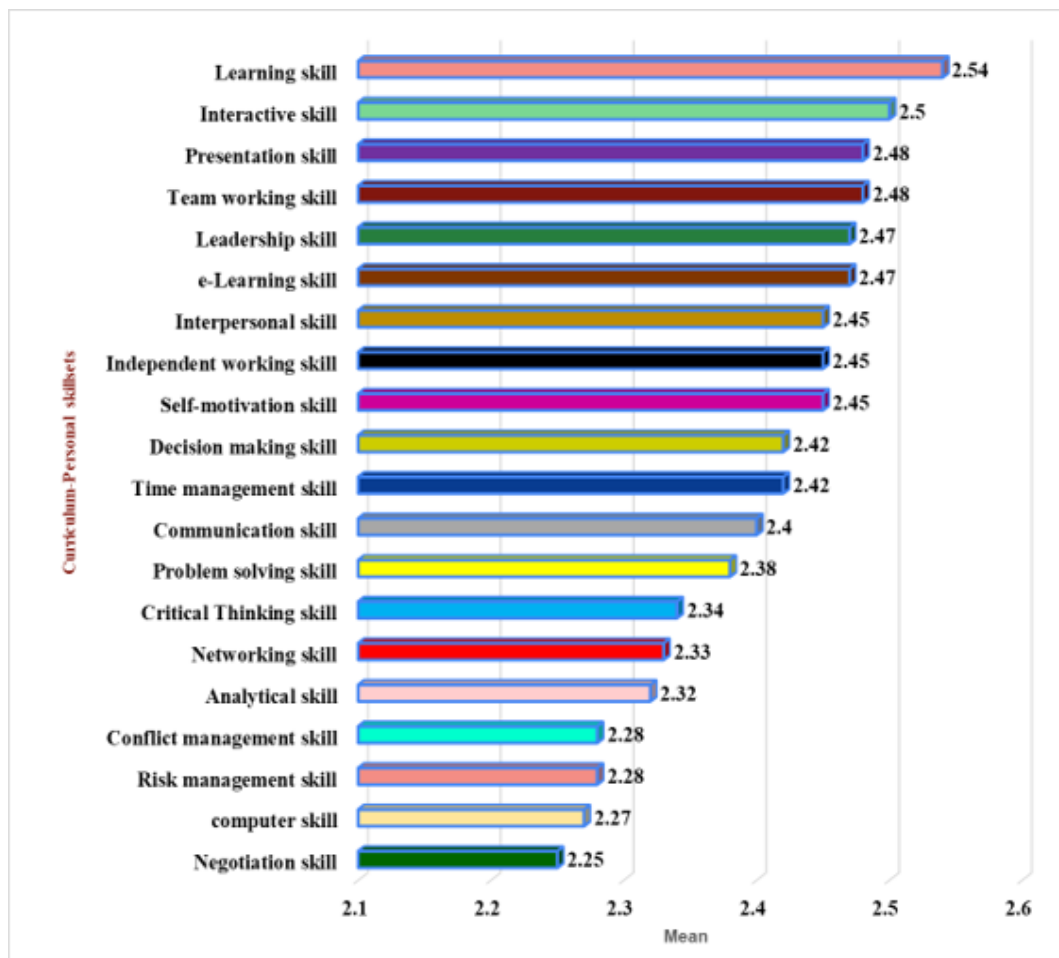


Illustration 1. Personal skillsets possessed by agricultural graduates acquired through curriculum

industry sector, which might be the possible reason for the strong possession of these skills.

Conversely, precision agricultural skill, food nutrient analysis skill, food preservation techniques skills, bee keeping management skill, silkworm rearing skill, plant tissue culture skill, livestock management skill, crop breeding skills surveying and topography skill and biogas production skill received lower ranks. Agricultural graduates did not perceive these skills as highly essential for broader agricultural industry sector, delivery of these skills often remains theoretical in curriculum and the short duration of practical session, which might be the possible reason for less possession of these technical skills.

The result of the study well aligned with the findings of Movahedi and Nagel (2012) and Ramsey and Edwards (2011), Albritton and Roberts (2020)

The data depicted in Table 3 and Figure 3 showed the mean score value of other job-oriented skillsets possessed by agricultural graduates, which were acquired through academic curriculum as follows: demonstration skill (Rank I), resource management skill (Rank II), agri-business management skill (Rank III), entrepreneurship skill and project planning skill (Rank IV), budget management skill and reporting skill (Rank V), statistical data analysis skill (Rank VI) and quantitative skill (Rank VII).

Based on the analysis, demonstration skill, resource management skill, agri-business management skill, entrepreneurial skill and project planning skill were highly possessed by the graduates. This might be because students were more involved in extension activities during their academic program, such as RAWEP and Experiential Learning Program, indicating that these skills were highly emphasized in the academic curricula.

II Technical skillsets possessed by agricultural graduates acquired through academic curriculum**Table 2. Technical skillsets possessed by agricultural graduates acquired through academic curriculum (n=120)**

S. No.	Technical skillsets	Mean score	Rank
1.	Farm management skill	2.33	I
2.	Irrigation management skill	2.31	II
3.	Conservation agriculture skill	2.30	III
4.	Monitoring and evaluation skill	2.30	III
5.	Need assessment skill	2.29	IV
6.	Laboratory working skill	2.29	IV
7.	Soil health management skill	2.28	V
8.	Audio and video preparation skill	2.28	V
9.	Project proposal writing skill	2.25	VI
10.	Nursery management skill	2.23	VII
11.	Market intelligence skill	2.23	VII
12.	Biocontrol management skill	2.21	VIII
13.	Farm advisory services skill	2.21	VIII
14.	Pest management skill	2.2	IX
15.	Disease management skill	2.18	X
16.	Integrated nutrient management skill	2.17	XI
17.	Nutrient media preparation skill	2.17	XI
18.	Waste management skill	2.17	XI
19.	Greenhouse management skill	2.16	XII
20.	Plant propagation skill	2.15	XIII
21.	Agroforestry system management skill	2.14	XIV
22.	Seed production skill	2.12	XV
23.	Climate smart agriculture planning skill	2.12	XV
24.	Watershed management skill	2.11	XVI
25.	Landscape designing skill	2.11	XVI
26.	Weather observation skill	2.10	XVII
27.	Biofertilizer production skill	2.09	XVIII
28.	Precision agriculture skill	2.08	XIX
29.	Food nutrient analysis skill	2.07	XX
30.	Food preservation technique skill	2.06	XXI
31.	Bee keeping management skill	2.02	XXII
32.	Silkworm rearing skill	1.99	XXIII
33.	Plant tissue culture skill	1.98	XXIV
34.	Livestock management skill	1.98	XXIV
35.	Crop breeding skills	1.97	XXV
36.	Surveying and topography skill	1.95	XXVI
37.	Biogas production skill	1.92	XXVII

(Source: Agricultural graduates primary survey during 2025)

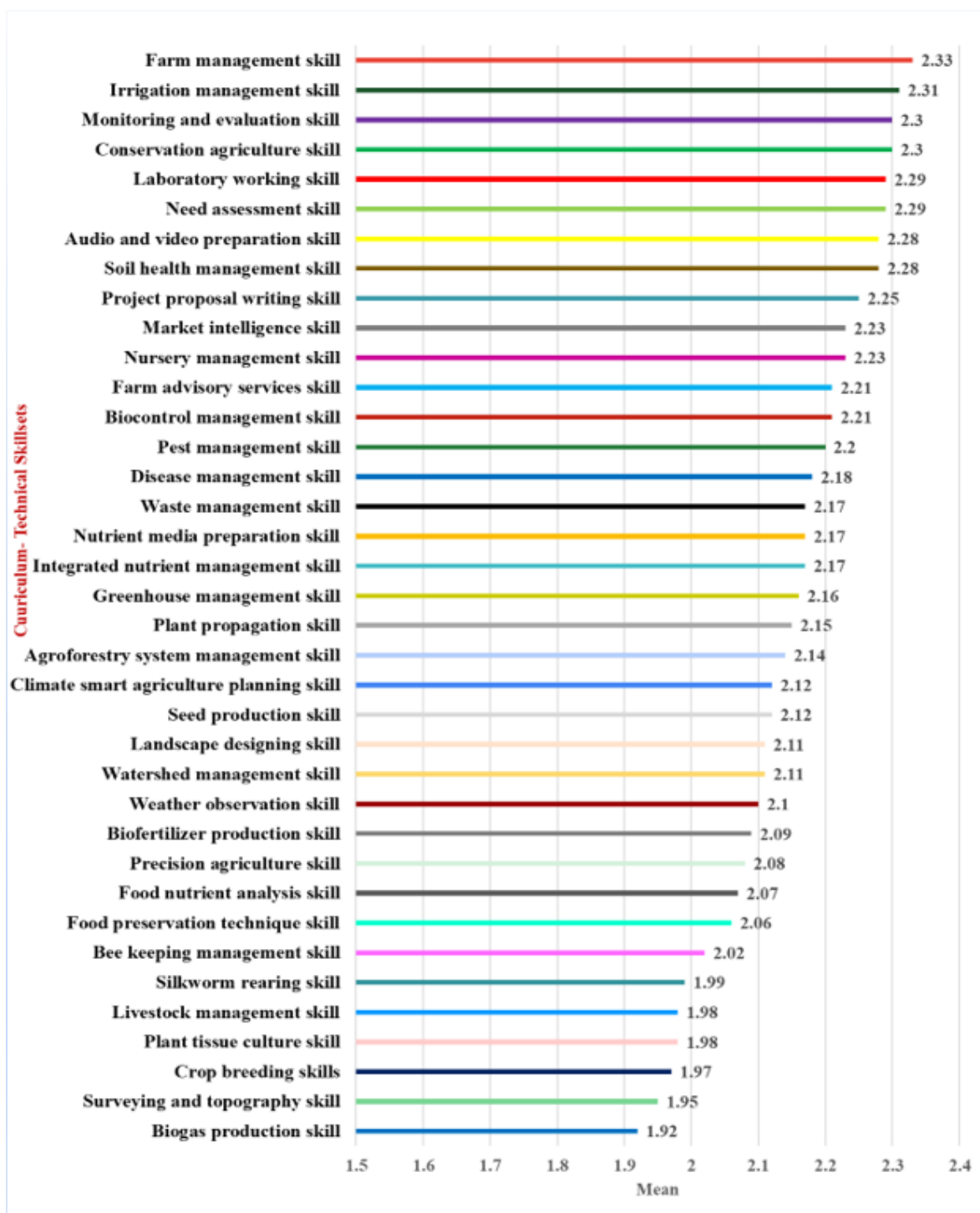


Illustration 2. Technical skillsets possessed by agricultural graduates acquired through curriculum

III Other Job-Oriented skillsets possessed by agricultural graduates acquired through academic curriculum
Table 3. Other job-oriented skillsets possessed by agricultural graduates acquired through academic curriculum (n=120)

S. No.	Other job-oriented skillsets	Mean score	Rank
1.	Demonstration skill	2.33	I
2.	Resource management skill	2.28	II
3.	Agri-business management skill	2.24	III
4.	Entrepreneurship skill	2.22	IV
5.	Project planning skill	2.22	IV
6.	Budget management skill	2.19	V
7.	Reporting skill	2.19	V
8.	Statistical data analysis skill	2.12	VI
9.	Quantitative skill	2.09	VII

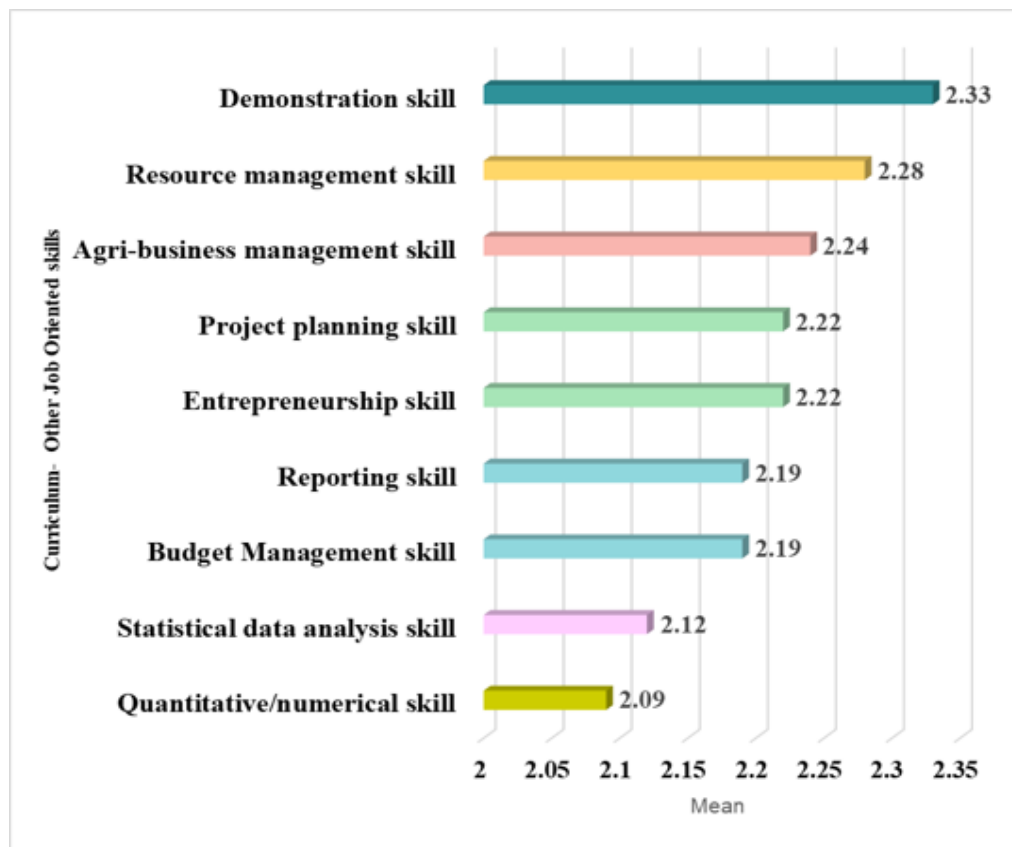


Illustration 3. Other job oriented skillsets possessed by agricultural graduates acquired through curriculum

Conversely, budget management skill and reporting skill were moderately possessed, while statistical data analysis skill and quantitative skills received low rankings, indicated these skills were the least possessed by agricultural graduates. This may be due to a lack of curiosity or motivation among graduates and limited hand-on- experience emphasized in curriculum, which might be a possible reason for their lower possession of these skills.

The results were in-line with the findings of Saikia (2014) who examined the agricultural competencies such as record keeping, financial management and business planning. Sarin (2019) emphasized the quantitative skill and resource planning skill needed in curriculum with industry requirement to bridge the gap.

In today complex world, universities face significant challenges in equipping graduates with necessary skills for workforce. Integrating core skillsets in curriculum requires strong collaboration between university and industries. As a result of the study revealed that graduates seem lack certain personal, technical and other job-oriented skills. Similarly, this study would be valuable for graduates, as it helps them to assess the level of skills they have acquired during academic programs. Based on the survey findings, it is recommended that, to prepare graduates to meet the industry expectations, university curriculum should integrate to knowledge application to real life problems, promote peer tutoring and encouraging interactive learning. Additionally, department should offer special courses along-side of university course to further enhance students' skill development.

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MARKETING EFFICIENCY OF COCOA CROP IN WEST GODAVARI DISTRICT OF ANDHRA PRADESH

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ABSTRACT

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The present study titled “Marketing Efficiency of Cocoa Crop in West Godavari District of Andhra Pradesh” was conducted to evaluate the marketing system of cocoa with specific focus on identifying marketing channels, assessing their efficiency, and identifying constraints faced by farmers. A multistage purposive sampling technique was employed to select 120 cocoa farmers and 40 intermediaries from six villages across three major mandals of the district. Four key marketing channels were identified:

Channel I (Farmers → Cadbury Agent),

Channel II (Farmers → Heritage Agent),

Channel III (Farmers → Village Trader → Cadbury Agent),

Channel IV (Farmers → Village Trader → Heritage Agent).

The most preferred marketing channel was Channel I, used by 48.3 percent of farmers. Marketing efficiency was highest in Channels I and II, both with a perfect efficiency score of 1.0, attributed to direct company procurement and absence of intermediaries. Producer's share in consumer rupee was also 100 percent in these channels. Major constraints identified through Kendall's Coefficient of Concordance were non-remunerative prices, price fluctuation, lack of market information, inadequate storage, and absence of regulated markets. Findings suggest strengthening regulated markets and farmer collectives like FPOs to improve marketing outcomes and farmer income.

KEYWORDS: Cocoa, marketing efficiency, marketing channels and constraints.

INTRODUCTION

The cocoa tree (*Theobroma cacao* L.), native to the tropical regions of Central and South America, has gained prominence as a valuable commercial crop globally, particularly for its seeds used in the production of chocolate, beverages, and cosmetics. Cocoa cultivation is gradually expanding in India due to increasing demand for chocolate-based products and its suitability as an intercrop in plantations like coconut and oil palm. Globally, cocoa is grown in over 50 tropical countries, with Côte d'Ivoire (47.91 Lha) having the highest area under cocoa followed by Indonesia (14.10 Lha) & Ghana (11.50 Lha).

Andhra Pradesh leads in cocoa cultivation with 44.9 thousand ha and 13.62 Mt production but lower productivity (397 kg/ha). Kerala, with 18.8 thousand ha, produces 11.82 Mt and has the highest productivity (692

kg/ha). This shows Kerala's more efficient and intensive cocoa farming practices.

West Godavari district leads cocoa production in Andhra Pradesh, cultivating 22,015 hectares and producing 11,773 tonnes. Cocoa is mainly grown as an intercrop under coconut and oil palm due to its shade-loving nature. Company linkages with Cadbury and Heritage boost adoption, yet farmers face market access and price transparency issues. Andhra Pradesh ranks first in cocoa area in India, with major cultivation in West Godavari, East Godavari, and Visakhapatnam. Despite potential, the cocoa supply chain remains underdeveloped, with issues like fragmented market access, low bargaining power, and inefficiencies in marketing channels. Therefore, this study was undertaken with the following objectives:

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To identify major marketing channels in cocoa marketing.

To assess the marketing efficiency in cocoa.

To explore the major marketing constraints in cocoa.

METHODOLOGY

The state of Andhra Pradesh was purposively selected for the study as it has the largest area under cocoa cultivation in India. Additionally, the researcher hails from this state and is well-acquainted with the regional language (Telugu), which facilitated better rapport with respondents and enabled in-depth data collection through personal interactions. The erstwhile West Godavari district was purposively chosen as it ranks first in area and production of cocoa in the state. From this district, three mandals Tadepalligudem, Pedavegi, and Denduluru were selected based on the highest area under cocoa cultivation. In each mandal, two villages with the largest cocoa area were selected, making a total of six villages. From each village, 20 cocoa farmers were selected, resulting in a total sample size of 120 farmers. Additionally, 40 marketing intermediaries from the same region were selected to assess marketing channels, costs, margins, and constraints. Primary data were collected using a well-structured and pre-tested interview schedule covering various aspects such as marketing channels, marketing costs, price spreads, marketing efficiency, and constraints in cocoa marketing. The study pertains to the agricultural year 2024–2025.

Marketing costs

$$TC = CP + \sum MC$$

Where, TC= Total cost of marketing

CP= Costs incurred by producer in marketing

MC_i= Marketing costs incurred by the *i*th trader

Marketing margins

$$Am = P_m - (P_b + Mc)$$

Where, Am = Margin of middlemen or trader

P_m = Selling price of trader

P_b = Buying price of trader

Mc = Marketing costs born by the trader

Producer's share in consumer's rupee

$$P = (PF / PR) \times 100$$

Where, P = Producer's share in consumer's rupee

PF = Price received by the farmer

PR = Price paid by the consumer

Marketing efficiency

Marketing Efficiency (ME) was calculated by the Acharya method. (Acharya and Agarwal, 2004)

$$MME = FP / (MC + MM) \text{ or}$$

$$MME = [RP / (MC + MM)] - 1$$

Where, MME = Modified measure of Marketing Efficiency

MM = Net marketing margins

FP = Net price received by the farmer

RP = Price paid by the consumer or Retailer's price

MC = Total marketing costs

Kendall's Coefficient of Concordance

Kendall's Coefficient of Concordance (K_c) is a non-parametric statistic used to assess the degree of agreement among raters (or judges) ranking a set of items.

$$K_c = \frac{\sum \left(R_j - \frac{R_j}{n} \right)^2}{\frac{1}{12} m^2 (n^3 - n)}$$

where ,

K_c = Kendall's coefficient

m = No. of respondents assigning ranks

n = No. of constraints ranked

R_j = Rank total of columns j.

J = Ranks assigned 1 to n.

$$\chi_{cal} = K_c (n-1) m$$

$$\chi_{tab \text{ at } (n-1) \text{ df}}$$

If χ_{cal} is higher than χ_{tab} , the judges are in strong agreement about the ranks they were assigned to the given constraints.

RESULTS AND DISCUSSION

Marketing Channels

Marketing channels for cocoa refer to the sequence of intermediaries through which cocoa beans pass

from farmers to final buyers or processors. The choice of marketing channel is influenced by factors such as accessibility, payment security, proximity, and company affiliations. In the study area, farmers had access to four primary marketing channels for selling their cocoa produce:

Channel I: Farmers → Cadbury Agent

Channel II: Farmers → Heritage Agent

Channel III: Farmers → Village Trader → Cadbury Agent

Channel IV: Farmers → Village Trader → Heritage Agent

These channels reflect the dominant procurement mechanisms adopted by private companies operating in the district. The agents act either as company-appointed buyers or licensed collectors working on a commission basis.

Distribution of Farmers by Marketing Channels

As shown in Table 1, the majority of farmers (48.3%) sold their produce directly to Cadbury agents (Channel I), followed by 30.8% through Heritage agents (Channel II). The remaining farmers sold their produce

via village traders, who then supplied to either Cadbury or Heritage.

2. Assessment of Marketing Efficiency

Marketing efficiency was calculated using the Acharya & Agarwal method. The results are summarized below:

The cost of production for farmers remains constant at (226.95 per kg across all four marketing channels, but the price received by farmers varies, being highest in Channel 1 (₹380.23/kg) and lowest in Channel 4 (₹354.15/kg). After accounting for marketing costs incurred by farmers, the net price received and farmer margins show a declining trend from Channel 1 to Channel 4, indicating reduced profitability as more intermediaries are involved. Channels 1 and 2 show minimal marketing costs and no price spread, resulting in the highest marketing efficiency (1.00) and a producer's share of 100 percent in the consumer rupee. In contrast, Channels 3 and 4 involve village traders, which increases total marketing costs and margins, leading to higher price spreads of ₹22.99/kg and ₹26.50/kg, respectively. Consequently, marketing efficiency declines to 0.94 and 0.93, and the producer's share in the consumer rupee falls to 93.98 percent in Channel 3 and 93.04 percent in

Marketing channels	Frequency	Percentage (%)
Channel I: Farmers → Cadbury Agent	58	48.3%
Channel II: Farmers → Heritage Agent	37	30.8%
Channel III: Farmers → Village Trader → Cadbury	14	11.6%
Channel IV: Farmers → Village Trader → Heritage	11	9.3%
Total	120	100.0%

Channel 4, highlighting that direct marketing channels are more efficient and beneficial to farmers.

From the above table, per hectare returns of cocoa orchard is presented. Based on the information given by respondents, the yield from hectare of cocoa fluctuates around 13 to 18 quintals based on the favourable climatic conditions like rainfall, low pests and disease attack etc. The mean yield per hectare was 782.2kgs of dried beans per hectare. The price received per kg dried beans by farmer varies based on demand and supply and also varies based on the buyer (village trader and company

agents). The average price per kg of cocoa dried beans was Rs. 372. The gross returns from cocoa was Rs. 2,92,938 with net returns of Rs. 1,14,284 per hectare.

Gross returns/cost of cultivation was 1.64 which indicated that the cocoa crop was profitable.

3. Major Constraints in Cocoa Marketing

The cocoa growers were asked on each constraint to identify and rank most important constraints. To verify whether the respondents are in agreement with each

Table 1. Marketing cost, market margin, price spread and marketing efficiency

Marketing Functionaries	Particulars	Price per kg (Rs.)			
		Marketing channels			
		1	2	3	4
Farmer	Cost of production	226.95	226.95	226.95	226.95
	Price received by farmer	380.23	377.85	359.18	354.15
	Marketing cost incurred by farmer	1.69	1.48	1.82	1.75
	Net price received by farmer	378.54	376.37	357.36	352.40
	Margin to farmer	151.59	149.42	130.41	125.45
Village trader	Marketing cost incurred by Village trader			5.75	6.23
	Price received by village trader or price paid by company agent			382.17	380.65
	Margin to village trader			17.24	20.27
Company agent	Marketing cost incurred by commission agents				
	Price Paid by company agent	380.23	377.85	382.17	380.65
	Total marketing cost	1.69	1.52	7.57	7.98
	Total margin	151.59	149.42	147.65	145.72
	Marketing efficiency	1	1	0.94	0.93
	Price spread	0	0	22.99	26.50
	Producer's share in consumer rupee	100	100	93.98	93.04

The analysis of marketing efficiency across four cocoa marketing channels in West Godavari district revealed that Channels I and II, where farmers sold directly to company agents (Cadbury and Heritage), were the most efficient.

Table 2. Cost return structure of cocoa crop (Rs./ha)

Particulars	Quantity	Value (in Rs.)	Percentage (%)
Variable Costs			
Human labour (Man days)	185.7	67,722	75.53
Machine labour	2.15	3,116	3.35
FYM (Tonnes)	1.89	2,877	3.45
Fertilizers (Kgs)	265.5	3,102	3.80
PPC's (Lit)	8.79	2,837	4.49
Irrigation (Number)	20.58	4,346	5.77
Interest on working capital	@ 7.5%	3,150	3.61%
Total Variable Cost (TVC)		87,150	100%
Fixed Costs		Value (in Rs.)	Percentage (%)
Depreciation		981	0.73%
Land cess		75	0.11%
Rental value of land		73,454	81.41%
Amortized cost		8,676	8.66%
Interest on fixed capital	@ 10%	8,318	9.09%
Total Fixed Cost (TFC)		91,504	100%
Total Cost (TVC+TFC)		1,78,654	100%
Main Out put	782.2 kgs	Rs. 372 per kg	
Gross returns		292938	
Net returns		114284	
Earnings per rupee of expenditure		1.64	

*MD= Man days, hrs= Hours, t= Tons, kgs= Kilograms, lts= Liters, No= Numbers

other, Kendall's Coefficient of Concordance (Kc) test was applied and the results

$$Kc = \text{Kendall's Coefficient} = 0.68$$

$$\chi^2 \text{ cal value} = 573.69$$

$$\chi^2 \text{ tab value} = 14.06$$

The χ^2 calculated value of Kendall's Coefficient of Concordance was higher than table value was significant and that all the interviewed retailers were in agreement in ranking the constraints.

The ranking of marketing-related problems based on the mean scores highlights that the most severe issue is "Non remunerative price for produce" (Rank 1), highlighting that farmers were not receiving fair price for their produce. This was followed by "Price fluctuations" (Rank 2), which cause uncertainty in income and affect farmers' decision-making. "Lack of market information" ranks third, showing that limited access to timely and accurate market data hinders farmers from making informed choices. The "Lack of storage facilities" came

Table 3. Ranking for Marketing constraints faced by Farmers

S. No.	Particulars	ΣR_j	Mean	Rank
1.	Lack of market information	375	3.125	3
2.	Price fluctuations	242	2.02	2
3.	Non remunerative price for produce	156	1.30	1
4.	Lack of storage facilities	465	3.86	4
5.	High transportation cost	933	7.78	8
6.	Lack of regulated markets	579	4.83	5
7.	Exploitation by commission agents/ middle men	732	6.10	6
8.	Malpractices in weighing/grading	838	6.98	7

next at Rank 4, suggesting that inadequate storage options compel farmers to sell produce quickly, often at lower prices. "Lack of regulated markets" ranked fifth, reflecting issues such as lack of transparency and vulnerability to exploitation. Exploitation by commission agent/middlemen ranked 6th as most of the middlemen offered less price by showing the quality parameters of product. Mal practices in weighing & grading and high transportation cost were other minor problems expressed by respondents.

The study identified four primary marketing channels, with Channel I (Farmers → Cadbury Agent) and Channel II (Farmers → Heritage Agent) being the most widely adopted due to their direct nature and assured procurement systems. The efficiency analysis revealed that these direct channels were highly efficient, offering a 100% producer share in consumer's rupee and perfect marketing efficiency (1.00), while Channels III and IV involving village traders showed relatively lower efficiency due to increased marketing costs and reduced farmer margins. Regarding marketing constraints, farmers reported challenges such as non-remunerative prices, price fluctuations, lack of storage facilities, absence of regulated markets, and limited access to market information, as identified through Kendall's Coefficient of Concordance. Overall, the study suggests that promoting direct marketing linkages with companies, establishing regulated markets, and encouraging farmer

collectives like FPOs can enhance marketing efficiency and ensure better income stability for cocoa farmers in the region.

Policy implications

The study emphasizes that streamlined channels and better infrastructure can boost cocoa marketing efficiency, raise farmer incomes, and support sustainable cocoa growth in West Godavari district.

Promoting direct company procurement with fewer middlemen can improve marketing efficiency and increase farmers' share of the consumer's rupee

Price instability and low returns make cocoa farming unpredictable, necessitating support measures like Minimum Support Prices and stabilization funds to protect farmers from market fluctuations.

Price stability and investment in modern storage facilities are vital to reduce income volatility, cut post-harvest losses, and improve cocoa quality and marketability.

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MARKET CHANNEL DYNAMICS OF THE FAST-MOVING CONSUMER GOODS SECTOR- A STUDY PREMISE TO NELLORE DISTRICT OF ANDHRA PRADESH

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ABSTRACT

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The aim of the study, “Market Channel Dynamics of the Fast-Moving Consumer Goods Sector: A Study Premise to Nellore District of Andhra Pradesh”, is to explore the various marketing channels available in the region of Nellore, Andhra Pradesh, the key factors influencing retailers in selecting these channels, the performance efficiency of each, and the nature of cooperation, conflict, and competition among them. Nellore was selected as the focal area due to its unique blend of urban and semi-urban demographics, emerging market infrastructure, and increasing integration of digital and traditional trade formats.

A total of 120 retailers participated in the study, of whom 66.7 per cent were male and 33.3 per cent female. The majority of respondents were middle-aged with considerable experience in FMCG retailing. A structured questionnaire was Prepared to gather socio-economic data, preferences, and perceptions related to different market channels such as wholesalers, manufacturers, carry forward agents, credit agents, and online platforms. The study employed analytical techniques such as percentage analysis, Likert scale, Garrett’s ranking method, and factor analysis to derive key insights into the efficiency and challenges of existing market distribution systems.

This study established demographic patterns influencing channel preference particularly that middle-aged, more experienced retailers strongly favour wholesalers and manufacturers, while younger retailers are more open to exploring online options. Furthermore, the research emphasized that market saturation, inventory management, and fluctuating consumer demand are key constraints hampering channel efficiency.

KEYWORDS: FMCG, marketing channel, effectiveness, factor analysis, retailers, operational efficiency.

INTRODUCTION

The structure and operation of market channels in the FMCG sector play a vital role in ensuring the efficient distribution of a wide variety of products, including food, beverages, personal care items, and household goods. These channels are shaped by India’s distinct socio-economic and demographic landscape. Several factors impact trading conditions within this sector, including product durability, perishability (shelf life), price volatility, profit margins per unit, average customer sales volume, and purchase frequency. FMCG products are typically fast-moving, generate low profit margins per unit, but compensate through high sales volumes. The majority of these products are considered non-durable because of their limited shelf life (Fareniuk, 2022).

The effectiveness of marketing channels is critical to the overall performance of the FMCG sector, especially in rapidly growing markets like India. Efficient channels ensure timely delivery, cost-effective distribution, and

increased customer satisfaction. Multiple factors ranging from logistics to marketing support influence this effectiveness (Patel *et al.*, 2025). As consumer demands evolve and competition increases, retailers seek more responsive and dependable marketing systems (Tsey, 2022). This study was undertaken to identify the primary factors affecting marketing channel performance in Nellore district.

MATERIAL AND METHODS

The study was conducted using primary data collected from 120 randomly selected FMCG retailers across Nellore district. A structured questionnaire captured retailer perceptions of ten variables related to channel performance. Responses were rated on a 5-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). Factor analysis was used to reduce the data into meaningful components. Prior to analysis, data adequacy was assessed using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett’s Test of Sphericity. The

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application of factor analysis for identifying underlying dimensions of marketing channel performance has been widely adopted in marketing research (Patel *et al.*, 2025).

RESULTS AND DISCUSSION

KMO and Bartlett's Test

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.635, indicating a satisfactory sample size.

Bartlett's Test of Sphericity was statistically significant ($p < 0.001$), confirming the appropriateness of factor analysis.

Principal Component Analysis

Out of the ten studied variables, four principal components were extracted with eigenvalues greater than one, together explaining 57.73 per cent of the total variance. These components are discussed below:

(Explained Variance: 21.48%)

Sales Volume (0.778)

Market Coverage (0.737)

Brand Image (0.687)

This factor reflects the commercial impact of a marketing channel. High sales volumes and broader market coverage directly translate to better channel effectiveness. Retailers also indicated that products with strong brand recognition tend to move faster and attract more customers. A positive brand image supports demand creation and builds long-term consumer trust, making this component essential for marketing success (Fareniuk, 2022).

Component 2: Marketing Strategy and Consumer Engagement

(Explained Variance: 13.99%)

Promotional Activities (0.753)

Pricing Strategy (0.688)

Retailers emphasized that attractive promotional campaigns (discounts, bundling, advertising) boost consumer engagement. Equally important is pricing flexibility—FMCG channels that allow margin-based pricing or offer price protection during demand fluctuations are preferred. Effective use of promotional tools and strategic pricing enhances channel

competitiveness (Fareniuk, 2022; Patel *et al.*, 2025).

Component 3: Technology and Service-Oriented Efficiency

(Explained Variance: 12.18%)

Technology Adoption (0.741)

Customer Service (0.607)

The ability of retailers and suppliers to integrate technologies such as inventory tracking, automated billing, and supply forecasting plays a key role in operational efficiency. In addition, after-sales service and grievance redressal mechanisms contribute to customer satisfaction, reinforcing channel loyalty (Tsey, 2022).

Component 4: Adaptability and Market Responsiveness

(Explained Variance: 10.07%)

Flexibility and Adaptability (0.756)

This standalone factor relates to how agile and responsive a channel is to changing market conditions, such as demand shifts, new product introductions, or supply disruptions. Retailers favoured channels that allowed for order revisions, credit adjustments, or switching SKUs based on customer preferences (Tsey, 2022).

Other Observations

Two variables Distribution Efficiency and Product Availability did not load strongly onto any single factor. However, they were consistently mentioned by retailers as necessary baseline requirements. While these may not differentiate channel effectiveness significantly, their absence leads to outright dissatisfaction. Similar observations regarding distribution constraints and product accessibility have been reported in both rural and emerging retail markets (Sarkar & Pareek, 2016; Siddiqui, 2017).

The effectiveness of marketing channels in the FMCG sector is a multi-dimensional construct influenced by factors ranging from tangible performance metrics (sales, coverage) to intangible traits like adaptability and trust. This study highlights that brand presence, promotional strategy, pricing flexibility, technological readiness, and customer service are among the most critical drivers of channel performance in Nellore district.

Retailers operating in this transitional market space prefer channels that are efficient yet adaptable, digital yet

Component 1. Market Performance and Brand Reach

Rotated Component Matrix^a				
	Component			
	1	2	3	4
Sales Volume	0.778			
Market Coverage	0.737			
Brand Image	0.687			
Promotional activities		0.753		
Pricing strategy		0.688		
Technology adoption			0.741	
Customer Service			0.607	
Distribution efficiency				
Flexibility and adaptability				0.756
Product availability				
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization				
a. Rotation converged in 6 iterations				

relationship-driven. Thus, manufacturers, wholesalers, and logistics players must recognize these preferences and align their operations accordingly. Policymakers and industry stakeholders should also invest in building capacity through digital infrastructure, retailer training, and regulatory support.

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ANALYZING TRENDS IN COTTON ARRIVALS AND PRICES OF ANDHRA PRADESH AND TELANGANA

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ABSTRACT

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The present study aimed to examine the trends in cotton arrivals and prices in five major markets across Andhra Pradesh and Telangana namely Adoni, Jammikunta, Karimnagar, Khammam, and Warangal using secondary monthly data from 2014 to 2024. Linear trend analysis and seasonal index methods were employed to identify temporal patterns in market behavior. Results revealed a significant upward trend in cotton arrivals in Adoni, while the Telangana markets experienced notable declines, potentially due to changing cropping patterns, profitability concerns, and market inefficiencies. Seasonal indices showed peak arrivals during the post-harvest period of October to January, with lean periods from June to September. Conversely, prices across all markets exhibited a consistent and statistically significant upward trend, indicating strong market demand and possible influence of policy support. These findings highlight a contrasting pattern of rising prices amidst declining arrivals, suggesting the need for strategic interventions to stabilize cotton production and enhance market efficiency in the region.

KEYWORDS: Market arrivals, Price trends, Seasonal indices, Trend analysis.

INTRODUCTION

The trends in cotton arrivals and prices is critical for evaluating market efficiency in Andhra Pradesh and Telangana, two major cotton-producing states in India. Cotton markets exhibit notable seasonal and temporal variations due to factors such as harvesting cycles, climatic conditions, policy interventions, and market infrastructure. Previous studies on agricultural commodities like rice, pulses, maize, castor, etc those by Govardhana *et. al* (2014) and Pandit *et. al* (2012) revealed that arrivals tend to peak after harvest, causing temporary price drops. Kakde *et. al* (2013) also reported lower prices during peak arrival months for pulses. Such seasonal price behavior underscores the importance of timely sales and improved storage facilities. Studying these trends enables policymakers and farmers to make better decisions regarding procurement and sales. In the cotton sector, researchers like Naidu Mohan (2014) and Kumar *et. al* (2015) identified rising trends in both arrivals and prices in select Andhra Pradesh markets. Mahesh *et. al* (2018) and Kumar *et. al* (2023) found stable price growth across Haryana markets, although arrivals declined due to shifts in crop preferences. Nagaraja *et. al* (2023) applied time-series models to analyze arrival trends, demonstrating the effectiveness of statistical tools in forecasting market behavior. These studies collectively highlight the need for region-specific trend

assessments. The present study focuses on five major markets Adoni, Jammikunta, Karimnagar, Khammam, and Warangal from 2014 to 2024. It uses linear trend equations and seasonal indices to evaluate variations in cotton arrivals and prices. The insights gained will aid in enhancing marketing strategies, procurement planning, and overall market stability.

MATERIAL AND METHODS

The study was conducted to analyze the trends in cotton arrivals and prices in selected major markets of Andhra Pradesh and Telangana, namely Adoni, Jammikunta, Karimnagar, Khammam, and Warangal. These markets were purposively selected based on their significance in cotton trade and consistent data availability. The study utilized secondary monthly data on cotton arrivals (in tonnes) and modal prices (₹/quintal) spanning the period from 2014 to 2024. The required data were collected from authenticated sources such as AGMARKNET, Cotton Corporation of India (CCI), and Indiatat. This secondary dataset enabled an objective and systematic assessment of long-term movements in market arrivals and price levels of cotton across the chosen regions.

To fulfill the first objective of the study, trend analysis was performed using a linear regression model $Y=a+bt$, where Y is the arrival or price, a is the intercept,

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b is the slope coefficient, and t is the time variable in months. This model helped determine the direction and magnitude of change in cotton arrivals and prices over the study period. Seasonal variations were examined using the ratio-to-moving-average method to compute seasonal indices, which helped identify the months of peak and lean market activity. A 9-month centered moving average was applied to smooth out fluctuations and isolate seasonal effects. All calculations and graphical analyses were carried out using Microsoft Excel, providing clear insights into the temporal behavior of cotton markets in the selected regions.

RESULTS AND DISCUSSION

Trends in Cotton Arrivals and Prices in the Selected Markets of Andhra Pradesh and Telangana

The analysis of cotton arrivals and prices from 2014 to 2024 across major markets in Andhra Pradesh and Telangana revealed significant trends and patterns. The analysis of cotton arrivals across markets in Andhra Pradesh and Telangana in Table 1. reveals mixed trends. Adoni market in Andhra Pradesh showed a significant increasing trend ($R^2 = 0.0671$, $t = 3.06^{***}$), indicating a gradual rise in arrivals. Conversely, markets in Telangana exhibited significant decreasing trends, with Karimnagar ($R^2 = 0.3581$, $t = -8.52^{***}$) and Jammikunta ($R^2 = 0.1633$, $t = -5.04^{***}$) showing strong declines. Khammam and Warangal also recorded notable reductions, though with lower R^2 values. These trends suggest regional variations in cotton production or market dynamics, potentially influenced by climate, policy, or farmer preferences. Targeted interventions are required to address declining trends in Telangana. The results obtained are similar to

findings of Naidu (2014) a significant rise in arrivals in Karimnagar during 2001–2012. However, the current study contrasts this by showing a reversal in trend, indicating possible recent shifts in cropping patterns or market conditions. This suggests a need for updated regional interventions to sustain cotton production.

As observed from Table 2, the analysis of cotton prices across five markets in Andhra Pradesh and Telangana reveals a consistent increasing trend. Adoni (AP) shows the strongest trend with the highest R^2 value (0.6486) and t-value (15.49^{***}), suggesting a robust upward price movement. Among Telangana markets, Jammikunta and Khammam exhibit significant positive trends with high coefficients and strong t-values. Although Karimnagar and Warangal have slightly lower R^2 values, their trends remain statistically significant. The overall positive slopes confirm a steady increase in cotton prices over time. This upward trend may reflect growing demand, improved market access, or inflationary effects in the region. The results obtained are similar to findings of Mahesh *et. al* (2018) observed a significant rise in cotton prices across Haryana markets over a decade. Both studies indicate price stability with minimal seasonal fluctuations. Such trends suggest improved price realization and market efficiency over time.

From Table 3, the analysis of seasonal indices for cotton prices across major markets Adoni in Andhra Pradesh, Jammikunta, Karimnagar, Khammam, and Warangal in Telangana reveals significant seasonal variation, with prices typically peaking during the winter months (October to January) and reaching their lowest during the monsoon season (July to September). Adoni

Table 1. Trends in cotton arrivals of Andhra Pradesh and Telangana

S. No.	Market	Regression equation	R^2 Value	t-Value	Trend direction
1.	Adoni (AP)	$y = 7.21x + 3238$	0.0671	3.06^{***}	Increasing
2.	Jammikunta (TS)	$y = 105.52 - 0.601x$	0.1633	-5.04^{***}	Decreasing
3.	Karimnagar (TS)	$y = 32.25 - 0.2714x$	0.3581	-8.52^{***}	Decreasing
4.	Khammam (TS)	$y = 226.1 - 0.808x$	0.0491	-2.59^{***}	Decreasing
5.	Warangal (TS)	$y = 17062 - 95.2x$	0.0747	-3.24^{***}	Decreasing

Table 2. Trends in cotton prices of Andhra Pradesh and Telangana

S. No.	Market	Regression Equation	R ² Value	t-Value	Trend Direction
1.	Adoni (AP)	$y = 36.24x + 3879$	0.6486	15.49***	Increasing
2.	Jammikunta (TS)	$y = 34.29x + 3638$	0.5874	13.60***	Increasing
3.	Karimnagar (TS)	$y = 27.49x + 3647$	0.5507	12.62***	Increasing
4.	Khammam (TS)	$y = 34.50x + 3463$	0.5666	13.04***	Increasing
5.	Warangal (TS)	$y = 28.71x + 3804$	0.5206	11.88***	Increasing

Table 3. Seasonal indices in cotton arrivals of Andhra Pradesh and Telangana

Month	Adoni	Jammikunta	Karimnagar	Khammam	Warangal
January	198.043	154.74	129.34	141.992	159.471
February	132.322	144.95	219.12	103.863	119.181
March	102.88	99.976	184.41	81.675	113.205
April	72.594	73.915	114.18	72.854	74.929
May	33.4	77.971	51.44	70.067	50.99
June	29.602	38.654	57.901	36.414	66.816
July	25.916	22.902	29.765	34.28	40.185
August	9.581	32.484	21.176	18.558	47.166
September	63.398	19.965	31.386	12.22	48.908
October	175.682	178.01	127.538	177.629	146.487
November	157.34	215.024	108.071	288.766	171.17
December	199.242	141.409	125.672	161.681	161.489

and Khammam showed particularly high indices in December and November, respectively, with Khammam recording the highest seasonal index of 285.8 in November, indicating that prices in these months are nearly triple the annual average. Conversely, all markets experience price dips during August and July, where indices fall as low as 9.2 (Adoni) and 12.1 (Khammam). These trends align with the cotton crop cycle, where harvesting begins in October, leading to increased supply and market activity. Understanding these seasonal patterns is crucial for

farmers, traders, and policymakers to optimize market timing, plan storage, and improve forecasting models for cotton pricing in the region. The results obtained are similar to findings of Kumar *et. al* (2015) in the Khammam market, where maximum arrivals occurred in November, and the lowest in September. Both studies confirm a strong seasonal pattern in arrivals linked to post-monsoon harvesting. This similarity validates the consistency of arrival behavior across different cotton markets in Andhra Pradesh.

Table 4. Seasonal indices in cotton prices of Andhra Pradesh and Telangana

Month	Adoni	Jammikunta	Karimnagar	Khammam	Warangal
January	97.652	100.439	100.959	99.19	97.227
February	97.68	98.347	96.424	96.729	96.036
March	97.665	99.05	98.621	97.925	98.942
April	101.414	103.082	104.489	101.598	103.988
May	102.062	102.06	102.243	101.24	100.673
June	104.903	102.35	100.546	105.638	104.684
July	106.752	104.049	102.938	105.877	104.738
August	104.374	105	103.708	106.532	104.684
September	100.913	102.423	100.299	103.469	103.352
October	95.868	93.469	95.005	92.45	97.635
November	94.814	95.918	96.051	93.225	93.146
December	95.903	93.814	98.717	96.129	94.896

Table 4 depicts, the seasonal indices of cotton prices across major markets in Andhra Pradesh and Telangana. The results revealed distinct monthly price variations, with higher indices observed from April to August and lower indices from October to December. For instance, Adoni reached its peak in July (106.752), while Karimnagar and Jammikunta also showed elevated indices in April (104.489 and 103.082 respectively), indicating stronger prices during the post-harvest and procurement phases. Conversely, markets experienced significant price drops in October and November, with Khammam recording the lowest index in October (92.450), likely due to increased supply from new arrivals. These seasonal trends suggest that farmers could benefit by storing produce and targeting high-index months for sales, while policymakers may consider market interventions during low-price periods to protect farmer incomes. The results obtained are similar to findings of Kumar *et. al* (2015) in the Khammam market, where seasonal indices of prices remained steady with no significant seasonal spikes. Both studies suggest efficient price transmission and low intra-year volatility. This consistency benefits farmers by reducing market risk during sales.

The analysis of trends in cotton arrivals and prices across selected markets in Andhra Pradesh and Telangana from 2014 to 2024 revealed contrasting patterns. While the Adoni market in Andhra Pradesh showed a statistically significant upward trend in cotton arrivals, the Telangana markets Jammikunta, Karimnagar, Khammam, and Warangal experienced notable declines, possibly due to crop diversification, reduced profitability, or market inefficiencies. Seasonal indices confirmed peak arrivals during the period from October to January, aligning with the harvest season. In contrast to fluctuating arrivals, all markets exhibited a consistent and significant upward trend in cotton prices, indicating robust demand and effective price support mechanisms. This divergence between declining arrivals and rising prices, particularly in Telangana, signals potential supply-side vulnerabilities. These findings highlight the need for targeted policy interventions to strengthen marketing infrastructure, support cotton cultivation, and enhance farmer profitability in the region.

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BIO-CHEMICAL AND MOLECULAR CHARACTERIZATION OF *XANTHOMONAS ORYZAE* PV. *ORYZAE* ISOLATES FROM THE RICE GROWING AREAS OF KURNOOL, NELLORE AND TIRUPATI DISTRICTS

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ABSTRACT

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Xanthomonas oryzae pv. *oryzae* (*Xoo*), the causal agent of bacterial leaf blight (BLB) in rice, poses a significant threat to rice cultivation in many parts of the world. The present study aimed to isolate and identify *Xoo* from infected rice leaves and confirm its pathogenicity, followed by preliminary biochemical and molecular characterization. Pathogenicity of the isolates was confirmed by clip inoculation on BPT 5204 cultivar, which reproduced BLB symptoms within 14 days. Biochemical characterization of the three isolates revealed catalase positivity, indicating the production of the catalase enzyme capable of breaking down hydrogen peroxide. The KOH solubility test yielded a positive result, supporting the Gram-negative nature of the isolates. However, the oxidase test was negative, which aligns with typical features of *Xoo*. Molecular characterization of three isolates was done with *Xoo* specific primers which yielded 290 bp size amplicon. These findings confirm the easy and reliable way to confirm the pathogen as *Xoo* without further sequencing.

KEYWORDS: Catalase, molecular characterization, oxidase, pathogenicity, *Xanthomonas*.

INTRODUCTION

Xanthomonas oryzae pv. *oryzae* (*Xoo*) is a major bacterial pathogen causing bacterial leaf blight in rice, significantly impacting global rice production (Mondal *et al.*, 2019; Zhao *et al.*, 2007). The pathogen can cause yield losses of 10-50 per cent and is prevalent in most rice-growing countries (Ayusma *et al.*, 2024; Yashitola *et al.*, 2000). The bacterium can survive for extended periods and transmit from seed to plant to seed, enabling its persistence across growing seasons (Mondal *et al.*, 2019).

Recent studies have focused on developing effective control measures against *Xoo*. These include the use of essential oils like eucalyptus and citronella (Ayusma *et al.*, 2024), antimicrobial peptides such as melittin (Shi *et al.*, 2016), and the development of highly sensitive real-time detection methods (Zhao *et al.*, 2007). Genomic studies of *Xoo* strains from diverse geographical locations and altitudes are also contributing to a better understanding of its virulence factors and host-pathogen interactions (Asysyuura *et al.*, 2017), paving the way for more targeted and effective management strategies for this significant rice pathogen.

Bacterial leaf blight (BLB) of rice, caused by *Xanthomonas oryzae* pv. *oryzae* (*Xoo*), manifests as severe symptoms that can lead to significant crop losses.

X. oryzae pv. *oryzae* enters the plant through wounds or hydathodes on the leaf margin and subsequently produces systemic infection (Mew, 1987). The disease could be characterized mainly into two distinct phases: the “leaf blight phase” and the “kresek phase.” The kresek phase occurs immediately after transplantation and is destructive (Reddy and Ou, 1976; Ou, 1985). The primary symptom is leaf wilting (Kim *et al.*, 2015). The wilting is often accompanied by yellowing and drying of the leaves, resulting in characteristic blight symptoms. (Babu *et al.*, 2003). The pathogen primarily colonizes and multiplies in the xylem vessels of rice plants, causing significant damage to the host tissue (Noda & Kaku, 1999).

The severity of symptoms can vary depending on the strain of *Xoo* and the rice cultivar's resistance. The incidence and progression of diseases are heavily influenced by topography and climate. Specific amounts of sunlight and dryness impact the development of the causal agent. The disease commonly occurs in regions where monthly rainfall exceeds 200mm. Lesion formation tends to occur at temperatures ranging from 25 to 30°C. In the early stages, acidic soil is believed to significantly contribute to the disease (Maruyama, 1909). Heavy use of fertilizers is a key agricultural practice that impacts the onset of bacterial blight in rice. Among the three primary fertilizer components,

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nitrogen is primarily responsible for promoting disease occurrence (Cha, 1982). The density of rice planting also plays a role in the disease's severity, with greater severity observed under wider spacing while maintaining a constant nitrogen level. Colonies of *Xoo* appear as shiny, pin headed, mucoid, yellow and convex on modified Wakimoto media (Shankara *et al.*, 2016).

Various methods have been used in the identification of the pathogen such as biochemical tests (Cruz *et al.*, 1984), serological assays (Benedict *et al.*, 1989), fatty acids and metabolic profiling (Chase *et al.*, 1992; Merieux and Balme-les Grottes, 1993)

The preliminary diagnosis of *Xoo* lay the groundwork for future studies on virulence, race differentiation, and biocontrol strategies to manage BLB in rice.

MATERIAL AND METHODS

Collection of BLB affected leaf samples

Leaf samples showing water-soaked to yellowish orange lesions along the leaf margin were collected from three districts of Andhra Pradesh *viz.*, Kurnool, Tirupati and Nellore were brought to lab for isolation of the pathogen and the isolates were named as *Xoo_K*, *Xoo_T*, *Xoo_N*.

Isolation of the pathogen

Infected leaves were excised with sterile scalpel. The leaf bits were sterilized with 1 per cent sodium hydroxide for three minutes and then washed with sterile distilled water. The leaf bits were macerated in sterile water to allow the bacteria to ooze out from the leaf tissue. After the water turns turbid, a loopful of suspension was streaked on modified Wakimoto Agar medium (MWA). After 48 hrs of incubation the emerging colonies which appeared as shiny, mucoid, convex, yellow colour were subcultured onto MWA media. The cultures were maintained on slants at 40C in refrigerator for short term use and in 20 per cent glycerol at -20°C for long term preservation.

Pathogenicity test

Artificial inoculation of the three *Xoo* isolates *viz* *Xoo_K*, *Xoo_T*, *Xoo_N* was carried out using the leaf clip inoculation technique to prove pathogenicity under greenhouse conditions. Studies were conducted on BPT 5204 cultivar with 48h old culture. The bacterial

suspension was clip inoculated to 45 days old plants by excising 2-3 cm of rice leaves with sterilized scissors immersed in the bacterial suspension (108 cells/ml). After inoculation plants were covered with polythene bags to maintain humid conditions. Plants were observed for symptoms after 72 h. The pathogen was re-isolated from artificially inoculated plants to prove Koch's postulates and obtained bacterial colonies similar to the original culture.

Biochemical Characterization of *Xanthomonas oryzae* pv *oryzae*

Gram staining

Bacteria were heat fixed on a glass slide and was treated with (0.5%) crystal violet for 30 seconds then washed with running tap water. Then decolorized with (95%) ethanol for 30 seconds, washed again and counter-stained with safranin for 1 min. It was eventually washed with water and observed under microscope (Jonit *et al.*, 2016).

Potassium hydroxide (KOH) test

KOH test was performed to confirm the gram staining results. The bacterial were aseptically transferred with a sterile loop onto the glass slide containing a drop of 3 per cent KOH solution and stirred for 10 seconds using a quick circular motion of hand (Suslow *et al.*, 1982).

Catalase test

A loopful of 24 h old culture was smeared on a glass slide and few drops of hydrogen peroxide was added in the smear. The reaction is positive if gas bubbles are produced (Taylor and Achanzar, 1972).

Oxidase test

Xoo was cultured on nutrient agar, supplemented with 1 per cent glucose. A loopful of 24 h was rubbed on filter paper impregnated with 15 per cent (w/v) freshly prepared aqueous solution of kovacs oxidase reagent (Kovacs, 1956). A colour change to purple is considered as positive.

Molecular characterisation of *Xoo*

The genomic DNA of three isolates was extracted by suspending a loopful of bacteria in TE buffer (500µl) followed by addition of 6 µl of Proteinase



Plate 1. Paddy leaves infected with BLB

K and 5 μ l of RNase A and incubated at 65°C for 30 minutes. NaCl (5M, 100 μ l) and CTAB (80 μ l) were added and once again incubated at 65°C for 30 minutes. An equal volume of chloroform: isoamyl alcohol (24:1) was added, mixed well and centrifuged at 13,000 rpm for 15 min. The supernatant was transferred to a new microcentrifuge tube. Chilled isopropanol was added and incubated overnight at -20°C. The next day the tube was centrifuged at 10000 rpm for 10 min, and supernatant was discarded to collect DNA pellet. Ethanol (500 μ l) was added, centrifuged and supernatant was discarded and pellet was air dried. Finally the DNA was dissolved in 30 μ l of molecular-grade water and stored at -20°C.

Polymerase Chain Reaction analysis

DNA was quantified using Nanodrop. The molecular characterization was done using X00290 F/R specific primers of *Xoo*. For amplification of DNA using specific primer the PCR conditions include initial denaturation at 94°C for 5 minutes, 25 cycles of denaturation at 94°C for 60 seconds, annealing at 56°C for 30 seconds followed by extension at 72°C for 60 seconds, final extension at 72°C 10 minutes and reaction was kept hold at 4°C. The PCR products were analyzed on 1 per cent agarose gel electrophoresis and amplified DNA was viewed under the UV transilluminator.

RESULTS AND DISCUSSION

Isolation of pathogen

After 48 hours of incubation, small, pin-headed, raised, shiny, mucoid, convex yellow colonies were identified as *Xoo*. Single colonies were picked and transferred to modified Wakimoto Agar media for obtaining pure cultures of *Xoo* (Plate 3) Similarly, Shankara *et al.* (2016) isolated *Xoo* and reported that



Plate 2. Clip inoculation

colonies are mucoid and slightly convexed.

Pathogenicity test

Koch's postulates were followed to prove the pathogenic nature of *Xanthomonas oryzae* pv. *oryzae*. The three *Xoo* isolates were subjected to pathogenicity testing by leaf clipping method. Symptoms of BLB were observed on rice leaves after seven days of inoculation. Initially small water soaked lesions were observed which after fourteen days developed as stripes from clipped end forming yellow-brown lesions with wavy margins. Reisolation was done from these lesions and compared to original culture to confirm pathogen's identity.

Similarly Akhtar *et al.* (2008) and Chandraprakash *et al.* (2018) performed isolation and pathogenicity tests and reported the water soaked lesions appeared in 5-7 days after inoculation of pathogen.

Gram staining and KOH test

The three isolates exhibited Gram negative reaction with red colour when studied under light microscope. Since Gram negative bacteria have thin peptidoglycan layer, they do not retain purple colour and are counter stained by safranin giving red colour appearance as seen in Plate3.

Potassium hydroxide (KOH) test is an excellent validation assay for Gram staining (Suslow *et al.*, 1982). The cell walls of Gram-negative bacteria are broken down in the presence of KOH and this results in releasing of the viscid chromosomal material which causes the bacterial suspension to become thick and stringy. The three *Xoo* isolates produced a characteristic slimy thread like structure when treated with 3 per cent KOH confirming gram-negative nature of *Xoo*(Plate 4). Rukhsana *et al.* (2012), reported that *Xoo* was Gram

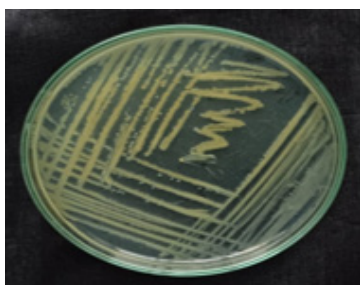


Plate 1. Culture of *Xoo_N*

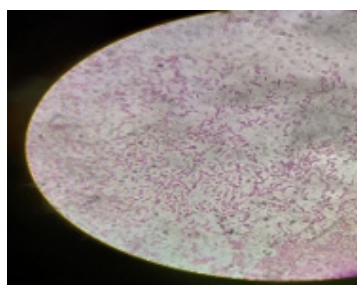


Plate 4. Gram stained and microscopic view of *Xoo_N*



Plate 5. KOH test of *Xoo_N*



Plate 6. Catalase test of *Xoo_N*

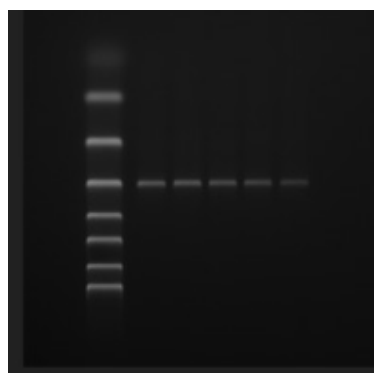


Plate 7. Amplicons of ~290 bp by three *Xoo* isolates with DNA marker of 100bp

negative, rod shaped and produced red colour when counter stained with safranin.

Catalase test

All the isolates were found to be positive for catalase production. Bubbles were formed when few drops of hydrogen peroxide were added on bacteria smear (Plate 6.) It is because catalase enzyme is able to decompose hydrogen peroxide releasing oxygen and water. Catalase plays a crucial role in the defense mechanisms of *Xoo* against oxidative stress, particularly in detoxifying hydrogen peroxide (H₂O₂) (Pan *et al.*, 2016).

Oxidase test

The isolates when smeared on filter paper dipped in Kovacs reagent there was no colour change indicating the isolates are negative for oxidase test. Similar results were obtained by Islam *et al.*, 2023 for oxidase test. It may be because the bacteria may not be able to produce cytochrome c oxidase, an enzyme in the electron transport chain.

Molecular characterisation of *Xoo*

The 16S rDNA primers 27F/1492R of three isolates of *Xoo* yielded amplicons of ~1500bp and when the PCR was done with specific primer set XOO290F/R, ~290 bp size amplicons were obtained. These results are in corroboration with studies of Tuan *et al.*, 2017. With the obtained amplicons with specific primers the three bacterial isolates were considered as *Xanthomonas oryzae* pv *oryzae*.

The present study successfully isolated and identified *Xanthomonas oryzae* pv. *oryzae* (*Xoo*), the causal agent of bacterial leaf blight (BLB) in rice. The isolates displayed characteristic yellow, mucoid colonies on Wakimoto Agar and reproduced typical BLB symptoms through clip inoculation. Biochemical tests confirmed the Gram-negative nature, catalase activity, and oxidase negativity of the isolates traits consistent with *Xoo*. Molecular confirmation using *Xoo*-specific primers resulted in distinct amplicons of ~290 bp validating the identity of the isolates. These findings offer a reliable and easy protocol for preliminary diagnosis of *Xoo* by

using specific primers without going for sequencing and lay the groundwork for future studies on virulence, race differentiation, and biocontrol strategies to manage BLB in rice.

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PREFERENCE PATTERNS OF FARMERS TOWARDS PESTICIDE BRANDS IN COTTON CULTIVATION IN KADAPA DISTRICT

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ABSTRACT

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Pesticides play a vital role in protecting crops from pest infestations and ensuring food security, particularly in cotton growing regions such as Kadapa district, Andhra Pradesh, where pest attacks are frequent and severe. This study, titled “Preference Patterns of Farmers Towards Pesticide Brands in Cotton Cultivation in Kadapa District,” aimed to identify key information sources, factors influencing brand preference and problems faced by cotton farmers. Four mandals were purposively selected based on the extent of cotton cultivation. From each mandal, three villages were randomly selected, resulting in a total of twelve villages. From each village, ten cotton farmers were randomly selected, accounting for 120 farmer respondents in total. Data were collected through structured interviews and focus group discussions and analyzed using Garrett’s Ranking Technique.

Most influential source of information was fellow farmers and progressive farmers (mean score 71.32, Rank 1), followed by television/radio (64.92, Rank 2) and demonstrations/field days (60.03, Rank 3). Regarding brand preference, previous product experiences ranked highest (mean score 72.75), followed by cost and affordability (64.13) and dealer’s influence (59.03) were the factors influencing. The major problems reported by farmers in using pesticide brands were high price of pesticides (mean score 72.28, Rank 1), poor after sales service (65.02, Rank 2) and presence of spurious products (58.97, Rank 3). The study emphasizes the importance of experiential learning, affordability and dealer networks were influencing farmer decisions, while also highlighting the need for better extension services, credit access and stricter regulation to address key challenges in pesticide usage.

KEYWORDS: Pesticide brand preference, factors influencing, problems, cotton.

INTRODUCTION

Pesticides are indispensable in modern agriculture as they protect crops from pests, diseases and weeds, thereby enhancing yield and ensuring food security. In India, agriculture remains the primary source of livelihood for nearly half of the population and the demand for crop protection chemicals has been rising steadily since the Green Revolution. The Indian pesticide industry, valued at around USD 11.2 billion in 2024-25, ranks fourth globally and is projected to grow annually at about 9 per cent (Rubix Data Sciences, 2025). Despite this growth, pesticide usage patterns vary across crops and regions depending on pest pressure, farmer awareness and brand availability.

Cotton a major commercial crop in India, is particularly vulnerable to pest infestations such as bollworms and sucking pests, which can cause severe yield losses if not effectively managed. Consequently, pesticide use in cotton is higher compared to many

other crops. Andhra Pradesh is one of the leading cotton producing states in the country, with about 4.27 lakh hectares under cotton cultivation during 2023-24 (Directorate of Economics and Statistics, 2024). Kadapa is one of the significant cotton growing districts in the state, leading to greater dependence on pesticide applications.

The availability of a wide range of pesticide brands from national and multinational companies offers farmers multiple options but also makes their decision making complex. Farmers’ brand preferences are shaped by several interrelated factors such as product efficacy, affordability, availability, dealer advice and promotional efforts. Understanding these preference patterns is essential for agrochemical companies to formulate effective marketing strategies and for policymakers to strengthen awareness programmes that encourage the safe and judicious use of pesticides.

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MATERIAL AND METHODS

The study was conducted in Kadapa district of Andhra Pradesh. Kadapa district was purposively selected due to its significant area under cotton cultivation and the widespread use of pesticide brands by farmers. Four mandals, namely Proddatur, Rajupalem, Mylavaram and Vempalli, were purposively selected based on the extent of cotton cultivation. From each mandal, three villages were randomly selected, making a total of twelve villages. Ten cotton farmers were randomly selected from each village, resulting in a total of 120 respondents.

Primary data were collected through structured interview schedules, personal interviews and focus group discussions, while secondary data were obtained from the Agriculture Department, published reports, pesticide company websites and relevant government portals. Garrett's Ranking Technique was employed to analyze the market share and preference patterns by converting rank data into scores for prioritization.

RESULTS AND DISCUSSIONS

Ranking of different Information Sources

Farmers in the study area accessed pesticide brand information from a variety of sources including fellow farmers, mass media, dealers, institutional experts, mobile apps and social media. Table 1 presents the classification and ranking of different sources of pesticide related information based on farmers' responses. The data were analyzed using Garrett's Ranking Technique to assess the relative influence of each source.

Table 1 reveals that the most influential source of information was fellow farmers, relatives and progressive farmers (71.32 mean score), followed by television/radio (64.92), demonstrations, field days and exhibitions (60.03), dealers and company representatives (53.33) and scientists from KVKs, DAATTCs and SAUs (51.23). These top five sources played a key role in influencing pesticide usage decisions among cotton farmers. Patel and Singh (2020), also reported that interpersonal communication and mass media were the most trusted sources of agricultural information. In contrast, sources such as pamphlets, brochures, extension workers, newspapers and NGOs/FPOs ranked lower, suggesting a limited role in information dissemination.

Factors Influencing the Farmers to Purchase a Particular Pesticide Brand

Farmers were asked to indicate the major factors influencing their selection of a particular pesticide brand. The responses were analyzed using Garrett's Ranking Technique and are presented in Table 2.

It was found that previous experience with the product was the most influential factor, with the highest mean score of 72.75, ranked first. This clearly indicates that farmers place significant trust in the performance of pesticides they have already used and found effective. A product that has consistently delivered desired results in the past creates a sense of reliability, reducing the risk associated with trying new brands.

The second most important factor was cost and affordability, scoring 64.13 and ranked second. This highlights the economic sensitivity of farmers, especially smallholders, for whom pesticide expenditure forms a substantial part of the total cost of cultivation. The preference for reasonably priced products indicates that affordability plays a crucial role in decision making, particularly in rainfed or financially constrained regions.

Dealer's influence and advice emerged as the third most important factor, with a mean score of 59.03 and ranked third. This reflects the dominant role of dealers as key intermediaries in the agro-input supply chain. Their personal rapport with farmers, accessibility and practical knowledge often make them a trusted source of guidance, particularly when farmers are unsure or choosing between similar products.

Other notable factors included credit availability (mean score 55.55, rank fourth), which is especially important for farmers operating on tight budgets or during cash strapped periods like pre-harvest seasons.

The long term positive effects on crops (mean 50.25, rank fifth) and sales and promotional activities (mean 50.00, rank sixth) also had noticeable influence, showing that visible crop benefits and company outreach strategies do shape perceptions and preferences to a certain extent. Factors like brand image and company reputation (mean 46.29, rank seventh), timely availability and packaging (mean 44.93, rank eighth) and quality and effectiveness (mean 43.48, rank ninth) had moderate impact, suggesting that while these are considered, they are often secondary to more immediate concerns like cost and familiarity.

Table 1. Ranking of different information sources n = 120

S. No.	Source of Information	Mean Score	Rank
1.	Fellow farmers, relatives and progressive farmers	71.32	I
2.	Television / radio	64.92	II
3.	Demonstrations, field days and exhibitions	60.03	III
4.	Dealers and company representatives	53.33	IV
5.	Scientists (KVKs, DAATTCs and SAUs)	51.23	V
6.	Agricultural mobile apps	49.47	VI
7.	Social media and messaging platforms (WhatsApp, Facebook, YouTube)	46.71	VII
8.	Extension workers (Department of Agriculture and allied sectors)	45.72	VIII
9.	Pamphlets, brochures and hoardings	43.88	IX
10.	Newspapers / magazines	42.21	X
11.	Agricultural research and extension publications	38.13	XI
12.	NGOs and farmer producer organizations (FPOs)	38.07	XII

Table 2. Factors influencing the farmers to purchase a particular pesticide brand n=120

S. No.	Factors Influencing Brand Choice	Mean Score	Rank
1.	Previous experience with the product	72.75	I
2.	Cost and affordability	64.13	II
3.	Dealer's influence and advice	59.03	III
4.	Credit availability	55.55	IV
5.	Long term and positive effects on crop	50.25	V
6.	Sales and promotional activities	50.00	VI
7.	Brand image and company reputation	46.29	VII
8.	Timely availability and packaging in different sizes	44.93	VIII
9.	Quality and effectiveness (efficacy, formulation)	43.48	IX
10.	Product information and ease of use	42.50	X
11.	After sales service	40.04	XI
12.	Peer and progressive farmer recommendations	36.05	XII

Relatively lower importance was given to product information and ease of use (mean 42.50, rank tenth), after sales service (mean 40.04, rank eleventh) and peer and progressive farmer recommendations (mean 36.05, rank twelfth). This indicates that social referrals and technical clarity, although helpful, are not the primary drivers of brand selection in the study area.

These findings align with earlier studies, such as Paghadar and Thakkar (2023), also reported that past product experience, dealer advice and brand reputation were key determinants in farmers' pesticide brand choices. The consistency of these patterns across different regions emphasizes the need for companies to focus on building long term trust, offering cost effective solutions and leveraging dealer networks to maintain brand loyalty among farmers. Bhalodiya and Thakkar (2024) also reported that dealers' influence and advice were the third most important factors shaping farmers' pesticide purchase decisions.

Ranking of the Problems faced by the Farmers while purchasing Pesticide Brands

The problems faced by farmers in the purchase and use of pesticide brands were assessed using Garrett's ranking technique, which converts respondent rankings into mean scores. As shown in Table 3, high price of pesticides was identified as the most significant constraint, with the highest mean score of 72.28, indicating that affordability remains the foremost concern for farmers. This was followed by poor after sales service, which scored 65.02 and ranked second, highlighting issues related to support and service quality. The presence of spurious or imitation products was ranked third with a mean score of 58.97, reflecting farmers' worries about product authenticity and reliability.

Other important constraints included lack of credit facilities (mean score 55.08) and fear of adulteration (mean score 50.31), both indicating financial limitations and concerns about product quality. Moderate mean scores were observed for factors such as lack of knowledge about recommended usage and neglect of Integrated Pest Management (IPM) practices (48.96), inappropriate package sizes (47.43) and poor quality of pesticides (44.81), suggesting a need for enhanced farmer education and better product standardization. Less critical yet relevant issues were environmental pollution and pest resistance (43.48), timely availability

of pesticides (42.66), wrong advice by dealers (39.99) and inadequate extension services and farmer support, which had the lowest mean score of 36.02. These lower scores imply that while these problems exist, they have comparatively less impact on farmers' pesticide purchase decisions than economic and service related constraints

The findings of Singh and Verma (2023) match the results of the present study. They found that high pesticide prices were a big problem for farmers, making it hard for them to buy enough for their crops. They also mentioned the issue of fake or adulterated products, which lowers farmers' trust. Likewise, Gupta and Sharma (2022) found that poor after sales service made farmers unhappy and led them to switch brands. They also noted that many farmers lacked proper knowledge about how to use pesticides and follow IPM practices.

In conclusion, the study effectively brought out the brand preference patterns of cotton farmers in Kadapa district. The most influential factors driving brand preference were previous experience with the product, cost and affordability and dealer's influence. These findings indicate that farmers place high trust in brands they have used before and weigh economic feasibility and dealer recommendations heavily in their decision making process.

Fellow farmers, relatives and progressive farmers emerged as the most trusted sources of information, followed by television and radio, emphasizing the importance of interpersonal networks and mass media in shaping farmer awareness. On the other hand, traditional sources such as pamphlets, newspapers and NGOs had limited impact on brand awareness and selection.

The major constraints faced by farmers included the high price of pesticides, poor after sales service and the presence of spurious products, reflecting significant challenges in affordability, service reliability and product authenticity. Lesser but still relevant issues such as lack of credit, inadequate knowledge and improper packaging also affected the purchase decisions.

Therefore, agrochemical companies and policymakers should tailor their strategies to address the practical concerns of farmers. Enhancing after sales service, ensuring product authenticity, offering credit options and leveraging dealer networks and farmer testimonials can greatly improve brand trust and market penetration. Moreover, strengthening extension services

and regulatory oversight will ensure that farmers make informed and safe pesticide choices, ultimately contributing to more effective and sustainable pest management in cotton cultivation.

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