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EVALUATION OF ACID LIME (*CITRUS AURANTIFOLIA*) VARIETIES IN LATERITIC SOIL CONDITIONS OF ANDHRA PRADESH

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ABSTRACT

The present study was undertaken at Agricultural Research Station, Kavali during 2022–2024 to assess the performance of three acid lime cultivars, namely Pramalini, Balaji and Petluru Selection 1 under red lateritic soil conditions. The experimental layout followed a Randomized Block Design comprising seven replications for comparative evaluation. Among the tested cultivars, Petluru Selection 1 recorded superior growth (plant height 4.47 m; plant spread 4.18 m), yield (414 fruits/plant; 15.71 kg/plant) and juice content (55.3%), along with higher consumer preference, indicating its suitability for lateritic soils of Andhra Pradesh.

Keywords: Acid lime, Andhra Pradesh, Laterite soils, Fruit weight, Fruit Yield.

INTRODUCTION

Acid lime (Citrus aurantifoliaSwingle) is an extensively cultivated citrus crop in tropical and subtropical regions of India, commonly referred to as Pati or Kagzi lime. It is classified under the family Rutaceae and is characterized by its thorny growth habit. The crop has gained commercial importance due to its adaptability and economic returns. The crop is cultivated across multiple states including Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Bihar, Madhya Pradesh, Assam and Chhattisgarh. India ranks among the leading producers of acid lime globally (Rajamanickam *et al.,* 2024). Within India, Andhra Pradesh contributes a substantial share of area and production.

The fruit is recognized for its high ascorbic acid content and possesses considerable antioxidant potential, making it valuable for nutritional and industrial uses. The red and lateritic zones of Andhra Pradesh, covering districts such as YSR Kadapa, Anantapur, Nellore, Prakasam and Kurnool, are characterized by low rainfall and prolonged dry periods, which favor acid lime cultivation. Although flowering occurs throughout the year, distinct bahar seasons (*Ambe, Mrig and Hasta)* influence productivity (Deshmukh *et al.,* 2016). Despite its importance, systematic evaluation of varieties under these specific soil conditions is limited; therefore, the present study was undertaken to identify suitable cultivars for this region.

MATERIAL AND METHODS

The varietal evaluation trial was conducted at Agricultural Research Station, Kavali in SPSR Nellore district. Three acid lime

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cultivars, Pramalini, Balaji and Petluru Selection 1, were included in the study. The experimental layout followed a Randomized Block Design with seven replications. One-year-old seedlings were transplanted at a spacing of 6 × 6 m under square planting geometry during 2016. The experimental field consisted of red lateritic soils, with high temperature conditions reaching up to 47°C during summer and extended dry periods.

All recommended agronomic practices related to nutrient, irrigation and plant protection were uniformly adopted as per recommendations of Dr. YSR Horticultural University. Growth observations such as plant height and canopy spread were recorded from the seventh year of planting during 2022–23 and 2023–24, across different bahar seasons.

Yield parameters including number of fruits per plant, fruit weight and total yield were documented for the same period. Fruit quality attributes such as juice content, total soluble solids (°Brix), titratable acidity (%) and ascorbic acid (mg/100 ml) were estimated using standard laboratory procedures.

Consumer acceptability was evaluated using a 9-point hedonic scale considering attributes such as fruit colour, texture, flavour and overall appearance. The evaluation was carried out by a panel of semi-trained judges, and mean scores were calculated for each variety.

The collected data were statistically analyzed through Analysis of Variance (ANOVA) to determine treatment effects after appropriate transformation to assess treatment differences.

RESULTS AND DISCUSSION

Data summarized in Table 1 demonstrated that the acid lime cultivars differed significantly with respect to plant height and canopy spread. The pooled data (2022–24) revealed that Petluru Selection 1 attained the maximum plant height (4.47 m) and spread (4.18 m), followed by Balaji, whereas Pramalini recorded the lowest values. The variation observed may be explained by differences in varietal response to soil and environmental conditions. Similar trends were reported by Mukunda Lakshmi *et al*. (2023), Rajamanickam (2023) and Srinivas and Govindarajulu (2017).

Statistically significant differences were observed among the cultivars for yield parameters (Table 2). Petluru Selection 1 produced the highest fruit yield (15.71 kg/plant) and number of fruits (414 fruits/plant),

Table 1. Comparative evaluation of growth and yield attributes of acid lime cultivars during 2022-23 and 2023-24 and pooled analysis

	Plant height (m)			Canopy spread (m)			No. of fruits plant^{-1} year^{-1}		
Cultivars	**2022-23**	**2023-24**	**Pooled data**	**2022-23**	**2023-24**	**Pooled data**	**2022-23**	**2023-24**	**Pooled data**
Balaji	4.05	4.08	4.06	3.65	3.90	3.77	320	260	290
Petlur Selection- 1	4.26	4.68	4.47	4.09	4.28	4.18	438	390	414
Pramalini	3.40	3.52	3.46	2.82	2.86	2.84	240	160	200
SEm (+/-)	0.15	0.21	0.40	0.22	0.30	0.51	4.48	6.28	3.70
CD @5%	0.46	0.60	1.26	0.68	1.02	1.62	13.93	18.93	11.26

Table 2. Yields of different Acid lime varieties (2022-23, 2023-24 and pooled)

Varieties	Fruit weight (g)			Yields (Kg per plant per year)		
	2022-23	2023-24	Pooled Data	2022-23	2023-24	Pooled Data
Balaji	40.08	37.08	38.58	12.82	9.64	11.23
Petlur Selection- 1	38.90	36.90	37.9	17.03	14.39	15.71
Pramalini	34.64	30.64	32.64	8.31	4.90	6.60
SEm (+/-)	1.35	1.31	1.10	0.74	0.60	0.55
CD @5%	4.21	4.01	3.42	2.30	1.80	1.65

Table 3. Comparative performance of acid lime cultivars for fruit quality parameters and overall acceptability (2022-24)

Name of the Cultivar	Juice (%)	TSS (°Brix)	Acidity (%)	Ascorbic Acid (%)	Over all Acceptability
Balaji	47.5	8.01	6.65	47.6	8
Petlur Selection- 1	55.3	7.8	6.82	45.4	9
Pramalini	46.4	8.55	6.50	49.7	7
SEm (+/-)	0.48	0.08	0.59	1.01	
CD @5%	1.05	0.18	0.13	2.21	

followed by Balaji variety.The enhanced yield performance may be associated with better canopy development and efficient utilization of available resources. In contrast, Pramalini recorded the lowest yield. Fruit weight was highest in Balaji, followed by Petluru Selection 1 and Pramalini. The superior performance of Petluru Selection 1 may be linked to its genetic potential and adaptability to local conditions. Comparable findings were reported by Kamatyanatti *et al*. (2015), Dinesh *et al.* (2018) and Sonkar *et al.* (2025).

Fruit quality parameters (Table 3) showed significant differences among cultivars. Petluru Selection 1 recorded higher juice content (55.3%) and acidity (6.82%), whereas Pramalini exhibited higher TSS (8.55%) and ascorbic acid content (49.7 mg/100 g). These variations are likely influenced by genetic factors and environment interactions affecting biochemical composition. Consumer preference evaluation based on sensory attributes such as colour, texture and appearance indicated higher acceptance for PetluruSelection 1 and Balaji. Similar observations were reported in earlier studies (Deshmukh *et al.*, 2015; Dinesh *et al.*, 2018).

CONCLUSION

The findings of the present investigation indicate that Petluru Selection 1 is the most suitable variety for lateritic soils of Andhra Pradeshdue to its superior yield (15.71 kg/plant), higher fruit number (414 fruits/plant), better juice content (55.3%) and favorable consumer acceptability.

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IMPACT OF FOLIAR APPLICATION OF SALICYLIC ACID ON SALINITY TOLERANCE IN SORGHUM

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ABSTRACT

Salinity is a major abiotic stress factor that restricts crop growth and yield, particularly in arid and semi arid regions. To mitigate the adverse effects of salinity on crop performance, a field experiment was conducted during the *kharif* seasons of 2023 and 2024 at Kakarlamoodi village. The objective was to evaluate the influence of foliar application of salicylic acid on enhancing salinity tolerance in sorghum. The study was arranged in a randomized block design with six treatments, replicated four times. Five concentrations of salicylic acid (50, 100, 150, 200, and 250 mg L^{-1}) along with a control were tested. Results indicated that foliar application of salicylic acid at 250 mg L^{-1} produced significantly higher grain yields (6300 and 6235 kg ha^{-1}), whereas the lowest yield was observed with 50 mg L^{-1}. Furthermore, total chlorophyll content and antioxidant enzyme activity were maximum under the 250 mg L^{-1} treatment, highlighting its effectiveness in improving sorghum performance under saline conditions.

Keywords: Abiotic stress, Antioxidants, Growth regulators, Salicylic acid, Salinity tolerance.

INTRODUCTION

Plants encounter multiple abiotic stresses during their growth and development, among which salinity is particularly detrimental to agricultural productivity worldwide. Excessive salt accumulation in soils disrupts osmotic balance, ionic homeostasis, and nutrient uptake. Elevated sodium (Naz) concentrations lead to ion toxicity, resulting in membrane destabilization, inhibition of cell division and expansion and impairment of key metabolic processes such as photosynthesis, protein synthesis and lipid metabolism. Collectively, salinity stress induces nutrient imbalances, enzymatic inhibition, metabolic disruption, and alterations in growth regulator levels, ultimately reducing plant growth and yield. Developing salt tolerance in crops is therefore essential to sustain economic productivity. While genetic improvement and breeding strategies offer long term solutions, they are complex and have achieved limited success. In contrast, exogenous application of plant growth regulators and related compounds provides a more practical and efficient approach to mitigate salinity stress. Previous studies have demonstrated that foliar application of growth regulators, fertilizers and antioxidants can alleviate the adverse effects of salinity on plant performance. In this context, the present investigation was undertaken to evaluate the impact of different concentrations

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Table 1. Effect of exogenous application of salicylic acid on Plant height, Ear head length and Test weight of sorghum

Treatments	Plant height (cm)		Ear head length (cm)		Test weight (g)	
	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T_1-Control	137.9	161.2	31.9	30.7	31.4	31.0
T_2-Salicylic acid 50mg L^{-1}	140.9	162.1	33.9	31.0	32.4	32.8
T_3- Salicylic acid 100mgL^{-1}	134.9	163.7	34.2	32.7	31.6	33.1
T_4- Salicylic acid 150mgL^{-1}	139.3	165.7	34.4	33.5	35.1	34.6
T_5-Salicylic acid 200mgL^{-1}	139.5	168.0	35.1	34.2	34.5	34.0
T_6-Salicylic acid 250mgL^{-1}	138.9	170.7	35.5	35.1	33.6	34.2
Sem+	3.59	4.8	0.84	1.3	1.9	1.4
CD (0.05)	NS	NS	2.5	3.9	NS	NS
CV (%)	5.2	5.9	12.0	7.9	11.7	9.6

of salicylic acid on the growth and yield of sorghum under saline conditions.

MATERIAL AND METHODS

A field experiment was conducted over two consecutive *kharif* seasons (2023 and 2024) in farmers' fields at Kakarlamoodi village. The soil at the site was clay textured, neutral in reaction (pH 7.5), and exhibited an electrical conductivity of 7.24 dS m^{-1}. It contained medium levels of organic carbon, low available nitrogen, medium phosphorus, and high potassium. The experiment was arranged in a randomized block design with six treatments, replicated four times. Foliar application of salicylic acid was tested at five concentrations (50, 100, 150, 200, and 250 mg L^{-1}) along with a control. Nitrogen was supplied in three equal splits through urea: one third as basal, one third at the knee high stage, and one third at flowering. Phosphorus (60 kg ha^{-1}) and potassium (40 kg ha^{-1}) were applied uniformly to all plots as basal doses using single superphosphate and muriate of potash, respectively. Irrigation and weed management were carried out as per recommended practices. Data were analyzed statistically following the procedures outlined by Panse and Sukhatme (1978), with significance tested at the 5% level.

RESULTS AND DISCUSSION

The plant height of sorghum was not significantly affected by the different concentrations of salicylic acid during the 2023 and 2024 seasons. However, foliar application of salicylic acid had a marked influence on yield attributes. Ear head length was highest at 250 mg L^{-1} (35.5 and 35.1 cm), which was statistically comparable to the 150 and 200 mg L^{-1} treatments, but significantly superior to the control (31.9 and 30.7 cm). These findings are consistent with earlier reports by Hasan Farahbakhsh and Mohaddeseh Shamsaddin Saiid (2011), who observed that salicylic acid enhanced panicle length and the number of productive structures in plants grown under saline conditions. No significant variation was recorded in the test weight of sorghum across treatments (Table 1).

Table 2 presents the effect of salicylic acid application on sorghum yield. Grain yield was significantly enhanced with foliar application of salicylic acid. The highest grain yield (6235 and

Table 2. Effect of exogenous application of salicylic acid on Yield and Harvest index of Sorghum

	Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Harvest index (%)	
Treatments	**2023-24**	**2024-25**	**2023-24**	**2024-25**	**2023-24**	**2024-25**
T_1-Control	4768	4875	6007	7025	44.2	41.0
T_2-Salicylic acid 50mg L^{-1}	4900	5113	6370	7350	43.5	41.0
T_3- Salicylic acid 100mgL^{-1}	5100	5300	6477	7500	44.1	41.4
T_4- Salicylic acid 150mgL^{-1}	5535	5588	6974	7788	44.2	41.8
T_5-Salicylic acid 200mgL^{-1}	5800	6125	7192	8375	44.6	42.2
T_6-Salicylic acid 250mg L^{-1}	6235	6300	7731	8800	44.6	41.8
Sem+	321.3	314.7	404.8	394.3	1.2	1.0
CD (0.05)	968	949	1220.1	1189	NS	NS
CV (%)	11.9	11.3	11.9	10.1	5.3	6.9

6300 kg ha^{-1}) was obtained at 250 mg L^{-1}, which was statistically comparable to the 150 and 200 mg L^{-1} treatments, but markedly superior to the control (4768 and 4875 kg ha^{-1}). Similarly, straw yield was significantly increased at 250 mg L^{-1} (7731 and 8800 kg ha^{-1}), remaining on par with the 150 and 200 mg L^{-1} treatments, yet significantly higher than the control (7025 and 6007 kg ha^{-1}). These findings corroborate earlier reports by Ahmad Rajabi Dehnavi *et al*. (2022) and Manish Jangra *et al.* (2023), who observed improvements in yield, chlorophyll stability, and assimilate transport in salicylic acid treated plants under saline conditions. Straw yield followed a similar trend, confirming enhanced biomass accumulation. Comparable results were also reported by Shazia Hanif *et al*. (2024) and Manish Jangra *et al*. (2023), who noted increased grain yield and spikelet fertility in barley and sorghum, respectively, under saline soils with foliar application of salicylic acid. No significant differences were observed in the harvest index of sorghum across treatments.

Table 3 illustrates the effect of salicylic acid application on chlorophyll activity in sorghum. Different concentrations of salicylic acid significantly influenced chlorophyll content. The highest chlorophyll *a* (1.62 and 1.79 mg g^{-1}) and total chlorophyll (2.46 and 2.69 mg g^{-1}) were recorded with foliar application of 250 mg L^{-1} salicylic acid, which was significantly superior to the T_1, T_2, T_3 and T_4 treatments, but statistically comparable to T_5. Similarly, chlorophyll *b* content (0.80 and 0.88 mg g^{-1}) was maximized at 250 mg L^{-1}, showing significant superiority over all other treatments. The lowest chlorophyll values (0.60 and 0.53 mg g^{-1}) were observed in the control. These findings are consistent with the observations of Anosheh *et al.* (2012), Ahmad Rajabi Dehnavi *et al.* (2022), and Tahir Mahmood *et al*. (2023), who reported that foliar application of salicylic acid under saline conditions improved chlorophyll retention and stability, protected chloroplast structures, and regulated antioxidant enzyme activity in sorghum.

Table 4 summarizes the influence of salicylic acid on antioxidant enzyme activity in sorghum. Foliar application of salicylic acid significantly affected proline content, peroxidase activity, and total phenol content.

Table 3. Effect of exogenous application of salicylic acid on Chlorophyll contents of Sorghum

	Chlorophyll a (mgg^{-1})		Chlorophyll b (mgg^{-1})		Total chlorophyll ($mg\ g^{-1}$)	
Treatments	**2023-24**	**2024-25**	**2023-24**	**2024-25**	**2023-24**	**2024-25**
T_1-Control	1.20	1.11	0.60	0.53	1.71	1.63
T_2-Salicylic acid 50mg L^{-1}	1.21	1.14	0.61	0.56	1.82	1.70
T_3- Salicylic acid 100mgL^{-1}	1.29	1.23	0.64	0.62	1.93	1.85
T_4- Salicylic acid 150mgL^{-1}	1.37	1.39	0.65	0.70	2.02	2.09
T_5-Salicylic acid 200mgL^{-1}	1.53	1.72	0.70	0.79	2.25	2.43
T_6-Salicylic acid 250mg L^{-1}	1.62	1.79	0.80	0.88	2.46	2.69
Sem+	0.03	0.09	0.03	0.03	0.14	1.66
CD (0.05)	0.09	0.27	0.09	0.08	0.43	0.5
CV (%)	15.3	14.3	9.6	9.5	11.5	12.5

The highest proline levels (1.45 and 1.29 mg g^{-1}) were observed with 250 mg L^{-1} salicylic acid, which was significantly superior to all other treatments. Maximum peroxidase activity was recorded under T6 (3.9 and 4.6 OD min{ ¹ g^{-1}), followed by T_5, T_4, and T_3, and was significantly higher than T_2 and T_1. The lowest peroxidase activity (3.0 and 3.7 OD min{ ¹ g^{-1}) was noted in the control. Similarly, total phenol content was greatest under T_6 (89.3 and 76.2%), significantly surpassing all other treatments and the control (41.9 and 39.5%), and was statistically comparable only to T_5. These improvements reflect enhanced osmotic adjustment and strengthened antioxidative defense mechanisms. Previous studies by Ahmad Rajabi Dehnavi *et al*. (2022) and Akanksha Jaiswal *et al.* (2014) reported similar

Table 4. Effect of exogenous application of salicylic acid on Proline, Peroxidise and Total Phenol content of Sorghum

	Proline content ($mg\ g^{-1}$)		Peroxidase activity (O.D $min^{-1}g^{-1}$)		Total Phenols (%)	
Treatments	**2023-24**	**2024-25**	**2023-24**	**2024-25**	**2023-24**	**2024-25**
T_1-Control	0.41	0.53	3.0	3.7	41.9	39.5
T_2-Salicylic acid 50mg/L	0.55	0.68	3.4	3.9	49.6	45.2
T_3- Salicylic acid 100mg/L	0.65	0.79	3.7	4.2	60.1	51.7
T_4- Salicylic acid 150mg/L	0.66	0.86	3.7	4.3	73.9	59.7
T_5-Salicylic acid 200mg/L	0.84	0.95	3.8	4.5	84.2	68.2
T_6-Salicylic acid 250mg/L	1.45	1.29	3.9	4.6	89.3	76.2
Sem+	0.06	0.106	0.14	0.13	3.77	3.8
CD (0.05)	0.18	0.32	0.4	0.4	11.4	11.6
CV (%)	14.6	9.6	12.4	14.1	11.3	13.5

Table 5. Effect of exogenous application of salicylic acid on Protein and Carotenoid content of Sorghum

	Proline content in grain (mg g^{-1})		Protein content in straw (mgg^{-1})		Carotenoids (mgg^{-1})	
Treatments	**2023-24**	**2024-25**	**2023-24**	**2024-25**	**2023-24**	**2024-25**
T_1-Control	6.7	6.0	2.4	2.5	0.57	0.37
T_2-Salicylic acid 50 mg L^{-1}	7.3	6.4	3.6	3.3	0.66	0.46
T_3- Salicylic acid 100mgL^{-1}	7.5	6.8	4.0	3.8	0.70	0.60
T_4- Salicylic acid 150mgL^{-1}	8.1	7.2	4.2	4.1	0.72	0.63
T_5-Salicylic acid 200mgL^{-1}	8.4	7.6	4.6	4.4	0.76	0.68
T_6-Salicylic acid 250mgL^{-1}	9.6	8.5	4.9	4.8	0.85	0.73
Sem+	0.4	0.3	0.3	0.3	0.04	0.03
CD (0.05)	1.3	1.1	0.8	0.7	0.13	0.09
CV (%)	10.9	11.8	11.8	12.0	12.1	10.7

outcomes, where salicylic acid application increased proline accumulation, peroxidase activity and phenolic compounds in sorghum and soybean. These effects were associated with activation of stress responsive genes, stimulation of the phenylpropanoid pathway, and more efficient scavenging of reactive oxygen species (ROS).

Table 5 presents the effect of salicylic acid application on protein and carotenoid content in sorghum. Different concentrations of salicylic acid significantly influenced both parameters. The maximum protein content in grain (9.6 and 8.5 mg g^{-1}) and straw (4.9 and 4.8 mg g^{-1}) was observed under T6 treatment. Grain protein content was statistically comparable to T_5, while straw protein content was on par with both T_5 and T_4, and significantly superior to the remaining treatments. Similar findings have been reported in tomato, where soluble protein levels increased in leaves and stems under saline conditions (Amini and Ehsanpour, 2005). Likewise, El Tayeb (2005) demonstrated that salicylic acid application enhanced protein and amino acid accumulation in maize grown under salinity stress. Carotenoid content was also significantly affected, with the highest values (0.85 and 0.73 mg g^{-1}) recorded under T_6, followed by T_4 and T_5. The lowest carotenoid content (0.57 and 0.37 mg g^{-1}) was observed in the control.

CONCLUSION

Salicylic acid is a plant derived phenolic compound that functions as a growth regulator and stimulates diverse physiological processes. It plays a role in seed germination, ion absorption and transport, ion compartmentalization, and regulation of membrane permeability. Salicylic acid is recognized as one of the most effective phyto protectants, mitigating the adverse effects of salt induced osmotic and ionic stress and thereby enhancing salt tolerance in many plant species. The present study demonstrated that foliar application of salicylic acid at 250 mg L^{-1} significantly improved yield attributes, grain yield, chlorophyll content, and antioxidant enzyme activity in sorghum grown under saline conditions, thereby contributing to enhanced salinity tolerance.

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IDENTIFICATION OF RESISTANT SOURCES TO WHIP SMUT OF SUGARCANE CAUSED BY *SPORISORIUM SCITAMINEUM*

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ABSTRACT

Whip smut causing pathogen in Sugarcane has the potential to cause substantial losses to farmers. Sugarcane cultivars which are susceptible, should be replaced with resistant ones that have desirable yield attributes. Twenty four Sugarcane genotypes were selected for artificial inoculation to identify resistant genotype to smut disease. Setts dipped in smut spore suspension before planting and collected data on production of smutted whips in genotypes. Among the genotypes tested, 2016 V130 was found resistant, while 2016 V 35, 2017 V 16, 2018 V 42, 2018 V 48, 2018 V 53 and 2018 V 79 were found moderately resistant to smut pathogen.

Key words: Genotypes, Resistance, Screening, Smut, Sugarcane

INTRODUCTION

India is the second major country producing 435 million tonnes of sugarcane from an area of 5.37 million ha. (First advance estimates, 2024-25, Ministry of Agriculture & Farmer's Welfare, India). Sugarcane production is affected by different biotic and abiotic stresses particularly plant diseases. Among the sugarcane diseases, whip smut is a major disease caused by a biotrophic fungus, *Sporisorium scitamineum* resulting in severe yield losses globally (Su *et al*., 2016). The intensity of the disease depends on two major factors, *viz*., level of resistance in the plant genotype and virulence level of the pathogen. The disease severity of sugarcane smut varies greatly, ranging from 10-80%, depending on the climatic conditions, the prevalence of pathogen races and the susceptibility of the sugarcane varieties under cultivation in a given area (Monteiro Vitorello *et al*., 2018 and Nalayeni *et al*., 2021). Due to frequent evolution of pathogen races it is essential to introduce resistant varieties to compete over. Therefore, screening genotypes for smut resistance should be done as continuous process. Due to overlapping of most of the characteristics within the species, there is a need for information on pre detection and diagnostics strategies to manage the smut causal organism (Rajput *et al*., 2021). Whip smut disease being the reason for substantial losses in cultivation of susceptible cultivars, the varieties should be replaced with resistant ones to minimize losses. The most potential and cheapest method of controlling sugarcane diseases are the growing of resistant cultivars. Until now, the most effective management strategy for

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Table 1. Disease rating scale (Amrate *et al*., 2019) for smut disease of sugarcane

S.No.	Percent Infestation	Reaction
1	0-1%	Resistant (R)
2	1-10 %	Moderately resistant (MR)
3	10-20 %	Moderately susceptible (MS)
4	20-30 %	Susceptible (S)
5	Above 30%	Highly susceptible (HS)

sugarcane smut is the cultivation of resistant cultivars (Sundar *et al*., 2015; Sundar *et al*., 2018). Hence, screening of sugarcane genotypes for smut resistance was undertaken to identify resistant sources.

MATERIAL AND METHODS

The screening field trial was conducted for three consecutive years (2021-22, 2022-23 and 2023-24) in Sugarcane Research station at Vuyyuru of Acharya N.G Ranga Agricultural university, Andhra Pradesh, India. Twenty four sugarcane genotypes with good qualitative and quantitative parameters were selected for smut screening studies. The varieties, 87 A 298 and 2003 V 46 were used as susceptible, resistant checks respectively for this study. Freshly collected smutted whips from previous season crop were air dried by keeping under shade and the teliospores of *Sporisorium scitamineum* were collected in butter paper bags and were stored in desiccators. Artificial inoculation was done by Sett dip method. Two budded Sugarcane setts were inoculated by soaking in a smut spore suspension (1 x 10^6 spores/ml) for 30 minutes. A sticker / spreader at 1 ml/ 2 litres was added to spore suspension. The concentrations of teliospores were standardized by using haemocytometer.

Data on number of smutted whips per stool, smut incidence per population, sprout count and number of tillers per plot were recorded. Data collection on smut incidence in sugarcane genotypes began one month after planting. Data on germination count and tiller population were taken at 45 days and four months after planting respectively. Except sprout and tiller count, the data collection was continued upto harvesting at fortnight intervals for the sugarcane genotypes under study. Percent disease incidence of the smut was computed using formula as indicated below.

$$\text{Smut incidence (\%)} = \frac{\text{Total member of infected stools / plot}}{\text{Total member of stools / plot}} \times 100$$

RESULTS AND DISCUSSION

Sugarcane genotypes which promoted to yield trials were screened for smut disease as the disease primarily spreads through setts and soil borne inoculum and causes significant losses in productivity of this crop. Twenty four genotypes including check varieties were evaluated during 2021-22, 2022-23 and 2023-24 season for their reaction to smut disease. The susceptible sugarcane stems were observed to be relatively small and the internodes are long. based on the disease rating scale, genotypes were categorized as resistant, moderately resistant and susceptible, susceptible and highly susceptible. Each genotype was screened for 3 consecutive years to identify the resistant source. Out of 24 genotypes screened, one genotype (2016 V130), was found resistant and seven genotypes (2016 V 35, 2017 V 16, 2018 V 42, 2018 V 47, 2018 V 48, 2018 V 53

Table 2. Reaction of Sugarcane genotypes to smut disease (Disease incidence observed over three years)

S.No	Variety/genotype	Percent smut infection	Smut Reaction
1	2016 V 35	7.3	MR
2	2016V74	10.8	MS
3	2016V130	0.0	R
4	2017 V2	11.6	MS
5	2017 V4	11.6	MS
6	2017V13	13.9	MS
7	2017V15	12.0	MS
8	2017V16	4.3	MR
9	2017 V 23	11.5	MS
10	2017 V 42	12.8	MS
11	2017V57	12.0	MS
12	2017 V70	11.0	MS
13	2018V7	12.5	MS
14	2018V38	11.0	MS
15	2018V42	2.8	MR
16	2018V47	3.1	MR
17	2018V48	1.4	MR
18	2018V53	2.2	MR
19	2018V57	12.0	MS
20	2018V60	11.0	MS
21	2018V78	14.6	MS
22	2018V79	2.4	MR
23	87 A 298 (SC)	30.4	S
24	2003V46 (RC)	0.0	R

and 2018 V 79) were found moderately resistant to smut pathogen. The varieties, 87 A 298 and 2003 V 46 were used as susceptible and resistant check respectively for this study.

CONCLUSION

The genotypes rated as resistant against whip smut of sugarcane can be exploited for development of smut resistant variety of sugarcane whereas genotypes rated as susceptible can be exploited as susceptible check for screening against smut disease of sugarcane. Development of resistant varieties is the eco-friendly and sustainable option to control the smut disease of sugarcane.

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RESPONSE OF COLOURED RICE CULTIVARS TO ZINC NUTRITION

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ABSTRACT

An experiment was conducted in the Farm of agricultural college, Bapatla, during *kharif,* 2023 to examine the response of zinc foliar fertilisation on the growth, yield attributes, yield and nutrient uptake of coloured rice (*Oryza sativa* L.). The experiment was laid by using split-plot design with three replications. The main plot contained four rice cultivars: M_1- Navara, M_2- BPT-2858, M_3- BPT-2841 and M_4- Kujipatalia. In the sub-plots, $ZnSO_4$ foliar spraying was done at various stages: S_1- No zinc, S_2- Application of $ZnSO_4$ @ 0.2% at tillering stage, S_3- Application of $ZnSO_4$ @ 0.2% at tillering and panicle initiation stages and S_4- Application of $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting stages. The results indicated that the Kujipatalia variety (M_4) produced the maximum number of tillers, dry matter accumulation, productive tillers per square meter, panicle length, total grains per panicle, grain yield (4480 kg ha^{-1}), straw yield, harvest index, and nutrient uptake. Foliar application of ZnSO„ at 0.2% during the tillering, panicle initiation, and booting stages (S_4) was found to be significantly superior to other treatments, except for S_3. Conversely, the Navara variety (M_1), when not received foliar zinc application, recorded the lowest values of all the parameters of coloured rice cultivars. However, it displays Kujipatalia variety shows highest yield and yield attributes relative to the other cultivars.

Keywords: Coloured rice; Growth; Nutrient uptake; Yield; Zinc fertilization.

INTRODUCTION

Rice has gained notable prominence in recent years, particularly among individuals who emphasize nutritional benefits (Mrudula *et al.,* 2023) while also appreciating its cultural and traditional significance. Among the coloured rice cultivars, different shades of black rice and red rice cultivars are popular in cultivation and germplasm improvement programmes. Black rice has a profound impact on culinary traditions and cultural activities, starting from its roots in Asia and continuing to its current comeback in world cuisine. Black rice had gained significant interest among coloured rice cultivars due to its sensory attributes (Ito and Lacerda, 2019).

Continuous use of primary nutrients alone has resulted in zinc (Zn) deficit in the majority of the rice-growing soils of the worldand in particular Andhra Pradesh, leading to inadequate zinc supplementation. The Zn deficiency in rice-eating regions like Andhra Pradesh is at risk from inadequate Zn intake.

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The levels of zinc in both polished and unpolished rice are naturally insufficient to fulfil the human body's requirements for this essential mineral . Zn deficiency also limits rice yields (Mrudula *et al*., 2023) and its availability is limited under high soil pH and bicarbonate conditions.

In addition to the non-coloured cultivars, coloured rice cultivars are evaluated for insufficient Zn to alleviate Zn malnutrition (Rakotondramanana *et al*., 2024).Enhancing the zinc concentration in rice can be addressed through foliar fertilisation. Foliar fertilization contributes more than soil application for increasing Zn concentration in rice, as assessed by immediate crop response to applied nutrients.Different cultivars of rice showed wide variation in grain and straw yield, uptake both with and without Zn application (Prakash *et al*., 2018) and in different environments (Wissuwa *et al*.,2008. Researchers worked on the time of application to correct the Zn deficiency and yield enhancement and concluded that correcting the zinc deficiency and application time at heading, flowering, and early milk stage (Fongfon *et al*., 2021) enhanced the yield. Limited research was reported on black-coloured rice cultivars response to different foliar nutrition of Zn on growth, yield attributes, and grain nutrient uptake and their effect on grain yield of rice. Hence the present study was under taken.

MATERIAL AND METHODS

The experiment was conducted during the *Kharif* season of 2023 at the Agricultural College Farm, Bapatla, Andhra Pradesh, India. The experimental site is situated at a longitude of 80.30^0 East and a latitude of 15.54^0 North, with an elevation of 5.49 metres. The soil at the experimental site is classified as sandy clay loam, with a pH of 7.2 and an electrical conductivity of 0.21 dS m^{-1}. It contains medium levels of organic carbon (0.45%) and phosphorus (38.2 kg ha^{-1}), but is deficient in nitrogen (235.2 kg ha^{-1}) and zinc (0.29 ppm). The mean maximum temperature recorded during the cropping period was 33.2ºC, while the average minimum temperature was 23.7ºC. In 2023, the cumulative rainfall recorded during the cropping season was 900.8 mm. The study was conducted using a split-plot design with three replications. The main plot included four different rice cultivars: M_1- Navara, M_2- BPT-2858, M_3- BPT-2841, and M_4- Kujipatalia. In the sub-plots, foliar application of $ZnSO_4$ at various stages. S_1 - No zinc; S_2- application of $ZnSO_4$ at a concentration of 0.2% during the tillering stage; S_3 - application of $ZnSO_4$ at a concentration of 0.2% during the tillering and panicle initiation stages; and S_4 - application of $ZnSO_4$ at a concentration of 0.2% during the tillering, panicle initiation, and booting stages were individually evaluated. Twenty-five-day-old seedlings were transplanted at a spacing of 20 cm × 15 cm. The recommended fertilizer dose of 120:60:40 kg N, P_2O_5 and K_2O ha^{-1} was applied in split doses at the basal, tillering, and panicle initiation stages. Other crop management practices were followed as per standard recommendations. The recorded data were subjected to statistical analysis using Fisher's method of analysis of variance as described by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Table 1 indicated that at harvest, the Navara variety exhibited significantly greater plant height (138.8 cm) compared to all other varieties, except BPT-2841. The tallest plants were observed under the application of $ZnSO_4$ during the tillering, panicle initiation, and booting stages (S_4), whereas the shortest plants were recorded under the control treatment without zinc application (S_1). Mandal and Ghosh (2021) reported that zinc enhances plant height through its role in chlorophyll synthesis, enzyme activation, and stomatal

Table 1. Plant height (cm) of coloured rice varieties at harvest influenced by zinc fertilization

Coloured rice varieties	Foliar application of $ZnSo_4$ @ 0.2%				Mean initiation
	S_1: No zinc	S_2 : Tillering stage	S_3:Tillering and panicle stages	S_4: Tillering, panicle initiation and booting stages	
M_1: Navara	127.1	138.4	143.0	146.8	138.8
M_2: BPT-2858	118.9	127.9	130.5	138.4	128.9
M_3: M_3: BPT-2841	117.2	123.6	124.5	128.4	123.4
M_4: Kujipatalia	118.6	123.0	124.5	127.5	123.4
Mean 120.5	128.2	130.6	135.3		
SEm+	CD (0.05)	CV (%)			
Main plot	3.4	11.6	9.0		
Sub plot 4.6	13.6	12.5			
(M X S)					
S at same M	8.0	23.5			
M at same or different S	7.5	21.1			

regulation. Adequate zinc availability promotes enzymatic activity and auxin metabolism, thereby contributing to increased plant height. The maximum plant height was achieved with the Navara variety in combination with $ZnSO_4$ application

As presented in Table 2, among the colored rice cultivars tested, Kujipatalia produced the highest drymatter, followed by BPT-2858 and Navara. The maximum drymatter accumulation was observed when $ZnSO_4$ was applied at the tillering, panicle initiation, and booting stages, followed by its application at the tillering and panicle initiation stages. Zinc supplementation enhanced the synthesis of tryptophan and indole-3-acetic acid (IAA), which are key factors contributing to both fresh and dry biomass production (Tetarwal *et al.* 2011).No zinc application treatment recorded the lowest drymatter. Suresh and Salakinkop (2016) observed that Zn increased photosynthetic rate and nutrient uptake, thereby increasing plant drymatter production. The highest drymatter production was recorded with Kujipatalia variety with $ZnSo_4$ @ 0.2% application at tillering, panicle initiation and booting stages and the lowest drymatter production was recorded with navara variety with no zinc application.

Cultivars and zinc fertilisation significantly affected productive tiller number (Table 3). The Kujipatalia (319 m^{-2}) reported maximum productive tillers, followed by the BPT-2841 variety (312m^{-2}), BPT-2858 variety (273m^{-2}) and Navara variety (245m^{-2}). Zinc fertilization applied at the tillering, panicle initiation, and booting stages resulted in the highest number of productive tillers (304 m^{-2}), followed by 294 m^{-2} and 285 m^{-2} in the subsequent treatments. Mustafa *et al.,* (2011) reported that adequate zinc supply enhances the uptake and availability of essential nutrients, thereby improving plant metabolic processes and overall crop growth. In the

Table 2. Drymatter production (kg ha^{-1}) of coloured rice varieties at harvest influenced by zinc fertilization

Coloured rice varieties		Foliar application of $ZnSo_4$ @ 0.2%				
		S_1: No zinc	S_2: Tillering stage	S_3:Tillering and panicle initiation stages	S_4: Tillering, panicle initiation and booting stages	Mean
M_1: Navara		7338	7325	7300	7373	7334
M_2: BPT-2858		9150	9439	10013	10698	9825
M_3: M_3: BPT-2841		8746	9625	10167	10692	9808
M_4: Kujipatalia		9408	9513	9835	10951	9927
Mean	8660	8976	9329	9929		
	SEm+	CD (0.05)	CV (%)			
Main plot		238.0	823	8.9		
Sub plot	318.4	657	8.5			
(M X S)						
S at same M		551.5	1138			
M at same or different S		559.5	1097			

Table 3. Number of productive tillers (m^{-2}) of coloured rice varieties influenced by zinc fertilization

Coloured rice varieties		Foliar application of $ZnSo_4$ @ 0.2%				
		S_1: No zinc	S_2: Tillering stage	S_3:Tillering and panicle initiation stages	S_4: Tillering, panicle initiation and booting stages	Mean
M_1: Navara		234	248	243	253	245
M_2: BPT-2858		262	271	277	283	273
M_3: M_3: BPT-2841		270	308	327	344	312
M_4: Kujipatalia		299	312	327	337	319
Mean	266	285	294	304		
	SEm+	CD (0.05)	CV (%)			
Main plot		6.9	24	8.4		
Sub plot	7.4	22	9.0			
(M X S)						
S at same M		12.8	37			
M at same or different S		12.6	35			

Table 4. Panicle length (cm) of coloured rice varieties influenced by zinc fertilization

Coloured rice varieties	Foliar application of $ZnSo_4$ @ 0.2%				Mean
	S_1: No zinc	S_2: Tillering stage	S_3:Tillering and panicle initiation stages	S_4: Tillering, panicle initiation and booting stages	
M_1: Navara	20.3	21.1	21.8	22.3	21.4
M_2: BPT-2858	20.7	21.3	21.9	22.6	21.6
M_3: BPT-2841	20.9	21.6	22.9	23.3	22.1
M_4: Kujipatalia	21.4	22.0	23.2	23.5	22.5
Mean	20.8	21.5	22.5	22.9	
SEm+	CD (0.05)	CV (%)			
Main plot	0.45	NS	8.1		
Sub plot0.34	1.0	9.3			
(M X S)					
S at same M	0.58	1.7			
M at same or different S	0.64	2.9			

absence of zinc application, the number of productive tillers was significantly lower (266 m^{-2}). The interaction effect between zinc fertilization and colored rice cultivars was also significant. The Kujipatalia variety, when supplemented with $ZnSO_4$ at tillering, panicle initiation and booting had at the tillering, panicle initiation, and booting stages, recorded the highest number of productive tillers (404 m^{-2}), whereas the lowest count was observed in the Navara variety under the control treatment without zinc application.

Panicle length did not alter significantlyamong the coloured rice cultivars, but zinc fertilisation influenced panicle length. With zinc fertilisation at tillering, panicle initiation and booting produced the longest panicles (22.5 cm)as presented in Table 4. Welch and Graham (2008) suggested that zinc's role in protein synthesis, membrane function, and cell elongation may explain the increase in panicle length. Welch *et al.* (2008) reported that the improvement in panicle length might be attributed to the vital role of zinc in maintaining the structural ability of cell membranes and its use in protein synthesis, membrane function and cell elongation. The Kujipatalia variety with $ZnSO_4$at tillering, panicle initiation and booting had the longest panicles, while the Navara variety with no zinc had the shortest panicles.

Coloured rice cultivars and Zinc fertilisation increased number of grains $panicle^{-1}$. Kujipatalia cultivar (255) had recorded the highest grains $panicle^{-1}$ followed by BPT-2841 (250) and BPT-2858 (244).Zinc fertilization at different growth stages significantly increased the number of grains per panicle. The application of ZnSO□ at the tillering, panicle initiation, and booting stages produced the highest grain count per panicle (249). Fergany (2018) reported that foliar application of zinc at three intervals resulted in the maximum number of grains per panicle.

Table 5.Total no. of grains panicle^{-1} of coloured rice varieties influenced by zinc Fertilization

Coloured rice varieties	Foliar application of $ZnSo_4$ @ 0.2%				Mean
	S_1: No zinc	S_2: Tillering stage	S_3:Tillering and panicle initiation stages	S_4: Tillering, panicle initiation and booting stages	
M_1: Navara	178	182	186	190	184
M_2: BPT-2858	229	239	246	263	244
M_3: M_3: BPT-2841	235	242	254	269	250
M_4: Kujipatalia	241	245	259	274	255
Mean	221	227	236	249	
SEm+	CD (0.05)	CV (%)			
Main plot	3.7	13	9.6		
Sub plot 4.0	11	10.0			
(M X S)					
S at same M	7.0	20			
M at same or different S	6.8	19			

Table 6.Spikelet sterility (%) of coloured rice varieties influenced byzinc fertilization

Coloured rice varieties	Foliar application of $ZnSo_4$ @ 0.2%				Mean
	S_1: No zinc	S_2: Tillering stage	S_3:Tillering and panicle initiation stages	S_4: Tillering, panicle initiation and booting stages	
M_1: Navara	17.8	16.9	17.1	16.4	17.0
M_2: BPT-2858	16.0	15.2	14.2	12.5	14.4
M_3: M_3: BPT-2841	14.1	13.3	12.5	11.7	12.9
M_4: Kujipatalia	14.2	13.4	12.4	11.7	12.9
Mean	15.5	14.7	14.1	13.1	
SEm+	CD (0.05)	CV (%)			
Main plot	0.2	0.7	8.3		
Sub plot 0.3	0.8	9.9			
(M X S)					
S at same M	0.5	1.5			
M at same or different S	0.5	2.9			

Table 7. Test weight (g) of coloured rice varieties influenced by zinc fertilization

Coloured rice varieties	Foliar application of $ZnSo_4$ @ 0.2%				Mean
	S_1: No zinc	S_2: Tillering stage	S_3:Tillering and panicle initiation stages	S_4: Tillering, panicle initiation and booting stages	
M_1: Navara	18.5	18.5	18.5	18.6	18.5
M_2: BPT-2858	12.1	12.1	12.2	12.2	12.1
M_3: M_3: BPT-2841	13.1	13.5	13.6	13.8	13.5
M_4: Kujipatalia	14.6	14.8	14.8	14.9	14.8
Mean	14.6	14.7	14.8	14.9	
SEm+	CD (0.05)	CV (%)			
Main plot	0.24	0.8	5.7		
Sub plot 0.41	NS	9.6			
(M X S)					
S at same M	0.71	2.1			
M at same or different S	0.65	2.9			

The Kujipatalia cultivar with $ZnSO_4$ at tillering, panicle initiation and booting hadat tillering, panicle initiation and booting had the higher grains panicle^{-1}, while the Navara cultivar with no zinc had the lowest grains panicle^{-1}.

Data in Table 6 shows that the spikelet sterility varied significantly on both the coloured rice varieties and zinc fertilization.In case of varieties, Kujipatalia variety (12.9%) and BPT-2841(12.9%) variety has recorded significantly thelowest spikelet sterility percent while,significantlythe highest spikelet sterility percent was recorded with Navara variety (17.0%).

Among the zinc fertilization treatments, the lowest spikelet sterility percentage (13.1%) was recorded with the foliar application of ZnSO„ at 0.2% during the tillering, panicle initiation, and booting stages. In contrast, the highest sterility percentage (15.5%) was observed under the control treatment without zinc application. Foliar application of zinc has been reported to enhance pollen grain viability, thereby reducing sterility (Karim *et al.,* 2012). Similar findings were documented by Kandil *et al*. (2022). The interaction between rice cultivars and zinc fertilization was also significant. The Kujipatalia variety, when supplied with ZnSO„ at the critical growth stages, exhibited the lowest spikelet sterility, whereas the Navara variety under the control treatment without zinc application recorded the highest sterility percentage.

As per Table 7, test weight differed significantly only by cultivar but not by zinc fertilisation.The cultivar Navara (18.5 g) and BPT-2858 (12.1 g) had the highest and lowest test weights, respectively. There was no statstically significant difference in zinc fertilisation treatments. The Navara variety with $ZnSO_4$ @ 0.2% at tillering, panicle initiation and booting had the highest test weight, while the BPT-2858 variety with no zinc had the lowest.

Table 8.Grain yield (kg ha^{-1}) of coloured rice varieties influenced by zinc fertilization

Coloured rice varieties	Foliar application of $ZnSo_4$ @ 0.2%				Mean
	S_1: No zinc	S_2: Tillering stage	S_3:Tillering and panicle initiation stages	S_4: Tillering, panicle initiation and booting stages	
M_1: Navara	2980	3330	3474	3489	3318
M_2: BPT-2858	3426	3461	4114	4470	3868
M_3: M_3: BPT-2841	3327	4300	4459	4661	4187
M_4: Kujipatalia	4201	4387	4640	4694	4480
Mean 3484	3869	4172	4328		
SEm+	CD (0.05)	CV (%)			
Main plot	100.90	349	8.8		
Sub plot 103.39	302	9.0			
(M X S)					
S at same M	179.08	523			
M at same or different S	178.01	493			

Grain yield (Table 8) was significantly influenced by colored rice cultivars, zinc fertilization, and their interaction. The Kujipatalia variety recorded the highest grain yield (4480 kg ha^{-1}), which was statistically comparable to BPT-2841 (4187 kg ha^{-1}), while the Navara variety produced the lowest yield (3318 kg ha^{1}. The maximum grain yield (4328 kg ha^{-1}) was obtained with foliar application of $ZnSO_4$ at tillering, panicle initiation and booting hadat 0.2% during the tillering, panicle initiation, and booting stages, which was on par with $ZnSO_4$ at tillering, panicle initiation and booting had application at the tillering and panicle initiation stages (4172 kg ha^{-1}). In contrast, the minimum yield (3484 kg ha^{-1}) was observed under the control treatment without zinc application. Wang *et al.* (2023) reported that foliar zinc application significantly enhances grain yield by increasing spikelet number per panicle, filled grain percentage, and 1000-grain weight. Similar findings were also documented by Xia *et al.* (2018) and Chen *et al*. (2022). The highest yield was achieved with the Kujipatalia variety in combination with $ZnSO_4$ at tillering, panicle initiation and booting had application at all three critical stages, whereas the lowest yield was recorded with the Navara variety under the control treatment.

Straw yield was significantly influenced by colored rice cultivars and zinc fertilization. The maximum straw yield was obtained with the Kujipatalia variety (5374 kg ha^{-1}), followed by BPT-2841 (5255 kg ha^{-1}), while Navara variety recorded the lowest yield (4116 kg ha^{-1}). Among the zinc fertilization treatments, the highest straw yield (5221 kg ha^{-1}) was achieved with $ZnSO_4$ application at the tillering, panicle initiation and booting stages, which was statistically comparable to $ZnSO_4$ application at the tillering and panicle initiation stages (5071 kg ha^{-1}). In contrast, the lowest straw yield

Table 9.Straw yield (kg ha-1) of coloured rice varieties influenced by zinc fertilization

Coloured rice varieties	Foliar application of $ZnSo_4$ @ 0.2%				Mean
	S_1: No zinc	S_2: Tillering stage	S_3:Tillering and panicle initiation stages	S_4: Tillering, panicle initiation and booting stages	
M_1: Navara	3739	4006	4364	4354	4116
M_2: BPT-2858	4460	4276	5082	5385	4801
M_3: M_3: BPT-2841	4805	5185	5473	5557	5255
M_4: Kujipatalia	5231	5313	5363	5589	5374
Mean	4559	4695	5071	5221	
SEm+	CD (0.05)	CV (%)			
Main plot	94.6	327	8.9		
Sub plot 98.9	289	9.2			
(M X S)					
S at same M	171.2	500			
M at same or different S	169.4	470			

Table 10. Harvest index (%) of coloured rice varieties influenced by zinc fertilization

Coloured rice varieties	Foliar application of $ZnSo_4$ @ 0.2%				Mean
	S_1: No zinc	S_2: Tillering stage	S_3:Tillering and panicle initiation stages	S_4: Tillering, panicle initiation and booting stages	
M_1: Navara	43.7	44.0	44.1	44.5	44.1
M_2: BPT-2858	43.4	44.6	44.7	46.0	44.7
M_3: BPT-2841	41.0	45.4	45.6	45.6	44.4
M_4: Kujipatalia	44.5	45.2	46.2	46.3	45.6
Mean	43.2	44.8	45.1	45.6	
SEm+	CD (0.05)	CV (%)			
Main plot	0.4	1.0	3.1		
Sub plot 0.51	1.0	4.0			
(M X S)					
S at same M	0.89	2.67			
M at same or different S	0.84	2.52			

(4559 kg ha^{-1}) was observed under the control treatment without zinc application. Singh *et al.* (2021) reported that zinc application positively influences vegetative growth by enhancing plant height, tiller number, leaf area, and dry matter accumulation, thereby contributing to higher straw yield. A significant interaction was also observed between rice cultivars and zinc fertilization. The Kujipatalia variety, when supplied with $ZnSO_4$ at all three critical stages, produced the highest straw yield, whereas the Navara variety under the control treatment recorded the lowest.

The harvest index (Table10) was significantly influenced by colored rice cultivars and zinc fertilization. The highest harvest index was recorded in the Kujipatalia variety (45.6%), while the lowest was observed in the Navara variety (44.1%). With respect to zinc fertilization, the maximum harvest index (45.6%) was obtained under ZnSO□ application at 0.2% during the tillering, panicle initiation, and booting stages, which was statistically comparable to $ZnSO_4$ application at the tillering and panicle initiation stages (45.1%) and at the tillering stage alone (44.8%). In contrast, the lowest harvest index (43.2%) was recorded under the control treatment without zinc application. Mohapatra *et al.* (2021) reported that zinc application significantly enhances the harvest index of rice. A significant interaction effect was also observed between cultivars and zinc fertilization. The Kujipatalia variety, when combined with $ZnSO_4$ application at all three critical stages, recorded the highest harvest index, whereas the BPT-2841 variety under the control treatment without zinc application exhibited the lowest.

CONCLUSION

The results revealed that the maximum grain yield (3,489 kg ha^{-1}) and straw yield (4,364 kg ha^{-1}) were obtained with Kujipatalia variety while, foliar zinc fertilization at all three stages *viz.,* tillering, panicle initiation and booting stages was an effective approach to increase yield of coloured rice cultivars through $ZnSO_4$ application which reduces the problem of zinc deficiency.

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SUITABILITY OF EARLY MATURING SUGARCANE GENOTYPES FOR DELAYED HARVESTING

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ABSTRACT

An experiment in sugarcane was conducted during 2021-22 to 2023-24 in strip-plot design with three replications at Sugarcane Research Station, Vuyyuru. Sugarcane clones viz., 2012 V 67, 2012 V 123, 2013 V 126 and 2003 V 46 were tested for delayed harvesting. Significantly more number of tillers per hectare were recorded by check variety 2003 V 46 (1,03,085) which was statistically at par with 2012 V 67 (97,154) and 2013 V 126 (94,316) at 90, 180 and 240 days after planting. Millable canes were also significantly higher with 2003 V 46. Significantly higher yield was recorded by 2003 V 46 (105.06 t/ha) followed by 2012 V 67 (96.42 t/ha) and 2013 V 126 (91.24 t/ha). Significantly more sucrose percent was recorded with 2003 V 46 (20.15%) which was followed by 2012 V 123 (20.05%), 2012 V 67 (19.32%) and 2013 V 126 (19.18%).The variety 2003 V 46 recorded significantly more commercial cane sugar (14.5 %) which was statistically at par with 2012 V 123 (14.4%).The study clearly revealed that, the higher cane yield, per cent sucrose and commercial cane sugar were obtained with check variety 2003 V 46 over other new genotypes tested in this study.

Keywords: Commercial cane sugar, Delayed harvesting, Early maturing sugarcane, Genotypes, Juice quality, Sucrose percent.

INTRODUCTION

Sugarcane, an important commercial crop after cotton, accounts for 75 % of the world sugar production (Wang *et al.,* 2010) and is becoming a promising source of biofuel production (Oliveira *et al.,* 2005). In India, sugarcane is grown in several states having varied agro-ecological conditions in tropical (Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Gujarat) and subtropical (Uttar Pradesh, Bihar, Haryana, Punjab, Uttarakhand) conditions. Regardless of vast development in sugarcane research, low productivity is being recorded in the Indian sub-continent (Kulkarni *et al.,* 2010) due to distinct and varied nature of sugarcane cultivation. Lack of early maturing variety, delayed harvesting during the fag end of the crushing season is leading to low recovery of sugar. Cultivation of early maturing high yielding varieties with more sucrose content, resistant to major pests and diseases and adaptability to different agro-ecological situation is viewed as viable solution to enhance the sugarcane production in the

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area. Hence, this study was initiated at Sugarcane Research Station, Vuyyuru to identify high yielding and high sucrose variety for delayed harvesting.

MATERIAL AND METHODS

Three clones viz., 2012 V 67, 2012 V 123 and 2013 V 126 along with one check viz., 2003 V 46 and three monthly intervals harvesting times at 10th, 11th and 12th months after planting (sub plots) were assessed for the study. The experiment was conducted from 2021-22 to 2023-24 in strip- plot design with three replications at Sugarcane Research Station, Vuyyuru of Andhra Pradesh. All the recommended package practices were followed to raise a healthy crop. The germination count was taken at 35 days after planting the setts. The data on yield components viz., tillers at 90, 180, 240 days (‘000/ha), millable canes (NMC) at harvest were recorded and presented in ‘000/ha. The data on yield components viz., single cane weight (kg), girth (cm) and length of millable cane (cm) were taken from randomly selected five plants of each genotype from each replication. Cane yield at harvest was recorded and presented in t/ha. Cane juice at harvest was extracted using power operated crusher and was clarified using lead acetate. The quality parameters *viz.*, juice brix %, sucrose %, commercial cane sugar (CCS) and purity percent were worked out as per Chen and Chou (1993) methodology. The Aalysis of Variance (ANOVA) for the collected data was pooled and was statistically analysed using OPSTAT programme (HAU OPSTAT, 14,139.232.166/ opstat/ default.asp).

RESULTS AND DISCUSSION

Perceptible variation was noticed (Pooled data) among the genotypes with regard to germination percentage. Among the genotypes, 2013 V 126 (57.2%) and 2003 V 46 (57.1%) recorded significantly more germination percentage (Table 1). The germination of the setts will be usually 60-80 percentage in tropical conditions (Jain *et al.* 2006). Similarly, variations were observed among the genotypes with regard to number of tillers at 90, 180, 240 days after planting as well as millable canes at harvest. Significantly more number of tillers per hectare were recorded in 2003 V 46 (1,03,085) which were statistically at par with the number of tillers recorded in 2012 V 67 (97,154) and 2013 V 126(94,316) at 90 days after planting and 180, 240 days after planting and the millable canes were also significantly higher in 2003 V 46 (94,792; 80,096 and 75,340 respectively). However it is comparable with new genotypes 2012 V 67 (91,195) and 2013 V 126 (89,078) at 180 days and with 2012 V 67 (76,211) at 240 days after planting. With reference to time of harvesting, tiller count decreased with delay in harvesting and higher was at 10 months and lesser number was in 12 month after planting (Table 1 and 2).

Significantly higher cane yield was recorded by 2003 V 46 (105.06 t/ha) which was followed by 2012 V 67 (96.42 t/ha) and 2013 V 126 (91.24 t/ha). With regard to time of harvesting early harvested crop (10 months) recorded significantly more cane yield (98.65 t/ha) which was followed by 11 (93.29 t/ha) and 12 months (88.27 t/ha) harvested crop (Table 2).With regard to length, girth and single cane weight there was no such significant differences among the genotypes and time of harvesting (Table 3).

Significantly highest per cent sucrose was recorded in 2003 V 46 (20.15) which was followed by 2012 V 123 (20.05), 2012 V 67 (19.32) and 2013 V 126 (19.18). These results reveal that the early varieties are more efficient in partitioning the dry mater into sucrose during the initial part of the crop cycle as also noticed by Nayamuth *et al.,* during 1999 (Table 4).

Table 1. Effect of genotypes and harvesting times on germination percentage at 35 DAP, number of tillers at 90 DAP and number of shoots at 180 DAP in sugarcane (Pooled analysis of 2021-22 to 2023-24) (Two Plant and One Ratoon Crop)

Varieties (Replace with the word Genotype) (Factor A)	Germination percent at 35 DAP				Number of tillers at 90 DAP				Number of shoots at 180 DAP			
	H-Time of harvesting (Months) (Factor B)				H-Time of harvesting (Months) (Factor B)				H-Time of harvesting (Months) (Factor B)			
	10^{th}	11^{th}	12^{th}	Mean	10^{th}	11^{th}	12^{th}	Mean	10^{th}	11^{th}	12^{th}	Mean
V_1: 2003 V46 (C)	56.3	57.3	57.7	57.1	103305	102970	102979	103085	94061	92882	97433	94792
V_2: 2012 V 67	54.0	52.3	51.3	52.6	107685	93865	89912	97154	96077	88002	89504	91195
V_3: 2012 V 123	48.0	46.7	47.0	47.2	85807	81737	79080	82208	80698	74610	72750	76019
V_4: 2013 V 126	56.3	57.0	58.3	57.2	102899	89977	90073	94316	98363	84703	84167	89078
Mean	53.7	53.3	53.6		99,924	92137	90511		92300	85049	85963	
	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A
CD (p=0.05)	6.9	NS	NS	NS	11695	6901	8813	8203	11888	NS	8635	7609
CV %	10.80	-	-		9.72	6.56	3.13		11.63	-	2.94	

Table 2. Effect of genotypes and harvesting times on number of stalks at 240 DAP, millable canes and cane yield (t/ha) in sugarcane (Pooled analysis of 2021-22 to 2023-24)

Varieties (Factor A)	Number of stalks at 240 DAP				Number of millable canes				Cane yield (t/ha)			
	H-Time of harvesting (Months) (Factor B)				H-Time of harvesting (Months) (Factor B)				H-Time of harvesting (Months) (Factor B)			
	10th	11th	12th	Mean	10th	11th	12th	Mean	10th	11th	12th	Mean
V_1: 2003 V46 (C)	78,930	79,451	81,908	80,096	77,290	73,945	74,785	75,340	105.63	104.78	104.77	105.06
V_2: 2012 V 67	77,846	73,984	76,804	76,211	70,286	68,123	67,125	68,511	98.35	96.69	94.23	96.42
V_3: 2012 V 123	65,320	63,337	59,062	62,573	61,183	57,663	54,430	57,759	93.56	81.42	67.79	80.92
V_4: 2013 V 126	74,728	70,751	70,171	71,883	68,429	64,772	64,427	65,876	97.09	90.30	86.32	91.24
Mean	74,206	71,881	71,986		69,297	66,125	65,191		98.65	93.29	88.27	
	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A
CD (p=0.05)	6,835	NS	5117	3482	6061	3029	4895	4250	8.63	5.78	4.57	4.27
CV %	8.07	-	2.3		7.78	4.02	2.912		8.48	5.14	2.93	

Table 3. Effect of genotypes and harvesting times on length of millable cane (cm), girth of millable cane (cm) and single cane weight (kg) in sugarcane (Pooled analysis of 2021-22 to 2023-24)

Varieties (Factor A)	Length of millable cane (cm)				Girth of millable cane (cm)				Single cane weight (kg)			
	H-Time of harvesting (Months) (Factor B)				H-Time of harvesting (Months) (Factor B)				H-Time of harvesting (Months) (Factor B)			
	10th	11th	12th	Mean	10th	11th	12th	Mean	10th	11th	12th	Mean
V_1: 2003 V46 (C)	264	269	250	293	2.62	2.53	2.63	2.59	1.41	1.42	1.36	1.40
V_2: 2012 V 67	265	282	252	300	2.46	2.54	2.49	2.50	1.40	1.44	1.38	1.41
V_3: 2012 V 123	266	267	263	251	2.45	2.40	2.39	2.41	1.28	1.28	1.24	1.27
V_4: 2013 V 126	263	257	256	292	2.45	2.47	2.42	2.45	1.42	1.39	1.34	1.38
Mean	265	269	255		2.49	2.48	2.49		1.38	1.38	1.33	
	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	-	-	-		-	-	-		-	-	-	

Table 4. Effect of genotypes and harvesting times on sucrose (%), commercial cane sugar and purity (%) in sugarcane (Pooled analysis of 2021-22 to 2023-24)

Varieties (Factor A)	Sucrose (%)				CCS (%)				Purity (%)			
	H-Time of harvesting (Months) (Factor B)				H-Time of harvesting (Months) (Factor B)				H-Time of harvesting (Months) (Factor B)			
	10th	11th	12th	Mean	10th	11th	12th	Mean	10th	11th	12th	Mean
V_1: 2003 V46 (C)	20.13	20.33	19.98	20.15	14.6	14.6	14.3	14.5	97.89	95.71	95.97	96.52
V_2: 2012 V 67	19.43	19.19	19.34	19.32	14.2	13.9	14.0	14.0	96.59	96.47	96.07	96.38
V_3: 2012 V 123	20.04	20.04	20.08	20.05	14.4	14.2	14.5	14.4	96.64	94.83	96.42	95.96
V_4: 2013 V 126	19.12	19.21	19.20	19.18	13.8	13.9	13.9	13.9	97.42	96.20	97.24	96.95
Mean	19.68	19.69	19.65		14.2	14.2	14.2		97.14	95.80	96.43	
	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A	Varieties	Harvesting Time	Factor A at same level of B	Factor B at same level of A
CD (p=0.05)	0.18	NS	NS	NS	0.14	NS	NS	NS	NS	NS	NS	NS
CV %	1.81	-	-		1.83	-	-		-	-	-	

The variety 2003 V 46 has recorded significantly more commercial cane sugar % of 14.5 which is statistically at par with 2012 V 123 (14.4) (Table 4). Similar observations of the significant differences among the promising sugarcane varieties for cane yield and quality characters was also reported by Prabhakar *et al.* (2012). The purity % did not vary among the various genotypes and times of harvesting. The genotype 2012 V 67 could able to maintain yield on delayed harvesting but the genotypes 2012 V 132 and 2013 V 126 fail to maintain yield on delayed harvesting.

CONCLUSION

The study revealed that, the higher yield and sucrose and commercial cane sugar % were obtained in 2003 V 46 over other genotypes tested. The new pre release genotypes tested in the study did not perform well when compared with the check variety and also are not able to maintain yield but the quality (sucrose) was not affected with delay in harvesting among the clones.

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INFLUENCE OF WEATHER PARAMETERS ON SUCROSE ACCUMULATION IN SUGARCANE (*SACCHARUM OFFICINARUM* L.)

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ABSTRACT

The ripening of sugarcane is largely influenced by weather factors such as sunlight, temperature, and rainfall. This study evaluated ten sugarcane clones over two crop years (2023–24 and 2024–25) under the agro-climatic conditions of Andhra Pradesh, India, to assess the effect of weather parameters on sucrose accumulation. The clones were observed from October to February and data on sucrose percentage and weather elements (maximum and minimum temperature, rainfall, and bright sunshine hours (BSSH)) were collected. Correlation analysis revealed that BSSH had a strong positive correlation (r = 0.75) with mean sucrose, followed by minimum temperature (r = 0.54), while rainfall showed a negative correlation (r = –0.68). These results affirm the critical role of incident sunlight and cold weather in enhancing ripening. Clones 2022A 93, 2022A 203, and 2022A 88 demonstrated superior performance across seasons and can be considered for further line development or trait introgression breeding.

Keywords: Sugarcane ripening, Sucrose, Weather impact, Bright sunshine hours, Clone selection

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is a commercially important and climate-sensitive crop, extensively cultivated for its high sucrose content, which serves as a primary source of sugar production in tropical and subtropical regions. Among the numerous factors influencing sugarcane productivity and sugar recovery, weather parameters play a pivotal role in modulating sucrose accumulation in the stalks. The process of ripening, which involves the accumulation of sucrose in internodes, is closely associated with environmental factors. In subtropical and tropical regions, ripening typically begins in the post-monsoon period when vegetative growth slows due to declining temperatures and light intensity (Legendre, 1975; Samui et al., 2003; Shanthi et al., 2023).

Optimal sucrose accumulation generally requires a well-balanced combination of warm temperatures during the growth phase and cool, dry conditions during the ripening phase. According to Legendre (1975), sunlight particularly bright sunshine hours (BSSH) plays a pivotal role in ripening, whereas rainfall during the ripening period may hinder sucrose accumulation by promoting continued

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vegetative growth. Excessive rainfall and elevated temperatures during maturation can reduce sucrose content due to enhanced respiration and dilution effects (Verma et al., 2019). Similarly, fluctuations in relative humidity, solar radiation, and wind speed influence stomatal activity, photosynthesis, and enzymatic processes involved in sucrose metabolism(Scarpari and Beauclair, 2004).

The interaction between weatherfactors such as sunlight, temperature, and rainfall varies significantly across genotypes and environments, necessitating location-specific studies to optimize harvest timing and clone selection. Understanding these interactions is critical for maximizing sugar recovery and ensuring sustainable sugarcane production under increasing climate variability (Mehdi et al., 2024).

The present investigation aimed to evaluate the performance of sugarcane clones under the agro-climatic conditions of Andhra Pradesh over two seasons, focusing on the effect of monthly weather variables on sucrose accumulation. Such studies provide valuable insights for refining varietal adaptation strategies and improving crop management practices to enhance productivity and sugar yield in the region.

MATERIAL AND METHODS

Ten sugarcane clones (2022A 88, 2022A 203, 2022A 241, 2022A 108, 2022A 224, 2022A 29, 2022A 143, 2022A 165, 2022A 93, and 2022A 220) were evaluated during the crop years 2023–24 and 2024–25 at the Regional Agricultural Research Station, Anakapalle, using a Randomized Block Design (RBD) with three replications. These clones were planted under uniform field conditions following standard agronomic practices. Sucrose percentage in cane juice was measured at maturity (February) for two consecutive years (2023–24 and 2024–25). Simultaneously, monthly weather data from October to February, including rainfall (mm), maximum and minimum temperatures (°C), and bright sunshine hours (BSSH), were obtained from the agrometeorological station (RARS, Anakapalle). The average mean sucrose percentage across both years was computed for each clone, and mean monthly weather parameters were calculated for the ripening period. To assess the relationship between environmental variables and ripening, Pearson's correlation coefficients (r) were determined between the mean sucrose values and each climatic parameter.

RESULTS AND DISCUSSION

Sucrose Accumulation in Clones

This variation in climatic conditions corresponded with changes in sucrose accumulation among the ten sugarcane clones. Most clones showed higher sucrose percentage in 2024–25, coinciding with drier and sunnier weather, suggesting favorable conditions for ripening. Clone 2022A 93 recorded a mean sucrose of 22.57%, followed by 2022A 203 (21.62%) and 2022A 88 (21.14%), which consistently outperformed other clones in both years (Table 1 and Fig 1).

Correlation between weather parameters and sucrose

To assess the influence of weather factors on ripening, correlation analysis was conducted between the mean sucrose percentage (across two years) and the seasonal averages of rainfall, maximum and minimum temperature, and BSSH (Table 2 and Fig 2).

Bright Sunshine Hours (BSSH) showed the strongest positive correlation (r = 0.75) with sucrose content. This finding aligns closely

Table 1. Mean Sucrose Percentage of Ten Sugarcane Clones across Two Crop Years (2023–24 and 2024–25)

Clone	Mean Sucrose (%)	Clone	Mean Sucrose (%)
2022A 93	22.57	2022A 143	18.62
2022A 203	21.62	2022A 108	18.58
2022A 88	21.14	2022A 220	18.89
2022A 224	19.6	2022A 29	18.4
2022A 165	18.63	2022A 241	17.83

Table 2. Pearson's correlation coefficients between mean sucrose percentage and climatic parameters

Weather Parameter	r (Correlation with Mean Sucrose)
Rainfall	“0.68
Max Temperature	0.41
Min Temperature	0.54
BSSH	0.75

with Legendre (1975), who identified incident sunlight as a major factor driving ripening by enhancing photosynthetic efficiency. Increased sunlight leads to better dry matter partitioning and higher sugar storage in the cane stalks (Legendre, 1975).

Minimum temperature also exhibited a moderate positive correlation (r = 0.54). Warmer nights during the ripening phase may facilitate enzymatic activity involved in sucrose synthesis and translocation. This supports previous findings that, although cooler temperatures can reduce vegetative growth and favor ripening, excessively low temperatures may hinder sugar accumulation. Maximum temperature had a weaker positive correlation (r = 0.41), indicating that day temperatures were not as critical as night temperatures or sunlight in this subtropical environment (Legendre, 1975).

Rainfall was negatively correlated with sucrose content (r = “0.68), suggesting that excess rainfall during ripening is detrimental to sucrose accumulation. This is likely due to reactivation of vegetative growth and dilution of sugars in the cane juice under wet soil conditions. Notably, during December 2023–24, rainfall peaked at 179 mm, and many clones recorded lower sucrose values compared to the following year (Cardozo *et al.* 2015).

Clone Performance and Environmental Responsiveness

Among the clones evaluated, 2022A 93, 2022A 203, and 2022A 88 stood out for their consistent high sucrose content across seasons. These genotypes appear to be more responsive to increased sunlight and less sensitive to rainfall, suggesting greater physiological efficiency in partitioning assimilates to sucrose under varying environmental conditions.

Conversely, clones like 2022A 241 and 2022A 29 performed poorly, with mean sucrose

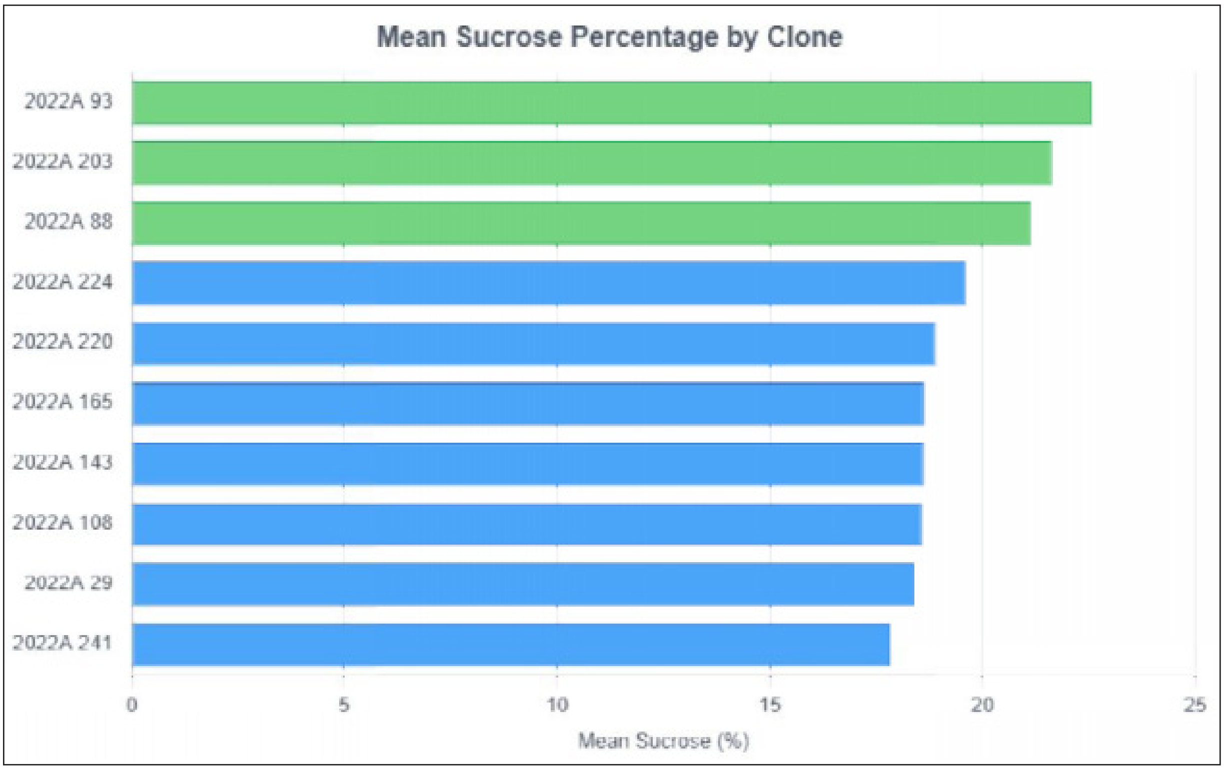

Fig 1. Mean sucrose concentration in ten sugarcane clones during 2023–24 and 2024–25

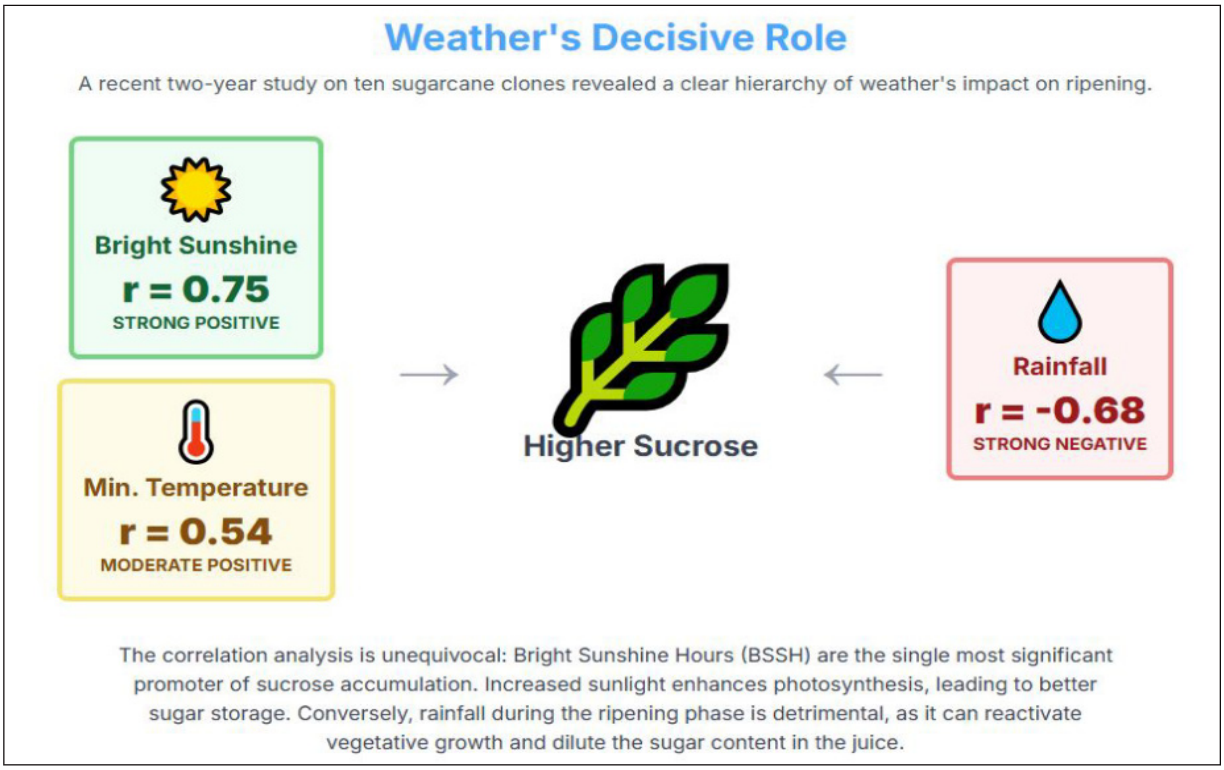

Fig. 2.Pearson's correlation of sucrose content with bright sunshine, temperature, and rainfall

levels below 18.5%, indicating either a late-ripening nature or lower adaptation to the given climatic conditions. These genotypes may require a longer maturation window or more favorable environments to express their full potential.

CONCLUSION

The results of this study indicate that sunlight is the most influential climatic factor affecting sugarcane ripening in subtropical conditions. In the present context, higher BSSH and lower rainfall created an optimal environment for sucrose accumulation. The impact of temperature, though present, was less direct, acting more through interactions with sunlight than as an independent factor. Moreover, the negative impact of rainfall during the ripening phase underscores the importance of regulated irrigation or rain sheltering practices in sugarcane farming during critical ripening stages, especially in regions experiencing untimely winter rainfall.

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TILLAGE AND NITROGEN MANAGEMENT EFFECT ON ENERGY EFFICIENCY IN AEROBIC RICE

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ABSTRACT

A field experiment conducted at the Indian Institute of Rice Research, Hyderabad, Telangana, India, during the *rabi* season (November-April) of 2022 and 2023 assessed the impact of tillage practices and nitrogen fertilizer schedules on energy efficiency in aerobic rice. The study employed three tillage treatments (T) and five nitrogen fertilizer schedules (N) in a strip plot design with three replications. Results revealed that Conventional tillage (T_1) showed higher energy input, whereas zero tillage (T_3) showed lower energy input. Higher Gross Energy Output (GEO), Net Energy Output (NEO), Energy Use Efficiency (EUE) and Energy Productivity (EP) obtained under Conventional tillage (T_1) which is statistically comparable with minimum tillage with residue retention (T_2) and significantly higher over zero tillage (T_3). Zero tillage (T_3) resulted in the highest energy intensity in physical terms (EIP). Energy Intensity in Economic terms (EIE) was not significantly influenced by tillage practices. Among nitrogen fertilizer schedules, the treatment 100% RDN + foliar spray of 2.5 ml l^{-1} nano urea at tillering and before panicle initiation stage (N_2) yielded the highest energy metrics, including GEO and NEO, EUE, EP and EIP which is statistically comparable to 100% RDN (N_1). Conventional tillage (T_1) and 100% RDN (N_1) treatment demonstrated superior performance across various energetics, emphasizing their effectiveness in enhancing the energetic efficiency of aerobic rice cultivation. Overall, conventional tillage and recommended nitrogen management were most effective, while conservation tillage performed on par with conventional tillage in aerobic rice.

Keywords: Aerobic Rice, Energy Efficiency, Tillage Practices, Nitrogen Fertilizer Schedules

INTRODUCTION

Energy optimization in crop production systems is crucial for enhancing sustainability, improving resource-use efficiency, and reducing environmental footprints, especially in the context of increasing energy costs and climate change challenges (Banerjee *et al*., 2021). Efficient energy use not only lowers input costs but also contributes to long-term agricultural productivity and ecological balance by minimizing greenhouse gas emissions and non-renewable energy consumption.

Aerobic rice cultivation, which is characterized by growing rice under non-flooded, unsaturated soil conditions, represents a water-saving alternative to traditional puddled rice systems (Mahapatra *et al*., 2021). However, the success of aerobic rice systems largely

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depends on effective soil and nutrient management strategies. Among these, tillage and nitrogen management are two critical agronomic practices that significantly influence energy inputs, crop growth dynamics, and overall system productivity. Tillage affects soil physical properties, root development (Martins *et al*., 2021), and controls weeds, while nitrogen management determines nutrient availability, crop biomass accumulation and grain yield.

This study is designed to systematically compare the energy efficiency of different tillage methods such as conventional tillage, minimum tillage and zero tillage alongside varying nitrogen fertilizer schedules, including conventional urea and innovative sources (nano urea and nano DAP). The objective is to identify combinations that not only maintain or improve yield but also optimize energy input-output ratios. Analyzing parameters such as energy input from fuel, fertilizers, labor, and machinery, and energy output in terms of grain and straw yields, the research aims to determine the most energy-efficient and sustainable management practices for aerobic rice systems.

MATERIAL AND METHODS

The present experiment on aerobic *rabi* rice was laid out in a strip plot design with three vertical plots and five horizontal plots that are allocated randomly and replicated thrice. Vertical plot treatments were conventional tillage (T_1), minimum tillage with residue retention (T_2) and zero tillage (T_3). Horizontal plot treatments were, 100 % RDN (N_1), 100 % RDN + foliar spray of 2.5 ml l^{-1} nano urea at tillering and before panicle initiation stage (N_2), 100 % RDN + foliar spray of 2.5 ml l^{-1} nano DAP at tillering and before panicle initiation stage (N_3), 75 % RDN + foliar spray of 2.5 ml l^{-1} nano urea at tillering and before panicle

Table 1. Energy equivalents for various inputs

Human labour	Input	Unit	Ec (MJ h"1)
	Adult men	Man-hour	1.96
	Women	Women-hour	1.57
Machinery and implements	Sickle	MJ kg-1	0.031
	Sprayer	MJ kg-1	0.502
	Cultivator	MJ kg-1	3.135
	Rotavator	MJ kg-1	10.283
	Tractor (>45 hp)	MJ kg-1	16.416
Irrigation	Electricity	KWh	11.93
	Electric motor 35 hp	KW h ha-1	0.343
	Diesel	Litre	56.31
	Water	m3	1.02
Chemicals	N	Kg	60.6
	P	Kg	11.1
	K	Kg	6.7
	Herbicide	kg	230
	Insecticide	kg	120
Seeds	Rice	kg	14.7

initiation stage (N_4) and 75 % RDN + foliar spray of 2.5 ml l^{-1} nano DAP at tillering and before panicle initiation stage (N_5). The succeeding experiment was continued on succeeding cowpea in strip plot design to find out the residual effect of the treatments imposed to *rabi* aerobic rice. Energy parameters were calculated for rice with their respective energy equivalent values(Table 1).

The field experiment data were statistically analyzed using ANOVA for a strip plot design in R Studio with the *agricolae* package. Significance of treatment effects was determined at the 5% level ($p < 0.05$). Post-hoc comparisons were made using the LSD test, with letter groupings indicating non-significant differences among treatment means.

RESULTS AND DISCUSSION

Energy Input (MJ ha^{-1})

The total energy input was significantly influenced by both tillage practices and nitrogen fertilizer schedules (Table 2 and Fig. 1). Among tillage practices, Conventional tillage (T_1) recorded the highest energy input, followed by minimum tillage with residue retention (T_2), while zero tillage (T_3) recorded the lowest energy input across both years and pooled data. This was attributed to greater fuel consumption, labor, and machinery requirements in conventional tillage operations. Regarding nitrogen schedules, the highest energy input was observed in 100% RDN + foliar nano urea spray (N_2), closely followed by 100% RDN + foliar nano DAP spray (N_3). The lowest energy input was associated with 75% RDN + foliar nano DAP spray (N_5). Increased fertilizer rates and the use of nano formulations contributed to the variation in energy input levels.

Gross Energy Output (MJ ha^{-1})

Gross energy output was significantly affected by tillage and nitrogen fertilizer schedules, while their interaction remained non-significant. Among tillage treatments, Conventional tillage (T_1) consistently produced the highest gross energy output, significantly outperforming zero tillage (T_3), and being statistically at par with minimum tillage with residue retention (T_2) in 2023–24 and pooled data. In terms of nitrogen management, 100% RDN (N_1), 100% RDN + foliar nano urea spray (N_2), and N_3 yielded significantly higher gross energy output than N_4 and N_5, suggesting that full-dose nitrogen application (with or without nano foliar supplements) enhanced crop biomass and yield, thereby increasing energy output. Despite their higher input energy, N_1–N_3 treatments translated more of the input into productive energy due to higher yields. Similar findings have been reported by Kumar *et al*. (2017) and Sinha *et al*. (2018).

Net Energy Output (MJ ha^{-1})

Net energy output followed a trend similar to gross output. Among tillage practices, T_1 and T_2 were statistically comparable and significantly superior to T_3 in both years and pooled data. The enhanced physical properties of the soil under T1 and the soil health benefits of residue retention under T2 contributed to greater biomass production, thus improving net energy output. Among nitrogen schedules, N_1, N_2, and N_3 had significantly higher net energy output compared to N_4 and N_5, underscoring the role of adequate nitrogen availability in enhancing yield and energy returns. These results reaffirm that reduced nitrogen rates (N4 and N5) could not compensate for lower input with foliar sprays alone. Similar results were corroborated by Pratap *et al*. (2022) Jin *et al*. (2024).

Energy Use Efficiency (%)

Energy use efficiency (EUE) was significantly influenced by tillage and nitrogen fertilizer treatments. T_1 recorded the highest EUE, followed closely by T_2, with both being statistically superior to T_3. In 2022–23, T_2 was

Table 2. Energetics of aerobic rice as influenced by tillage practices and nitrogen fertilizer schedules

Treatments	Gross energy output (MJ ha^{-1})			Net energy output (MJ ha^{-1})			Energy use efficiency (%)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Tillage practices (T)									
T_1	140759a	143126a	141943a	86952a	89185a	88069a	2.61a	2.64a	2.63a
T_2	131295b	134863a	133079a	78757a	82159a	80458a	2.49a	2.55ab	2.52ab
T_3	117859c	119848b	118853b	66208b	67937b	67073b	2.27b	2.3b	2.29b
SEm±	3056	2846	2747	3056	2846	2747	0.05	0.05	0.05
CD (p=0.05)	12001	11176	10786	12001	11176	10786	0.22	0.21	0.20
P-value	0.02	0.01	0.01	0.02	0.01	0.01	0.04	0.03	0.02
Nitrogen fertilizer schedules (N)									
N_1	139100a	142057a	140578a	85817a	88588a	87203a	2.6a	2.65a	2.63a
N_2	141367a	143214a	142291a	87936a	89596a	88766a	2.64a	2.66a	2.65a
N_3	137599a	139612a	138606a	84191a	86017a	85104a	2.57a	2.6a	2.58a
N_4	118553b	120595b	119574b	66940b	68795b	67868b	2.29b	2.32b	2.31b
N_5	113235b	117583b	115409b	61645b	65806b	63725b	2.19b	2.26b	2.23b
SEm±	3096	3283	2995	3096	3283	2995	0.05	0.06	0.05
CD (p=0.05)	10099	10709	9768	10099	10709	9768	0.19	0.20	0.18
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEm±	4179	3898	3663	4179	3898	3663	0.08	0.07	0.07
P-value	0.40	0.20	0.23	0.40	0.20	0.23	0.49	0.27	0.33

T_1: Conventional tillage, T_2: Minimum tillage with residue retention, T_3: Zero tillage. N_1: 100% RDN, N_2: 100% RDN + Foliar spray of 2.5 ml l^{-1} nano urea at tillering and before panicle initiation stage, N_3: 100% RDN + Foliar spray of 2.5 ml l^{-1} nano DAP at tillering and before panicle initiation stage, N_4: 75% RDN + Foliar spray of 2.5 ml l^{-1} nano urea at tillering and before panicle initiation stage, N_5: 75% RDN + Foliar spray of 2.5 ml l^{-1} nano DAP at tillering and before panicle initiation stage.

Table 2 (Cont.).

Table 2 (Cont.).

Treatments	Energy productivity (kg MJ^{-1})			Energy intensity in physical terms (MJ kg^{-1})			Energy intensity in economic terms (MJ □$^{-1}$)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Tillage practices (T)									
T_1	0.0834a	0.0844a	0.0839a	5.17b	5.08b	5.12b	3.33	3.40	3.37
T_2	0.0782a	0.0811a	0.0796a	5.46ab	5.33ab	5.4ab	3.24	3.33	3.28
T_3	0.0699b	0.0709b	0.0704b	5.92a	5.86a	5.89a	3.05	3.09	3.07
SEm±	0.0020	0.0019	0.0018	0.13	0.14	0.13	0.07	0.08	0.07
CD (p=0.05)	0.008	0.007	0.007	0.49	0.54	0.50	NS	NS	NS
P-value	0.02	0.01	0.01	0.03	0.03	0.03	0.11	0.10	0.09
Nitrogen fertilizer schedules (N)									
N_1	0.0820a	0.0838a	0.0829a	5.18b	5.08b	5.13b	3.51a	3.58a	3.55a
N_2	0.0831a	0.0845a	0.0838a	5.11b	5.08b	5.09b	3.50a	3.54a	3.52a
N_3	0.0811a	0.0823a	0.0817a	5.25b	5.13b	5.19b	3.33a	3.41a	3.37a
N_4	0.0715b	0.0728b	0.0721b	5.89a	5.80a	5.84a	2.94b	3.00b	2.97b
N_5	0.0682b	0.0706b	0.0694b	6.17a	6.02a	6.09a	2.75b	2.83b	2.79b
SEm±	0.0024	0.0023	0.0021	0.13	0.14	0.13	0.08	0.08	0.07
CD (p=0.05)	0.0079	0.0075	0.0067	0.41	0.45	0.40	0.25	0.27	0.24
P-value	0.0071	0.0063	0.0029	0.00	0.01	0.00	0.00	0.00	0.00
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEm±	0.003	0.004	0.002	0.18	0.17	0.16	0.11	0.10	0.09
P-value	0.52	0.86	0.31	0.81	0.57	0.71	0.57	0.34	0.41

T_1: Conventional tillage, T_2: Minimum tillage with residue retention, T_3: Zero tillage. N_1: 100% RDN, N_2: 100% RDN + Foliar spray of 2.5 ml l^{-1} nano urea at tillering and before panicle initiation stage, N_3: 100% RDN + Foliar spray of 2.5 ml l^{-1} nano DAP at tillering and before panicle initiation stage, N_4: 75% RDN + Foliar spray of 2.5 ml l^{-1} nano urea at tillering and before panicle initiation stage, N_5: 75% RDN + Foliar spray of 2.5 ml l^{-1} nano DAP at tillering and before panicle initiation stage.

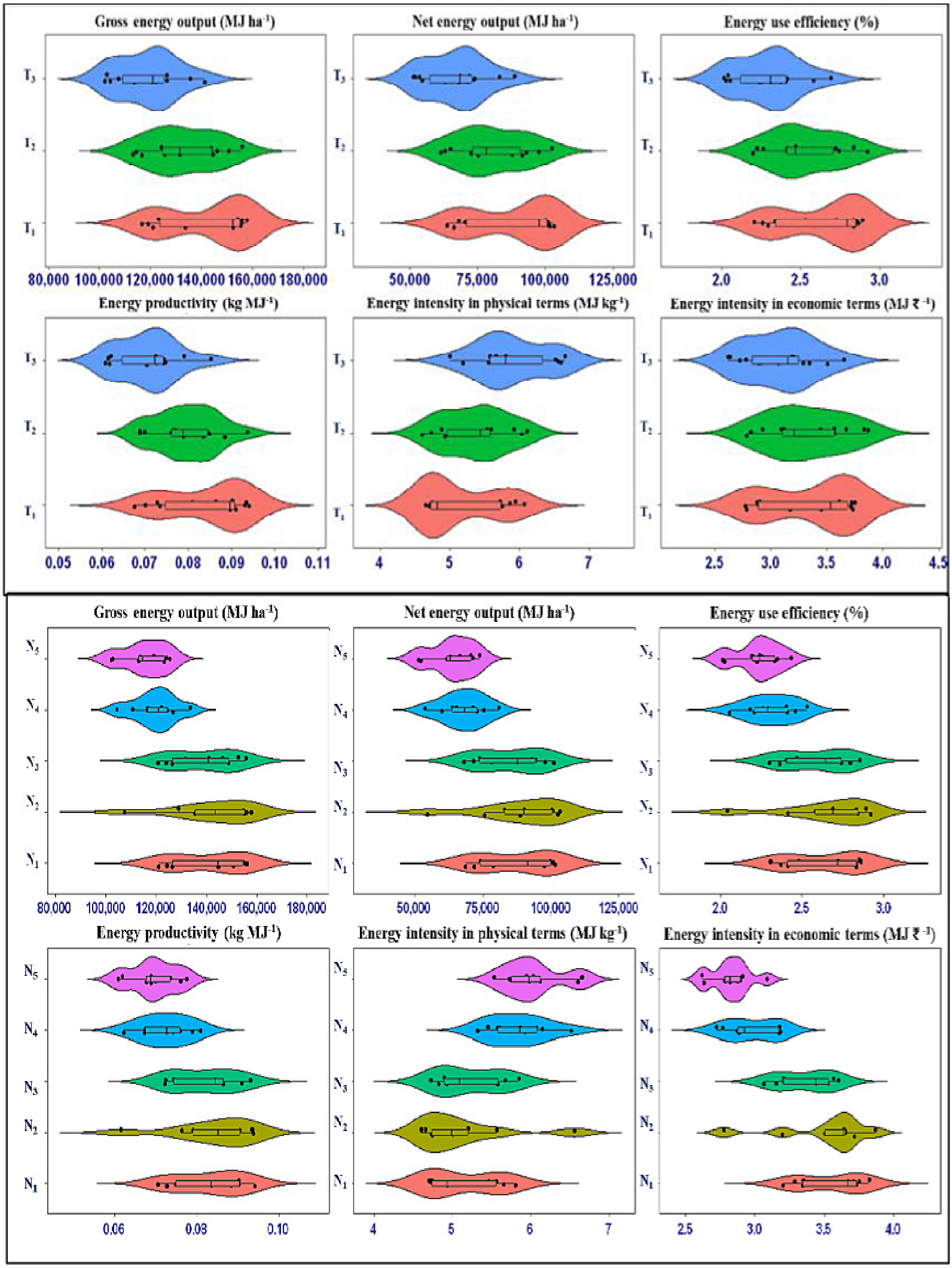

Fig. 1 Energetics of aerobic rice as influenced by tillage practices and nitrogen fertilizer schedules (pooled mean).

significantly better than T3, but in 2023–24 and the pooled mean, their differences narrowed. Nitrogen schedules N_1, N_2, and N_3 exhibited significantly higher EUE than N_4 and N_5. While foliar application of nano fertilizers improved nitrogen use efficiency, it did not fully offset the effects of reduced basal nitrogen. Therefore, full-dose nitrogen treatments remained more efficient in energy utilization. Similar findings were reported by Tiwari *et al.* (2023) and Kundu *et al.* (2024).

Energy Productivity (kg MJ^{-1})

Energy productivity, representing grain yield per unit of energy input, showed significant variation across treatments. Among tillage treatments, T_1 exhibited the highest energy productivity, followed by T_2, both statistically superior to T_3. The improved soil conditions and nutrient availability under conventional tillage likely promoted better energy conversion into yield. For nitrogen treatments, N_1, N_2, and N_3 were again significantly more productive compared to N_4 and N_5, demonstrating that sufficient nitrogen supply remains essential for maximizing energy use in crop production. The reduced productivity under N_4 and N_5 reflects the adverse effects of nitrogen deficiency despite foliar supplementation. These results were substantiating with Prakash *et al*. (2023) and Pedireddy *et al.* (2024).

Energy Intensity in Physical Terms (MJ kg^{-1})

Energy intensity in physical terms was significantly affected by treatments. Among tillage methods, T_3 recorded the highest energy intensity, indicating lower yield per unit of energy input, while T_1 and T_2 had significantly lower and comparable values.

For nitrogen fertilizer schedules, N5 exhibited the highest energy intensity, followed by N_4, whereas N_1, N_2, and N_3 had significantly lower and statistically similar values. This suggests that inadequate nitrogen supply in N_4 and N_5 led to inefficient energy conversion, resulting in higher energy requirements per unit of yield.

Energy Intensity in Economic Terms (MJ $^{-1}$)

Energy intensity in economic terms was significantly influenced by nitrogen management but not by tillage or their interaction. Among tillage practices, T_1 showed the highest economic energy intensity, while T_3 recorded the lowest. However, due to lower production costs, T3's energy intensity in economic terms was statistically comparable with T_1 and T_2.

Among nitrogen treatments, N_1, N_2, and N_3 showed significantly higher energy intensity per rupee of output compared to N_4 and N_5. This trend reflects the stronger energy returns from full-dose nitrogen treatments, even though the input costs for N_4 and N_5 were relatively lower.

CONCLUSION

The study highlights the energetic advantages of conventional tillage and nitrogen schedule 100 % RDN + foliar spray of 2.5 ml l^{-1} nano urea at tillering and before panicle initiation stage in aerobic rice cultivation. However, minimum tillage with residue retention exhibited comparable performance to conventional tillage, indicating its potential as a sustainable and energy-efficient alternative. Among nitrogen strategies, 100 % RDN + foliar spray of 2.5 ml l^{-1} nano urea at tillering and before panicle initiation stage optimized energy productivity and efficiency, while 100% RDN alone produced statistically comparable results and emerged as the more economical option for energy-conscious rice farming.

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CONSERVATION TILLAGE PRACTICES FOR ENHANCED PRODUCTIVITY IN SUGARCANE–PADDY SYSTEM

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ABSTRACT

A field study was carried out at Regional Agricultural Research Station farm, Anakapalle from 2022-23 to 2024-25 for three years to study the feasibility of conservation tillage practices and its impact on crop establishment, growth of crop and weed, and productivity of Sugarcane in Sugarcane-Paddy cropping system. The trial was carried out using a strip plot design with three replications. The main plot factor comprised of conservation tillage practices and weed management techniques in sub plots. The cropping cycle of sugarcane planting in furrows with ridgemar in rice fallows + Cowpea during first year followed by Sugarcane (ratoon)+Cowpea during second year andtaking up Pulse-Green manure-Paddy with minimal tillage and sowing during the third year in addition to chemical weed control methods for effective weed management was found suitable to improve the overall productivity of Sugarcane-paddy system(217.47 t ha^{-1}) and economically profitable instead of the normal conventional system.

Key words: Conservation tillage, Paddy, Sugarcane, System productivity

INTRODUCTION

Sugarcane is an important commercial crop in North Coastal Zone. The Conventional method of tillage is not only laborious but is also expensive. Besides, this it does not allow more crops to be taken in rotation unlike in Conservation agriculture. Sugarcane-Paddy being the predominant system in this zone needs to be exploited well for improving its system productivity. By following conservation tillage practices, there will be more scope for taking more crops in a cropping cycle enabling to cover the soil for longer time besides improving the net returns.The area under sugarcane crop hassignificantly decreased in recent years as land preparation is extremely expensive and insufficient rainfall during growth stages. Therefore, the current investigation was undertaken to work out conservation agriculture methods and the efficiency of different weed management methods to improve the overall productivity of Sugarcane-Paddy system.

MATERIAL AND METHODS

Athree year experiment was carried out at Regional Agricultural Research Stationfarm, Anakapalle from 2022-23 to 2024-25 to study the feasibility of conservation tillage practices and its impact on crop establishment, crop and weed growth and sugarcane productivity in

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Sugarcane-Paddy cropping system. The trial was taken up with conservation tillage practices in main plots and weed management techniques in sub plots in strip plot design replicated thrice. The main plot treatments were M_1-Monocropping of Sugarcane (Sugarcane plant-ratoon-ratoon), M_2-Sugarcane (Plant)–Sugarcane(ratoon)-pulse-greenmanure – Paddy under conventional tillage and sowing, M_3-Sugarcane(working with ridgemar and planting in furrows in rice fallows)–Sugarcane(ratoon)-Pulse-Green manure-Paddy under minimum tillage and sowing, M_4-Sugarcane(working with ridgemar and planting in furrows in rice fallows)+trash mulching–Sugarcane(ratoon)+ trash mulching-Pulse-Green manure-Paddy under minimum tillage and sowing and M_5-Sugarcane(Planting in furrows with ridgemar in rice fallows) + Cowpea–Sugarcane(ratoon)+Cowpea-Pulse-Green manure-Paddy under minimum tillage and sowing. The sub plot treatments were S_1-Chemical weed control, S_2- Mechanical Weed control through Power weeder +row weeding and S_3-Chemical weed control+ Mechanical weed control. The weather conditions were favourable for the crop growth during these three years. The experimental site soil was sandy loam with pH (7.08), E.C (0.40dS/m), OC (0.68), available nitrogen (196Kg ha^{-1}), phosphorus (63Kg ha^{-1}) and potassium (312Kg ha^{-1}). All the recommended package of techniqueswereused for raising a good and healthy crop. Number of tillers were counted at 120 DAP and shoot population was counted at 240 DAP.Weeds were collected per sq.m randomly in plot area, oven dried and expressed as weed dry weight.Cane samples were crushed and the percentage of sucrose wasnoted on sucrolyzer. Cane yield and number of millable canes were recorded at harvest on plot basis and expressed in numbers and tons ha^{-1}respectively. Three years data was pooled and statistical analysis was done as suggested by Panse and Sukhatme (1986).

RESULTS AND DISCUSSION

Growth parameters

As per table 1, pooled mean of tiller population at 120 days did not vary among the main plots and sub plot treatments. However, significantly higher shoot population at 240 days and lowest dry weight of weeds in conservation tillage practices were noted with the treatment Sugarcane(Planting in furrows with ridgemar in rice fallows) + Cowpea–Sugarcane (ratoon)+ Cowpea-Pulse-Green manure-Paddy under minimum tillage and sowing and with Chemical weed control among weed management techniques which was comparable with chemical weed control+ Mechanical weed control. Gepolani *et al.* (2020) reported higher profitability of intercropping of corn and cowpea than sugarcane monocroppingimplying suitable intercrops to ratooned sugarcane. Geetha *et al.*(2019), observed that Weed smothering efficiency (WSE) was considerably greater in sugarcane + cowpea (36.3%) intercropping system followed by sunnhemp (32.3%) and soybean (32.0%) compared to the sole sugarcane (control). Considerably more number of millable canes (93,260 ha^{-1}) were noted with pre-emergence herbicide (atrazine @1.00 kg/ha) and post emergence herbicide (Metribuzin @0.75 kg/ha) @ 60 DAP compared to mechanical options by Nageswari *et al.* (2022).

Yield attributes, Yield and System productivity

Table 1 revealed that among the conservation tillage techniques, millable cane number and cane yield were significantly highest with Sugarcane (Planting in furrows with ridgemar in rice fallows) + Cowpea–Sugarcane(ratoon)+Cowpea-Pulse-Green manure-Paddy under minimum tillage and sowing and with Chemical weed control method which was on par with Chemical weed control+ Mechanical weed control among weed

Table 1.Yield and quality of Sugarcane under Sugarcane-Paddy system as influenced by conservation tillage and weed management practices (Pooled mean)

Treat-ments	No.of Tillers/ha at 120 days (thousands ha^{-1})	Shoot population at 240 days ('000/ha)	Weed dry wt (gm^{-2})	No. of Millable Canes (thousa-nds ha^{-1})	Suc-rose (%)	Cane Yield (tha^{-1})	System produ-ctivity (tha^{-1})
Main plots- Conservation tillage practices							
M1	110.18	79.41	632	60.61	17.58	65.73	197.19
M2	115.35	83.28	522	65.07	16.96	65.30	186.41
M3	104.82	72.38	575	64.16	16.65	66.11	186.06
M4	103.46	74.94	471	66.94	16.19	70.36	200.49
M5	107.95	89.59	383	77.49	16.70	77.20	217.47
CD (5%)	NS	7.43	105	5.68	NS	3.78	9.78
CV (%)	16.88	8.54	18.72	7.81	6.93	5.04	4.56
Sub plots- Weed Management practices							
S1	108.21	81.90	413	71.04	17.00	72.81	206.67
S2	107.78	77.11	615	62.07	16.95	64.37	186.64
S3	109.07	81.46	523	67.45	16.49	69.64	197.50
CD (5%)	NS	3.47	83	3.77	NS	5.00	11.09
CV (%)	8.32	5.7	21.00	7.41	5.27	9.53	7.39
Interaction	NS	S	NS	NS	NS	NS	NS

management practices. Comparative yields of sugarcane under zero till system combined with trash mulching as against conventional tillage was reported by Surendran *et al.* (2016). According to Shukla *et al.* (2020) sugarcane (96.32 t ha^{-1}) and sugar yields (12.14 t ha^{-1}) were significantly enhanced with the minimum tillage through subsoiling in contrast to conventional tillage/mouldboard ploughing. Srivastava *et al.* (2023), reported more cane yield (79211 kgha^{-1}) with sugarcane + cowpea intercropping than sugarcane mono-cropping (72239.5 kgha^{-1}). De Oliveira *et al.*(2022), reported higher cane productivity with no. tillage system. The productivity of greengram and paddy were highest among the Sugarcane paddy cropping system with Sugarcane (Planting in furrows with ridgemar in rice fallows) + Cowpea – Sugarcane (ratoon)+ Cowpea-Pulse-Green manure-Paddy under minimum tillage practice and sowing and with Chemical weed method which was on par with Chemical weed control+ Mechanical weed control among weed management practices. Ghorai and Ghorai (2023) reported rice yield of 3-5 t ha^{-1} with Zero till green manure which added 35- 60 tonnes bio mass ha^{-1} and saved 20-27 kg (30 per cent) nitrogen ha^{-1}in different locations of Paschim Medinipur and Purulia districts of West Bengal.Pooled mean of sucrose percent did not differ by the main and sub plot treatments. On computation, the system productivity in terms of cane equivalent yield was also found significantly highest with

Table 2. Effect of conservation tillage practices on post-harvest soil properties

Treatment	pH	EC (dSm^{-1})	OC (%)	Available Nutrient Status ($Kgha^{-1}$)			Bulk density (gcc^{-1})
				N	P	K	
Initial	**7.08**	**0.40**	**0.68**	**196**	**63**	**312**	**1.34**
Main plots- Conservation tillage practices							
M1	7.28	0.170	0.69	212	86.50	320	1.35
M2	7.42	0.260	0.71	225	81.20	321	1.35
M3	7.26	0.150	0.69	230	91.20	328	1.36
M4	7.27	0.195	0.72	242	88.50	342	1.37
M5	7.21	0.165	0.69	228	83.60	338	1.35
CD (5%)	NS	NS	NS	NS	NS	NS	NS
Sub plots- Weed Management practices							
S1	7.24	0.24	0.69	215	88.0	324	1.35
S2	7.28	0.18	0.69	220	91.0	322	1.35
S3	7.25	0.20	0.70	212	90.0	321	1.36
CD (5%)	NS	NS	NS	NS	NS	NS	NS

Table3. Economics ofSugarcane-Paddy system as influenced by conservation tillage and weed management practices

Treatments	System productivity (tha^{-1})	Gross Returns (Rs. ha^{-1})	Net Returns (Rs. ha^{-1})	B:C ratio
Main plots- Conservation tillage practices				
M1	197.19	586633	60685	1.12
M2	186.41	554565	78785	1.17
M3	186.06	545490	81854	1.18
M4	200.49	596467	130331	1.28
M5	217.47	647004	181368	1.39
Sub plots- Weed Management practices				
S1	206.67	611502	134253	1.28
S2	186.64	555398	71649	1.15
S3	197.50	591196	113912	1.24

conservation tillage practices in the cropping system Sugarcane (Planting in furrows with ridgemar in rice fallows) + Cowpea– Sugarcane(ratoon)+Cowpea-Pulse-Green manure-Paddy under minimum tillage and sowing and among weed management techniques with Chemical weed control method which was however found to be on par withChemical weed control+ Mechanical weed control.Ishita and Vaidya (2020) concluded that intercropping of legumes in addition to offering higher system profitability, also enhances soil quality and createsa sustainable plant-ratoon system.

Effect on Soil Physico-Chemical properties

An analysis of the data (Table 2) showed that the soil's physical and chemical characteristics (pH, EC, Organic carbon content and available nutrient status) did not differ among conservation tillage practices and weed management practices.There was no difference in bulk density of the soil also among the treatments implying that these conservation practices have not increased the soil compaction and were congenial for growth of sugarcane and paddy in this cropping cycle.

Economics

On Computation of the system economics (Table 3), it is observed that gross returns, net returns and benefit cost ratio among the conservation tillage practices were the highest with the cropping system Sugarcane (Planting in furrows with ridgemar in rice fallows) + Cowpea–Sugarcane (ratoon)+ Cowpea-Pulse-Green manure-Paddy under minimum tillage and sowing and among weed management techniques with Chemical weed control. Higher net field benefits were obtained when lentil was intercropped in sugarcane (Nadeem *et al*., 2020). Singh *et al*., 2015 reported higher net returns in summer planted sugarcane in the absence of pre-planting tillage in contrast to conventional tillage.The findings of experiments carried out at farmer's field by ICAR-RCER, Patna reported by Singh and Meena, 2013 suggestedthat zero tillage technology in rice has proved more remunerative to farmers.

CONCLUSION

The cropping cycle of planting of sugarcane in furrows with ridgemar in rice fallows + Cowpea during first year followed by Sugarcane(ratoon)+Cowpea during second year andtaking up Pulse-Green manure-Paddy under minimum tillage and sowing during the third year along with Chemical weed control method for efficient weed management was found suitable to enhance the overall productivity and profitability of Sugarcane-paddy system in contrast to normal conventional system of practices for Sugarcane-Paddy sequence in North Coastal Zone of Andhra Pradesh.

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CLIMATE SMART VARIETIES OF GROUNDNUT SUITABLE FOR SCARCE RAINFALL AGRO CLIMATIC ZONE OF ANDHRA PRADESH

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ABSTRACT

A field experiment was carried out to evaluate the influence of wet and dry spells on groundnut varieties in scarce rainfall agro climatic zone under rainfed conditions for two consecutive years during kharif 2022 and 2023 at AICRPDA, Agricultural Research Station, Ananthapur of Andhra Pradesh. Among groundnut varieties tested during wet spell of 2022, Kadiri Lepakshi (2635 kg/ha) followed by TCGS 1694 (1900 kg/ha) recorded higher pod yield when compared to other varieties tested. During drought year of 2023, TCGS-1694 recorded significantly higher pod yield when compared to other tested varieties with rain water use efficiency of 4.42 kg/ha mm. TCGS-1694 proved as the top climate resilient groundnut variety for scarce rainfall agro climatic zone of Andhra Pradesh, maintaining high pod yields (1556 -1900kg ha^{-1}), haulm yields (2,834-3,289 kg ha^{-1}), and superior rain water use efficiency (3.80-4.42 kg ha^{-1}mm) across wet and dry extremes. Kadiri Lepakshi proved ideal for high rainfall events (2,635 kg ha^{-1} pod yield), extreme while Nithya Haritha and K-9 showed consistent intermediate performance.

Keywords: Climate resilience, Drought tolerance, Rainfed groundnut, Rain water use efficiency, Wet and dry spells

INTRODUCTION

Andhra Pradesh comprises approximately 4.0 million hectares of rainfed land, with nearly 45% (1.6 million ha) located in the scarce rainfall agro climatic zone that includes Kurnool, Nandyal, Anantapuram and Sri Sathyasai districts with an annual average rainfall of 627, 747, 525 and 596 mm respectively (Yellamanda Reddy *et al.,* 2020).Out of the major rainfed crops grown in Andhra Pradesh, scarce rainfall zone occupies 4.0 lakh ha with groundnut (80%), 0.32 lakh ha with castor (92%), pigeon pea 1.53 lakh ha (59%), pearl millet 0.10 lakh ha (42%) and foxtail millet 0.08 lakh ha (61%). As part of the climate-smart agriculture approach, the adoption of climate-resilient crop varieties has the potential to build farmers' climate resilience but could also induce agricultural transformation in developing nations. Climate change such as erratic distribution of rainfall and higher frequency of extreme climatic events pose new challenges to groundnut production. Since many studies evaluating

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production systems for groundnut were performed prior to or during the 1970s and 1980s, groundnut cultivars used in those studies are no longer cultivated for production. In groundnut K9 and Dharani varieties are tolerant to drought (Radha Kumari and Sahadeva Reddy, 2019). Pavithra devi *et al.* (2015), reported that drought tolerant (ICGV 91114, K1375 and ICGV 02125) and drought susceptible (ICGV 01279, ICGV 98170 and ICGV 98175) varieties in groundnut. New cultivars may have different responses to nutrient, irrigation, and environmental factors. It is thus imminent to re-evaluate and modify currently adopted management practices and develop new guidelines towards improved groundnut productivity under ever-changing climate conditions. However, the crop productivity is fluctuating and highly influenced by the rainfall during crop growth period. In general groundnut always required moderate soil moisture and excess moisture and drought during pegging to pod development is undesirable. Extreme weather events at critical stages of crop growth can reduce yields or lead to crop failures also. However, information on the effect of extreme weather events during crop growth period on productivity of groundnut varieties is meagre and hence in this backdrop, the present study was conducted.

MATERIAL AND METHODS

A field experiment was carried out to study effect of wet and dry spells on groundnut varieties in scarce rainfall agro climatic zone under rainfed conditions for two consecutive years during kharif 2022 and 2023 at AICRPDA, Agricultural Research Station, Ananthapuramu, Andhra Pradesh". The experiment was laid out in Randomized Block Design and replicated thrice. The soils were red sandy loam in texture, near neutral in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and potassium. The treatments comprised of eight varieties viz., K-6, Kadiri Lepakshi, TCGS-1694, Nithyaharitha, Kadiri Harithandra, Kadiri Amaravathi, Dharani and K-9. An amount of 562 and 411 mm rainfall was received in 26 and 25 rainy days during the crop season of 2022 (21-6-22 to 10-10-22) and 2023 (10-6-23 to 12-10-23), respectively at the experimental site. During *kharif,* 2022 groundnut varieties faced wet spells at flowering to pegging (78.2 mm for 5 rainy days), pegging to pod development (182.6 mm for 5 rainy days) and pod development stages (97.8 mm for 4 rainy days) due to continuous rains in consecutive days. During 2023, dry spell of 14 days during flowering stage to pegging, 18 days during pod initiation to pod development and 19 days during pod maturity. Groundnut crop experienced 68 days of dry spell and 18 days of wet spells during 2022 and dry spell of 88 days during 2023. The rainwater use efficiency (kg ha^{-1} mm^{-1}) could be derived as ratio of pod yield attained by a treatment and crop seasonal rainfall received in a season as reported by Maruthi Sankar *et al*., (2013). The cost of cultivation was determined by considering inputs like seed and fertilizer costs, and agricultural operations from sowing to harvest. The gross return was computed as a product of yield and its market price (Rs. Kg^{-1}). Net returns were calculated by subtracting the total cost of cultivation from the gross returns obtained from the produce. The BCR was computed as a ratio of gross returns and cost of cultivation for each crop.

RESULTS AND DISCUSSION

During *kharif*, 2022 groundnut varieties *viz*. K-6, Kadiri Lepakshi, TCGS-1694, Nityaharitha, Kadiri Harithandhra, Amaravathi, Dharani, K-9 were tested for wet spells/high rainfall events. These varieties faced wet spells at flowering to pegging (78.2 mm for 5 rainy days), peg formation to pod development (182.6 mm for 5 rainy days) and different stages of pod development (97.8 mm for 4 rainy days) due to continuous rains in consecutive days (Fig.1). Under these situations among groundnut varieties tested, Kadiri Lepakshi followed by TCGS 1694 recorded higher pod yield of 2635 kg ha^{-1} and 1900 kg ha^{-1}, haulm yield of 5101 kg ha^{-1} and 3289 kg ha^{-1} respectively compared to other varieties (Table 1). In 2023, although Kadiri Lepakshi still maintained a higher yield compared to most varieties, its performance dropped sharply to 882 kg/ha, reflecting its sensitivity to drought conditions. Harithandhra, on the other hand, showed an unusual increase in pod yield from 922 kg ha^{-1} in 2022 to 1357 kg ha^{-1}in 2023, suggesting its adaptability to the conditions in 2023. Further, higher net returns (Rs.1,12,063/ha), benefit cost ratio (2.79) and rainwater use efficiency (4.60 kg/ha mm) were realized with Kadiri lepakshi followed by TCGS 1694 (Table 2). During 2023, all the tested varieties were subjected to drought. During drought year of 2023, TCGS-1694 recorded significantly higher dry pod yield (1556 kg ha^{-1}) and haulm yield (2834 kg ha^{-1}) compared to other tested varieties with rain water use efficiency of 4.42 kg ha^{-1}mm. Some varieties, such as Harithandhra and Nitya Haritha, maintained stable haulm production across both years, indicating their consistent vegetative growth. The non-significant difference in 2023 indicates that the weather conditions may have had a uniform effect on vegetative biomass across the varieties. Overall, Kadiri Lepakshi and TCGS-1694 emerged as high pod-yielding varieties, while Amaravathi consistently produced high haulm yield. The year-to-year variation highlights the influence of environmental factors on yield components, emphasizing the need to consider both yield and stability in variety selection for different agro-climatic conditions.

Moisture stress during groundnut reproductive stages (especially pegging and pod filling) severely reduces pod set, dry matter accumulation and final yield in K-6, Kadiri lepakshi and Dharani during 2023 (Radha Kumari and Sahadeva Reddy,2019). Drought during these phases often causes greater yield loss than stress at vegetative stages. Naik *et al.,* 2023 reported that Kadiri lepakshi recorded 3840 kg ha^{-1} and 2666 kg ha^{-1} dry pod yield and kernel yield, respectively with 31.87% increase and 29.74% increase compared to TAG 24. Several groundnut varieties are known for their resilience to climate stress, particularly drought and heat. Some notable examples include Kadiri Lepakshi, Kadiri Harithandhra, Visishta, and K-6, which are well-suited for rainfed conditions and offer high yield potential. Other varieties like G2-52, TMV-2, and GPBD-4 have also demonstrated good drought tolerance and yield potential (Gangurde *et al.,* 2019). Sahadeva Reddy *et al.* (2016) reported that 93 per cent yield reduction in terms of pods in groundnut due to wet spells in Ananthapur district. Wet spell ranging from 5 to 10 days period during 2008 and 2020 immediately after first flush of flowering was found detrimental. Further, excess rains resulted in incidence of leaf spot disease and sucking pests like jassids which reduced the conversion of photosynthates to economic yield. TCGS-1694, Nithya Haritha and K9 are the most climate resilient varieties compared to K6 and Dharani. These results indicate that Kadiri Lepakshi and TCGS-1694 are superior for pod production, while Amaravathi ensures high biomass, emphasizing the need to select varieties for both productivity and stability.

Table 1. Effect of extreme weather events on filled pods, pod and yield in different varieties of groundnut during Kharif 2022 and 2023.

Varieties	'Filled pods per plant'		'Pod yield (kg/ha)'		'Haulm yield (kg/ha)'	
	2022	2023	2022	2023	2022	2023
K-6	13.6	9.1	1159	831	2693	2361
Kadiri Lepakshi	30.3	13.9	2635	882	5101	2709
TCGS-1694	21.5	17.2	1900	1556	3289	2834
Nitya haritha	17.4	15.7	1587	1325	2644	2662
Harithandhra	15.8	12.9	922	1357	2450	2986
Amaravathi	15.2	13.6	1446	1337	3532	2942
Dharani	12.6	13.3	1144	896	2588	2571
K-9	16.2	8.5	1483	1147	2995	2474
S.Em.±	1.3	1.09	89	102	309	178
C.D. at 5 %	4.1	3.28	270	305	937	NS

Table 2. Effect of extreme weather events on net returns, B:C ratio and rain water use efficiency in different groundnut varieties during Kharif 2022 and 2023.

Varieties	Net returns (Rs/ha)		B:C Ratio		RWUE (kg/ha mm)	
	2022	2023	2022	2023	2022	2023
K-6	16088	-1991	1.26	0.97	2.32	2.36
Kadiri Lepakshi	112063	1242	2.79	1.02	4.60	2.51
TCGS-1694	61807	44226	1.99	1.71	3.80	4.42
Nitya haritha	40920	29495	1.65	1.46	2.77	3.76
Harithandhra	1251	31562	1.02	1.50	1.61	3.86
Amaravathi	36235	30282	1.58	1.48	2.89	3.80
Dharani	14802	2149	1.24	1.03	2.29	2.55
K-9	36257	18114	1.58	1.29	2.87	3.26

Groundnut variety TCGS-1694 is climate resilient for extreme weather events followed by Nithya Haritha and K9 in scarce rainfall agro climatic zone of Andhra Pradesh.

CONCLUSION

Among the varieties tested, TCGS-1694 identified as the most climate resilient groundnut variety for scarce rainfall agro climatic zone of Andhra Pradesh, maintaining high pod yields (1556 -1900kg ha^{-1}), haulm yields (2,834-3,289 kg ha^{-1}), and superior rain water use efficiency (3.80-4.42 kg ha^{-1}mm) across wet and dry extremes. Kadiri Lepakshi proved ideal for high rainfall events (2,635 kg ha^{-1} pod yield), extreme while Nithya Haritha and K-9 provided consistent intermediate performance. Farmers should prioritise these

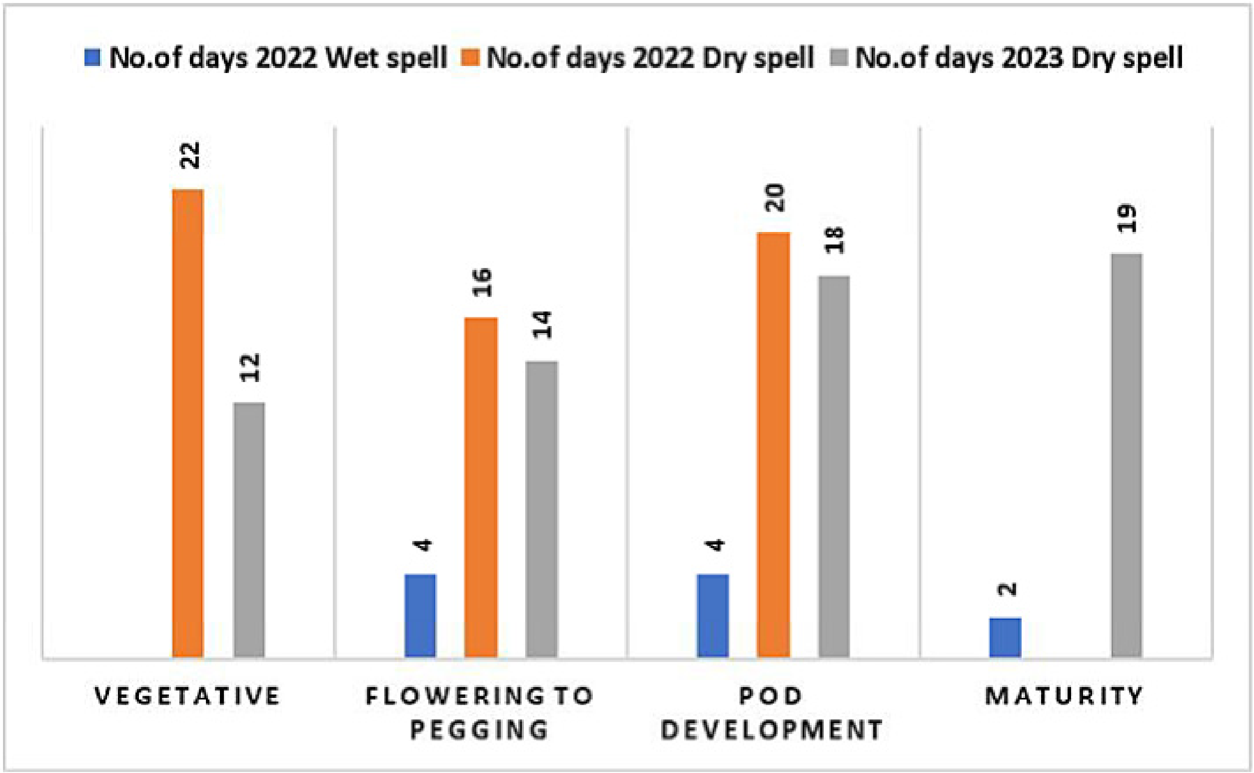

Fig.1. No.of days of dry and wet spell during crop growth stages in groundnut during 2022 and 2023

varieties -TCGS 1694 for dual resilience, Kadiri Lepakshi for wet conditions- to mitigate climate risks, enhance rainfed productivity (20-30% yield gain over susceptible checks like K-6), and improve economic returns (B:C ratio1.71-2.79) in challenging agro ecosystem of Ananthapur district.

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EFFECT OF PHOSPHORUS LEVELS ON YIELD AND QUALITY OF FODDER COWPEA VARIETIES UNDER RAINFED CONDITIONS

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ABSTRACT

The experiment was conducted during *kharif*, 2018-19 on red loam soils of Regional Agricultural Research Station, Tirupati. The experiment was laid in the randomized block design with factorial concept and each treatment replicated thrice. The results showed that the higher green fodder yield (21,054 kg ha^{-1}) and dry fodder yield (3,473 kg ha^{-1}) was obtained with MFC 08-14 variety. Significantly higher crude protein content (12.15%) was registered with APFC 10-1 variety, while the difference in crude fibre content among the varieties were found non-significant. Among the different levels of phosphorus, application of 60 kg P_2O_5/ha recorded significantly higher green fodder yield (21,590 kg/ha). Crude fibre content was not significantly influenced either by varieties or different levels of phosphorus application under rainfed conditions of Southern Zone of Andhra Pradesh.

Key Words: Crude protein,Fodder cowpea,Green fodder yield,Phosphorus, Rainfed.

INTRODUCTION

Fodder production plays a pivotal role in supporting the livestock sector, particularly in regions where mixed farming systems are practiced. Fodder cowpea (*Vigna unguiculata* L. Walp) is a versatile leguminous crop widely cultivated for its high biomass yield, excellent nutritional profile and soil-enriching properties. Its dual-purpose nature, providing both grain and green fodder, makes it an indispensable component of sustainable farming systems, especially in resource-constrained and rainfed regions. Particularly under rainfed conditions, it serves as a critical forage resource for livestock due to its drought tolerance and rapid growth.However,the productivity and nutritional quality of cowpea fodder are largely influenced by varietal selection and nutrient management practices, particularly phosphorus (P) nutrition. Phosphorus plays a crucial role in several physiological and biochemical processes, root development, energy transfer and overall plant vigor, synthesis of nucleic acids, proteins and directly influencing biomass accumulation and forage quality (Boakye and Wilson, 2019). Furthermore, the response to phosphorus application may vary across different cowpea varieties, owing to their genetic makeup and adaptability (Ahmad *et al*., 2017). Hence, understanding the interaction between phosphorus levels and varietal performance is essential to develop location-specific

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phosphorus needs strategies and to identify high-yielding, quality fodder cowpea genotypes suited to low-input rainfed systems. Hence, the present investigation was taken up with an objective to identify the best cowpea fodder variety and optimum dose of phosphorus for higher fodder yield and quality for Southern Zone of Andhra Pradesh.

MATERIAL AND METHODS

A field experiment was conducted during the *kharif* season of 2018–19 at Regional Agricultural Research Station, Tirupati of Acharya N.G. Ranga Agricultural University. The experimental site is geographically situated at 13.5°N latitude and 79.5°E longitude, with an altitude of 182.9 m, which falls under the Southern Agro-Climatic Zone of Andhra Pradesh. The region experiences a tropical climate with erratic rainfall typical of rainfed conditions. The soil type of the experimental plot was red loamy, with a neutral pH and good drainage. Prior to the initiation of the experiment, a composite soil sample was collected and analyzed for its initial fertility status, revealing available nutrient contents of 173 kg N/ha, 25 kg P_2O_5 /ha, and 234 kg K_2O/ha. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications. The experiment consisted of two factors and factor one consists of four fodder cowpea varieties (V1: MFC 08-14, V2: Co-8, V3: APFC10-1 and V4: EC-4216) and factor two consist of four Phosphorus levels (P1: Control, P2: 40, P3: 60 and P4: 80 kg P_2O_5/ha). A total of 16 treatment combinations (4 varieties × 4 phosphorus levels). Each treatment was randomly allotted within each replication to minimize experimental error. Line sowing of cowpea varieties was done at a recommended spacing of 30 x 10 cm. Phosphorus was applied in the form of single super phosphate (SSP) as per the treatment levels as a basal dose at the time of sowing. A uniform dose of nitrogen and potassium, as per standard agronomic recommendations, was applied to all plots to eliminate their variability. Other intercultural operations such as weeding, irrigation (if necessary), pest and disease management were carried out uniformly across all plots following recommended practices to ensure optimal crop growth. At maturity, data were collected on yield and quality parameters from the net plot area, excluding border rows to avoid edge effects. Samples for quality analysis were dried and ground for chemical estimation. Crude protein content was estimated using standard procedures, such as the Kjeldahl method. Crude fibre content in whole plant was estimated by acid-alkali digestion method and was expressed in percentage. The collected data were subjected to analysis of variance (ANOVA) as per the FRBD design. Treatment means were compared using the Least Significant Difference (LSD) test at a 5% level of significance to determine the effect of phosphorus levels and variety on growth and yield attributes.

RESULTS AND DISCUSSION

Data pertaining to growth, yield and quality parameters of fodder cowpea varieties influenced by phosphorous levels were presented in Table no.1.

Growth Parameters

Plant height at 30 days after sowing (DAS) and at harvest did not significantly vary among the varieties. EC-4216 (V4) recorded the highest plant height at 30 DAS (18.0 cm) and at harvest (111.1 cm) while lower plant height was noticed with MFC 08-14 (Table 1). However, all the varieties were statistically non-significant. Among phosphorus levels, all the levels of phosphorus application showed a significant effect on plant height over control both at 30 DAS and at harvest. Maximum plant height at 30 DAS was recorded with 40 kg/ha of P_2O_5 (18.2 cm), while the tallest plants at harvest were noted under 80 kg/ha of P_2O_5

Table 1. Growth, yield and quality parameters of fodder cowpea varieties at varied phosphorus levels.

Treatment	Plant height at 30 DAS (cm)	Plant height at harvest (cm)	Green fodder yield (kg/ha)	Dry fodder yield (kg/ha)	Crude protein (%)	Crude fibre (%)
Varieties						
V1: MFC 08-14	17.7	104.0	21054	3473	11.89	52.43
V2: Co-8	17.0	106.6	20834	3464	11.51	53.05
V3: APFC10-1	17.6	107.9	21009	3412	12.15	52.21
V4: EC-4216	18.0	111.1	21011	3454	12.04	53.19
CD (0.05)	NS	NS	NS	NS	0.47	NS
P_2O_5 Levels (kg/ha)						
P_1: Control	16.8	99.5	19981	3222	12.09	51.93
P_2: 40		18.2	106.4	21371	3579	12.54
51.80						
P_3: 60		17.7	111.6	21590	3458	12.49
52.12						
P_4: 80		17.6	112.4	20964	3545	12.25
51.94						
C.D (P=0.05)	0.8	8.3	835	NS	NS	NS

(112.4 cm) followed by 60 kg/ha (111.6 cm) and 40 kg/ha of P_2O_5(106.4 cm) which inturn comparable with one another. Significantly lower plant height was observed with control (99.5 cm). These results suggest a positive influence of phosphorus on vegetative growth (Bhagat *et al*., 2018, Anjeela *et al*., 2021 and Gangadhar *et al*., 2023).

Yield Parameters

With refer to green fodder yield, non-significant response was observed among the fodder cowpea varieties tested. Among graded levels of phosphorus application, green fodder yield increased with increasing levels of phosphorus application up to 60 kg P_2O_5/ha, which recorded the highest yield of 21,590 kg/ha, followed closely by 40 kg P_2O_5 /ha. However, a further increase to 80 kg P_2O_5 /ha resulted in a slight decline in yield (20,964 kg/ha), possibly due to secondary impact of extremely high levels or existing micronutrient deficiencies, not a direct reduction of green fodder yield across all varieties at typically studied high levels (Table 1). With respect to the dry fodder yield,the differences among the varieties were non-significant. Among the different levels of phosphorus tried, higher dry matter yield (3579 kg/ha) was recorded at 40 kg P_2O_5/ha, suggesting upper limit for maximizing biomass production. However, dry matter yield differences across phosphorus levels were not statistically significant, suggesting that phosphorus application mainly enhanced fresh biomass rather than dry matter accumulation(Rakesh*et al*., 2016, Bhagat*et al*.,2018, Neeraj*et al*., 2022, Biraj *et al*., 2024, and Dula *et al*., 2024).

Quality Parameters

With respect to quality parameters, crude protein content was significantly influenced by varieties. The variety APFC10-1 recorded the highest crude protein content (12.15%), which was on par with EC-4216 (12.04%) (Table 1)while, Co-8 had the lowest protein content (11.51%). Among the phosphorus levels, crude protein content was highest at 40 kg P□O□ /ha (12.54%), while non application of phosphorus resulted in the lowest crude protein (12.09%). Crude fibre content did not differ significantly among the varieties, although values ranged between 52.21% (APFC10-1) and 53.19% (EC-4216). This suggests that while all varieties produced comparable yields, APFC10-1 stands out for nutritional quality, and EC-4216 for overall biomass and height. There was no significant difference in crude fibre content. These results indicate that 40–60 kg P_2O_5/ha is optimum for both yield and quality of fodder cowpea, while further increase to 80 kg offers no additional benefit. These results are collaborated with Velayudham *et al*., 2015.

CONCLUSION

Among the fodder cowpea varieties tested, MFC 08-14 and EC- 4216 performed well in terms of green and dry fodder yield, while APFC10-1 had shown higher crude protein content. Phosphorus application, particularly at 60 kg/ha, significantly improved green fodder yield, making it a beneficial practice for enhancing fodder productivity under rainfed conditionsof Southern Zone of Andhra Pradesh.

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IDENTIFICATION AND ESTIMATION OF RICE SOWN AREA IN GUNTUR DISTRICT USING SENTINEL 1A SATELLITE DATA

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ABSTRACT

Accurate estimation of rice-sown area is critical for informed agricultural planning, particularly in Andhra Pradesh's complex irrigated landscapes. This study mapped rice cultivation in Guntur district using Sentinel-1A SAR (Synthetic Aperture Radar) data integrated with machine learning classifiers. A total of 84 ground-truth observations supported supervised classification using Random Forest (RF) and K-Nearest Neighbours (KNN). Both models overestimated rice extent, but RF showed superior performance with 94% user's accuracy, 96% producer's accuracy and kappa coefficient of 0.76. Overestimation by KNN was largely due to confusion with waterlogged fallow areas. Results confirm the utility of SAR and RF for precise rice area assessment and underscore the importance of localized model calibration in heterogeneous agroecosystems.

Key words: Crop classification, Random Forest, Rice, SAR, Sentinel-1A

INTRODUCTION

Accurate and timely estimation of crop-sown area is crucial for effective agricultural management, efficient resource allotment and informed policy planning, particularly in regions where agriculture plays a major economic role. Rice is a dominant crop in India's agrarian economy, mainly in Andhra Pradesh, where cultivation is concentrated in the Krishna Western Delta (KWD) and Nagarjuna Sagar Project (NSP) command areas. Estimating rice area in these regions is challenging due to fragmented landholdings, large spatial extent, and variability in cropping patterns and water availability, which limit the reliability of conventional assessment methods. These command areas are economically important and exhibit pronounced spatial and temporal variation in rice cultivation driven by irrigation dynamics and cropping intensity.

Traditional field-based surveys for crop area mapping are labor-intensive, costly, and constrained in spatial coverage. Their effectiveness further declines during the monsoon season, when persistent cloud cover restricts the make use of optical remote sensing (Choudhary *et al*., 2014). These restrictions have raised interest in remote sensing–based approaches that can provide consistent and scalable observations.

Synthetic Aperture Radar (SAR) has appeared as an important tool for agricultural monitoring because it operates independently of weather conditions and sunlight (Liu *et al*., 2019). Sentinel-1A, under the European Space

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Agency's (ESA) Copernicus program, offers frequent revisit cycles and free access to high-resolution data, making it well suited for monitoring rice-growing regions affected by seasonal cloud cover. Many studies have demonstrated its effectiveness in identifying rice fields, including flooded paddies, under diverse environmental conditions (ESA, 2024).

Despite these advantages, SAR-based rice mapping remains challenging due to the similarity in backscatter between rice fields and other land types, such as waterlogged fallows and shallow water bodies, which can develop misclassification (Singh *et al*., 2015). Machine learning classifiers, including Random Forest (RF) and K-Nearest Neighbours (KNN), have shown potential for upgrading classification accuracy, but their performance depends on careful calibration and high-quality training data, particularly in heterogeneous agricultural landscapes (Kumar *et al*., 2022).

With this context, the present study evaluates the effectiveness of RF and KNN classifiers for estimating rice-sown areas in the KWD and NSP command regions. Special attention is given to reducing misclassification caused by saturated lowlands, shallow inundation, and uncultivated seasonal fallows that exhibit SAR backscatter characteristics similar to rice. The study further explores improvements in model performance through the integration of local agricultural knowledge and finer temporal resolution in model calibration.

MATERIAL AND METHODS

The study was done during the 2024 *kharif* season in Guntur district, Andhra Pradesh, India, an area known for extensive canal-irrigated rice cultivation under the KWD and NSP command areas. Time-series Sentinel-1A SAR data were received from the ESA Copernicus Open Access Hub for the kharif season, when rice growth is at its maximum. Multiple SAR acquisitions were selected to capture the peak vegetative and reproductive stages of the rice crop.

SAR data preprocessing was carried out using ESA's Sentinel Application Platform (SNAP) version 10. This involved orbit correction, speckle filtering to reduce inherent SAR noise, and geometric terrain correction to minimize topographic distortions. Backscatter values were converted from digital numbers to decibels to normalize the data and allow comparison across different acquisition dates. The processed SAR data were then used to derive information related to key rice growth stages.

To support model development, ground-truth data were collected from 84 locations across the study area. These sites represented different rice cultivation practices and landscape conditions, ensuring broad spatial coverage. Field visits during the kharif season provided GPS coordinates and visual confirmation of land-cover types.

The ground-truth observations were utilized to train two supervised machine learning models, RF and KNN, to distinguish rice fields from other land types, including waterlogged fallow areas with similar radar backscatter. Cross-validation was applied to reduce overfitting and improve model reliability.

Model performance was assed using user's accuracy, producer's accuracy, and the kappa coefficient (Singh *et al*., 2015). User's accuracy indicates how often pixels classified as rice are actually rice, while producer's accuracy reflects how well rice fields were correctly identified. The kappa coefficient assessed the agreement between classified results and field observations beyond chance.

RESULTS AND DISCUSSION

In this investigation, two machine learning classifiers, RF and KNN, were applied to estimate the rice-sown area in Guntur district using SAR data presented in Fig.1 & 2. Both models overestimated the actual rice-sown area, with KNN showing a stronger overestimation tendency compared to RF (Table 1). The misclassification was largely on account of the spectral similarity between rice fields and other land types, particularly shallow water bodies and water-retaining fallow lands, which present similar radar backscatter signatures. This spectral confusion is a well-documented challenge in SAR-based classification, as various land covers in agricultural landscapes often have overlapping backscatter characteristics, leading to inaccuracies (Gao *et al*., 2017).

Among the two classifiers, RF outperformed KNN, particularly in regions with complex land-use patterns such as the KWD and NSP command areas. RF is known for its ability to manage heterogeneous datasets and to capture complex relationships between input variables, which is a key strength when dealing with complex agricultural environments (Liu *et al*., 2020). The RF classifier achieved user's accuracy of 94%, producer's accuracy of 96%, and a kappa coefficient of 0.76, showing strong agreement with field data. These results are in accordance with previous studies that have demonstrated RF's effectiveness in classifying land cover using SAR data, especially in regions with diverse land use (Yu *et al*., 2020; Surya *et al*., 2024). The relatively high kappa coefficient further confirms that RF delivers reliable results with minimal random misclassification, making it suitable for large-scale monitoring.

In contrast, the KNN classifier displayed a higher degree of overestimation, especially in areas where mixed land types were present. This issue was especially noticed in zones where rice fields were adjacent to waterlogged fallow lands or shallow water bodies, which share similar radar signatures with rice paddies. KNN's reliance on pixel-level classification without considering spatial context can lead to confusion in areas with complex or mixed land covers (Benediktsson *et al*., 2018). While KNN is a simple and widely-used classification method, its performance is often compromised in heterogeneous landscapes where contextual relationships between neighbouring pixels are vital for discriminate land types.

Another crucial observation from this investigation was the spatial variability in the rice area estimates across Guntur district. Specifically, RF underestimated the rice area in the KWD, likely due to the heterogeneity of the fields and varying cropping intensities that were not fully characterised in the training samples. Previous study has highlighted that crop classification can be difficult in regions with highly variable field sizes, land use patterns, and cropping intensity, as these factors introduce significant spatial complexity (Li *et al*., 2021). In this case, the limited number of ground-truth points available for training might have contributed to the underestimation by failing to capture the diversity of field patterns in this region.

Conversely, the NSP command areas showed the highest overestimation in rice area estimates. This could be attributed to late water availability and the existence of self-sown rice from the previous season. While self-sown rice is inactively cultivated, its radar backscatter signature closely resembles that of actively cultivated rice, leading to misclassification. A similar issue was observed by Huang *et al*. (2021), where residual crop growth or land with standing water was mistakenly identified as active crop fields. This issue underscores the importance of incorporating temporal

Table 1: Estimated rice crop areas using random forest and KNN algorthims

S.No	Mandal Name	Normal	Estimated area (ha)		S.No	Mandal Name	Normal	Estimated area (ha)	
			RF	KNN				RF	KNN
1	Amaravathi	294	1088	1240	30	Nagaram	11016	10664	10514
2	Amruthalur	10502	9233	10521	31	Nekarikallu	4742	423	652
3	Atchampet	609	557	745	32	Narasaraopet	1451	5147	6814
4	Bapatla	13453	13401	12564	33	Nizampatnam	5437	8747	9538
5	Bellamkonda	557	1313	1473	34	Nuzendla	1077	2593	4834
6	Bhattiprolu	6031	5855	5128	35	Pittalavanipalem	4921	4949	5949
7	Bollapalle	1143	2622	2463	36	Pedakakani	4967	410	628
8	Chebrolu	5908	6155	5864	37	Pedakurapadu	131	420	592
9	Cherukupalle	7491	5989	5637	38	Pedanandipadu	115	1087	1450
10	Chilakaluripet	92	3736	3296	39	Sattenapalle	1405	2364	4109
11	Dachepalle	352	830	1008	40	Phirangipuram	768	2715	3716
12	Duggirala	8531	8180	10985	41	Piduguralla	1959	4716	5072
13	Durgi	379	2322	2224	42	Ponnur	13210	13072	11588
14	Guntur	145	470	494	43	Prathipadu	362	588	712
15	Edlapadu	657	956	908	44	Rajupalem	1432	2280	2814
16	Gurazala	1249	2691	3055	45	Rentachintala	2203	11214	13485
17	Ipur	2805	3064	3894	46	Repalle	10677	4215	3778
18	Kakumanu	9921	10463	10643	47	Rompicherla	3368	1778	2319
19	Karempudi	2839	2652	2968	48	Savalyapuram	2056	724	621
20	Karlapalem	6453	6575	5724	49	Tadepalle	661	1851	2147
21	Kollipara	6308	5638	4931	50	Tadikonda	385	6763	6249
22	Kollur	5088	5422	4957	51	Tenali	8279	920	1230
23	Krosuru	1226	717	920	52	Thullur	109	7111	7612
24	Machavaram	664	1209	1720	53	Tsundur	8089	3807	3462
25	Macherla	700	2357	3303	54	Vatticherukuru	3622	2138	2810
26	Mangalagiri	2584	1822	2104	55	Veldurthi	22	8453	9568
27	Medikonduru	140	1465	1379	56	Vemuru	8142	1964	2420
28	Muppalla	1872	2584	2486	57	Vinukonda	828	2048	3607
29	Nadendla	153	449	310	**Total**	**199581**	**222978**	241234	

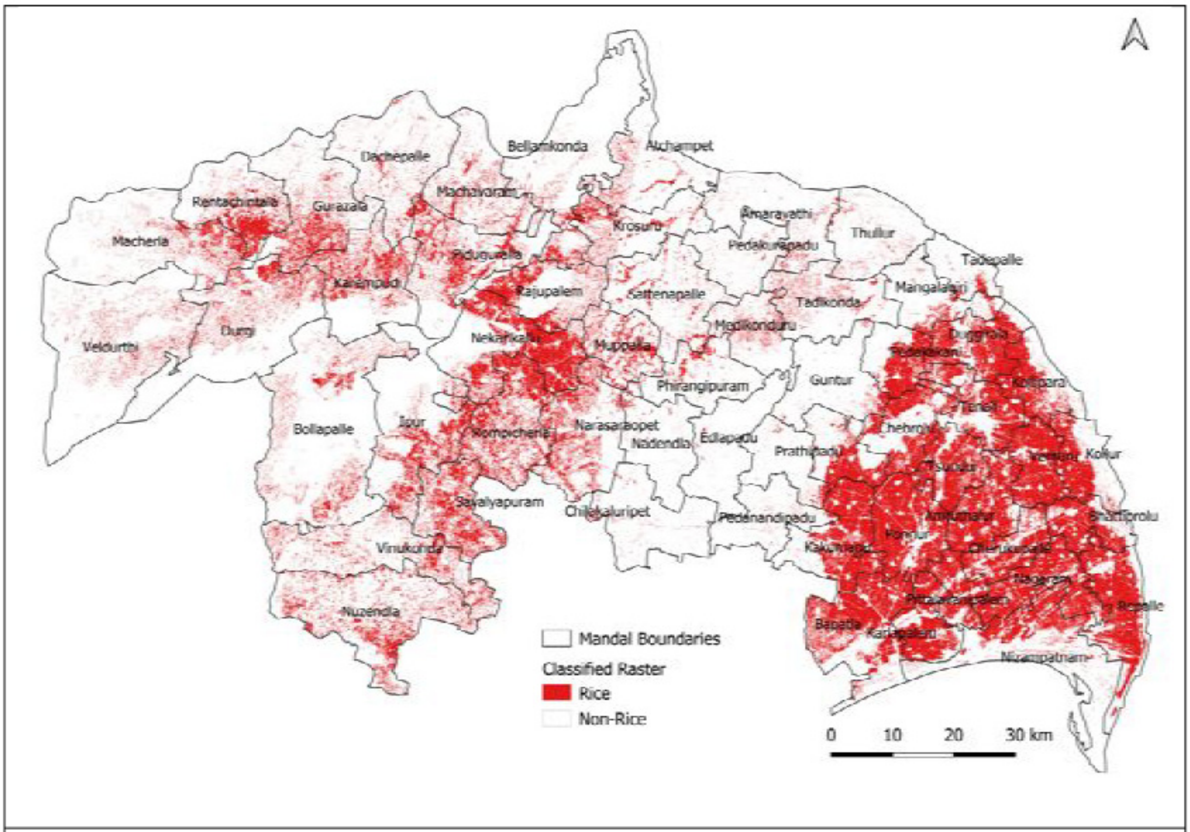

Fig1: Estimated rice area of Guntur district using RF algorithm

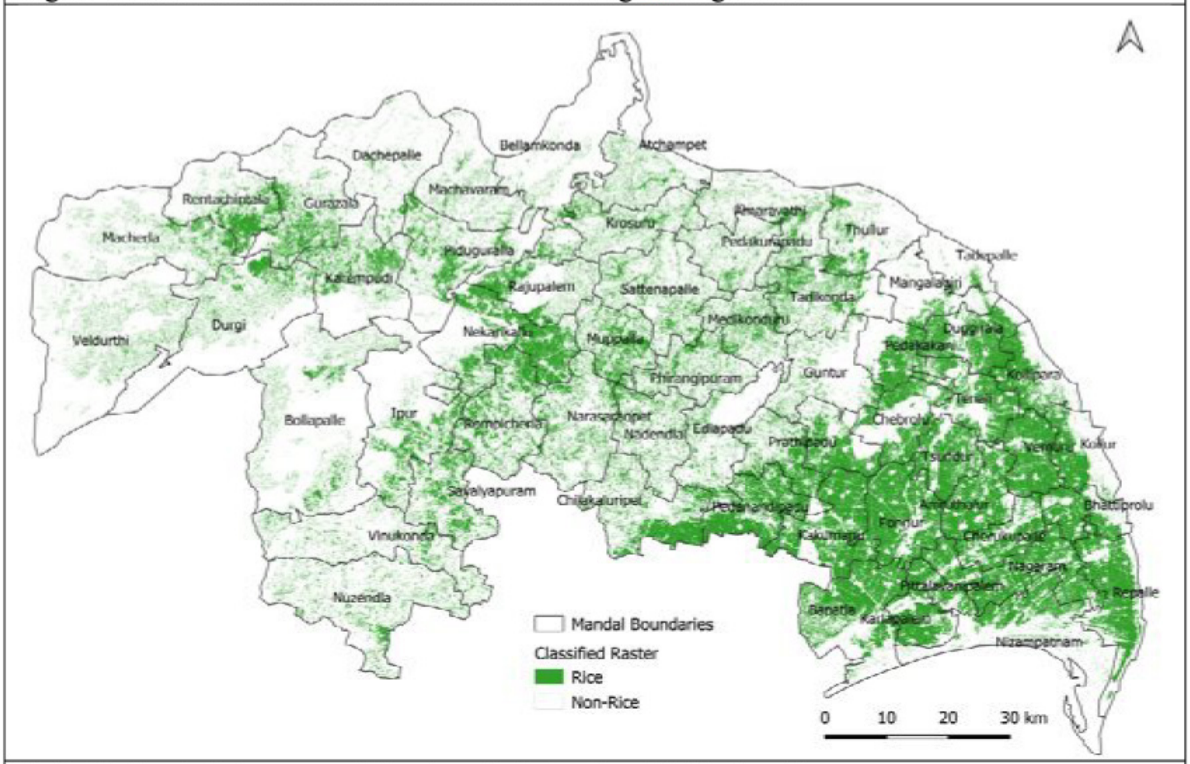

Fig2: Estimated rice area of Guntur district using KNN algorithm

dynamics, such as variations in crop growth stages and water availability, into the classification model for more accurate estimations.

Both the RF and KNN classifiers highlighted the importance of using high-quality, region-specific training datasets for improving classification accuracy. The performance of these algorithms is more sensitive to the diversity and quality of the input training data, which must reflect the spatial and temporal variability of land cover types and crop growth stages. In this study, although 84 ground-truth reference points were collected from different locations, the limited number of samples might not have fully recorded the full range of spatial complexities, particularly in regions with varying cropping intensities and land use. The inclusion of more detailed agronomic data and better representation of crop phenology could further enhance model performance (Kumar *et al*., 2022).

The results also emphasize the need for model calibration specific to local conditions, as machine learning algorithms such as RF and KNN benefit significantly from incorporating region-specific parameters, such as local crop calendars, irrigation practices, and field sizes (Benediktsson *et al*., 2018). Additionally, integrating multi-source remote sensing data, such as combining SAR data from Sentinel-1 with optical imagery from Sentinel-2, could improve classification accuracy. Combining these data sets allow for complementary data that can assist to resolve ambiguities in land cover classification, especially in mixed and heterogeneous agricultural landscapes (Wang *et al*., 2021). This multi-source approach has been successfully implemented in previous studies to enhance classification accuracy and overcome the limitations of using a single remote sensing source.

CONCLUSION

This investigation established that Sentinel-1A SAR imagery, integrated with RF and KNN, is effective for estimating rice-sown areas in irrigated regions. RF outperformed KNN, achieving higher accuracy with a kappa coefficient of 0.76. However, overestimation due to confusion with waterlogged fallow lands where self-sown rice was observed. The results emphasize the importance of region-specific training datasets and temporal dynamics in model calibration. Future work should focus on integrating multi-source remote sensing data and expanding ground-truth data to enhance classification accuracy for real-time agricultural monitoring.

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RESPONSE OF GREENGRAM (V*igna radiata* L.Wilczek) TO FOLIAR NUTRITION OF NANO UREA AND NANO DAP

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ABSTRACT

A field experiment entitled was conducted during *rabi* 2022-23 at Regional Agricultural Research Station, ANGRAU, Lam, Andhra Pradesh, to study the response of greengram (*Vigna radiata* L.Wilczek) with foliar nutrition of nano urea and nano DAP.The experiment comprised of nine treatments and three replications with RBD design.The results indicated that foliar spray of nano DAP and nano urea resulted in higher grain yield (929 kg ha^{-1}&900 kg ha^{-1}) with yield advantage over control (water spray) 739 kg ha^{-1}.The highest net returns and B:C ratios of Rs. 34056 /- & Rs. 31962/- and 0.92 & 0.86 were realized with foliar spray of nano DAP @1.25 ml/l and nano urea @ 2.5 ml/l at flowering initiation, respectively.

Keywords: Greengram, Nano urea, Nano DAP, Growth and Yield

INTRODUCTION

Greengram (*Vigna radiata* L.) is a major pulse crop in India that belongs to the Leguminosae family and contains significant amounts of proteins, minerals, nutrients, and essential amino acids. Greengram is cultivated approximately to an extent of 55.5 lakh hectares, yielding 36.8 lakh tonnes with a productivity of 663 kg ha^{-1} in India. In Andhra Pradesh, greengram is cultivated over an area of approximately 0.59 lakh hectares, with a total production of about 0.58 lakh tonnes and an average productivity of 973 kg ha^{-1} (IIPR, 2024). Nitrogen (N) is the most significant mineral nutrient required by crop plants and is essential for their vegetative growth because it is a component of numerous proteins and enzymes in addition to chlorophyll, while Phosphorus (P) is essential for all life and plays a major role in preserving and improving the fertility of natural soil. The increasing cost of P fertilizer is creating financial hardships, which is why there is an increasing interest in improving P use efficiency. Thus, it is necessary to produce fertilizers that can be taken up more readily by plants while posing no threat to soil and the environment. In this context, nanotechnology has a growing role in crop production with strong promise to alter the existing state of fertilizer use with environmental safety, ecological sustainability and economic stability (Nandhakumar *et al*., 2023).

Foliar nutrition refers to the application of nutrients to the vegetative part at specific concentrations and times so that the plant can

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absorb them through the stomata of leaves or through the cell walls and membranes to participate in vital plant physiological processes. This enhances the vegetative and qualitative aspects to prevent circumstances that restrict the availability of plant nutrients in the soil (Surender Kumar and Kuldeep, 2024). Nano DAP is an efficient source of available nitrogen (N) and phosphorus (P_2O_5) for all the crops. It corrects the nitrogen & phosphorus deficiencies in standing crops. Nutrient use efficiency is more than 90 percent under optimum field conditions. Now-a-days nano fertilizer technology is gaining importance for foliar application of nitrogen (N) through nano urea and phosphorus (P) through nano DAP with respect of growth and development, yield, quality and tolerance to abiotic stress in crops. With this background, the present study involving nano urea and nano DAP foliar application on performance of greengram crop was conducted.

MATERIAL AND METHODS

A field experiment was conducted during *rabi* 2022-23 at Regional Agricultural Research Station (RARS), ANGRAU, Lam, AP located at a latitude of 16'18' North and longitude of 80'29' East with an elevation of 33 meters of above MSL with nine treatments and three replications of RBD design *viz*.T_1 Control (water spray),T_2 Urea 2% at flowering initiation (FI), T_3 nano Urea 2.5 ml/L at flowering initiation, T_4 nano urea 1.25 ml/L at flowering initiation, T_5 nano urea 1.25 ml/l at flowering initiation + 1.25 ml/L at pod development (PD), T_6 DAP 2% at flowering initiation, T_7 nano DAP 2.5 ml/L at flowering initiation, T_8 nano DAP 1.25 ml/L at flowering initiation, and T_9 nano DAP 1.25 ml/L at flowering initiation +1.25 ml/L at pod development. The experimental soil was deep black clay loam in texture. The crop was sown during first fortnight of October with greengram variety LGG630 at 30 cm x10 cm spacing. The recommended dose of fertilizers was (20:50:00 NPK kg ha^{-1}) applied in the form of urea and Single Super Phosphate (SSP) at the time of sowing as basal. The nano formulation of nanourea (4% N w/v) andnano DAP (8:16:0) were utilized as the sources of nano nitrogen and nano phosphorous from IFFCO. Nano urea and nano phosphorous were sprayed at 30 and 45 days after sowing (DAS)using knapsack sprayer @500 lha^{-1}. Each treatment was accommodated in 4.8 m x 4.0 m plots and all the biometric data were recorded from five plants selected randomly at harvest but chlorophyll content was recorded at 35 DAS with SPAD meter. The data from each plot were tested for normality and analyzed using ANOVA with treatment means compared using CD at $P<0.05$ in JMP software.

RESULTS AND DISCUSSION

Effect of Nano Urea

Among the nano urea treatments, foliar application of nano urea @ 1.25 ml L^{-1} at flowering initiation followed by 1.25 ml L^{-1} at pod development (T_5) resulted in the maximum plant height (52.5 cm) and highest number of branches (2.1 $plant^{-1}$) (Table 1). This indicates improved vegetative growth due to sustained nitrogen availability during critical crop growth stages. However, the highest chlorophyll content (51.1 SPAD) was observed in T_3 (nano urea @ 2.5 ml L^{-1} at flowering initiation), followed closely by T_2 and T_5. All nano urea treatments showed significantly higher values compared to the control, though they remained statistically comparable with conventional urea spray. The improvement in growth parameters may be attributed to enhanced nitrogen uptake through foliar application, which increases leaf production and expands leaf area. This results in higher photosynthetic efficiency and greater

Table 1. Growth and yield attributes of greengram as influenced by nano urea and nano DAP

Treatments	Plant height at harvest (cm)	Bran-ches /plant	Chloro-phyll (SPAD)	Pods/ plant	Pod length (cm)	Seeds/ pod	Test wt. (g)
T_1 Control (water spray)	43.1	1.5	43.5	22.9	7.7	11.9	3.45
T_2 Urea 2% at flowering initiation(FI)	45.9	1.6	50.8	28.2	7.8	12.1	3.62
T_3 Nano Urea 2.5 ml l^{-1}at FI	46.6	1.8	51.1	29.3	7.9	12.1	3.65
T_4 Nano urea 1.25 ml l^{-1}at FI	48.0	1.6	46.3	25.3	7.8	12.4	3.84
T_5 Nano urea 1.25 ml l^{-1}at FI + 1.25 ml l^{-1} at pod development (PD)	52.5	2.1	49.7	26.7	7.9	12.1	3.54
T_6 DAP 2% at FI	43.5	1.6	46.8	27.1	7.8	12.5	3.87
T_7 Nano DAP 2.5 ml l^{-1}at FI	51.7	2.2	47.2	28.1	8.0	12.9	3.85
T_8 Nano DAP 1.25 ml l^{-1}at FI	49.6	1.9	50.7	25.1	7.9	12.3	3.75
T_9 Nano DAP 1.25 ml l^{-1}at FI +1.25 ml l^{-1}at PD	52.7	2.0	51.3	31.3	8.1	12.9	4.00
Sem+	1.846	0.042	1.752	1.084	0.149	0.163	0.059
CD (0.05)	5.5	0.1	3.8	3.3	NS	0.5	0.18
CV (%)	6.6	4.0	5.1	6.9	3.3	2.3	2.8

translocation of assimilates from source to sink, ultimately supporting branch development. Similar observations were reported by Marimuthu *et al*. (2024), who found increased branching with nitrogen supplementation.

Further, the combined effect of basal fertilizer and foliar nano nitrogen likely ensured continuous nitrogen availability, promoting active cell division and elongation. Comparable findings were reported by Arun Kumar *et al*. (2024). Alqader *et al*. (2020) also reported enhanced branching in pulse crops following nano nitrogen application. The small particle size of nano urea allows better absorption through leaf surfaces, improving nutrient use efficiency and enhancing photosynthate production. Yield attributes such as pods plant $^{-1}$, seeds pod^{-1} and test weight were significantly improved under nano urea treatments (Table 1). The highest number of pods plant^{-1} (29.3) was recorded in T_3, while T_5 recorded stable improvement across all yield parameters. These improvements were significantly superior to the control.

Grain yield (Table 2) followed a similar trend . The maximum yield of 900 kg ha^{-1} was obtained with T_5, which was significantly higher than the control (739 kg ha^{-1}). However, differences among nano urea treatments and conventional urea were statistically at par. The increased yield can be attributed to improved yield components, especially higher pod number and grain weight. Similar improvements due to nano urea application were reported by Islam *et al*.,2023 and Kunwar and Victor (2023) in blackgram. Economic analysis showed that nano urea treatments recorded higher profitability. The average net returns and B:C ratio of nano urea treatments

Table 2. Yield and economics of Greengram as influenced by nano urea and nano DAP

Treatments	Yield (kg/ha)	COC (Rs.)	Gross Returns (Rs.)	Net Returns (Rs.)	B:C ratio
T_1 Control (water spray)	739	36230	57309	21079	0.58
T_2 Urea 2% at flowering initiation(FI)	836	36289	64832	28543	0.79
T_3 Nano Urea 2.5 mll^{-1}at FI	889	36980	68942	31962	0.86
T_4 Nano urea 1.25 mll^{-1}at FI	846	36605	65607	29002	0.79
T_5 Nano urea 1.25 mll^{-1}at FI + 1.25 mll^{-1} at pod development (PD)	900	37730	69795	32065	0.85
T_6 DAP 2% at FI	862	36500	66848	30348	0.83
T_7 Nano DAP 2.5 mll^{-1}at FI	894	37730	69330	31600	0.84
T_8 Nano DAP 1.25 mll^{-1}at FI	916	36980	71036	34056	0.92
T_9 Nano DAP 1.25 mll^{-1}at FI +1.25 mll^{-1} at PD	929	38480	72044	33564	0.87
Sem+	33.229				
CD (0.05)	100				
CV (%)	6.6				

Note: Nano urea: Rs.250/- per 500 ml; Nano DAP: Rs.600/- per 500 ml, urea: Rs.5.92/- per kg, DAP: Rs.27/- per kg & produce (seed): Rs.7755/-per quintal

(T_3, T_4 and T_5) were Rs.31,010 ha^{-1} and 0.83, respectively, which were higher than conventional urea and control. Enhanced returns may be due to better photosynthetic efficiency and efficient partitioning of assimilates towards grain development, supported by sustained nitrogen availability. These findings are in agreement with Islam *et al.,*2023.

Effect of Nano DAP

Among nano DAP treatments, T_9 (nano DAP @1.25 ml L^{-1} at flowering initiation + 1.25 ml L^{-1} at pod development) recorded the highest plant height (52.7 cm) and maximum chlorophyll content (51.3 SPAD) (Table 1). Branch number was also higher under nano DAP treatments. Nano DAP treatments were comparable with conventional DAP for plant height but significantly superior for chlorophyll content. Improved growth under nano DAP application may be attributed to increased phosphorus availability, which plays a vital role in energy transfer, root development and cell division. Enhanced nutrient absorption through foliar application improves overall plant vigor. Similar findings were reported by Wu *et al*. (2024).

Yield attributes such as pods $plant^{-1}$ (31.3), seeds pod^{-1} (12.9) and test weight (4.00 g) were maximum in T_9 (Table 1). Consequently, the highest grain yield (929 kg ha^{-1}) was also recorded in this treatment, which was significantly superior to the control (739 kg ha^{-1}) (Table 2). However, yields among nano DAP and conventional DAP treatments were statistically comparable. Economic evaluation indicated that T_8 (nano DAP @1.25 ml L^{-1} at flowering initiation) recorded the highest net returns (Rs. 34,056 ha^{-1}) and B:C ratio (0.92), making it the most cost-effective treatment. This suggests that a single spray at flowering stage is sufficient to achieve higher profitability.

The superior performance of nano DAP can be attributed to its controlled nutrient release, ensuring continuous phosphorus supply during reproductive stages. Enhanced enzymatic activity associated with phosphorus metabolism improves carbohydrate translocation and grain filling. Similar results were reported by Yadav *et al*. (2023) in chickpea and Henarani *et al*. (2022) in rice.

CONCLUSION

The study concluded that foliar application of nano fertilizers significantly enhanced greengram productivity and profitability. The highest grain yield (929 kg ha^{-1}) was recorded with nano DAP @1.25 ml L^{-1} applied twice, registering a 23.5% yield increase over control, while nano urea applied twice produced 900 kg ha^{-1}, showed an 18.8% yield advantage. The highest net returns (₹ 34,056 ha^{-1}) and B:C ratio (0.92) were obtained with nano DAP @1.25 ml L^{-1} at flowering initiation, whereas nano urea @2.5 ml L^{-1} recorded Rs.31,962 ha^{-1} net returns and 0.86 B:C ratio. Thus, foliar application of nano DAP @1.25 ml L^{-1} at flowering initiation can be recommended as an efficient and economically viable nutrient management strategy for greengram cultivation.

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'ABV04' A NEW BAJRA VARIETY SUITABLE TO THE TRIBAL AREAS OF ASR DISTRICT

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ABSTRACT

Frontline demonstrations on the pearl millet variety ABV-04 were conducted over two consecutive years (2023-24 and 2024-25) in the tribal regions of Alluri Sitarama Raju (ASR) district to evaluate its performance under rainfed upland conditions. A total of 20 demonstrations covering 8 hectares were carried out to compare the yield advantage of ABV-04 over the existing local farmer practice, i.e., Pittaganti variety. The results indicated that ABV-04 consistently outperformed local landraces, recording a pooled average grain yield of 1451.3 kg ha^{-1}, compared to 979.9 kg ha^{-1} from the Pittaganti variety, with a yield advantage of 47.6%. In the first year, the variety showed a 57.7% higher yield, while in the second year, the yield advantage was 37.6%, despite climatic challenges such as reduced rainfall and delayed sowing.In addition, a gap analysis based on these frontline demonstrations was carried out to assess performance and identify yield-limiting factors. The average technology gap was 1176.3 kg ha^{-1}, indicating constraints such as poor soil fertility, erratic rainfall, and low input usage. The extension gap averaged 471.4 kg ha^{-1}, demonstrating the effectiveness of improved practices over traditional methods. The technology index was recorded at 42.0%, suggesting moderate feasibility under field conditions and highlighting the need for enhanced adoption support.

Key words:ASR District, Bajra, Extension gap, Front Line Demonstration, Technology gap, Technology Index, Tribal areas.

INTRODUCTION

Pearl millet (*Pennisetum glaucum*.), commonly known as bajra, is a vital cereal crop ranking next to rice, wheat, maize, and sorghum in terms of importance. It is predominantly cultivated in arid and semi-arid regions, where it thrives under harsh climatic conditions due to its exceptional drought resistance and adaptability to poor soils. Apart from being a nutritious food grain for human consumption, bajra also serves as an important fodder crop for livestock.

Bajra is especially valuable in dryland agriculture, offering a sustainable livelihood option for farmers in regions with limited water availability.India is the largest producer of pearl millets covering about 8.75 million ha of marginal and sub marginal lands primarily in the states of Rajasthan, Gujarat, Haryana, Uttar Pradesh and Maharashtra ranking 3rd after rice

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and wheat in acreage (Muniratnam and Gautam,2002)

In the tribal-dominated regions of Alluri Sitarama Raju (ASR) district, particularly in the hilly terrains of Paderu and its surrounding mandals, traditional agricultural practices continue to dominate farming systems. One of the staple crops cultivated by tribal farmers in these areas is bajra (*Pearl millet)*, primarily using local landraces such as "*Pitta Ganti*". These indigenous varieties, while naturally adapted to the rugged and moisture-deficient conditions of the region, are characterized by very low productivity due to their limited genetic potential and the absence of scientific crop management practices. Most farmers rely on age-old methods without the application of improved seeds, balanced fertilization, effective pest and weed control, leading to consistently low yields and sub-optimal returns. In this context, there is a growing need to introduce climate-resilient and nutritionally superior crop alternatives that align with the agro-ecological realities of hill agriculture.

Given its minimal input requirements and robust adaptability, pearl millet in generaland ABV-04 in particularoffers a low-risk, climate-smart alternative to traditional crops. Its dual-purpose nature increases its economic value, while its nutritional profile supports better health and resilience in vulnerable rural households. In regions like Paderu, where conventional crop choices are constrained by topography, rainfall variability and poor infrastructure, ABV-04 emerges as a highly promising option for transforming subsistence farming into a more productive and sustainable system. The ongoing efforts to promote this variety through frontline demonstrations, farmer training and seed distribution will be critical in bridging the technology and extension gaps, thereby enabling tribal farmers to realize the full potential of their agro-ecosystems. Hence, the present study was conducted with the objective to assess the field performance and yield potential of ABV-04 under tribal farming conditions and compare its performance with local farmer practices i.e., *Pittaganti* variety

MATERIAL AND METHODS

The demonstrations were conducted over two consecutive *Kharif* seasons (2023-24 and 2024-25) in seven tribal villages, including Sirsapalli, Gasabu, Pedabhyalu, Tadigiri, Neelamputtu, Baramasiand Galaganda, which fall under hill zone farming systems characterized by poor soils, erratic rainfall and traditional agricultural practices. A total of 20 frontline demonstrations were conducted across 8 hectares of tribal farmers fields. The objective was to assess the performance of ABV-04 under field conditions and evaluate its superiority over traditional farmer practices, particularly in terms of growth attributes, yield componentsand overall productivity. The variety ABV-04, developed and released by ANGRAU, is known for its short duration, drought tolerance and dual-purpose utility (grain and fodder), making it suitable for low-input and moisture-stressed areas.

For each demonstration, paired plots were selected: one for the improvedpractice (ABV-04) and one for the farmer's traditional practice. The growth and yield observations were recorded at different crop growth stages*viz.,*30, 60 DAS and at harvest

Similarly the following parameters were recorded from both demonstration and farmer plots:

- Plant population (No m^{-2})
- Plant height (cm)
- Number of tillers m^{-2}
- Number of ear heads m^{-2}
- Ear head length (cm)

For yield estimation, a 5 m × 5 m (25 m²) area was harvested separately in each plotand the grain weight was recorded and converted to kilograms per hectare (kgha^{-1}) using standard conversion methods. The average grain weight was taken to ensure uniformity in comparison.

Analytical Tools Used

To analyse the performance of the demonstrated variety and assess the yield gaps, standard methodologies as suggested by Yadav *et al.* (2004) and Verma *et al.* (2014) were followed. The following formulas were applied:

1. Technology Gap (kg ha^{-1})

Technology Gap = Potential yield - Demonstration yield

This measures the shortfall in achieving the crop's potential under field conditions and reflects environmental and management constraints.

2. Extension Gap (kg ha^{-1})

Extension gap = Demonstration yield – Farmer's yield

This shows the yield advantage achieved due to improved technology adoption and helps in identifying extension needs.

3. Technology Index (%)

Technology index =

$$\frac{\text{(Potential yield – Demonstration yield)}}{\text{Potential yield}} \times 100$$

A lower value indicates better performance and feasibility of the technology under real farm conditions.

4. Percent Yield Increase (%)

% Yield Increase =

$$\frac{\text{(Demonstration yield – Farmer's practice yield)}}{\text{Farmer's practice yield}} \times 100$$

This represents the relative benefit of improved practices over traditional practice.

RESULTS AND DISCUSSION

Growth and Yield Parameters

Growth and yield parameters of ABV 04 and local variety (*Pittaganti*) were presented in Table1 and revealed that, with regard to growth attributes like plant population was almost similar across both treatments at all stages (30, 60 DAS and harvest), indicating uniform germination and crop establishment under both practices. During crop growth period, ABV-04 maintained a slightly higher plant population at harvest (14.5) compared to the local variety (13.4), indicating better crop stand. Similarly, ABV-04 recorded significantly higher plant height than the local variety at all stages *i.e* at 30 DAS (59.4 cm & 43.8 cm), at 60 DAS (121.3 cm & 95.6 cm) and at harvest (190.9 cm & 153.1 cm), respectively. This indicates better vegetative growth, likely due to the genetic superiority and responsiveness of ABV-04 to improved management practices.

Likewise, in yield attributing parameters like number of tillers m^{-2}, number of ear heads m^{-2} and ear head length (cm) showed the superior performance. With regard to number of tillers m^{-2}, ABV-04 consistently recorded more tillers than the local variety at all stages *i.e*. at 30 DAS (18.0 & 15.3), at 60 DAS (19.8 &16.6) and at harvest (18.3 & 15.2), respectively. Higher tillering contributes to greater yield potential due to more productive shoots plant^{-1}. Likewise the highest number of ear heads m^{-2} (17.6 ear heads m^{-2})in ABV 04, while the local variety had 15.0 ear heads m^{-2}.This demonstrates a direct yield advantage through better reproductive efficiency. And another important yield attributing parameter *i.e*ear head length (cm), in ABV-04 recorded longer ear heads (22.4 cm) compared to the local variety (18.2 cm), indicating higher grainbearing capacity ear head^{-1}.

Grain Yield: Two years pooled data of 20 demonstrations revealed (Table:1a) that the use of high yielding variety (ABV-04) gave an average of 47.6% more grain yield of pearl millet as compared to farmers practice. During the year 2023–24, ten frontline demonstrations were conducted in 4 hectares using the ABV-04 bajra variety in the tribal areas of ASR district. The demonstration yield (DY) recorded was 1620 kg ha^{-1}, significantly higher than the farmers practice yield (FP) of 1027.5 kg ha^{-1}, resulting in a yield increase of 57.7%. This dramatic increase in yield is attributed to the adoption of improved practices such as quality seed use and other agronomic timely management practices. In the subsequent year 2024–25, another ten demonstrations were carried out over 4 hectares, where the average demonstration yield dropped to 1282.5 kg ha^{-1}, while the farmers practice yield was 932.3 kg ha^{-1}. Although the yield advantage was still positive, the percentage increase over FP dropped to 37.6%, potentially due to climatic variability such as lower rainfall and delayed sowing. The overall mean results across 20 demonstrations in 8 hectares revealed that ABV-04 yielded an average of 1451.3 kg ha^{-1}, compared to 979.9 kg ha^{-1} under traditional farmer practices, marking a mean yield improvement of 47.6%. The results were in similarity with results reported by Kumar *et al.*(2022) and Jayalakshmi *et al*., (2024).

Gap Analysis: (Technology Gap, Extension Gap and Technology Index)

The technology gap represents the difference between the potential yield and the yield achieved under improved technology demonstrations. It is considered more significant than other parameters as it reflects the constraints in implementation as well as limitations in the recommended package of practices, which may be environmental or varietal in nature. Despite the improved performance, a mean technology gap of 1176.3 kg ha^{-1} (Table 2a) was observed when compared to the potential yield of 2500 kg ha^{-1}. This gap may be attributed to several constraints prevalent in tribal farming systems, such as poor soil fertility, uneven rainfall, low input use, and limited access to timely extension services. It also indicates the need for further improvements in adoption and crop management practices to achieve the full yield potential of the variety.

The extension gap is an important parameter used to assess the difference in yield between demonstrated technologies and existing farmers' practices. The mean extension gap of 471.4 kg ha^{-1} indicates a significant yield advantage of demonstration plots over traditional practices. This gap underscores the need for timely dissemination of improved agricultural technologies, particularly in remote tribal areas where access to information is limited. The observed gap may be attributed to the adoption of improved varieties in demonstration plots, which resulted in higher grain yield compared to farmers' conventional practice.Similarly, the technology index for all demonstrations conducted over different years was found to be consistent with the observed technology gap. The average technology index was 42.0%, indicating the feasibility of the technology under field conditions. This relatively high value suggests that although the variety performed satisfactorily, certain constraints still limit the realization of its full yield potential in tribal hill ecosystems. Factors such as variability in rainfall, lack of irrigation facilities, and reliance on traditional farming

Plate:1 Seed Distributed to the tribal farmers

Plate :2 Biometric observations

Plate :3 &4 Bajra fields during crop growth period

Plate : 5 Ear heads of ABV-04

Table.1. Growth and yield parameters of ABV 04 and *Pittaganti* under Front line demonstrations.

Treatments	At 30 DAS			At 60 DAS			At Harvest				
	Plant Population (No/m^{-2})	Plant height (cm)	No.of Tillers m^{-2} (No.)	Plant Population (No m^{-2})	Plant height (cm)	No.of Tillers m^{-2} (No.)	Plant Population (No m^{-2})	Plant height (cm)	No.of Tillers m^{-2} (No.)	No.of Ear heads m^{-2}	Ear Head Length (cm)
T1: Bajra var. ABV04	14.9	59.4	18.0	14.6	121.3	19.8	14.5	190.9	18.3	17.6	22.4
T2: farmers Practice (Pitta Ganti)	14.8	43.8	15.3	14.0	95.6	16.6	13.4	153.1	15.2	15.0	18.2

Table.1a Performance of Bajra ABV 04 under Front line Demonstrations

Year	Demos	Area	Yield (Kg ha^{-1})			% increase Yield Over farmers Practice	Technology gap (Kg ha^{-1})	Extension Gap (Kg ha^{-1})	Technology Index (%)
			PY	DY	FP				
2023-2024	10	4	2500	1620	1027.5	57.7	880	592.5	35.2
2024-2025	10	4	2500	1282.5	932.3	37.6	1473	350.2	48.7
Total/Mean	20	8	2500	1451.3	979.9	47.6	1176.3	471.4	42.0

practices may have contributed to this index. The higher technology index highlights the need to strengthen farmer awareness and capacity-building through appropriate extension methods, promoting the adoption of improved varieties and recommended production practices to reduce existing gaps. Similar findings were reported by Singh et al. (2020), Jayalakshmi et al. (2022), and Jadhav et al. (2022).

CONCLUSION

The introduction of high-yielding bajra variety ABV 04, combined with timely management practices, significantly enhanced yield and productivity in the tribal regions of ASR district when compared to the traditionally cultivated local variety,Pittaganti. While Pitta ganti yielded lower due to poor genetic potential and minimal input use under frontline demonstrations. This improvement highlights the importance of varietal replacement with ABV-04 and scientific management in tribal agriculture. However, to fully realize its potential, it is essential to bridge existing technology and extension gaps through sustained capacity building, timely input support and location-specific advisories. The results reaffirm that strategic varietal introduction and field-level demonstrations are vital for increasing crop productivity, resilience and farmer incomes in under-served and climate-vulnerable regions.

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ANTIXENOSIS AND ANTIBIOSIS EFFECTS OF SELECTED RICE CULTURES AGAINST THE BROWN PLANTHOPPER (*NILAPARVATA LUGENS* (STÅL))

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ABSTRACT

Pot culture experiments were carried out in glasshouse at Andhra Pradesh Rice Research Institute and Regional Agricultural Research Institute, Maruteru, West Godavari district, Andhra Pradesh during the period 2010 to 2011 to study the antixenosis and antibiosis effects of twelve rice cultures on rice brown planthopper feeding activity along with resistant check (Ptb 33) and susceptible check (TN1). Among those, the rice cultures which recorded significantly maximum number of feeding marks were MTU 1075 (128.10), MTU IJ 206-7-4-1 (112.80), MTU PLA 99-1-3-1-2 (110.20) and resistant check, Ptb 33 (61.50) than TN1 (24.30). The rice cultures, MTU IJ 206-7-4-1 (25.60 mm^2), Ptb 33 (58.80 mm^2), NLR 3093 (65.60 mm^2) and RGL 7002 (87.80 mm^2)excreted significantly less amount of honeydew compared to the susceptible culture, TN1 (450.40 mm^2) indicating that these were less preferable for BPH feeding.

Key Words: Brown planthopper, Feeding preference, Feeding rate, Pot culture experiments, Rice cultures.

INTRODUCTION

The brown planthopper (BPH), *Nilaparvata lugens* (Stal) (Homoptera: Delphacidae) is one of the most destructive monophagous insect pests of rice throughout the rice growing countries in Asia. The BPH causes serious yield reduction in rice by sucking the phloem sap and plugging with their feeding sheaths (Hu *et al.,* 2015). Heavy dependence on chemical pesticides for the control of this pest leads to many adverse effects like harmful effects on natural enemies, development of insecticide resistance,environmental pollution and high cost of production. Cultivation of resistant rice varieties is the most economical and efficient method for the management of BPH (Li *et al.,* 2011) and is an important approach in Integrated Pest Management. Understanding the mechanisms underlying rice resistance to BPH is very essential for developing appropriate breeding strategies. Generally, the insect resistance types with regard to the physiological function were classified into antixenosis (non-preference), antibiosis and tolerance (Painter, 1951).In general, resistant rice plants exhibit two strategies i.e. antixenosis and antibiosis against BPH. The present study was conducted with

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an aim to identify the antixenosis and antibiosis effects of certain identified resistant rice cultures on feeding activity of BPH.

MATERIAL AND METHODS

Plant material

Twelve rice cultures previously identified as highly resistant ormoderately resistant in field screening *viz.,*NLR 3090, NLR 3093, MTU 1075, WGL 401, WGL II 218-5-1, MTU PLA 99-1-3-1-2, NLR 20131, BPT 2404, RDR 34, RGL 7001, RGL 7002 and MTU IJ 206-7-4-1were used to study the antixenosis and antibiosis effects on BPH feeding activity along with resistant check (Ptb 33) and susceptible check (TN1). Pot culture experiments were carried out in the glasshouse facility of Andhra Pradesh Rice Research Institute and Regional Agricultural Research Institute, Maruteru, West Godavari district, Andhra Pradesh during the period 2010 to 2011. The mean temperature during the study period ranged from 25°C to 32°C and the relative humidity ranged from 54% to 86 %.

Mass culturing of BPH

To obtain different instar nymphs and adults of BPH required for the study, the insect was mass reared in the greenhouse and iron framed rearing cages covered with fine mesh wire net. Four to six weeks old potted plants of susceptible rice variety, Taichung Native1 (TN1) were used for culturing the BPH. To start the culture of BPH, the potted TN1 plants were cleaned and the dried, outer leaf sheaths were removed. They were then placed in an oviposition cage. Gravid females of BPH obtained from the maintenance cage were released on to the potted TN1 plants for oviposition and exposed for three days. Then the oviposited plants were placed in maintenance cage for hatching of the eggs. The host plants in culture maintenance cage were changed twice a week and replaced them with fresh potted plants (Sarao and Bentur, 2016).

Antixenosis effect on feeding preference

Two adult female hoppers were enclosedin a parafilm sachet attached to the leaf sheaths of each test cultureand allowed to feed for 24 hours. Each test culture was replicated ten times.After 24 hours, the insects were removed and the test plant was stained by dipping in 0.1% erythrosine dye for 10-15 minutesto distinguish the feeding marks on the test entries. The pink stained feeding marks were counted by using microscope.The feeding preference was determined on the basis of average number of stylet sheaths/plant among the cultures (Sarao and Bentur, 2016).

Antibiosis effect on feeding rate

The antibiosis resistance of rice to BPH was assessed by estimating the amount of honeydew excreted by the adult hoppers. Whatman No.1 filter paper was dipped in a 0.02% bromocresol green solution in ethanol was placed around the base of the feeding chamber and infested with five freshly emerged female BPH hoppers, pre-starved for four hours. The BPH adults were allowed to feed for 24 hours at the base of the stem. Honeydew excreted by BPH was absorbed onto the filter paper and appeared as a blue spot. The area blue spots appeared on filter paper was measured by graph method. Area of the spot was proportional to the honeydew production and therefore to the amount of BPH feeding (Sarao and Bentur, 2016).Data were subjected to analysis of variance (ANOVA) in a randomized block design (RBD) after appropriate data transformation (Gomez and Gomez, 1984). Treatment means were compared using the critical difference (CD) test at P=0.05.

RESULTS AND DISCUSSION

Antixenosis effect on feeding preference

The stained salivary sheath (feeding) marks as a result of stylet probing were counted and used as a parameter to assess the antixenosis effect on feeding activity. The number of feeding marks on the leaf sheaths due to BPH feeding on the tested rice cultures along with resistant and susceptible check was presented in table 1 and fig. 1. The results indicated that the feeding marks on leaf sheath differed significantly among the rice cultures. The number of feeding marks (Plate 1) ranged from 12.50 to 128.10. The feeding marks were observed to be significantly higher in rice cultures, MTU 1075 (128.10), MTU IJ 206-7-4-1 (112.80), MTU PLA 99-1-3-1-2 (110.20) and were higher than the resistant check, Ptb 33 (61.50). These were followed by NLR 3090 (105.40), WGL II 218-5-1 (97.10), BPT 2404 (91.80), WGL 401 (62.00), NLR 20131 (56.80), RGL 7001 (51.30), NLR 3093 (48.80) and RDR 34 (39.40). RGL 7002 (12.50) recorded significantly lower number of feeding marks than susceptible check, TN1 (24.30).

In the present investigation, some of the rice cultures *viz*., MTU 1075, MTU IJ 206-7-4-1 and MTU PLA 99-1-3-1-2 recorded maximum number of feeding marks compared to resistant check, Ptb 33 indicating that the BPH does not find a suitable feeding site on those and making numerous probes in an attempt to locate a suitable feeding site. Whereas, the rice culture RGL 7002 recorded significantly lower number of feeding marks even than the susceptible check, TN1 indicated that it was more preferable for BPH feeding.Significantly higher feeding marks in rice cultures like MTU 1075, MTU IJ 206-7-4-1 and MTU PLA 99-1-3-1-2 from the present study were in concurrence with the results of Sarao and Bentur, 2016, who reported a greater number of feeding marks in RP2068-18-3-5, Ptb33, MR1523, Rathu Heenati, Sinnasivappu, ARC10550, MO1 and INRC3021 compared to susceptible TN1.

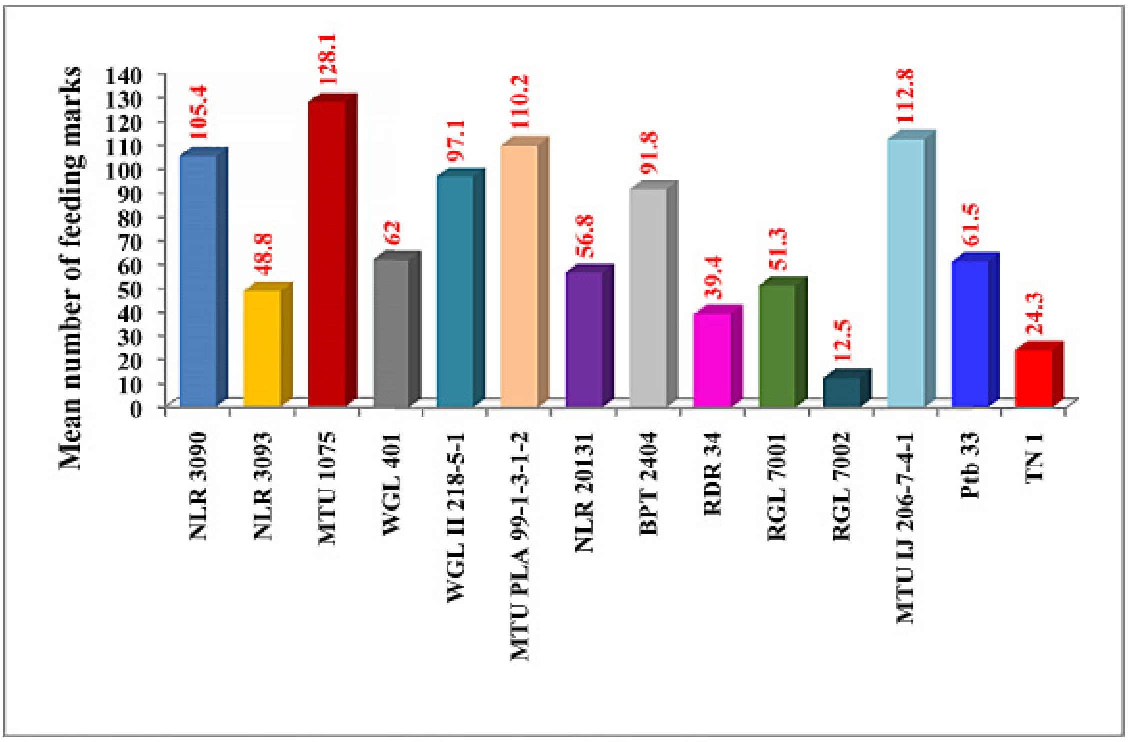

Fig. 1. Feeding marks of BPH adults on tested rice cultures

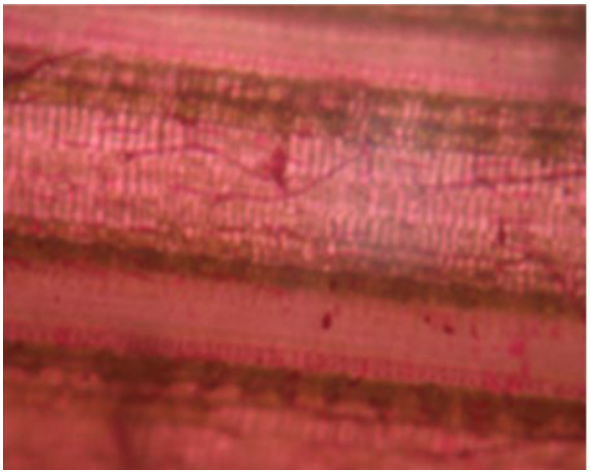
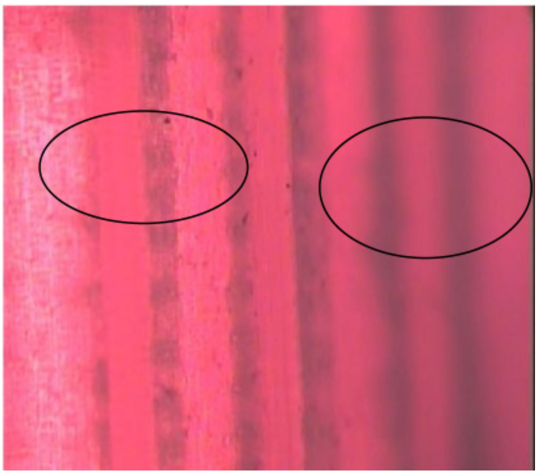

Plate 1a. Leaf sheath without feeding marks Plate 1b. Leaf sheath with feeding marks

Greater number of feeding marks on the resistant genotypes may be because of BPH does not find a suitable feeding site on those and moves around, making numerous probes in an attempt to locate a suitable feeding site (Khan and Saxena, 1986) or due to the presence of certain feeding deterrents or toxic chemicals present in the plant sap (Sogawa, 1982).

Antibiosis effect on feeding rate

The quantity of excretion of honeydew by brownplanthopper, in general, is directly related to intake of plant sap. Therefore, the amount of honeydew excreted by the insect in unit time when fed on different rice cultures is considered as an index of antibiosis mechanism of resistance on BPH feeding rate. The honeydew excreted area of BPH adults in mm^2 on selected rice cultures in comparison to the susceptible and resistant check were presented in table 1 and fig. 2. The amount of honeydew excreted in the present study ranged from 25.60 mm^2 to 456.40 mm^2 (Plate 2). The results indicated that all the resistant rice cultures showed significantly less amount of honeydew excretion as compared to susceptible check, TN1 (456.40 mm^2). Among the resistant rice cultures, MTU IJ 206-7-4-1 recorded lowest honeydew excreted area of 25.60 mm^2 and followed by resistant check, Ptb 33 (58.80 mm^2), NLR 3093 (65.60 mm^2) and RGL 7002 (87.80 mm^2). The rice cultures *viz.*, RGL 7001 (133.20 mm^2), MTU 1075 (160.80 mm^2), NLR 20131 (164.00 mm^2), WGL II 218-5-1 (168.20 mm^2) recorded moderate honeydew excreted area and MTU PLA 99-1-3-1-2 (200.80 mm^2), NLR 3090 (218.40 mm^2), WGL 401 (260.80 mm^2) and BPT 2404 (340.60 mm^2) recorded highest honeydew area among the rice cultures tested.

In the present investigation, the BPH excreted significantly higher amounts of honeydewon the susceptible TN1, but significantly low quantities were excreted when the insects were confined onto the resistant and moderately resistant cultures. Significant variation was also observed among the resistant cultures. The resistant culture MTU IJ 206-7-4-1 (25.60 mm^2) recorded lowest honeydew excreted area than the resistant check, Ptb 33 (58.80 mm^2). These results corroborate the findings of Udayasree and Rajanikanth (2018) who also noted lower honeydew excretion in resistant genotypes, suggesting reduced sap ingestion as a resistance mechanism.Alagar *et al*. (2007) and Boopathi and Bharathi (2008) also reported similar results. It was also observed from the present investigation that the rice culture RGL 7002 though it doesn't show antixenosis effect on BPH feeding but exhibited antibiosis effect

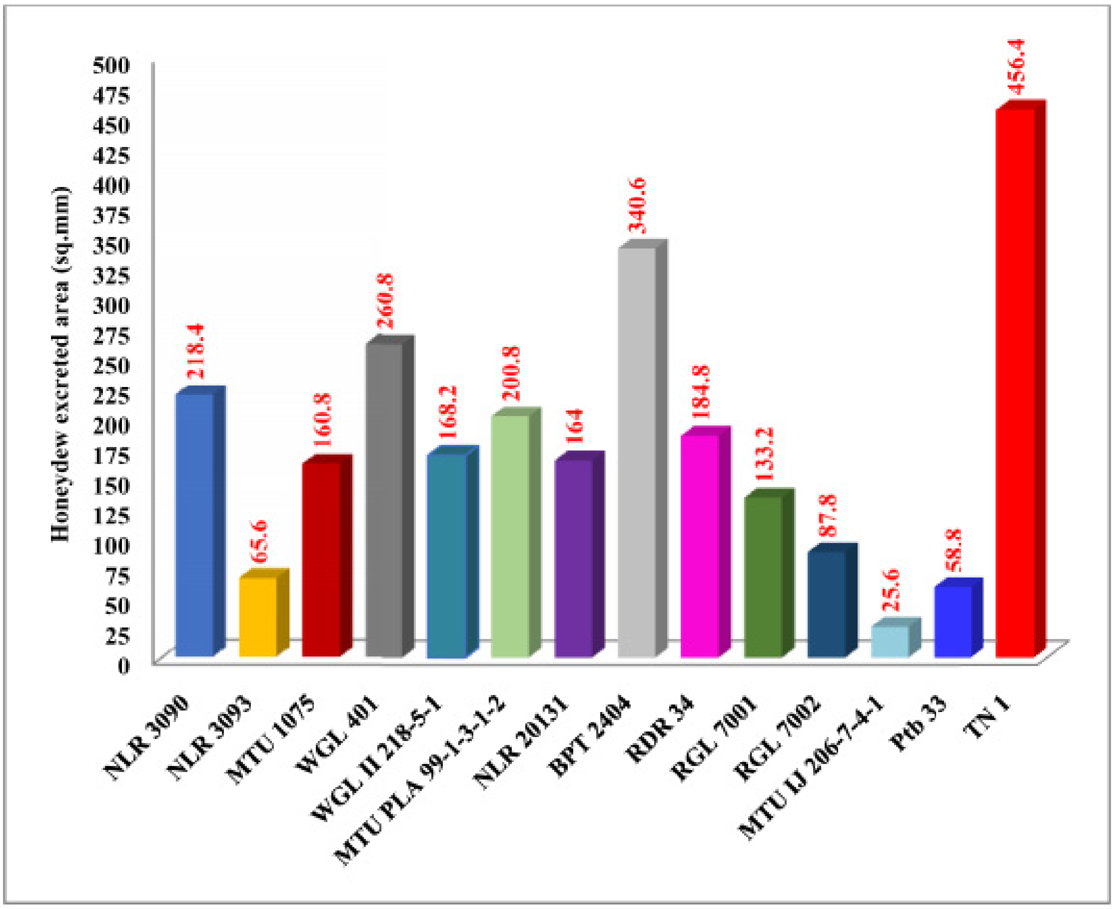

Fig. 2. Honeydew excreted area (mm²) by females of BPH on tested rice cultures

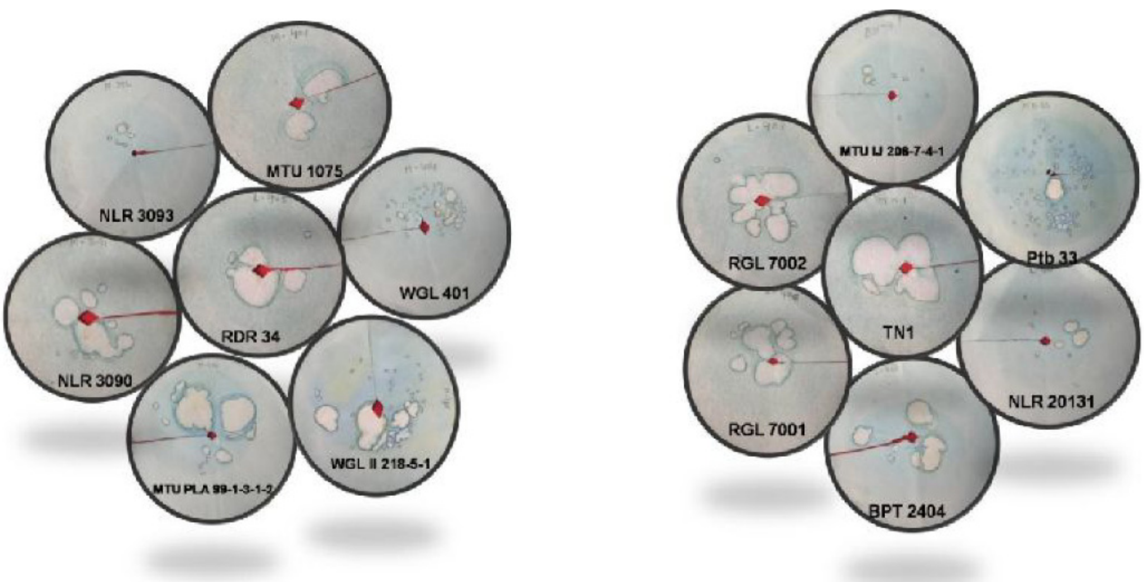

Plate 2. Bromocresol green treated filter paper with honeydew excretion spotson selected rice cultures

Table 1. Antixenosis and antibiosis effect of certain rice cultures on feeding activity of brown planthopper, *Nilaparvata lugens* (Stal)

Rice culture No.	Field reaction to BPH	Mean no. of feeding marks	Honeydew excreted area (mm²)
NLR 3090	MR	105.40(10.05)	218.40 (14.63) [d]
NLR 3093	MR	48.80(6.83) [cd]	65.60 (8.06) [b]
MTU 1075	R	128.10(11.27) [g]	160.80 (12.58) [cd]
WGL 401	MR	62.00(7.67) [cd]	260.80 (16.05) [de]
WGL II 218-5-1	MR	97.10(9.68) [e]	168.20 (12.93) [cd]
MTU PLA 99-1-3-1-2	MR	110.20(10.46) [fg]	200.80 (13.97) [d]
NLR 20131	MR	56.80(7.32) [cd]	164.00 (12.75) [cd]
BPT 2404	MR	91.80(9.45) [e]	340.60 (18.29) [e]
RDR 34	MR	39.40(6.24) [bc]	184.80 (13.48) [cd]
RGL 7001	R	51.30(7.05) [cd]	133.20 (11.49) [c]
RGL 7002	R	12.50(3.37) [a]	87.80 (9.33) [b]
MTU IJ 206-7-4-1	HR	112.80(10.20) [efg]	25.60 (4.89) [a]
Ptb 33	HR	61.50(7.77) [cd]	58.80 (7.62) [b]
TN 1	HS	24.30(4.90) [b]	456.40 (21.63) [f]

HR= Highly resistant; R=Resistant; MR= Moderately resistant; HS= Highly susceptible
Figures in parenthesis are square root transformed values
Mean with same letter are not significantly different at 5 % level by Duncan's Multiple Range test

with lesser area of honeydew excretion. This might be due to that the BPH experiences no difficulty in reaching the vascular bundles indicating that there is no mechanical barrier in the resistant varieties preventing stylet insertion and location of a sucking site, and the insect's behavior is normal, at least up to the exploratory probing phase even on resistant varieties (Sogawa and Pathak, 1976).

CONCLUSION

A higher number of feeding marks observed on resistant genotypes reflects the antixenosis mechanism, where BPH makes repeated probing attempts without establishing prolonged feeding. In this study, all the rice cultures, except RGL 7002, exhibited sustained feeding of BPH. Low honeydew excretion in MTU IJ 206-7-4-1, Ptb 33, NLR 3093, and RGL 7002 further confirmed the role of antibiosis in conferring resistance. These cultures can be considered as effective sources of resistance against BPH and hold promise as donor parents in breeding programs aimed at developing durable BPH-resistant rice varieties.

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RESISTANCE MECHANISM STUDIES IN SELECTED RICE GENOTYPES AGAINST BROWN PLANTHOPPER, *NILAPARVATA LUGENS* (STAL)

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ABSTRACT

Twelve identified rice genotypes along with susceptible check (TN 1) and resistant check (PTB 33) were investigated for resistance against BPH during rabi 2021-22 at Regional Agricultural Research Station, Maruteru, Andhra Pradesh. Preference/non-preference mechanism was assessed through honeydew excretion studies and tolerance was measured through number of days to wilt. Brown planthopper fed on these genotypes excreted significantly lower quantity of honeydew than the susceptible TN 1 (529.33 mm^2). Among the genotypes, PTB 18 and HWR-21-IR 71033-121-15-B recorded minimum honeydew excreted area of 91.00 mm^2 and were equivalent with the resistant check (78.67 mm^2). The number of days taken by the genotypes to wilt ranged from 21.33 to 34.67 days. The susceptible check TN 1 and resistant check PTB 33 took 21.33 and 34.67 days to wilt respectively. Among the genotypes, MTU 2837-31-1-1-1 took longer (32.33 days) to wilt followed by PTB 18 which took 30.33 days.

Keywords: BPH, Honeydew, Non-preference, Preference, Tolerance

INTRODUCTION

Rice, *Oryza sativa* (Linnaeus) is one of the major cereal crops, being the staple food for more than 65 per cent of the global population (Mathur *et al*., 1999). The rice crop is subjected to attack by beyond 100 insect species; Out of them, 20 species can cause economic damage by infesting the plant at all growth stages and a few can transmit viral diseases (Pathak and Khan, 1994). Among various biotic constraints of rice production, the Brown Planthopper (BPH), *Nilaparvata lugens* (Stal) is the leading destructive pest. Indiscriminate use of insecticides for the control of BPH leads to the disruption of ecological balance leading to development of multiple insecticide resistance and causes pest resurgence. Hence, cultivation of BPH resistant varieties is a key pest management strategy and environmentally sound.

Plants establish resistance mechanisms to protect from nature's damage in three different ways *viz.,* antixenosis, antibiosis and tolerance. (Alam and Cohen, 1998). Antixenosis mechanism avoids insect pest damage through repelling the insects, thereby reducing pet colonization and oviposition. Antibiosis mostly affects the insect behavior like survival,

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feeding. Tolerance mechanism is a peculiar type in which plants can produce good quality crop with little or no decrease in fitness despite being attacked. (Strauss and Agarwal, 1999). Understanding different mechanisms of resistance *viz.,* antixenosis, antibiosis and tolerance is important for evolving resistant varieties. By considering all, studies on preference/non preference and tolerance mechanisms were undertaken in the identified genotypes.

MATERIAL AND METHODS

Investigations were conducted to study the resistance mechanisms in different rice genotypes against BPH at ANGRAU-RARS, Maruteru during *rabi* 2021-22. Twelve genotypes which were moderately resistant to BPH were used in the study along with susceptible check, TN 1 and resistant check, PTB 33. Selected rice genotypes seeds were sown in pots containing puddled alluvial soil. Ten days aged seedlings of each genotype were transplanted @ 3 seedlings pot^{-1}. Each entry consisted of three pots, each pot serving as a replication. The potted seedlings were kept in the polyhouse, where there is ample sunlight and they were protected from arthropod pests and predators.

Honeydew Excretion: The relative preference of BPH among the selected genotypes along with susceptible and resistant check was evaluated by estimating the amount of honey dew excreted as an indication of the feeding rate (feeding index) by the adult planthoppers following the technique developed by Pathak and Heinrichs (1980).

Thirty days aged plants were used to study honeydew excretion which were replicated thrice. Tillers of each plant were thinned out and only one tiller was retained in each pot. The culm was inserted through a hole in the middle of cardboard sheet. A polythene sheet was kept on the cardboard to prevent moisture absorption by the filter paper. Whatman No.1 filter paper of 9.0 cm diameter were taken with a small hole in the center and a longitudinal cut from the margin to the center. These filter paper circles were dipped in bromocresol green solution (2 mg bromocresol green powder/1 ml of ethanol) and were dried for one hour. The filter papers were dipped repeatedly till they turned to yellowish orange. The treated filter paper was kept over polythene sheet and cardboard present below the potted plant. Plastic cup containing a hole in the middle was kept in an inverted position over the single potted plant (Figure 1). Five newly hatched female hoppers, pre-starved for two hours were released into the cup through the hole and plugged the hole with non-absorbent cotton to prevent escape of the insects. The hoppers were allowed to feed at the base of the stem for 24 hours. The honey dew droplets excreted by the adults, when get in touch with the filter paper turned into blue spots. The filter paper was removed 24 hours after the commencement of feeding and the total area of the blue spots appeared on each filter paper was measured by graph paper method. The honeydew spot areas were marked on a tracing paper and calculated the areas of each spot by counting the number of squares on graph paper. The area thus obtained in each replication was treated as the feeding index and expressed in terms of area (mm^2) of honeydew excretion per 5 females.

Days to wilting: To observe the level of tolerance, 30-days aged seedlings of each genotype were wrapped with a mylar cage which is provided with nylon cloth and kept in a room with well-ventilated windows (Figure 2). A total of twenty-five nymphs (2^{nd} to 3^{rd} instar) of brown planthopper were introduced onto each plant. When plants began to wilt, planthoppers were removed and number of days taken to wilt by the plant were documented.

Table 1. Honeydew excretion by BPH adults and days to wilt of rice genotypes

S.No.	Genotypes	Area of honeydew excreted in mm^2*	Days to wilt*
1	Cul M4	171.00(13.05) ^{c}	27.67 (5.35) ^{bcd}
2	PTB 18	91.00(9.48) ^{a}	30.33(5.60) ^{ed}
3	HWR-21-IR 71033-121-15-B	91.00(9.51) ^{a}	28.67(5.44) ^{ed}
4	MCM 125	213.33(14.59) ^{d}	28.33(5.41) ^{cde}
5	MTU2889-12-1-1	166.00(12.88) ^{c}	27.00(5.29) ^{bcd}
6	MTU2837-31-1-1-1	167.67(12.89) ^{c}	32.33(5.77) ^{ef}
7	MTU2837-56-1-1-1	132.67(11.40) ^{b}	24.00(5.00) ^{ab}
8	MTU2842-36-1-1-1	241.67(15.52) ^{de}	28.00(5.39) ^{cd}
9	MTU2843-52-1-1-1	178.33(13.30) ^{c}	26.67(5.25) ^{bcd}
10	MTU2843-239-1-2-1	273.67(16.53) ^{e}	24.67(5.07) ^{abc}
11	MTU2846-21-4-1-1	121.00(10.99) ^{b}	27.00(5.28) ^{bcd}
12	MTU2846-58-1-1-1	139.33(11.62) ^{b}	29.00(5.47) ^{de}
13	TN 1	529.33(22.99) ^{f}	21.33(4.72) ^{f}
14	PTB 33	78.67(8.86) ^{a}	34.67(5.98) ^{a}
	Sem +	0.73	0.13
	CD (0.05)	2.13	0.37
	CV (%)	9.73	4.15

*Mean of three replications; Figures in parentheses are square root transformed values
In a column, means followed by common letter are not significantly different by DMRT at 5% level

Fig. 1. Arrangement of different genotypes for honeydew test

Fig. 2. Experimental setup for studying days to wilting on selected genotypes

Statistical analysis: Observations on different parameters recorded were analyzed after suitably transforming (square root transformations) the original values. ANOVA technique (Gomez and Gomez, 1984) was employed for data analysis in completely randomized design (CRD) and comparing the means by using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS AND DISCUSSION

Honeydew excretion: The quantity of honeydew excreted by planthoppers which is a sign of feeding preference was estimated in the selected rice genotypes. The quantity of honeydew excreted by BPH is directly related to intake of the plant sap. The average honey dew excretion values varied from 78.67 to 529.33 mm^2 among the fourteen rice genotypes. All the genotypes showed significantly lower quantity of honeydew compared to the susceptible check TN 1 (529.33 mm^2). The genotypes; PTB 18 and HWR-21-IR 71033-121-15-B recorded minimum honeydew excreted area of 91.00 mm^2 and were significantly equivalent with the resistant check, PTB 33 (78.67 mm^2). The genotypes viz., MTU 2846-21-4-1-1 (121.00 mm^2), MTU 2837-56-1-1-1 (132.67 mm^2), MTU 2846-58-1-1-1 (139.33 mm^2), MTU 2889-12-1-1 (166.00 mm^2), MTU 2837-31-1-1-1 (167.67 mm^2), Cul M4 (171.00 mm^2) and MTU 2843-52-1-1-1 (178.33 mm^2) recorded moderate honeydew excreted area and MCM 125

(213.33 mm^2), MTU2842-36-1-1-1 (241.67 mm^2), MTU2843-239-1-2-1 (273.67 mm^2) recorded highest honeydew area among the genotypes tested. (Table 1).

Alagar *et al*. (2007) stated that the quantity of food intake is directly proportional to the quantity of honeydew excreted by BPH. Mollah *et al*. (2011) reported the lowest amount of excreted honeydew on resistant cultivars T27A, IR64, ARC10550 and Swarnalata and indicated that the female fed less and excreted less honeydew on resistant rice cultivars. Sarao and Bentur (2018) indicated the area of honeydew excretion was greater when the insects fed on susceptible varieties than on resistant varieties.

Days to wilting: The number of days required to wilt by different rice genotypes were significantly varied from 21.33 to 34.67 days. The susceptible check TN 1 and resistant check PTB 33 took 21.33 and 34.67 days to wilt respectively. Among the genotypes, MTU 2837-31-1-1-1 took longer (32.33 days) to wilt followed by PTB 18 which took 30.33 days. The other genotypes *viz.,* MTU 2846-58-1-1-1, HWR-21-IR 71033-121-15-B, MCM 125, MTU 2846-36-4-1-1, Cul M4, MTU 2889-12-1-1, MTU 2846-21-4-1-1, MTU 2843-52-1-1-1, MTU 2843-239-1-2-1and MTU 2837-56-1-1-1 took 29.00, 28.67, 28.33, 28.00, 27.67, 27.00, 27.00, 26.67, 24.67 and 24.00 days, respectively to wilt. (Table 1).

Bhanu *et al*. (2014) revealed that the number of days required to wilt was significantly high in highly resistant, resistant and moderately resistant rice varieties than susceptible check, TN 1. BPH feeding was minimum on resistant entries, therefore the plants could withstand wilting compared to the susceptible check, TN1 and moderately resistant entries. (Reddy *et al*, 2016).

CONCLUSION

The genotypes; PTB 18 and HWR-21-IR71033-121-15-B showed minimum honeydew excreted area of 91.00 mm^2 and were significantly equivalent to resistant check, PTB 33. The genotypes MTU2837-31-1-1-1 took longer days (32.33) to wilt followed by PTB 18 which took 30.33 days to wilt. The identified genotypes can be further studied for gene sequencing. Based on the sequencing, these rice genotypes can be utilized as donors in the future crossing programme to develop varieties resistant to BPH.

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ASSESSMENT OF RAINFALL FORECAST ACCURACY FOR VIZIANAGARAM DISTRICT OF NORTH COASTAL ANDHRA PRADESH

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ABSTRACT

The rainfall forecast and validation are important because of the socio-economic implications for the nation. An attempt was made to confirm the correctness and dependability of the spatial rainfall forecast of Vizianagaram district of North Coastal Andhra Pradesh during the year 2024 - 2025.The rainfall forecast provided by IMD, Pune for Vizianagaram districtwas verified with daily observed weather data obtained from the Chief Planning Office,by calculating a variety of categorical statistical measures from the elements of the contingency table on seasonal basis. Statistics were presented for Percentage correct (PC),Probability of Detection(POD), Critical Success Index (CSI), Heidke Skill Score (HSS) and Hansen Kuipers score(HKS) of the district wise forecast.Overall, rainfall accuracy was found to be successful, with moderate to high performance. The positive HSS and HKS indicated the reliability of forecast at satisfactory level.

Key words: Forecast,Rainfall, Verification, Vizianagaram

INTRODUCTION

Rainfall is very crucial for agriculture, impacting crop production directly. Precise prediction of district wise rainfall in medium range time frame for the country like India will greatly benefit the farmers.Because of their socio-economic impact on the country, monsoon forecast and verification are always of great interest.Forecast verification entails assessing the quality, skill, and value of a given forecast.The forecast and a matching observation of an actual event are compared in the prediction verification procedure.Various verification approaches can reveal details about various statistical and physical aspects of the accuracy of the forecast-observations. Sahu *et al.* (2022) used various skill scores for rainfall verification in Bihar. In order to improve forecasting methods and provide value for end users, an attempt has been made to verify the accuracy and dependability of the rainfall forecast of Vizianagaram district.

MATERIAL AND METHODS

The Andhra Pradesh state has different geographical regions and the climate varies in each of these regions. South West Monsoon contributes maximum to the rainfall in the state. Based on soil characteristics, rainfall pattern, cropping systems and other additional ecological straits, Andhra Pradesh iscategorized into six Agro-Climatic zones. In

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Table1. 2 × 2 Contingency table for verification of rainfall forecast based on yes/no forecast

Observed	Forecast	
	YES	NO
YES	A	B
NO	C	D

the present study Vizianagaram district of North Coastal Zone of Andhra Pradesh was chosen.The medium range weather forecast on rainfall for the district was received from India Meteorological Department (IMD), Pune for 365 days for the year 2024-25, which was further value added by Cyclone Warning Centre, Visakhapatnam and confirmed using the daily observed weather data for corresponding days obtained from Chief Planning Office to investigate the verification of rainfallby calculating many categorical statistical skill measures from the components of the contingency table on seasonal basis. They include Percentage Correct (PC), Probability of Detection (POD), Critical Success Index (CSI), Heidke Skill Score (HSS) and Hansen Kuipers score (HKS) to consider the performance of the forecast and were calculated using contingency table for various rainfall thresholds.The detailed procedure of this forecast verification was given in Table 1& 2.

The four count (A, B, C, D) events in the 2 × 2 contingency table that contains the number of hits (A), false alarms (B), misses (C)and correct rejections (D) at different rainfall thresholds are used to assess the performance of rainfall forecast.

For 2 × 2 contingency table, the percent correct was the percent of accurate forecasts. It served as the forecast verification standard score. The percentage of detected "yes" events is indicated by the probability of detection. Although it overlooks false alarms, it is sensitive to hits.Critical success index indicates the degree to which the forecast "yes" events matched the observed "yes" events. It calculates the percentage of forecasted and/or observed events that were accurately predicted. The forecast's fractional improvement over the standard forecast is measured by the Heidke Skill Score (HSS). Like other skill scores, it is normalized by the entire range of possible improvement over the standard, which means Heidke Skill scores can safely be compared on various datasets. HK score is the measure of forecasting accuracy and is used for verification of quantitative precipitation. Brief findings of these statistical scores are provided by

Table 2. Indices adapted for qualitative evaluation of rainfall forecast accuracy

Error structure indices	Expression	Range
Percent Correct (PC)	(A+D)/(A+B +C+D)	0 (no correct forecast) to +1 (all forecast correct)
Probability of Detection (POD)	A/(A+B)	0 (poor end) to +1 (perfect end)
Critical Success Index (CSI)	A/(A+B+C)	0 (poor end) to +1 (perfect end)
Heidke Skill Score (HSS)	2(ADBC)/[(A+C)(C+D) +(A+B)(B+D)]	HSS=1 (perfect forecast); HSS=0 (no skill) HSS < 0, (worse than reference forecast)
Hansen and Kuipers Scores (HKS)	(AD-BC)/(A+C)(B+D)	-1 (= poor end)to +1 (=perfect end), 0=no skill

Chauhan *et al*. (2008) and Debnath and Das (2017).

RESULTS AND DISCUSSION

Seasonal analysis was focused as there is precise need for improvement of rainfall forecast during major rainy months in North Coastal zone. It was quite clear that percent correct (PC) for the district was extremely high in winter period (0.9). Chakraborty *et al*. (2022) reported accuracy of correct forecasts at maximumduring the winter season followed by the post-monsoon season. POD and CSI were highest during the south west monsoon period followed by North east monsoon period. Joseph *et al*. (2017) noted highest CSI index for Tirunelveli district of Tamil Nadu. Lowest CSI index was noticed during pre-monsoon months and no score in winter.During the North East monsoon period,the HSS score attained an index greater than 0.5, with more skill and reliability, followed by pre-monsoon period. Saha *et al*. (2024) observed remarkably higher forecast skill score during February to May and the highest in April month in Mizoram. The HSS score was not particularly promising during the south west monsoon period. Sarmah *et al.* (2015) conducted a study at AMFU, Sonitpur, Assam and reported similar results of Heidke Skill Score (HSS), which is positive in all three seasons except monsoon where the HSS is zero.

The true skill score (HKS) was remarkably higher during the monsoon period (0.57) indicating a good forecast which is more economical compared to other seasons. Similar findings of higher HK score during monsoon season was observed by Kaur and Singh (2019). Sahu *et al*. (2022) recorded HK scores between 0.6 and 0.7 for all the blocks of Bihar. The overall skill score during the year was moderate to high with good success.More than 50 percent districts of Chhattisgarh state had moderately accurate rainfall forecasts most of days (Rajavel *et al*., 2019).Chattopadhyay *et al*. (2016) observed moderate improvement in skill of predicting rainfall in Telangana state. The results insighted huge scope for future improvement in qualitative regular rainfall

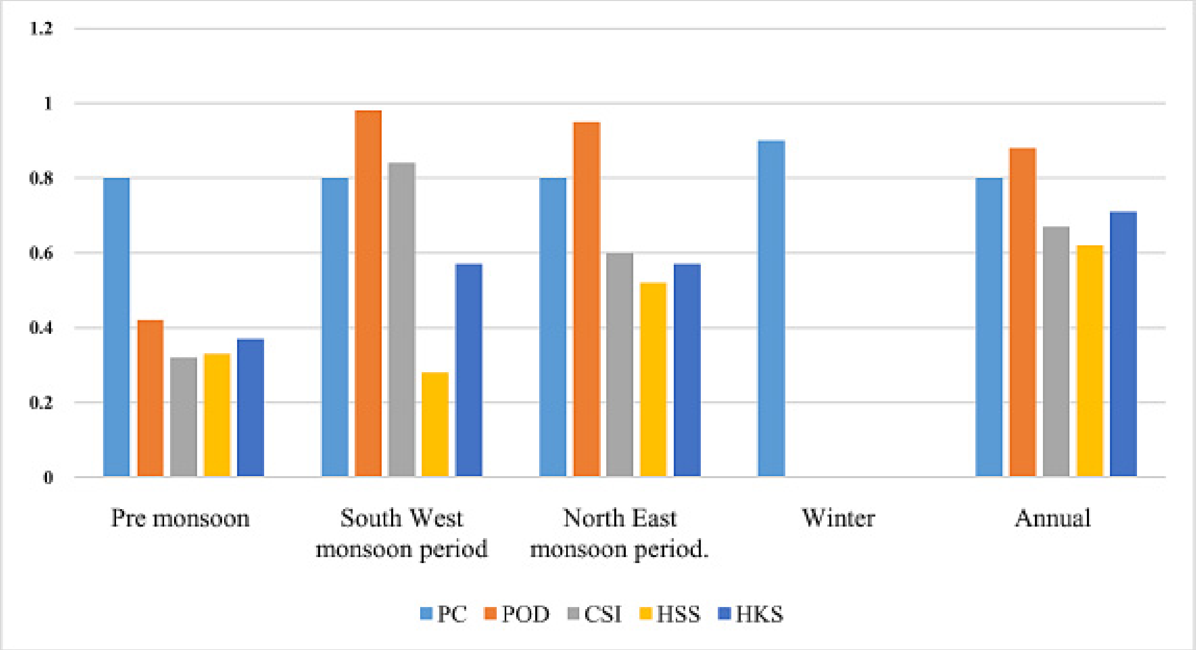

Fig. 1. Qualitative evaluation of Seasonal and Annual Rainfall forecast of Vizianagaram district

forecast skills which inturn increases the actual quality of the agro-advisories issued under Gramin Krishi Mausam Seva (GKMS) scheme in North Coastal Zone of Andhra Pradesh.

CONCLUSION

The analysis shows very good PC, POD and CSI during South west monsoon period followed by North east monsoon period. HSS and HKSshowed moderate score during North east monsoon period followed by South west monsoon period. For the year as a whole,good success was observed for rainfall correctness with moderate to high performance. The reliability of forecast to the satisfactory levelwas indicated by the positive HSS and HKS. Improvement in forecast accuracy and by reducing the number of false alarms and the number of misses undoubtedly benefit Agriculture.

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WEED CONTROL EFFICACY OF TRIAFAMONE 200 SC IN TRANSPLANTED RICE

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ABSTRACT

A field investigation conducted during two consecutive cropping seasons (*Rabi* 2017–18 and *Kharif* 2018–19) at the Agricultural Research Station, Jangamaheswarapuram, Andhra Pradesh, India, to evaluate the performance of Triafamone 200 SC in transplanted Rice."Among the various herbicide treatments, Triafamone 200 SC applied at 100 g a.i. ha-¹ at 0-3 days after transplanting (DAT) recorded superior weed suppression efficiency in *Rabi* 2017-18 (68.64%) and in *Kharif* 2018-19 (60.83%) and also yielded 4967 kg ha^{-1} in *Rabi* and 5518 kg ha^{-1} in *Kharif,*with performance comparable to conventional farmer-managed two hand weeding practices, which produced 5342 kg ha^{-1} in Rabi and 5849 kg ha^{-1} in *Kharif*. The weed-free treatment recorded the maximum yields (5762 kg ha^{-1} in *Rabi* and 6376 kg ha^{-1} in *Kharif*), while the weedy check plots showed the lowest yields (3066 kg ha^{-1} in *Rabi* and 3825 kg ha^{-1} in *Kharif*).

Keywords: Herbicide efficacy,Transplanted Rice,Triafamone 200 SC, Weed control efficiency, Weed management

INTRODUCTION

Rice (*Oryza sativa* L.) serves as a staple food crop and plays a crucial role in ensuring food security in India. It contributes 45 per cent to the total food grain production in India and is grown in an area of 47.83 million ha with a production of 137.82 million tones and productivity of 2.88 t ha^{-1}(Anonymous, 2025). Effective weed management remains a crucial constraint, as uncontrolled weed growth significantly reduces crop productivity. Previous studies indicate that yield losses due to weed competition may range from moderate (>30%) to severe (>70%), depending on management practices and environmental conditions (Patel *et al.,* 2023; Yadav *et al.,* 2018). Therefore, proper management of weeds is the fundamental requisite for ensuring quality rice production. In situations where continuous standing water cannot be maintained particularly during the first 45 days, weed infestation in transplanted rice may be as high as direct-seeded rice.

Manual weeding has traditionally been the predominant method of weed control in rice cultivation. Although this approach can be effective, rising labour costs and a shrinking agricultural workforce make hand weeding less practical. Rising labour shortages and increasing wage rates have limited the feasibility of manual weeding, thereby accelerating the adoption of chemical weed

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Table 1. Treatment Details

Treatment	Dosage(g a.i. ha^{-1})
$T_{1.}$ Untreated control	-
$T_{2.}$ Triafamone 200 SC at 2-3 leaf stage of weed growth	30
$T_{3.}$ Triafamone 200 SC at 2-3 leaf stage of weed growth	40
$T_{4.}$ Triafamone 200 SC at 2-3 leaf stage of weed growth	50
$T_{5.}$ Triafamone 200 SC at 2-3 leaf stage of weed growth	100
$T_{6.}$ Pyrazosulfuron ethyl 10% WP	15
$T_{7.}$ Triafamone 200 SC at 0-3 DAT	30
$T_{8.}$ Triafamone 200 SC at 0-3 DAT	40
$T_{9.}$ Triafamone 200 SC at 0-3 DAT	50
$T_{10.}$ Triafamone 200 SC at 0-3 DAT	100
$T_{11.}$ Pretilachlor 50% EC at 0-3 DAT	750
$T_{12.}$ Farmer practice (two hand weedings)	-
$T_{13.}$ Weed free	-

control methods. A new herbicide Triafamone 200 SC has shown excellent control of weeds in recent trials a single application and also along with tank mix application with ethoxysulfuron, for rapidly knocking down diverse weed species and boosting Rice yields. Yet its performance in transplanted rice, across different doses and application timings, remains to be fully compared against established approaches. In view of these constraints, the present study was designed to assess the effectiveness of Triafamone 200 SC under transplanted rice conditions.

MATERIAL AND METHODS

The experiment was conducted over two consecutive years under field conditions atthe Agricultural Research Station, Jangamahes-warapuram, Guntur District, Andhra Pradesh, India, during *Rabi*, 2017-18 and *Kharif*, 2018-19. The design followed a Completely Randomized Block Design (CRBD) with 13 treatments and four replications. Weed control efficiency (WCE), weed density, weed biomass reduction, and Rice yield were recorded at different growth stages to evaluate the impact of each treatment.Weed data were subjected to square root transformation prior to statistical analysis, and analysis of variance (ANOVA) was performed following standard procedures (Gomez and Gomez, 1984).

Weed control efficiency (WCE) was used to quantify the reduction in weed biomass in treated plots relative to the untreated control. Based on dry matter of weeds produced at 42 days after application the WCE was calculated by using the following formula and expressed in percentage (AICRPWC, 1988).

$$\text{WCE (\%)} = \frac{\text{DWC - DWT}}{\text{DWC}} \times 100$$

Where,

DWC = Weed dry weight in unweeded control

DWT = Weed dry weight in treated plot

Yield loss attributed to weed competition was expressed in terms of weed index and determined using the formula outlined by Gill and Vijay Kumar (1969).

Table 2. Effect of weed management practices on total weed dry weight (g m-²) and weed control efficiency (%) measured at 42 days after herbicide application in transplanted rice during *Rabi* 2017–18 and *Kharif* 2018–19.

Treatments	Dose (g *a.i.* ha^{-1})	*Total weed dry weight 42 DAA 2017-18	*Total weed dry weight 42 DAA 2018-19	**Weed control efficiency 42 DAA 2017-18	**Weed control efficiency 42 DAA 2018-19
$T_{1.}$ Untreated control	-	15.35 (235.4)	13.98(195.9)	0.00 (0.0)	0.00 (0.0)
$T_{2.}$ Triafamone 200 SC at 2-3 leaf stage of weed	30	9.87 (98.5)	9.67 (93.1)	49.54 (57.7)	46.05 (51.8)
$T_{3.}$ Triafamone 200 SC at 2-3 leaf stage of weed	40	8.51 (72.0)	8.72 (75.7)	56.34 (69.3)	50.88 (60.0)
$T_{4.}$ Triafamone 200 SC at 2-3 leaf stage of weed	50	8.01 (64.1)	7.98 (63.3)	58.54 (72.7)	54.98 (66.9)
$T_{5.}$ Triafamone 200 SC at 2-3 leaf stage of weed	100	6.83 (46.5)	7.19 (51.2)	63.60 (80.1)	59.02 (73.4)
$T_{6.}$ Pyrazosulfuron ethyl 10% WP	15	9.96 (99.2)	10.28 (105.8)	49.32 (57.4)	42.53 (45.7)
$T_{7.}$ Triafamone 200 SC) at 0-3 DAT	30	9.53 (90.6)	8.46 (71.2)	51.58 (61.3)	52.77 (63.4)
$T_{8.}$ Triafamone 200 SC) at 0-3 DAT	40	8.58 (73.4)	7.84 (61.2)	56.01 (68.7)	55.65 (68.0)
$T_{9.}$ Triafamone 200 SC) at 0-3 DAT	50	7.59 (57.1)	7.19 (51.2)	60.35 (75.4)	59.06 (73.5)
$T_{10.}$ Triafamone 200 SC) at 0-3 DAT	100	5.61 (31.1)	6.79(45.8)	68.64 (86.7)	60.83 (76.1)
$T_{11.}$ Pretilachlor 50% EC at 0-3 DAT	750	10.13 (102.7)	10.14(103.1)	48.32 (55.7)	43.37 (47.2)
$T_{12.}$ Farmer practice (two hand weedings)	-	3.63 (13.2)	3.71 (13.3)	76.56 (94.4)	74.78 (93.0)
$T_{13.}$ Weed free	-	0.71 (0.0)	0.71 (0.0)	90.00 (100.0)	90.00 (100.0)
SEm +	-	0.35	0.29	1.70	1.47
CD (P = 0.05)	-	1.01	0.84	4.87	4.23

Note: *Data are “x+0.5 transformed. Values in parentheses correspond to the original data

** Data were subjected to arcsine transformation; original values are provided in parentheses for reference.

Table 3. Effect of weed management practices on grain yield and weed index of transplanted rice during *Rabi* 2017–18 and *Kharif* 2018–19.

Treatments	Dose (g *a.i.* ha^{-1})	Grain yield (kg ha^{-1})		*Weed index (%)	
		42 DAA		42 DAA	
		2017-18	2018-19	2017-18	2018-19
$T_{1.}$ Untreated control	-	3066	3825	42.71 (46.0)	39.24 (40.1)
$T_{2.}$ Triafamone 200 SC at 2-3 leaf stage of weed	30	3838	4459	34.87 (33.0)	33.12 (30.2)
$T_{3.}$ Triafamone 200 SC at 2-3 leaf stage of weed	40	4251	4936	30.38 (26.0)	27.76 (22.6)
$T_{4.}$ Triafamone 200 SC at 2-3 leaf stage of weed	50	4527	5178	27.42 (21.4)	25.01 (18.9)
$T_{5.}$ Triafamone 200 SC at 2-3 leaf stage of weed	100	4651	5313	23.86 (18.5)	22.31 (16.7)
$T_{6.}$ Pyrazosulfuron ethyl 10% WP	15	4168	4898	31.44 (27.7)	27.63 (23.0)
$T_{7.}$ Triafamone 200 SC) at 0-3 DAT	30	4211	4672	30.51 (26.4)	30.73 (26.7)
$T_{8.}$ Triafamone 200 SC) at 0-3 DAT	40	4329	5037	28.56 (24.4)	25.61 (20.9)
$T_{9.}$ Triafamone 200 SC) at 0-3 DAT	50	4659	5276	24.10 (18.8)	23.57 (17.4)
$T_{10.}$ Triafamone 200 SC) at 0-3 DAT	100	4967	5518	21.01 (13.5)	19.91 (13.4)
$T_{11.}$ Pretilachlor 50% EC at 0-3 DAT	750	3797	4328	34.84 (33.3)	34.46 (32.2)
$T_{12.}$ Farmer practice (two hand weedings)	-	5342	5849	14.04 (7.4)	15.06 (8.2)
$T_{13.}$ Weed free	-	5762	6376	0.00 (0.0)	0.00 (0.0)
SEm +	-	242.27	335.92	3.04	3.04
CD (P = 0.05)	-	694.87	963.46	8.71	8.71

*Note: Data are “x+0.5 transformed. Values in parentheses correspond to the original data

$$W1\ (\%) = \frac{X - Y}{X} \times 100$$

Where,

X = Grain yield in weed free plot

Y= Grain yield in treated plots.

RESULTS AND DISCUSSION

Effect of herbicides on Weeds

The experimental field was dominated by weed species such as *Echinochloa colonum, Cyperus rotundus, Cyperus difformis, Eclipta alba, Ammania baccifera,* and *Trianthema portulacastrum*. Triafamone 200 SC at 100 g *a.i.* ha^{-1} applied at 0-3 DAT achieved the highest weed control efficiency, 68.64% in *Rabi,* 2017-18 and 60.83% in *Kharif,* 2018-19 at 42 days after application of herbicide and this resulted in the lowest weed dry matter among herbicide treatments. The weed-free treatment recorded the highest weed control efficiency (76.56% in r*abi,* 2017-18 and 74.78% in *kharif,* 2018-19). The Triafamone 200 SC at higher doses and early application timing (0-3 DAT) helped in lower weed establishment and early weed competition. Similar trends have been reported in earlier studies (Jyothi Basu *et al.,* 2023).

Effect on Rice Yield

The weed-free treatment recorded the highest Rice grain yield (6376 kg ha-¹ in *Kharif,* 2018-19 and 5762 kg ha-¹ in *Rabi,* 2017-18). Among herbicide treatments, Triafamone 200 SC at 100 g *a.i.* ha-¹ applied at 0-3 DAT yielded 5518 kg ha-¹ in *Kharif* and 4967 kg ha-¹ in *Rabi*, making it the most effective chemical strategy. Two hand weedings (Farmer practice) in transplanted Rice reported the grain yield 5849 kg ha-¹ in *Kharif* and 5342 kg ha-¹ in *Rabi.* These results shows that weed management with herbicides was comparable to Hand weeding practices. The untreated control recorded the lowest yield (3825 kg ha-¹ in *Kharif* and 3066 kg ha-¹ in *Rabi*), emphasizing the detrimental impact of weed competition on Rice yields.

The weed index is a crucial parameter that quantifies the impact of weed competition on crop yield. In this study, lower weed index values were observed in plots treated with Triafamone 200 SC at 100 g *a.i.* ha-¹ (T_{10}), with values of 21.01% in *Rabi* and 19.91% in *Kharif*. This indicates its effectiveness of triafamone 200 SC in minimizing yield losses due to less weeds and it helps the Rice crop to utilize available resources effectively. The results of this research align closely with the findings of Jyothi Basu *et al.,* 2023.

The superior performance of Triafamone 200 SC at 100 g a.i. ha-¹ can be attributed to its higher herbicidal activity at this concentration, effectively controlling a broad spectrum of weed species in transplanted rice. The early application timing (0-3 DAT) proved particularly effective, as it targets weeds during their vulnerable establishment phase, preventing early weed-crop competition that is critical for achieving higher yields.The weed index values confirm that chemical weed management with Triafamone 200 SC minimizes yield losses effectively, positioning it as a viable alternative to labor-intensive weeding practices.

CONCLUSION

The findings of the present investigation demonstrate that Triafamone 200 SC is effective for weed management in transplanted Rice, when applied at 100 g *a.i*. ha-¹ at either 2-3 days after transplanting or the 2-3 leaf stage of weeds. These herbicidal treatments significantly reduced weed competition, enhanced rice yield, and provided an efficient alternative to manual weeding.

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PERFORMANCE OF NEW MID LATE SUGARCANE GENOTYPES UNDER DIFFERENT NITROGEN LEVELS IN NORTH COASTAL ZONE OF ANDHRA PRADESH

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ABSTRACT

A field experiment was conducted at Regional Agricultural Research Station farm, Anakapalle with an objective to determine ideal amount of nitrogen requirement for mid-late Sugarcane genotypes during the year 2024-25. Three new sugarcane genotypes viz.,2015A230 (CoA20325), 2015A233 (CoA20326),2015A93(CoA) along with check variety 2009A252 (CoA14323) were tested at four nitrogen levels viz., FYM @ 25 t ha^{-1} + 100% recommended dose of Nitrogen (F1), FYM @ 25 t ha^{-1}+ 125% recommended dose of Nitrogen (F2), FYM @ 25 t ha^{-1} + 150% recommended dose of Nitrogen (F3) and application of 100% recommended dose of Nitrogen + *In situ* incorporation of sunhemp sown as intercrop (F4). The recommended dose was 168 kg N ha^{-1}. The trial was conducted in Factorial RBD with three replications. The findings of the study showed that, the genotypes 2015A233 (85.6 t ha^{-1}) and 2015A230 (82.1 t ha^{-1}) recorded considerably greater cane yield in comparison to the other genotype 2015A93(77.7 t ha^{-1}) and check variety 2009A252 (79.2 t ha^{-1}). Among the four nitrogen levels new mid late sugarcane genotypes produced superior cane yield with application of FYM @ 25 t ha^{-1}+150% RDN (84.3 t ha^{-1}) and 100% RDN + Sunhemp grown as intercrop and *in situ* incorporation (83.4 t ha^{-1}). Application of FYM @ 25 t ha^{-1}+100% Recommended dose of Nitrogen recorded significantly lower cane yield of 76.9 t ha^{-1}. There was no difference in the juice quality parameters for different treatments, however 2015A233 recorded high sucrose percent of 18.8. Among nitrogen levels, application of 100% RDN + Sunhemp grown as intercrop and *in situ* incorporation recorded high sucrose percent of 18.1.

Key words: FYM, Nitrogen levels, Sugarcane genotypes, Sunnhemp incorporation

INTRODUCTION

In Andhra Pradesh, the cultivated area of sugarcane is gradually decreasing due to several reasons. Identification of suitable high yielding sugarcane genotypes is need of the hour to increase the cultivated area and cane productivity under current situation. Several studies (Ahmed *et al*., 2020, Yousif *et al*., 2021 and Yousif *et al*, 2023) showed significant variation in yield and juice quality across sugarcane genotypes. Promising genotypes are being developed through various approaches of plant breeding and suitable agro-techniques holds the key for realizing high sugarcane

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productivity of the new genotypes. New genotypes may need different management requirements, nutrient management in particular. The primary causes for lower cane yield are a lack of high-potential cultivars, restricted irrigation supplies and technology (Bahadar *et al*., 2002). Larger cane output is the function of higher genetic potential of a variety. India's sugarcane yield is relatively low due to a number of problems, including inadequate crop management, poor soil conditions, biotic and abiotic stresses, etc. Balanced use of plant nutrients is essential for mainataining the soil and crop productivity (Yadav *et al.,*2014). A trial was conducted during 2024-25 with an objective to identify suitable new mid late sugarcane genotypes and their performance at different nitrogen levels in North Coastal Zone of A.P.

MATERIAL AND METHODS

An experiment was conducted during 2024-25 at Regional Agricultural Research Station, Anakapalle to assess the performance of three new mid late sugarcane genotypes namely 2015A230, 2015A233 and 2015A93 along with the check 2009A252 (Naveen) under four different nitrogen levels i.e F1- Application of FYM @ 25 t ha^{-1}+100% Recommended Dose of Nitrogen, F2- FYM @ 25 t ha^{-1}+125% Recommended Dose of Nitrogen, F3-FYM @ 25 t ha^{-1}+150% and F4- Application of 100% N + sunnhemp intercrop and *in situ* incorporation with a view to identify suitable genotype and its response to varied levels of nitrogen. The experiment was laid out in factorial randomized block design with three replications. Trial was conducted at Regional Agricultural Research Station, Anakapalle during the final week of March, 2024. The soil type of the experimental site was sandy loam with a pH of 7.1, E.C 0.57 dSm^{-1}, OC 0.60, available nitrogen (263 Kg ha^{-1}) phosphorus (90.5 Kg ha^{-1}) and potassium (267 Kg ha^{-1}). All the suggested package of practices are used for raising a good and healthy crop. Number of tillers were counted at 90 and 120 DAP and shoot population was counted at 180 and 240 DAP. Ten canes were chosen at random from each plot and data were recorded on yield parameters like cane length, girth and number of internodes. These samples were crushed and juice quality (brix, sucrose and purity) was analyzed. Number of millable canes and cane yield were observed at harvest on plot basis and reported in numbers and tons / hectare respectively. Sugar yield was determined based on cane yield and CCS percent. Available sucrose percent in cane juice was calculated by using the following formula:

Available sugar percent (CCS) =

$$\{S - \{0.4(B - S)\} \times 0.73$$

Where, S = Sucrose percent in juice ,

B = Corrected brix of juice, and

0.4 & 0.73 are constants

The sugar yield per hectare at harvesting stage was computed as follows:

$$\text{Sugar Yield} = \frac{\text{Available sugar percent (CCS)}}{100} \times \text{Cane Yield(t/ha)}$$

RESULTS AND DISCUSSION

Germination Percent

Percentage of germination was recorded at 35 days after planting expressed as % and presented in table-1. Germination percentage did not vary significantly due to use of different doses of nitrogen fertilizers. Among the new sugarcane genotypes, 2015A233 (82.0 %) and 2015A230 (81.3%) recorded significantly higher germination percentage than the check variety 2009A252 (79.7%). 2015A93 genotype recorded significantly lower germination percent of 74.2%.

No. of milliable canes

2015A233 recorded significantly higher number of millable canes (73,550 ha^{-1}) followed by 2015A230 (72,024 ha^{-1}) as compared to the check variety 2009A252 (67,245 ha^{-1}). 2015A93 recorded lowest number of milliable canes (67,892 ha^{-1}) as compared to the 2015A230 and 2015A233. Among different nitrogen levels, application of 100% N + Sunnhemp intercrop and *in situ* incorporation (72,832 ha^{-1}) and FYM @ 25 t ha^{-1}+150% (72,129 ha^{-1}) recorded greater cane yield as compared to the FYM @ 25 t ha^{-1}+100% RDN. Higher dose of nitrogen reduced tiller mortality besides improving tiller production capability of the genotypes, nitrogen nutrition also helped and maintained the retention of tillers (Shukla, 2003).

Cane Yield (t/ha)

Genotype 2015A233 recorded noticeably increased cane yield (85.6 t ha^{-1}) followed by 2015A230 (82.1t ha^{-1}) as compared to the check variety 2009A252 (79.2 t ha^{-1}). Higher cane length, more number of inter nodes, greater number of millable canes coupled with higher girth (Table 1) contributed to higher cane yield of 2015A233 genotype. Among all, 2015A93 recorded lowest cane yield of 77.7 t ha^{-1} (Fig.1). Among different nitrogen levels application of FYM @ 25 t ha^{-1}+150% RDN recorded significantly greater cane yield (84.3 t ha^{-1}) but comparable with the 100% RDN + Sunhemp intercrop and *in situ* incorporation (83.4 t ha^{-1}) and application of FYM @ 25 tha^{-1}+125% RDN (81.1 t ha^{-1}) as compared to the application of FYM @ 25 t ha^{-1}+100% Recommended dose of Nitrogen (76.9 t ha^{-1}). The increase in cane yield with increase in nitrogen application in sugarcane was due to the increase in yield attributing characters like number of milliable canes, number of inter nodes, length of internodes etc., The role of nitrogen in chlorophyll formation and carbohydrate metabolism is well known. Hence, improvement in millable cane count and yield at high doses of N application might be due to more availability and absorption of the nutrients nitrogen and in build character of the genotypes to respond to high levels of fertilizer 'N' (Shankar *et al.,* 2018). Pandey and Shukla (2001) also reported the increased cane yield due to the interventions of effective agro-techniques particularly nitrogen management on productivity of sugarcane genotypes.

Juice Quality

Sucrose content is the most crucial quality indicator for sugar milling, hence the higher the better. Under the conditions of the present study, 2015A233 genotype showed increased sucrose content and application of 100% N + Sunhemp intercrop and *insitu* incorporation recorded highest juice sucrose per cent of 18.1. The greater N supply will lead to the decrease of sucrose content in cane (Deo *et al*., 2011). These outcomes are consistent with Chitkala Devi *et al*, 2022 and Gouri *et al.,* 2017.

Sugar Yield (t ha^{-1}**)**

Cane yield and sugar yield both showed a similar pattern. New mid late genotype 2015A233 recorded higher sugar yield (11.7 t ha^{-1}) followed by 2015A230 (10.0 t/ ha^{-1}) as compared to the check variety 2009A252 (9.8 t ha^{-1}). High sucrose content coupled with high cane yield resulted in greater sugar yield of 2015A233. Among all, 2015A93 recorded lowest sugar yield of 9.7 t ha^{-1}. Among various nitrogen levels, 100% RDN + Sunnhemp intercrop and in situ incorporation (11.1 t ha^{-1}) and application of FYM @ 25 t ha^{-1}+150% RDN (10.5 t ha^{-1}) recorded higher sugar yield which was comparable with the application of FYM @ 25 t ha^{-1}+100% Recommended dose of Nitrogen (9.8 t ha^{-1}). Singh *et al.*, 2001 also

Table 1. Growth parameters of sugarcane genotypes as influenced by different levels of nitrogen (Plant Crop) during 2024-25

Treatment	Percent germination	No. of Inter-nodes	Girth of the cane (cm)	Length of Millable cane (cm)	NMC ha^{-1}	Cane yield (t ha^{-1})
V1-2015A230	81.3	22.0	2.14	178.1	72,024	82.1
V2-2015A 233	82.0	23.0	2.17	209.4	73,550	85.6
V3-2015A 93	74.2	19.0	1.70	131.3	67,892	77.7
V4-2009A252	79.7	21.0	2.13	190.8	67,245	79.2
SEm+	1.54	0.741	0.068	9.843	928	1.12
C.D. (0.05)	4.5	2.141	0.196	28.428	2679	3.24
F1- FYM @ 25 t/ha+100% Rec. N	76.0	21.0	2.04	177.733	66,643	76.9
F2- FYM @ 25 t/ha+125% Rec. N	78.5	22.0	2.03	184.233	69,107	81.1
F3-FYM @ 25 t/ha+150% Rec. N	81.9	23.0	2.10	181.708	72,129	84.3
F4- 100% N + Sunnhemp intercrop and *insitu* incorporation	80.8	22.0	2.00	165.933	72,832	83.4
C.D. (0.05)	NS	2.141	0.196	28.428	2679	3.24
C.V. %	6.4	12.1	11.6	12.0	6.0	5.3
Interaction	NS	NS	NS	NS	NS	NS

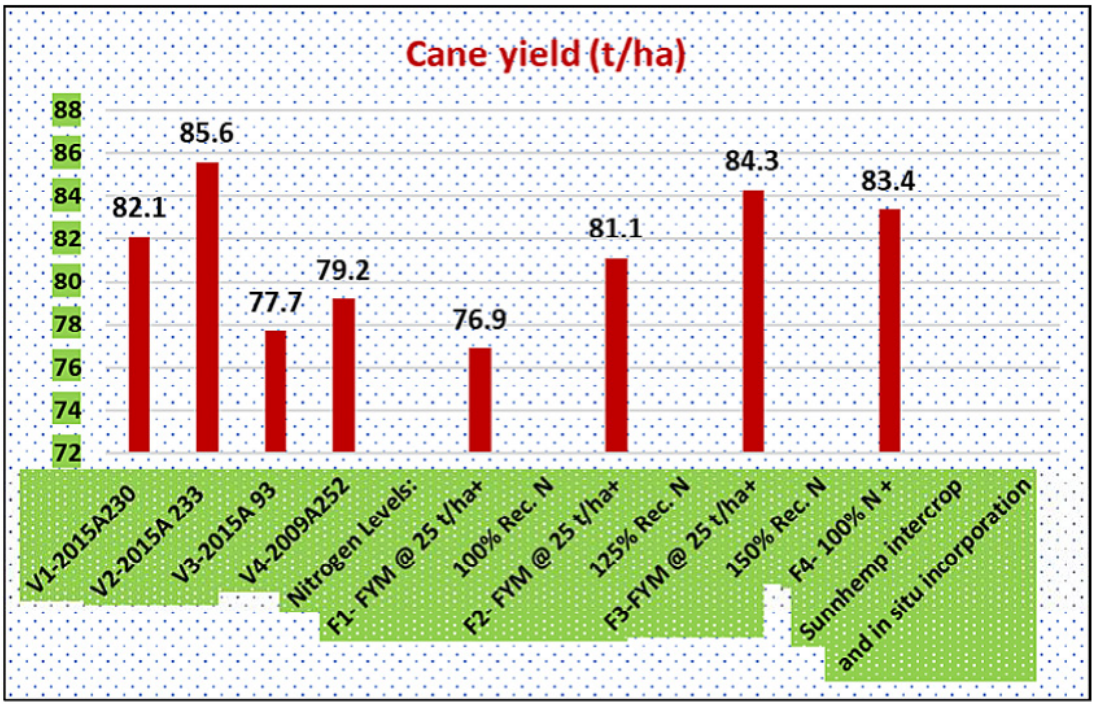

Fig.1 Cane yield of sugarcane genotypes as influenced by different levels of nitrogen during 2024-25 (Plant Crop)

Table 2. Quality of sugarcane genotypes as influenced by different levels of nitrogen during 2024-25 (Plant Crop)

Treatment	Percent juice sucrose	CCS%	Sugar yield (t ha^{-1})
Sugarcane genotypes:			
V1-2015A230	17.1	12.2	10.0
V2-2015A 233	18.8	13.7	11.7
V3-2015A 93	17.8	12.8	9.7
V4-2009A252	17.3	12.4	9.8
SEm+	0.541	-	-
C.D. (0.05)	NS	NS	-
Nitrogen Levels:			
F1- FYM @ 25 t ha^{-1}+100% Rec. N	17.7	12.7	9.8
F2- FYM @ 25 t ha^{-1}+125% Rec. N	17.5	12.5	10.1
F3-FYM @ 25 t ha^{-1}+150% Rec. N	17.6	12.5	10.5
F4- 100% N +Sunnhemp intercrop and *in situ* incorporation	18.1	13.3	11.1
C.D. (0.05)	NS	-	-
C.V. %	10.6	NS	-
Interaction	NS	NS	-

reported the variation in sugar yield among various genotypes and levels of nitrogen.

CONCLUSION

Among new mid late sugarcane genotypes tested, 2015A233 followed by 2015A230 performed well at various nitrogen levels and were found promising and are best suitable for N.C zone of A.P. Among the nitrogen levels studied, FYM @ 25 t ha^{-1}+150% RDN (84.3 t ha^{-1}) recorded greater cane yield which was comparable with 100% N + Sunhemp intercrop and *in situ* incorporation (83.4 t ha^{-1}) and FYM @ 25 t ha^{-1}+125% recommended dose of nitrogen. Application of 100% N + Sunhemp intercrop and *in situ* incorporation and application of FYM @ 25 t ha^{-1}+125% recommended dose of nitrogen is recommended for sustainable sugarcane production as it was proven to be the most cost-effective and resource-saving.

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CROP–WEATHER INTERACTION AND CORRELATION ANALYSIS OF SUGARCANE (*SACCHARUM SPP.*) YIELD IN NORTH COASTAL ZONE OF ANDHRA PRADESH

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ABSTRACT

Eleven sugarcane clones were evaluated in a randomized block design over two consecutive plant crop seasons (2022–23 and 2023–24) at the Regional Agricultural Research Station, Anakapalle, to quantify the influence of key meteorological parameters on cane yield. Pearson's correlation analysis of five weather variables – rainfall, number of rainy days, maximum temperature, minimum temperature and bright sunshine hours (BSSH) – revealed that rainfall, rainy days and minimum temperature were positively correlated with cane yield ($r = +0.273$, $p < 0.05$), while maximum temperature and BSSH showed significant negative correlations (r = ”0.273, $p < 0.05$). Among the clones, 2012A 340 recorded the highest mean yield of 123.84 t/ha, followed by 2012A 319 (123.06 t/ha), while 2013T 124 recorded the lowest (73.84 t/ha). Weather parameters during the tillering phase were most influential in determining final yield. These results demonstrate that moderate precipitation and favourable nocturnal temperatures during early crop growth are critical drivers of productivity in the north coastal zone of Andhra Pradesh, and provide a basis for developing climate-informed agronomy and clone selection strategies.

Key words: Climate variability, Correlation analysis, Meteorological factors,Sugarcane yield

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is a pivotal commercial crop in tropical and subtropical regions, with its productivity profoundly shaped by agro-climatic variables including rainfall, temperature and solar radiation. These meteorological factors govern key physiological processes across all growth stages, from germination and tillering to grand growth and maturation (Zhao *et al.*., 2023; Misra*et al.*., 2021). The North Coastal Zone of Andhra Pradesh, particularly the tract around Anakapalle, has long been associated with commercial sugarcane cultivation and is characterised by considerable intra- and inter-seasonal variability in weather parameters, posing persistent challenges to yield stability.

Among the phenological stages of sugarcane, the tillering and elongation phases are most sensitive to climatic fluctuations. Deviations from optimal conditions during these phases can substantially restrict biomass

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accumulation and final yield (Zhao *et al.*., 2023; Bhatt *et al.*., 2023). Under a warming climate, the interaction between elevated temperatures, altered rainfall distribution and sunshine duration assumes added significance for crop management and clone evaluation (Misra*et al.*., 2021; Hegde *et al.*., 2023). Quantifying these crop-weather relationships is, therefore, essential for refining predictive yield models and designing adaptive agronomic strategies.

Earlier investigations at RARS Anakapalle established that temperature and relative humidity during the early post-planting period decisively influence final cane yield. More recent studies corroborate that the combined effect of multiple meteorological parameters – rather than any single variable – determines sugarcane productivity, and that this effect varies with growth stage (Zhao *et al.*., 2023; Kumar *et al.*., 2024). Not with standing this body of evidence, updated crop-weather analyses using contemporary clonal material under current climatic conditions in the north coastal zone remain scarce.

The present study was therefore undertaken to assess the relationship between cane yield and key meteorological parameters across two consecutive plant crop seasons (2022–23 and 2023–24) at RARS Anakapalle, using eleven elite clones and Pearson's correlation analysis. The objective is to identify statistically significant weather-yield associations that can guide climate-informed clone selection and crop management in this ecologically distinctive coastal tract.

MATERIAL AND METHODS

Eleven sugarcane clones (Table 1), including three check varieties viz. 87A 298 (C), 2009A 107 (C) and 2003V 46 (C) were evaluated over two plant crop seasons: 2022–23 and 2023–24. The experiment was laid out in a randomized block design (RBD) with three replications under standard agronomic practices at RARS, Anakapalle, Andhra

Table 1. Mean Cane yield (t/ha) of sugarcane clones at Anakapalle

S.No	Clone	Yield (2022–23) (t/ha)	Yield (2023–24) (t/ha)	Mean Yield (t/ha)
1	2012A 340	123.25	124.43	123.84
2	2012A 319	127.22	118.89	123.06
3	2016T 7	114.55	106.74	110.65
4	2014A 210	100.19	103.67	101.93
5	2012A 123	104.05	100.37	102.21
6	87A 298 (C)	111.53	96.98	104.26
7	2013V 126	63.75	90.07	76.91
8	2009A 107 (C)	117.88	89.14	103.51
9	2013T 16	98.37	83.57	90.97
10	2003V 46 (C)	116.44	79.30	97.87
11	2013T 124	85.86	61.81	73.84

Pradesh.Cane yield (t/ha) was recorded at harvest for each clone in both years and the mean yield was computed to assess overall performance. The yield data are summarized in Table 1.Monthly meteorological data were obtained from the weather observatory at the Regional Agricultural Research Station (RARS), Anakapalle, covering the entire crop duration from March to February for both 2022–23 and 2023–24 seasons. Key variables recorded included monthly total rainfall (mm), number of rainy days, average maximum and minimum temperatures (°C), and Bright Sunshine Hours (BSSH, hrs/day). These parameters were averaged across the crop season to obtain representative climatic indicators for each year. To assess the influence of these meteorological variables on sugarcane yield, Pearson's correlation coefficient was employed. Correlation analysis was performed between annual cane yield data (year-wise and mean) and the corresponding weather parameters.

RESULTS AND DISCUSSION

Clone Performance across Seasons

Clone 2012A 340 recorded the highest mean yield (123.84 t/ha), followed by 2012A 319 (123.06 t/ha). Clones 2016T 7, 2014A 210 and 2012A 123 formed an intermediate group (101.93–110.65 t/ha). The check varieties 87A 298 (C), 2009A 107 (C) and 2003V 46 (C) yielded 104.26, 103.51 and 97.87 t/ha, respectively, validating their suitability as performance benchmarks. Clone 2013T 124 recorded the lowest mean yield (73.84 t/ha). Season-wise data (Table 1) reveal that yield of several clones declined from 2022–23 to 2023–24, notably 2003V 46 (C) (116.44 to 79.30 t/ha) and 2013V 126 (63.75 to 90.07 t/ha), indicating differential responsiveness to inter-seasonal weather variability.

Correlation with Meteorological Variables

Pearson's correlation analysis (Table 2) revealed that rainfall (mm) and number of rainy days were positively correlated with cane yield ($r = +0.273$, $p < 0.05$), confirming that adequate precipitation during the crop season supports tillering and biomass accumulation. Minimum temperature likewise showed a significant positive correlation ($r = +0.273$), indicating that warmer nights favour metabolic activity, elongation and sucrose translocation. In contrast, maximum temperature and BSSH both exhibited significant negative correlations ($r = -0.273$), suggesting that high daytime temperatures and prolonged sunshine, particularly during the tillering phase, impose heat stress and increase evaporative demand

Table 2. Pearson's correlation coefficients between meteorological parameters and sugarcane yield

Meteorological Parameter	Correlation Coefficient (r)
Rainfall (mm)	+0.273*
Number of Rainy Days	+0.273*
Minimum Temperature (°C)	+0.273*
Maximum Temperature (°C)	-0.273*
BSSH (hrs/day)	-0.273*

**Significant at 5% probability level*

beyond the compensatory capacity of moderate rainfall (Table 2).

The positive correlation of rainfall and rainy days with yield (r = +0.273) is consistent with the recognised water requirement of 1,000–1,500 mm for tropical sugarcane production and the key role of soil moisture in supporting tiller emergence and early biomass accumulation (Zhao *et al.*., 2023; Kumar *et al.*., 2024). Similarly, the positive association of minimum temperature with yield aligns with evidence that warmer nights during elongation accelerate internode formation and sucrose translocation (Bhatt *et al.*., 2023). The negative correlation of maximum temperature and BSSH with yield points to heat and radiation stress during the tillering phase, when temperatures above the optimal range of 28–35°C can suppress tiller density and reduce final stalk number (Hegde *et al.*., 2023; Misra *et al.*., 2021). These findings are broadly consistent with earlier work at the same location (Subbaramayya and Rupa Kumar, 1980) and with contemporary multi-location studies confirming the primacy of early-season weather on final cane yield (Zhao *et al.*., 2023; Kumar *et al.*, 2024).

The inter-seasonal yield variation observed in several clones – particularly 2003V 46 (C) and 2013V 126 – indicates differential genotypic sensitivity to weather fluctuations and underscores the value of multi-season evaluation in clone selection programmes. The superior and stable performance of 2012A 340 and 2012A 319 across both seasons suggests resilience to the prevailing weather variability of the north coastal zone.

CONCLUSION

Over two consecutive plant crop seasons at RARS Anakapalle, rainfall, number of rainy days and minimum temperature were positively correlated with sugarcane yield (r = +0.273, $p < 0.05$), while maximum temperature and bright sunshine hours showed significant negative correlations (r = -0.273). These relationships were most pronounced during the tillering phase, identifying it as the critical weather-sensitive window for yield formation in the north coastal zone. Clone 2012A 340 (123.84 t/ha) and 2012A 319 (123.06 t/ha) consistently outperformed all checks across both seasons and are recommended for advancement and wider evaluation. The weather-yield correlations established in this study provide a quantitative foundation for constructing agro-meteorological yield prediction models and for designing climate-adaptive management practices—such as adjusted planting dates and targeted irrigation during dry spells—to sustain sugarcane productivity under the variable coastal climate of Andhra Pradesh.

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EVALUATION OF DEFOLIANTS TO FACILITATE MECHANICAL PICKING IN RAINFED COTTON

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ABSTRACT

A field experiment was conducted during the *kharif* season of 2024 at Regional Agricultural Research Station, Nandyal to evaluate the effect of defoliants on facilitating mechanical picking in cotton.The treatments consisted of T_1:Control, T_2:Ethrel@3000ppm,T_3:Thidiazuron@500ppm, T_4:Sodiumchlorate@0.9%, T_5:CICRDefoliant, T_6:Hydrogencyanamide @5000ppm, T_7:T_2+5%ofurea, T_8:T_2+Diuron@400 ppm, T_9:T_2+Sodiumchlorate @0.9% and T_{10}:T_3+Diuron@400ppm. Higher percent defoliation (95.5) at 10 days after spraying was recorded with T_3 (Thidiazuron @500 ppm) and was on par withT_{10} (93.1) followed byT_9(89.5), T_5(86.2) and lower percent defoliation (5.3) was recorded with T_1(Control). Further, higher earliness index (75%) was recorded with T_{10} (Thidiazuron@500ppm+Diuron @ 400ppm) and was on par T_3 (72%) followed by T_4 (65%);and lower earliness index(38)was recorded with T1 (Control). It can be concluded that higher defoliation was attained with application of Thidiazuron @500 ppm+ Diuron @400ppm and also higher cotton seed yield. There was considerable correlation between defoliation at 5 DAS and 10 DAS. Further, the quality parameters were not significantly effected due to defoliants application.

Keywords: Cotton, Defoliants, Mechanical picking

INTRODUCTION

The increasing scarcity and high cost of manual labor has accelerated the need for mechanization in cotton harvesting, particularly in developing countries like India. Manual picking, while still common, is labour-intensive, time-consuming, and often results in inconsistent fiber quality due to delayed harvests. Mechanical picking offers a solution, but its efficiency is often hampered by the presence of green leaves and immature bolls, which increase trash content and reduce the quality of the harvested lint (Ashraf *et al.,*2023).Defoliants are agrochemicals applied before harvest to induce the shedding of leaves, promote boll opening, and reduce plant moisture. They function by disrupting hormonal balances—primarily increasing ethylene synthesis and reducing auxin activity, thereby accelerating senescence and abscission (Rajasekar *et al.,* 2025). This leads to better boll exposure, reduced leaf trash, and improved machine efficiency, making them an essential component of pre-harvest management in mechanized systems (Chandrasekaran *et al.,* 2023a).Several defoliants are used in cotton,

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Table1. Physiological parameters and seed cotton yield as influenced by different defoliant treatments.

Treatments	Boll Opening perce-ntage	% defo-liation at 5 DAS	% defo-liation % at 10 DAS	Earli-ness	Seed cotton yield (kg/ha)
T1-Control	45.0	3.7	5.3	38	1952
T2-Ethrel@3000ppm	73.2	13.8	59.1	51	2386
T3-Thidiazuron@500ppm	77.8	73.2	95.5	72	2602
T4-Sodiumchlorate@0.9%	76.9	53.3	80.9	65	2167
T5-CICRDefoliant	67.0	65.8	86.2	60	2280
T6-Hydrogencyanamide @ 5000ppm	65.8	22.7	55.6	55	2229
T7-T2+5%ofurea	71.2	28.2	65.6	54	2447
T8-T2+Diuron@400 ppm	66.8	52.3	77.5	59	2339
T9-T2+Sodiumchlorate @0.9%	74.4	53.4	89.5	60	2257
T10-T3+Diuron@400ppm	83.9	72.5	93.1	75	2555
SEd	5.7	3.0	5.3	6.0	207
CD (p=0.05)	11.2	5.9	10.5	11	410
CV(%)	10	11	9	4.1	12

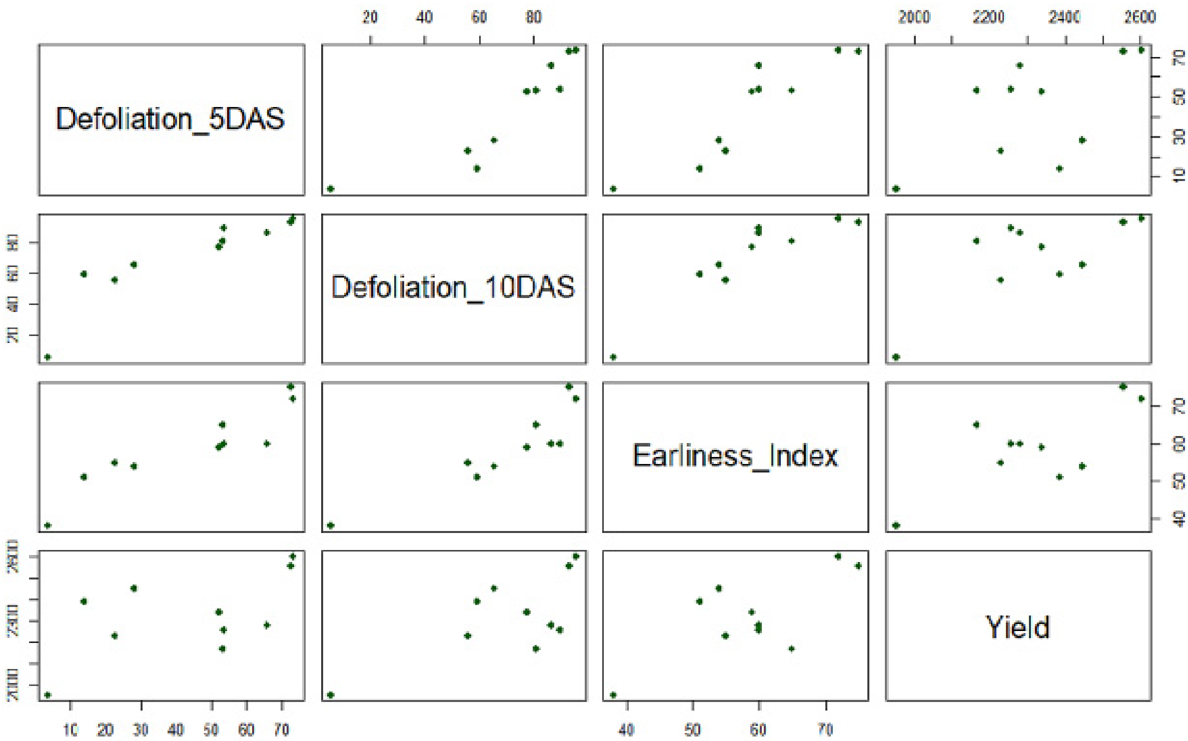

Fig.1. Correlation studies between defoliation at 5 days and 10 days after application, earliness index and seed cotton yield

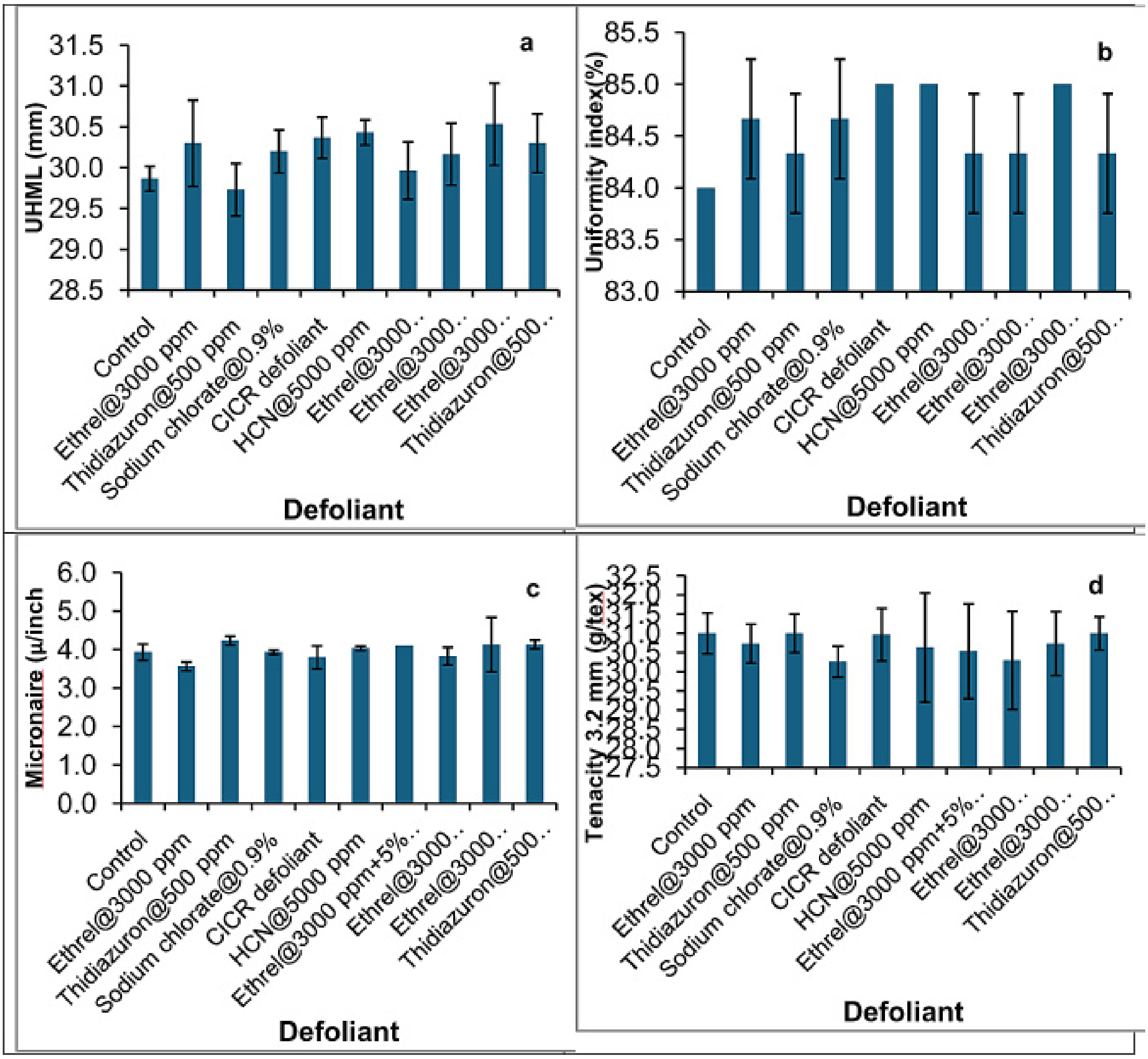

Fig.2. Quality parameters as influenced by various defoliants in cotton during 2024-25 at RARS, Nandyal

including thidiazuron, ethephon, tribufos, and their combinations. Their effectiveness depends on crop age, variety, climatic conditions, and application timing. Recent field studies in China reported that the application of a 10% thidiazuron + 40% ethephon mixture significantly improved boll opening (from 77.3% to 84.9%) and increased lint yield by 14.8%, highlighting its potential for enhancing mechanical harvest readiness when applied 4–5 days earlier than conventional timings (Chen *et al.,* 2024).

In India, research on high-density cotton planting systems has shown that defoliants like thidiazuron and ethephon not only assist in efficient leaf drop but also preserve fiber quality and maintain photosynthetic efficiency until harvest (Chandrasekaran *et al.,* 2023b). Adequateliterature supports the adoption of defoliants as a cost-effective and agronomically viable solution for facilitating clean, timely, and efficient mechanical picking.In this context, the present study was undertaken to evaluate the effect of selected defoliants on leaf shedding, boll opening and seed cotton yield with the aim of optimizing conditions for mechanical harvesting under the prevailing agroclimatic conditions.

MATERIAL AND METHODS

A field study was carried out during the *kharif* season of 2024 at Regional Agricultural Research Station, Nandyal to assess the effect of defoliants on facilitating mechanical picking in cotton. The soil at the test location is classified as deep Vertisols, characterized by a clay texture with a moisture-holding capacity of 14.5 %, pH of 8.5, EC 0.46 dS m^{-1}, Organic carbon 0.35%, low in available Nitrogen (118 kg/ha), high in available phosphorus (71 kg/ha) and potassium (453 kg/ha). The experiment was laid out in a Randomized Block Design (RBD) with 10 treatments and 3 replications. Each plot measured 5.4 m × 3.6 m. The treatments consisted of T_1:Control, T_2:Ethrel@3000ppm, T_3:Thidiazuron @500ppm,T_4:Sodiumchlorate @0.9%, T_5:CICRDefoliant, T_6:Hydrogency anamide @5000ppm, T_7:T_2+5%ofurea, T_8:T_2+Diuron @400 ppm, T_9:T_2+Sodiumchlorate @0.9% and T_{10}:T3+Diuron@400ppm. The cotton hybrid Dr.Chandra Gold BGII was sown with inter row spacing of 90 cm and intra-row spacing of 45 cm. The crop received 150 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha, and were applied as urea, single super phosphate and muriate of potash, respectively. The 100% recom-mended dose of P_2O_5 was applied as basal. The nitrogen and K_2O were applied in 3 equal splits at 30,60 and 90 days after sowing. Need based plant protection measures were taken up. The treatments were imposed after 65% boll opening stage. The data pertaining to leaf shedding at 5 days and 10 days after defoliant application, earliness index and seed cotton yield was recorded. The data were subjected to Analysis of Variance (ANOVA) using RBD. The means of treatments were compared using the critical difference (CD) at 5% probability level (p = 0.05) to determine statistical significance.

RESULTS AND DISCUSSION

The outcomes of the field experiment showed that significantly lower seed cotton yield (1952 kg ha^{-1}) was recorded with T_1(Control) compared to other treatments. Higher boll opening percentage (83.9) was recorded with T_{10} (Thidiazuron @500 ppm+ Diuron @400ppm) and was on par with T_3 (77.8), T_4 (76.9) and lower boll opening percentage (45) was noticed withT_1(Control).Higher percentdefoliation(73.2) at 5 days after spraying was recorded with T_3 (Thidiazuron @500 ppm) and lower percent defoliation was recorded with T_1(Control). Higher percent defoliation (95.5) at10 days after spraying was recorded with T_3 (Thidiazuron @ 500 ppm) and was on par withT_{10} (93.1), T_9(89.5), T_5(86.2) and lower percent defoliation (5.3) was recorded with T_1(Control). Further, higher earliness index (75%) was recorded with T_{10}(Thidiazuron @ 500ppm+Diuron @ 400ppm) and was on par withT_3 (72%)and T_4 (65%);lower earliness index (38%) was registered with T_1 (Control) (Table 1). The correlation between defoliation at 5 DAS and 10 DAS was considerable (Fig.1). Further, the quality parameters were not substantially influenced due to defoliants application (Fig.2).

CONCLUSION

The findings of the trial clearly showed that higher defoliation was attained with Thidiazuron application @500 ppm+ Diuron @400ppm and also higher cotton seed yield and is effective to ease mechanical picking in rainfed cotton.

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EFFECT OF PUDDLING PRACTICES AND CROP ESTABLISHMENT METHODS ON THE PRODUCTIVITY OF RICE (*ORYZA SATIVA*.L)

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ABSTRACT

A research trial was conducted in clay loam soils at Regional Agricultural Research Station, Maruteru, Andhra Pradesh during *rabi*, 2022-23 to assess the effects of puddling and crop establishment methods on rice productivity.The study comprised two factors: puddling practice, *viz*., power tiller (M_1), rotovator (M_2,) and roto-puddler (M_3) as main plot treatments and crop establishment method, *viz*..,drum seeding (E_1),line planting (E_2),machine planting (E_3),diagonal planting (E_4,) and Bengal planting (E_5) as sub-plot treatments.The results showed that among the puddling practices, the use of a roto-puddler registered the highest growth parameters at harvest, such as number of tillers m^{-2} (401), crop dry matter (11053 kg ha^{-1}), and yield attributes, that is, the number of panicles m^{-2} (371), total number of grains $panicle^{-1}$ (259), grain (4697 kg ha^{-1}), and straw yield (6098 kg ha^{-1}). This was statistically at par with the use of a rotovator but significantly superior to that of a power tiller. Among crop establishment methods, growth parameters at harvest, that is, number of tillers m^{-2} (416), crop dry matter (11427 kg ha^{-1}), and yield parameters, that is, the number of panicles m^{-2} (386), total number of grains $panicle^{-1}$ (257), grain (4837 kg ha^{-1}), and straw yield (6148 kg ha^{-1}) were higher with the diagonal planting method; however, it was found statistically at par with Bengal planting and drum seeding but significantly superior over machine planting and line planting.

Keywords: Bengal planting, Diagonal planting, Power tiller, Rice, Roto-puddler

INTRODUCTION

Rice is the foremost food crop of India, cultivated in an area of approximately 45.07 m ha with a production of 129.5 m t and productivity of 2798 kg ha^{-1} during 2019-2020 (Ministry of Agriculture & Farmers Welfare, 2022).Land preparation is a crucial part of rice production because puddling is required to decrease the loss of water and nutrients through excessive percolation, and it can also reduce weeds and enhance nutrient availability (Hazra *et al*., 2014; Alam *et al*., 2018).However, the long-term effects of puddling could lead to the formation of large clods in fine-textured soils, resulting in negative effects on soil characteristics, leading to a decline in rice yield.Therefore, great emphasis has been placed on the development of suitable puddling practices and machinery for wetland rice cultivation.Rotovators and roto-puddlers are new options through which puddling and levelling can be performed together.The roto-

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puddler aids in green manure inclusion in wetland areas.

Manual transplanting under puddled conditions is the regular practice of rice establishment.However, the conventional establishment of rice by transplanting is laborious, and vigorous tillage consumes more energy and water and spoils the soil structure.In transplanting, major operations such as nursery preparation and management, pulling of nursery, and transporting and distributing seedlings to the main field consume 30–40 percent of the total expenses on cultivation (Rani and Jayakiran, 2010).Alternate establishment methods can be utilized to reduce the cost of cultivation, even if the productivity remains static or increases.Rice crops are grown in many ways, depending on resource availability.The drum seeder is a simple piece of equipment thatsolves problems tremendously.Apart from monetary savings, it also has advantages such as a reduction in crop duration by 10-12 days the possibility of better weed management and fertilizer application under row seeding, which is not possible in traditional transplanting. The machine transplanting of rice has been apprised the most promising option, as it saves labour, ensures timely transplanting, and attains required plant density that contributes high productivity, saves energy, minimizes drudgery besides early crop maturity and efficient water use besides benefit:cost ratio. Diagonal planting is a new method of planting in which the number of plants is doubled compared to common line planting (Dhawan, 2018).This planting method is a variant of the line-planting system.An extra plant is often set at the center of each square.Recently, farmers have been using skilled manpower for planting with early aged seedlings, locally called the Bengal planting method, which is a standard practice throughout the Godavari region of Andhra Pradesh. This method enables stable rice yields by way of effective weed control; stimulated root growth and optimum plant stand with enhanced tillering under reduced inputs and unpredictable climatic conditions

MATERIAL AND METHODS

A field trial was conducted to study the effect of puddling and crop establishment methods on rice productivity at the Regional Agricultural Research Station, Maruteru,during *rabi*, 2022-23. The experimental soil was clay loam, slightly acidic in reaction pH (5.7), EC 0.32 dSm^{-1}, medium in organic carbon (0.54%), low in available nitrogen (220 kg ha^{-1}), medium in available phosphorus (28.4 kg ha^{-1}), and high in available potassium (312 kg ha^{-1}).The rice variety “MTU- 1121” (Sri Druthi) was used as the test variety.The experiment was designed as a split-plot with three main plots of puddling practices and five subplots of crop establishment methods with three replications.The main plots comprised three different puddling practices: power tiller (M_1), rotovator (M_2), and roto-puddler (M_3). Five crop establishment methods of rice, *viz.*, drum seeding (E_1), line planting (E_2), machine planting (E_3), diagonal planting (E_4), and Bengal planting (E_5) were assigned to sub-plots.

RESULTS AND DISCUSSION

Crop Growth Parameters

Plant growth parameters, such as the number of tillers and crop dry matter accumulation (kg ha^{-1}), were studied during the experiment (Table 1).All growth parameters were significantly influenced by both puddling practices and crop establishment methods, but not due to their interaction.Among the puddling practices, significantly higher values of growth parameters were observed in the Roto-puddler (M_3), which was at par with the Rotovator (M_2).Significantly lower values of growth parameters were observed with the power tiller

(M_1).Higher tiller count per m^{-2} (401) and higher dry matter accumulation (11053 kg ha^{-1}) were observed with the roto-puddler, which was due to enhanced and prolific rice growth under puddled tillage using a roto-puddler, which provided adequate soil physical characteristics and balanced nutrient availability throughout crucial phenophases, which might have resulted in a greater number of tillers and greater dry matter accumulation with biomass.Similar results were observed by Dewanti and Mandang (2022), and Srinivas *et al*. (2023).The lower tiller number and less dry matter accumulation with the power tiller treatment was due to greater hill mortality and bulk density of soil leading to lesser root growth. These results are in accordance with the findings of Srinivas *et al*. (2023).

In terms of crop establishment methods, the diagonal planting method had the paramount tiller number m^{-2} (416) and higher drymatter accumulation (11427 kg ha^{-1}) at harvesting stage and it was equal to bengal planting and drum seeding but it was significantly superior over machine planting and line planting.This was due to more plant population due to an extra plant set in the centre of each square, which doubles the plant population under diagonal planting as confirmed by Dhawan (2018*)* as well as transplanting under puddled conditions, which lowers weed density of competition

Table1. Growth parameters of rice as influenced by puddling practices and crop establishment methods during *rabi*, 2022-23

Treatments	Number of tillers(m^{-2})	Dry matter accumulation(kg ha^{-1})
Puddling Practices (3)		
M_1- Power tiller	340	9607
M_2- Rotovator	375	10585
M_3- Roto-puddler	401	11053
SEm +	10.71	263.53
CD (P=0.05)	42.06	1034.75
CV (%)	11.15	9.80
Establishment Methods (5)		
E_1- Drum Seeding	386	10309
E_2- Line Planting	343	9964
E_3- Machine Planting	326	9541
E_4- Diagonal Planting	416	11427
E_5- Bengal Planting	391	10835
SEm +	11.41	412.90
CD (P=0.05)	33.30	1205.16
CV (%)	9.20	11.89
Interaction	NS	NS

(interference) and improves the nutrient uptake by crop, that prevalentfavourable conditions for crop growth. Similar results were registered by Srinivas *et al*. (2023) which shows that increased number of tillers m^{-2} (416) and higher drymatter accumulation (11427 kg ha^{-1}) registered under diagonal planting. Whereas, bengal planting and drum seeding recorded next best in case of tiller number m^{-2} (391 and 386) and higher drymatter production (10835 and 10309 kg ha^{-1}) respectively was observed due to adequate spacing. There is an improvement in tillering ability and root development due to maximum use of the input because of wider plant spacing in bengal planting (E_5). These results are in accord with the results of Duraisamy *et al*. (2011) who reported the same that there is hike in rice growth and grain yield due to wider plant spacing.

Despite the higher tiller count, Bengal planting and drum seeding were also noticed on par with diagonal planting because its early aged and sprouted seedlings on puddled soil resulted in less competition of weed density, improved nutrient uptake, and increased number of tillers with great vigor, thereby improving dry matter accumulation.Similar results were reported by Rao *et al.* (2020), Choudhary *et al.* (2021), and Srinivas *et al*. (2023).

A lower number of tillers m^{-2} (326) was observed under machine planting, which is possibly a result of underlying factors such as less space between hills, leading to more competition for nutrients, inadequate supply of nutrients and moisture during the post-rainy season, and also planting by machine, which ensures only 1 to 2 seedlings per hill, resulting in a lower number of tillers m^{-2}(326) and less dry matter accumulation (9541 kg ha^{-1}).

Yield Attributes and Yield

The number of panicles m^{-2}, total grain number $panicle^{-1}$, and grain and straw yield (kg ha^{-1}) were significantly influenced by the different puddling practices and crop establishment methods during *rabi*, 2022-23. Regarding number of panicles m^{-2} and grain yield, the significant interaction was found among puddling practices and crop establishment methods. 1000 grain weight (g) did not influence by puddling practices and crop establishment methods (Table 2).

Yield assigning characters *i.e.* the number of panicles (371), total number of grains panicle(259), grain yield (4697 kg ha^{-1}) and straw yield (6098 kg ha^{-1}) of rice at harvest were significantly higher in roto-puddler and it was found on par with rotovator but significantly superior over power tiller treatment.This could be attributed to the fact that puddling with a roto-puddler provided good land levelling and better friable conditions in soil by incorporation of weeds and straw into the soil, which reduced crop weed competition and improved soil physical and chemical properties, leading to better tillering ability and conversion of total number of tillers to productive tillers, increasing the number of panicles m^{-2} and, in turn, increasing grain yield.Srinivas *et al*. (2023) also observed an improvement in yield attributes, grain yield and straw yield by puddling using a roto-puddler under transplanted conditions with uniform plant spacing.

Similarly, with the crop establishment treatments, significantly higher values of yield attributing characters, that is, the number of panicles m^{-2} (386), total number of grains $panicle^{-1}$ (257), grain yield (4837 kg ha^{-1}), and straw yield (6148 kg ha^{-1}) were recorded with the diagonal planting method, which was at par with Bengal planting and drum seeding but was significantly superior to machine planting and line planting (Table 2).This was due to the increased tiller number and greater dry matter accumulation, including better environmental conditions, characterized by less crop-weed competition for moisture and light and better availability of nutrients for proper accumulation of plant dry matter and yield attributing characters, such as productive tillers and filled grains per panicle, thereby increasing grain and straw yields under these treatments. However, the machine planting (E_3) treatment registered the lowest grain yield, which might be due to wider row spacing during *the rabi* season and planting using machines, which ensures only 1-2 seedlings per hill, leading to a lower plant population and a lower number of tillers, thereby resulting in decreased grain and straw yields. Similar to the number of panicles, an interaction effect between puddling practices and crop establishment methods was also detected for grain yield.

The interaction effect between puddling and crop establishment methods was found to be significant with respect to the number of panicles m^{-2} and grain yield (kg ha^{-1}).The highest number (417) panicles m^{-2} (Table 3) and the highest grain yield (5252 kg ha^{-1}) were

Table 2. Yield attributes and yield of rice as influenced by puddling practices and crop establishment methods during *rabi*, 2022-23

Treatments	No. of panicles m^{-2}	No. of grains panicle^{-1}	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Puddling practices (3)					
M_1- Power tiller	325	233	20.52	4192	5400
M_2- Rotovator	355	243	20.79	4531	5834
M_3- Roto-puddler	371	259	20.71	4697	6098
SEm +	6.78	4.43	0.41	96.71	133.22
CD (P=0.05)	26.61	17.40	NS	379.7	523
CV (%)	7.49	7.02	7.59	8.37	8.93
Establishment Methods (5)					
E_1- Drum Seeding	358	248	20.13	4495	5720
E_2- Line Planting	332	237	20.67	4305	5635
E_3-MachinePlanting	306	231	20.17	4134	5375
E_4-DiagonalPlanting	386	257	20.71	4837	6148
E_5- Bengal Planting	368	250	20.26	4595	6009
SEm +	11.87	5.95	0.45	123.48	165.99
CD (P=0.05)	34.65	17.38	NS	360.4	485
CV (%)	10.17	7.30	6.61	8.28	8.62
Interaction					
MXE	60.62	NS	NS	624.24	NS
E X M	59.57	NS	NS	669.61	NS

Table 3. Panicles m^{-2} of rice as influenced by puddling practices and establishment methods

Puddling practices/Crop establishment methods	Drum seeding (E_1)	Line planting (E_2)	Machine planting (E_3)	Diagonal planting (E_4)	Bengal Planting (E_5)	Mean
M_1-Power tiller	341	334	251	363	337	325
M_2- Rotovator	357	354	289	377	396	354
M_3-Roto-puddler	376	309	377	417	373	370
Mean	358	332	306	386	369	
			SEm +CD(P=0.05)			
Sub at same level of main				20.56	60.02	
Main at same level of sub				19.60	59.57	

Table 4. Grain yield (kg ha^{-1}) of rice as influenced by puddling practices and establishment methods

Puddling practices/Crop establishment methods	Drum seeding (E_1)	Line planting (E_2)	Machine planting (E_3)	Diagonal planting (E_4)	Bengal Planting (E_5)	Mean
M_1-Power tiller	4372	4268	3957	4213	4148	4191
M_2- Rotovator	4635	3835	4397	5045	4741	4530
M_3-Roto-puddler	4478	4811	4048	5252	4897	4697
Mean	4494	4304	4134	4837	4595	
				SEm +	**CD (P=0.05)**	
Sub at same level of main				213.87	624.24	
Main at same level of sub				214.35	669.61	

observed (Table 4) in diagonal planting on puddling with a roto-puddler 4). This could be attributed to the increased plant population under diagonal planting, which resulted in a greater number of tillers and panicles, as well as puddling withroto-puddler, resulting in improved soil physical conditions and improved nutrient uptake thereby resulting in higher yield attributes and yield. These findings are in accordance with those of Srinivas *et al*. (2023).

CONCLUSION

The present study demonstrated that growth parameters, yield characteristics and rice yield were significantly affected by the puddling techniques and crop establishment methods. The findings clearly showed that using a roto-puddler for puddling, combined with a diagonal planting method, proved more effective, as evidenced by enhanced growth, yield characteristics and rice yields.

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INFLUENCE OF ROW SPACING, SEED MATERIAL TYPE AND PLANT DENSITY ON GOWTH AND YIELD OF SUGARCANE UNDER DUAL ROW PLANTING

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ABSTRACT

Field experiment was conducted to study influence of row spacing and plant density on growth and yield of sugarcane under dual row planting in plant ratoon system at Regional Agricultural Research Station, Anakapalle, during the year 2023-24. The experimental soil was sandy loam in texture. Row spacings of 150 cm, 165 cm and 180 cm were tried with sett and seedling planting under three different plant densities of 100 %, 125% and 150%. Studies on plant crop of sugarcane revealed that sugarcane yield under dual row planting of 150 cm (79.2 t ha^{-1}) and 165 cm (77.8 t ha^{-1}) were found to be statistically similar but significantly higher over 180 cm row spacing (71.9 t ha^{-1}).Higher cane yield of 78.2 t ha^{-1} recorded with seedling planting which was found on par with sett planting (74.3 t ha^{-1}). There is no significant difference in yield with respect to plant densities of 100 % (75.6 t ha^{-1}) 125% (76.5 t ha^{-1}) and 150 % (76.7 t ha^{-1}). In ratoon crop indicated that dual row planting of 150 cm and 165 cm gave statistically on par cane yield of 67.2 t ha^{-1} and 64.8 t ha^{-1} respectively and significantly superior over cane yield at 180 cm row spacing (62.8 t ha^{-1}). Cane yield was not influenced either due to type of planting material or plant densities in ratoon crop of sugarcane.

Key words: Dual row planting, Plant densities, Sugarcane seedlings, Sugarcane setts.

INRODUCTION

Sugarcane is traditionally planted at a row spacing of 80-90 cm and spacing between sugarcane rows play an important role for realizing higher yields (Nalawade *et al.,* 2018). In recent years, farmers are adopting different planting methods like paired row, wide row and dual row to facilitate mechanical weeding, earthing up, machine harvesting etc., to overcome labour problem and to reduce cost of cultivation. Irrespective of planting method, a spacing of 5 feet between rows / pairs is recommended to facilitate mechanization. However, working with mini tractor for intercultivation, earthing up etc., is becoming difficult in grown up crop at formative phase especially in ratoons. A seed rate of 40,000 three bud setts under sett planting or 18,750 seedlings per ha under seedling transplantation is recommended for Sugarcane. Therefore, the present study has been proposed to study the influence of row

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spacing, type of seed material and plant densities on yield and quality of sugarcane under dual row planting.

MATERIAL AND METHODS

Experiment was conducted during 2023-24 at Regional Agricultural Research Station, Anakapalle. The experimental site was located in North Coastal Zone of Andhra Pradesh with average annual rainfall of 520 mm and geographical coordinates of the site are approximately $17^0 38^1$ N latitude and $83^0 01^1$ E Longitude. The experimental soil was sandy loam and it was laid out in split-split plot design replicated thrice. The three main plot treatments include row spacing of 150 cm, 165 cm and 180 cm, the two sub plot treatments consisting of setts and seedlings as planting material and the three sub sub plots consists of plant population of 100%, 125% and 150% of recommended population of 40,000 and 18750 setts and seedlings respectively. Sugarcane variety 2009 A 107 was taken as the test variety. In plant crop of sugarcane 112 of nitrogen 100 kg of phosphorous and 120 kg of potassium ha-^{1} was applied. Entire phosphorous and potassium was applied as basal and nitrogen was applied in two equal splits at 45 and 90 days after planting. In ratoon crop of sugarcane, 224 kg of nitrogen 100 kg of phosphorous and 120 kg of potassium ha-^{1} was applied. Entire phosphorous, potassium and half of nitrogen was applied at the time of ratooning and remaining half of Nitrogen was applied at 45 days after ratooning.

RESULTS AND DISCUSSION

In plant crop of sugarcane, dual row planting of 150 cm and 165 cm gave statistically on par cane yield (79.2 t ha^{-1} and 77.8 t ha^{-1} respectively) and significantly superior over 180 cm row spacing (71.9 t /ha) (Table 1). Christy Nirmala Mary *et al.,* (2019) also reported highest yield with wider spacing of 150 cm between sugarcane rows. Higher cane yield of 78.2 t ha^{-1} recorded with seedling planting which was found on par with sett planting (74.3 t ha^{-1}). There is no significant difference in yield with respect to plant densities of 100 % (75.6 t ha^{-1}) 125% (76.5 t ha^{-1}) and 150 % (76.7 t ha^{-1}). The variation in seed rate did not influence the population of millable canes statistically. Sucrose per cent and CCS % were found non-significant among the different treatments under test. The interaction between spacing and planting material was significant and the results showed that planting of seedlings in combination with 150 cm dual row planting gave highest cane yield of 83.2 t ha^{-1} (Table. 2) Gouri *et. al*., 2019 and Sathiya *et. al.*, (2024) also reported that planting of single node/bud chip seedlings is viable and economical alternative in reducing the cost of sugarcane production (ANY SPECIFIC RESAON FOR HIGHER YIELD).

Data on ratoon crop indicated that dual row planting of 150 cm and 165 cm gave statistically on par cane yield of 67.2 t ha^{-1} and 64.8 t ha^{-1} respectively and significantly superior over cane yield at 180 cm row spacing (62.8 t ha^{-1}) (Table. 3) . Highest cane yield of 65.9 t ha^{-1} was recorded with seedling planting which was on par with sett planting (64.0 t ha^{-1}). Bhullar et. al., (2008) also reported similar results with respect to type of planting material. There is no significant difference in yield with respect to plant densities of 100 % (63.6 t ha^{-1}) 125% (65.1 t ha^{-1}) and 150 % (66.1 t ha^{-1}). Sucrose per cent and CCS % were found non-significant among the different treatments under test.

CONCLUSION

The results of the study indicated that, dual row planting of 150 cm or 165 cm in

Table 1. Number of Millable canes, Quality and Yield of sugarcane as influenced by different treatments (Plant crop) during 2023-24

Treatments	NMC ha^{-1}	Sucrose (%)	CCS (%)	Cane Yield (t ha^{-1})	Sugar yield (t ha^{-1})
Spacing					
150cm	83,012	19.33	14.03	79.2	11.1
165cm	80,012	19.26	14.85	77.8	11.6
180cm	74,635	18.90	13.63	71.9	9.8
SEm+	662	0.17	0.15	0.83	-
C.D @5%	2585	NS	NS	3.2	-
Type of seed material					
Setts	81,274	19.22	13.90	74.3	10.3
Seedlings	77,166	19.11	13.78	78.2	10.8
SEm+	573	0.22	0.18	0.62	-
C.D @5%	1977	NS	NS	2.1	-
Population					
100%	77,533	19.55	14.19	75.6	10.7
125%	79,513	18.81	13.47	76.5	10.3
150%	80,613	19.13	13.87	76.7	10.6
SEm+	578	0.29	0.27	0.53	-
C.D @5%	1687	NS	NS	NS	-
Interaction					
AXB	NS	NS	NS	Sig	-
AXC	NS	NS	NS	NS	-
BXC	NS	NS	NS	NS	-
AXBXC	NS	NS	NS	NS	-

sugarcane with single node seedlings @ 18750 ha^{-1} realized higher cane yield. Dual row planting of sugarcane facilitates mechanization for taking up weeding and harvesting operations as mechanization is need of the hour. Raising sugarcane crop with single node seedlings helps in reducing the seed material when compared to sett planting.

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Table 2. Sugarcane yield (t ha^{-1}) as influenced by type of seed material and spacing

Spacing	Cane yield (t ha^{-1})		
	Setts	Seedlings	Mean
150cm	75.1	83.2	79.1
165cm	77.1	78.4	77.8
180cm	70.6	73.1	71.9
Mean	74.3	78.3	-
SEm+		1.10	
C.D @ 5%		3.7	

Table 3. Number of Millable canes, Quality and Yield of sugarcane as influenced by different treatments (Ratoon crop) during 2023-24

Treatments	NMC ha^{-1}	Sucrose (%)	CCS (%)	Cane Yield (t ha^{-1})	Sugar yield (t ha^{-1})
Spacing					
150 cm	90611	18.59	13.18	67.2	8.86
165 cm	83714	18.77	13.51	64.8	8.75
180 cm	80739	18.96	13.43	62.8	8.43
SEm+	1136	0.3	0.27	0.74	-
C.D @ 5%	4438	NS	NS	2.9	-
Type of seed material					
Setts	85194	18.73	13.23	64.0	8.47
Seedlings	84848	18.83	13.51	65.9	8.90
SEm+	1127	0.29	0.28	0.94	-
C.D @ 5%	NS	NS	NS	NS	-
Population					
100%	81970	19.14	13.74	63.6	8.74
125%	85394	18.34	12.92	65.1	8.41
150%	87700	18.86	13.46	66.1	8.90
SEm+	789	0.25	0.23	0.81	-
C.D @ 5%	2306	NS	NS	NS	-
Interaction	NS	NS	NS	NS	

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EFFECT OF NANO FERTILIZER ON GROWTH, YIELD, NITROGEN UPTAKE AND ECONOMICS OF RICE IN ALLUVIAL SOILS OF GODAVARI ZONE OF ANDHRA PRADESH

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ABSTRACT

A field trial was conducted during the *Kharif* and *Rabi* seasons of 2023–24 to evaluate the efficacy of nano urea (NU) and super nano urea (SNU) on the growth, yield, nutrient uptake, and economics of rice. The experiment consisted of 11 treatments: T_1–Control (0% N; 100% P & K); T_2–Recommended Fertilizer Dose (RDF) representing 100% RDN (*Kharif*: 90-60-60 kg NPK ha^{-1}; *Rabi*: 180-90-60 kg NPK ha^{-1}); T_3–50% RDN; T_4- 50% RDN + two sprays of conventional urea @1.0% at active tillering (AT) and panicle initiation (PI) stages; T_5- 50% RDN + two sprays of NU @0.4% at A.T & PI; T_6- 50% RDN + three sprays of NU @0.4% at A.T, PI & heading; T_7- 50% RDN + two sprays of SNU @0.25% at A.T & PI; T_8- 50% RDN + two sprays of SNU @0.5% at A.T & PI; T_9- 50% RDN + two sprays of SNU @1.0% at A.T & PI; T_{10}- 33% RDN + three sprays of SNU @0.5% at A.T, PI & heading; and T_{11}- 66% RDN + one spray of SNU @0.5% at heading. The resultsrevealed that the application of 50% RDN with two foliar sprays of nano urea at the active tillering and panicle initiation stages (T_8) proved effective in enhancing rice growth, yield attributes, grain and straw yields, economic returns and nitrogen uptake. However, this treatment performed on par to the 100% RDN (T_2) across two consecutive seasons on alluvial soils of the Godavari zone.

Keywords: Grain yield, Nano urea,Nutrient uptake

INTRODUCTION

Rice (Oryza sativa L.) is important staple food crop for more than half of the global population. As a major source of carbohydrates, rice plays a vital role in meeting worldwide caloric requirements and supplying key micronutrients, including vitamins, minerals, and dietary fiber. The steady growth of the global population has strengthened the need to expand rice production to meet global food security. Beyond its nutritional value, rice has considerable economic, cultural, and religious significance across regions of the world.

In recent years, the agricultural sector has encountered a multitude of challenges that have posed significant threats to its stability and productivity. In response, the development of innovative technologies has been pivotal in overcoming these constraints and sustaining farm-level productivity. In this context, nanofertilizers have emerged as a promising component in crop nutrition, although their

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application is in the early stages of development. These advanced formulations hold considerable potential for promoting sustainable crop growth, with particular emphasis on nano nitrogen. Nanofertilizers enhance nutrient use efficiency in plants, reduce adverse effects on soil microorganisms, and alleviate stress associated with the overapplication of conventional fertilizers, thereby reducing the fertilizer requirements of crops (Kantwa and Yadav, 2022). Consequently, nanofertilizers may also serve as a viable and environmentally responsible alternative to conventional fertilization. Considering these factors, the present investigation was undertaken to evaluate the influence of nano-fertilizers on the yield performance, nitrogen uptake and economics of rice crops.

MATERIAL AND METHODS

A field trial was conducted during *kharif* and *rabi* seasons of 2023–24 at the Regional Agricultural Research Station, Maruteru, West Godavari district, to evaluate the effectiveness of nano urea (NU) and super nano urea (SNU) on the growth, yield, nitrogen uptake, and economic viability of rice. The Godavari zone is characterized by a tropical climate with hot summers and a dominant southwest monsoon from June to October, with an average rainfall ranging from 755 to 1500 mm. The experimental soil is alluvial.

The experiment consisted of 11 treatments arranged in a randomized block design with three replications: T_1–control (0% N; 100% P & K); T_2–recommended fertilizer dose (RDF) representing 100% RDN (*Kharif*: 90-60-60 kg NPK ha^{-1}; *Rabi*: 180-90-60 kg NPK ha^{-1}); T_3–50% RDN; T_4–50% RDN + two sprays of conventional urea @1.0% at active tillering (AT) and panicle initiation (PI) stages; T_5–50% RDN + two sprays of NU @0.4% at AT and & PI; T_6 50% RDN + three sprays of NU @0.4% at AT, PI and & heading; T_7 50% RDN + two sprays of SNU @ 0.25% at AT & PI; T_8 50% RDN + two sprays of SNU @0.5% at AT & PI; T_9 50% RDN + two sprays of SNU @1.0% at AT & PI; T_{10} 33% RDN + three sprays of SNU @0.5% at AT, PI & heading; and T_{11} 66% RDN + one spray of SNU @0.5% at heading.

IFFCO nano Urea (liquid), with a particle size ranging from 20 to 50 nm and containing 4.0% total nitrogen (w/v) uniformly dispersed in water, was utilized in this study. This product is officially listed under the Fertilizer Control Order (FCO), as notified by the Government of India. Both Nano Urea and Super Nano Urea are recognized as advanced formulations relative to conventional fertilizers owing to their superior efficacy. While both nano urea plus and nano urea are liquid fertilizers developed using nanotechnology (<100 nm), Nano urea plus is further distinguished by a higher nitrogen content (20% N), incorporation of improved bio-polymers, and enhanced nutrient absorption capacity attributes to improved crop performance.The recommended nutrients were applied in the form of urea, SSP, and MOP under transplantation conditions.The prescribed doses of P_2O_5 and K_2O were uniformly applied across all treatments.MTU 1061 and MTU 1121 were the test varieties used during the *Kharif* and *Rabi* seasons, respectively.

Plant samples were collected and assessed for nitrogen content using standard analytical procedures and nutrient uptake values were subsequently computed. The data were statistically analysed using Fisher's method of analysis of variance and interpreted following Gomez and Gomez (1984).An economic analysis was performed based on the prevailing market prices of inputs and the minimum support price for grain to compute the cost of cultivation, gross returns, net returns, and benefit-cost ratio.

RESULTS AND DISCUSSION

Growth and Yield Attributes

As presented in Tables 1 and 2, plant height showed a positive response with application of Super Nano Urea in combination with 50% of the recommended nitrogen dose during the active tillering and panicle initiation stages (T_8) during both *Kharif* and *Rabi* seasons. The significant enhancement in plant height may be attributed to enhanced seedling vigour, which promotes more active cell division and elongation (Nithya *et al.*, 2018).

Data regarding the yield attributing parameters, *viz.,* number of panicles m^{-2}, panicle weight^{-1}, panicle length, number of grains panicle^{-1}, and 1000-grain weight are furnished in Tables 1 and 2. During the *Kharif* season, reducing the nitrogen dose to 50% did not significantly reduce yield attributes compared to full 100% nitrogen application. Similarly, the supplementation of nano urea and super urea sprays with 50% RDN produced results comparable to both 50% N and 100% N treatments, suggesting a limited response to nitrogen inputs during the *Kharif* season. In the *Rabi* season, substitution of nano urea with a reduced nitrogen dose produced comparable yield attributes.However, a more severe reduction to 33% nitrogen led to a decline in yield-contributing parameters.

Grain Yield

During the *Kharif* season (Table 1), the 100% RDN recorded the highest grain yield (5150 kg/ha), closely followed by T_9 (50% RDN + two sprays of SNU @1.0% at AT and PI stages). The latter was comparable to other reduced nitrogen as well as those supplemented with nano-urea or super-nano-urea. The lowest grain yield (3971 kg/ha) was observed with the control. In the *Rabi* season, the same treatment, that is, 100% RDN, recorded the highest grain yield (6183 kg/ha) and was comparable to T_8 (50% RDN + two sprays of SNU @ 0.5%; 5260 kg/ha) and T_9 (50% RDN + two sprays of SNU @1.0%; 5350 kg/ha) applied at AT and PI stages.The lowest yield of 3347 kg/ha was recorded under 0% N, that is,the control.The comparable grain yield obtained with 50% RDN with two nano-urea sprays to the 100% recommended dose of nitrogen may be attributed to the timely and efficient delivery of nitrogen during the critical growth stages of the crop. This targeted approach adequately nourished the crop and enhanced yield attributes through a precise nutrient delivery mechanism, thereby maximizing nutrient uptake and utilization efficiency. Benzon *et al.* (2015) reported a synergistic relationship between nano-fertilizers and conventional fertilizers, resulting in superior nutrient absorption by plant cells when applied at critical crop stages, such as tillering and panicle initiation. These nano-fertilizers have been shown to increase tiller numbers and chlorophyll content, thereby supporting optimal metabolic processes, including photosynthesis, and ultimately promoting greater photosynthate accumulation and translocation to economic plant parts. These findings were correlated with the findings of Upadhyay *et al.* (2023).

Straw Yield

During the *Kharif* season, straw yield was not enhanced by either nano-urea or super-nano-urea combinations (Table 1). In contrast, during the *Rabi* season (Table 2), the application of 50% recommended nitrogen with nano-urea or super-nano-urea resulted in straw yields comparable to those achieved with 100% RDN. The improvement in straw yield with foliar nano-urea application may be attributed to its rapid uptake and efficient translocation within the plant, which facilitated faster photosynthesis and greater dry matter accumulation, ultimately contributing to a higher straw yield.

Table 1. Influence of Nanofertilizer application on performance of rice during *Kharif* season

	Treatment	Plant Height at Harvest (cm)	No of Tillers at Harvest (m^{-2})	No of Panicles m^{-2}	Panicles Weight (g)	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
T_1	Control (0% N; 100% P&K)	105.87	234	259	4.15	5294	6855
T_2	Recommended Dose of Fertilizer (RDF) (90-60-60 kg NPK/ha)	117.43	251	269	5.12	6866	7115
T_3	50 % RDN	113.37	235	259	4.34	6150	7920
T_4	50 % RDN + 2 sprays of conventional urea @ 1.0 % at AT& PI	116.33	226	244	4.32	6194	7871
T_5	50 % RDN + 2 sprays of Nano urea @ 0.4 % at AT& PI	115.97	240	259	4.26	6011	7479
T_6	50 % RDN + 3 sprays of Nano urea @ 0.4 % at AT, PI & Heading stage	116.73	239	265	4.38	5638	7174
T_7	50 % RDN + 2 sprays of SNU @0.25 % at AT& PI	117.63	234	239	4.59	6438	8151
T_8	50 % RDN + 2 sprays of SNU @0.5 % at AT& PI	119.93	261	270	4.64	6550	8017
T_9	50 % RDN + 2 sprays of SNU @1.0 % at AT& PI	118.00	236	265	4.48	6472	7915
T_{10}	33 % RDN + 3 sprays of SNU@0.5 % at AT, PI & Heading stage	112.87	224	255	4.03	6027	7579
T_{11}	66 % RDN + 1 spray of SNU @ 0.5 % at Heading stage	122.73	233	242	4.05	6294	8571
	CD at 0.05	**11.40**	**39.05**	**19.97**	**0.81**	**1286**	**2796**
	CV (%)	**5.76**	**9.65**	**4.56**	**10.91**	**12.22**	**21.33**

Table. 2. Influence of Nano fertilizer application on performance of rice during *Rabi* season

	Treatment	Plant Height at Harvest (cm)	No of Tillers at Harvest (m^{-2})	No of Pani-cles m^{-2}	Pani-cles Weight (g)	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
T_1	Control (0% N; 100% P&K)	85.7	188	163	3.24	3347	4817
T_2	Recommended Dose of Fertilizer (RDF) (180-90-60 kg NPK/ha)	103.9	317	296	4.28	5247	6763
T_3	50 % RDN	97.0	264	233	3.95	4527	5710
T_4	50 % RDN + 2 sprays of conventional urea @ 1.0 %at AT& PI	100.6	269	247	4.01	4740	6260
T_5	50 % RDN + 2 sprays of Nano urea @ 0.4 % at AT& PI	96.5	278	234	3.82	4673	6277
T_6	50 % RDN + 3 sprays of Nano urea @ 0.4 % at AT , PI & Heading stage	101.5	288	263	3.88	4843	6597
T_7	50 % RDN + 2 sprays of SNU @0.25 % at AT& PI	102.6	315	297	4.00	5367	6827
T_8	50 % RDN + 2 sprays of SNU @0.5 % at AT& PI	105.3	335	314	4.26	5793	7330
T_9	50 % RDN + 2 sprays of SNU @1.0 % at AT& PI	101.1	318	292	3.86	4883	6277
T_{10}	33 % RDN + 3 sprays of SNU@0.5 % at AT, PI & Heading stage	93.6	231	210	3.65	4280	5793
T_{11}	66 % RDN + 1 spray of SNU @ 0.5 % at Heading stage	102.5	292	273	3.90	4617	6170
	CD at 0.05	**8.70**	**66.25**	**60.85**	**0.53**	**1009**	**1075**
	CV (%)	**5.27**	**14.16**	**14.26**	**8.15**	**12.8**	**10.3**

Table: 3. Influence of Nano fertilizer application on Economics of rice during *Kharif* and *Rabi* seasons

	Treatment	Gross Returns (Rs/ha)		Cost of Cultivation (Rs/ha)		Net Returns (Rs/ha)		B:C Ratio	
		Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
T_1	Control (0% N; 100% P&K)	86687	73065	74425	78117	12262	-5052	1.16	0.94
T_2	Recommended Dose of Fertilizer (RDF) (180-90-60 kg NPK/ha)	112425	134975	75602	80469	36823	54506	1.49	1.68
T_3	50 % RDN	100702	98824	75013	79293	25689	19531	1.34	1.25
T_4	50 % RDN + 2 sprays of conventional urea @ 1.0 % at AT& PI	105963	103474	81513	85793	24450	17681	1.30	1.21
T_5	50 % RDN + 2 sprays of Nano urea @ 0.4 % at AT& PI	98410	102012	78813	83093	19597	18919	1.25	1.23
T_6	50 % RDN + 3 sprays of Nano urea @ 0.4 % at AT , PI & Heading stage	92319	105723	80713	84993	11606	20730	1.14	1.24
T_7	50 % RDN + 2 sprays of SNU @0.25 % at AT& PI	105417	106596	78138	82418	27279	24178	1.35	1.29
T_8	50 % RDN + 2 sprays of SNU @0.5 % at AT& PI	101422	114826	79263	83543	22159	31283	1.28	1.37
T_9	50 % RDN + 2 sprays of SNU @1.0 % at AT& PI	107251	116791	81513	85793	25738	30998	1.32	1.36
T_{10}	33 % RDN + 3 sprays of SNU@0.5 % at AT, PI & Heading stage	98693	93432	81188	85268	17505	8164	1.22	1.10
T_{11}	66 % RDN + 1 spray of SNU @ 0.5% at Heading stage	103059	100789	77326	81794	25733	18995	1.33	1.23

Table: 4. Nitrogen content and uptake as influenced by Nano fertilizer application in Paddy

	Treatment	**Grain N Uptake (kg/ha)**		**Straw N Uptake (kg/ha)**	
		Kharif	***Rabi***	***Kharif***	***Rabi***
T_1	Control (0% N; 100% P&K)	34.6	30.5	22.9	20
T_2	Recommended Dose of Fertilizer (RDF) (180-90-60 kg NPK/ha)	48.2	57.8	25.8	33.4
T_3	50 % RDN	48.6	47.8	30.9	31.1
T_4	50 % RDN + 2 sprays of conventional urea @ 1.0 % at AT& PI	52.3	51.0	33.4	34.9
T_5	50 % RDN + 2 sprays of Nano urea @ 0.4 % at AT& PI	44.8	46.6	30.1	33.3
T_6	50 % RDN + 3 sprays of Nano urea @ 0.4 % at AT, PI & Heading stage	45.4	51.8	31.0	36.9
T_7	50 % RDN + 2 sprays of SNU @0.25 % at AT& PI	54.0	49.3	34.6	40.7
T_8	50 % RDN + 2 sprays of SNU @0.5 % at AT& PI	42.8	48.4	27.7	31.1
T_9	50 % RDN + 2 sprays of SNU @1.0 % at AT& PI	53.3	54.9	34.2	35.6
T_{10}	33 % RDN + 3 sprays of SNU@0.5 % at AT, PI & Heading stage	44.3	42.0	29.9	30.5
T_{11}	66 % RDN + 1 spray of SNU @ 0.5 % at Heading stage	49.0	47.7	31.3	37.8
	CD at 0.05%	**9.0**	**11.1**	**7.5**	**6.0**
	CV (%)	**11.2**	**13.5**	**14.6**	**10.6**

These findings are in agreement with those reported by Anushka *et al.* (2023) and Upadhyay *et al.* (2023).

Economic Analysis

An economic analysis of the data (Table 3) revealed that a higher B:C ratio of 1.49 was attained with the 100% RDN, followed by 50% RDN + two sprays of SNU @0.25% at the active tillering and panicle initiation stages (1.35)during *the Kharif season*. However, during the *rabi* season, the 100% RDN treatment achieved a higher B:C ratio of 1.68, followed by 50% RDN + two sprays of SNU @0.5% at the AT and PI stages (1.37).

Nitrogen Uptake

During both the *kharif* and *rabi* seasons,nitrogen uptake was analysed separately for grain and straw are presented in Table 4.During the *kharif* season, the highest grain N uptake (53.3 kg/ha) was recorded under T_9 (50% RDN + two sprays of SNU @1.0% at active tillering and panicle initiation stages), which was statistically comparable to all remaining treatments except the control.In the *rabi* season, grain N uptake was highest under the 100% RDN treatment (57.8 kg/ha), performing on par with all 50% N treatments supplemented with nano urea.

Straw N uptake was greatest under T_7 (50% RDN + two sprays of SNU @0.25% at AT and PI) during both *kharif* (34.6 kg/ha) and *rabi* (40.7 kg/ha), highlighting the contribution of SNU to straw N content. The increase in nitrogen uptake associated with nano urea may be due to its immediate absorption and efficient translocation within the plant (Abdel-Aziz *et al.*, 2018). Nano fertilizers possess a large surface area and smaller particle size, which facilitates deeper penetration into plant tissues and improves overall nutrient uptake and use efficiency (Qureshi *et al.*, 2018). Furthermore, the foliar route enables rapid nutrient absorption during fast-growing crop stages, particularly when soil nutrient availability is limited (Wojtkowiak *et al.*, 2014).

CONCLUSION

Based on these findings, it can be stated that the application of 50% of the recommended dose of nitrogen (RDN) in combination with two foliar sprays of nano urea at the active tillering and panicle initiation stages was an effective treatment for improving rice growth, yield attributes, grain and straw yields, economic returns, and nutrient uptake. Importantly, this treatment performed comparably to the full 100% RDN application across two consecutive cropping seasons on alluvial soils in the Godavari zone.

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EFFICACY OF POST-EMERGENCE HERBICIDES ON WEED CONTROL, PRODUCTIVITY AND ECONOMICS OF SUGARCANE

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ABSTRACT

A field experiment in sugarcane weed control was conducted from 2020-21 to 2022-23 in randomized block design with three replications in alluvial soils of Krishna – Godavari delta of Andhra Pradesh. Results revealed that, comparatively higher weed control efficiency was recorded with post-emergence application of tembotrione @ 125 g/ha + halosulfuran methyl @ 125 g/ha *fb* IC at 60 and 90 DAP. Significantly more cane yield was recorded with application of topramezone @ 40 g/ha + halosulfuron methyl @ 125 g/ha *fb* IC at 60 and 90 DAP (115.9 t/ha) which was however statistically at par with rest of the herbicide treatments. The quality parameters like sucrose %, CCS and purity % were not affected by the herbicide treatments. With regard to economics, higher gross returns (Rs. 3,43,296), net returns (Rs. 45,130/-) and B:C ratio (1.15) was recorded with topramezone @ 40 g/ha + halosulfuron methyl @ 125 g/ha *fb* IC at 60 and 90 DAP.

Keywords: Post emergence, Sugarcane, Weed management, Yield.

INTRODUCTION

Around 85 percent Sugarcane production of India comes from Uttar Pradesh, Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka and Gujarat (Takalkar and Pawar 2012). Sugarcane faces tough competition due to weeds during first 60 to 120 days of planting which causes heavy reduction in yield ranging from 40-67% (Shauhan and Srivastava 2002). Wide spacing of Sugarcane allows diverse weed flora to grow profusely in the interspaces between the rows. Frequent irrigations and heavy fertilizer application during early growth stages, increase the weeds problem by many folds in the crop (Ramesha *et al.* 2018). It is well known that cultural method of weed management is most effective to control weeds but timely availability of agricultural labourers is a limitation. Herbicidal control of weeds has been suggested to be economical in sugarcane (Chaudhari *et al.* 2016). The present experiment was undertaken to study the effect of weed control on growth and yield of sugarcane.

MATERIAL AND METHODS

The experiment was conducted from 2020-21 to 2022-23 at Sugarcane Research Station, Vuyyuru of Andhra Pradesh. Six treatments *viz*. metribuzine @ 0.75 kg/ha + 2,4-D amine salt @0.58 kg/ha *fb*inter cultivation (IC)

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Table 1. Weed density and weed dry matter as influenced by different herbicidal treatments in sugarcane (Pre spray at 20 DAP and Post spray at 40 DAP).

		Weed density ($No./m^2$)		Weed dry matter (g/m^2)	
S. No	Treatment	Pre spray	Post spray	Pre spray	Post spray
T_1	Weedy Check	13.68	12.21	86.2	63.1
T_2	Metribuzine @ 0.75 kg/ha + 2,4 D amine salt @ 0.58 kg/ha at 30 days fb IC at 60 and 90 DAP.	13.23	7.46	80.6	29.5
T_3	Topramezone @ 40 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	13.03	7.54	77.0	30.2
T_4	Tembotrione @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	12.79	6.93	75.8	23.2
T_5	Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	13.34	7.23	73.9	24.7
T_6	Topramezone @ 40 g/ha + Halosulfuran methyl @ 125 g /ha as post at 30 DAP fb IC at 60 and 90 DAP	13.54	4.63	78.0	15.4
T_7	Tembotrione @ 125 g/ha + Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	13.70	4.52	80.3	13.8
	CD at 5%	NS	0.7	NS	7.0
	CV %	7.5	5.6	10.4	9.6

at 60 and 90 DAP (T_2);topramezone @ 40g/ha as post at 30 DAP*fb* ICat 60 and 90 DAP (T_3);tembotrione @ 125 g/ha post at 30 DAP*fb* IC at 60 and 90 DAP (T_4); haloslfuron methyl @ 125 g/ha as post at 30 DAP *fb* IC at 60 and 90 DAP (T_5);topramezone @ 40 g/ha + halosulfuron methyl @125 g/ha as post at 30 DAP *fb* IC at 60 and 90 DAP (T_6); tembotrione @ 125 g/ha + halosulfuron methyl @ 125 g/ha as post at 30 DAP *fb* IC at 60 and 90 DAP (T_7) and weedy check (T_1) were tested under three replications in a randomized block design. All the chemicals were applied at 30 DAP of sugarcane with spray volume of 500 l/ha. Two inter cultivations at 60 and 90 DAP were uniform for all the treatments. The soils of experimental site comprised of alluvial soils of Krishna delta region with low available form of nitrogen, medium available phosphorus and high potassium. Single node seedlings of sugarcane variety 2003 V 46 were planted in the month of January. Irrigation was scheduled once in a week during formative phase and once in three weeks during maturity phase. Weed density was recorded as pre and post emergence weedicide application using quadrat of 1 m^2 from three randomly selected spots in each treatmental plot. Further, total

Table 2. Tiller/stalk population at different stages of sugarcane as influenced by different herbicides

S.No	Treatment	Number of tillers/stalks		
		90 DAP	180 DAP	240 DAP
T_1	Weedy Check	69027	65681	64949
T_2	Metribuzine @ 0.75 kg/ha + 2,4 D amine salt @ 0.58 kg/ha at 30 days fb IC at 60 and 90 DAP.	82862	80627	78069
T_3	Topramezone @ 40 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	89934	84970	82112
T_4	Tembotrione @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	89794	90064	85197
T_5	Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	87100	92842	85817
T_6	Topramezone @ 40 g/ha + Halosulfuran methyl @ 125 g /ha as post at 30 DAP fb IC at 60 and 90 DAP	90628	94491	88452
T_7	Tembotrione @ 125 g/ha + Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	90650	98704	91558
	CD at 5%	12547	13945	13521
	CV %	8.2	9.1	9.3

weeds biomass was recorded for calculating weed control efficiency (WCE). WCE was calculated by using the following formula

$$\text{Weed control efficiency (WCE)} = \frac{\text{DWC - DWT}}{\text{DWC}} \times 100$$

DWC= Dry weight of weeds in control plot
DWT= Dry weight of weeds in treatment plot

Similarly weed index is calculated by using the formula

$$\text{Weed Index (WI)} = \frac{\text{Yield in treatment plot- Yield in weed free plot}}{\text{Yield in weed free plot}} \times 100$$

Sugarcane cane yield was recorded plot wise and expressed as yield per hectare. The data of each year were analysed separately. OPSTAT was used for statistical analysis and means were separated using critical difference (CD) at p=0.05. The weed density and biomass values were transformed by square root transformation before being subjected to ANOVA (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Major weeds in experimental field were of sedges (*Cyperus rotundus*), grasses (*Echinochloa crusgalli*, *Digitaria sanguinalis* and *Dactyloctenium aegyptium*) and broad leaved weeds (*Trianthema portulacastrum*,

Table 3. Length, girth and yield of sugarcane as influenced by different herbicides.

S.No	Treatment	At Harvest		
		LMC (cm)	Girth (cm)	Cane yield (t/ha)
T_1	Weedy Check	256	2.66	79.23
T_2	Metribuzine @ 0.75 kg/ha + 2,4 D amine salt @ 0.58 kg/ha at 30 days fb IC at 60 and 90 DAP.	264	2.73	110.1
T_3	Topramezone @ 40 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	262	2.70	109.7
T_4	Tembotrione @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	261	2.78	112.0
T_5	Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	275	2.72	111.5
T_6	Topramezone @ 40 g/ha + Halosulfuran methyl @ 125 g /ha as post at 30 DAP fb IC at 60 and 90 DAP	266	2.65	115.9
T_7	Tembotrione @ 125 g/ha + Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	262	2.68	114.8
	CD at 5 %	NS	NS	18.6
	CV %	4.4	4.6	9.7

Phyllanthus niruri and *Ipomoea* sps). Post-emergence application of tembotrione @ 125 g/ha + halosulfuran methyl @ 125 g/ha *fb* IC at 60 and 90 DAP(T_7) recorded significantly low weed density ($4.52m^{-2}$) and weed dry matter (13.8 g/m^2), but it is statistically on par with topramezone @ 40 g/ha + halosulfuran methyl @ 125 g /ha at 30 DAP *fb* IC at 60 and 90 DAP in terms of reduced weed density (4.63) and weed dry matter (15.4 g/m^2) (Table 1).With regard to number of tillers/stalks, application of tembotrione @ 125 g/ha + halosulfuran methyl @ 125 g/ha as tank mix *fb* IC at 60 and 90 DAP (T_7) recorded significantly higher number of tillers/stalks per hectare at all the stages of crop growth i.e at 90, 180 and 240 days after planting which was however statistically at par with the number of tillers/stalks recorded in all the weedicide treated plots(Table 2). Similar results were also obtained by Ramesha *et al.*, 2018.

The non-significant difference among the treatments were noticed with regard to length and girth of harvested cane (Table 3). Significantly higher yield was recorded with application of topramezone @ 40 g/ha + halosulfuron methyl @ 125 g/ha *fb* IC at 60 and 90 DAP (T_6) (115.9 t/ha) which was however statistically at par with all the herbicide treatments.Singh *et al.* (2008 & 2012) stated that, on an average, presence of total weeds throughout the crop period caused 55.94% reduction in the cane yield.The quality parameters like sucrose %, CCS and purity %

Table 4. Juice quality of sugarcane as influenced by different herbicides.

S.No	Treatment	Juice quality parameters		
		Sucrose (%)	CCS (%)	Purity (%)
T_1	Weedy Check	19.8	14.3	97.5
T_2	Metribuzine @ 0.75 kg/ha + 2,4 D amine salt @ 0.58 kg/ha at 30 days fb IC at 60 and 90 DAP.	19.8	14.3	97.9
T_3	Topramezone @ 40 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	19.8	14.3	97.6
T_4	Tembotrione @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	19.8	14.4	98.1
T_5	Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	19.8	14.4	97.7
T_6	Topramezone @ 40 g/ha + Halosulfuran methyl @ 125 g /ha as post at 30 DAP fb IC at 60 and 90 DAP	19.8	14.3	98.0
T_7	Tembotrione @ 125 g/ha + Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	19.8	14.2	97.2
	CD at 5 %	NS	NS	NS
	CV %	1.1	1.3	2.8

Table 5.Weed parameters in sugarcane as influenced by different herbicides.

S.No	Treatment	Weed parameters	
		WCE (%)	Weed Index (%)
T_1	Weedy Check	—	33.2
T_2	Metribuzine @ 0.75 kg/ha + 2,4 D amine salt @ 0.58 kg/ha at 30 days fb IC at 60 and 90 DAP.	53.3	5.1
T_3	Topramezone @ 40 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	52.2	5.2
T_4	Tembotrione @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	63.2	4.0
T_5	Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	60.8	4.2
T_6	Topramezone @ 40 g/ha + Halosulfuran methyl @ 125 g /ha as post at 30 DAP fb IC at 60 and 90 DAP	75.5	—
T_7	Tembotrione @ 125 g/ha + Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	78.2	1.1

Table 6. Gross returns (Rs./ha) and cost of cultivation (Rs./ha) in sugarcane as influenced by different treatments.

S.No	Treatment	Economics(Rs./ha) B:C			
		Gross returns	Net returns	Cost of cultivation	Ratio
T_1	Weedy Check	2,34,679/-	-20,551/-	2,55,230/-	0.92
T_2	Metribuzine @ 0.75 kg/ha + 2,4 D amine salt @ 0.58 kg/ha at 30 days fb IC at 60 and 90 DAP.	3,26,116/-	37,286/-	2,88,830/-	1.13
T_3	Topramezone @ 40 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	3,24,931/-	37,131/-	2,87,800/-	1.13
T_4	Tembotrione @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	3,31,744/-	41,004/-	2,90,740/-	1.14
T_5	Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	3,30,263/-	37,597/-	2,92,666/-	1.13
T_6	Topramezone @ 40 g/ha + Halosulfuran methyl @ 125 g /ha as post at 30 DAP fb IC at 60 and 90 DAP	3,43,296/-	45,130/-	2,98,166/-	1.15
T_7	Tembotrione @ 125 g/ha + Halosulfuran methyl @ 125 g/ha as post at 30 DAP fb IC at 60 and 90 DAP	3,40,038/-	42,332/-	2,97,706/-	1.14

were not affected by the different herbicide treatments (Table 4). With regard to economics, higher gross returns (Rs. 3,43,296) and B:C ratio (1.15) was with topramezone @ 40 g/ha + halosulfuron methyl @ 125 g/ha *fb* IC at 60 and 90 DAP (T_6). Higher weed control efficiency in sugarcane was with post-emergence application of tembotrione @ 125 g/ha + halosulfuran methyl @ 125 g/ha *fb* IC at 60 and 90 DAP(T_7). Similar results of chemical control of weeds has been suggested to be economical in sugarcane by Chaudhari *et al.,* 2016.

CONCLUSION

Based on the above experimental results, for realizing higher weed control efficiency and benefit - cost ratio,post emergence application of tembotrione@ 125 g/ha (WCE of 78.245) and topramezone @ 40g/ha combined with halosulforon methyl @ 125 g/ha at 30 DAP followed by intercultivation at 60 and 90 days of planting is most suitable.

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PERFORMANCE ASSESSMENT OF RICE VARIETY MCM 103 IN SALINE SOILS OF WEST GODAVARI DISTRICT THROUGH FRONTLINE DEMONSTRATIONS

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ABSTRACT

The study was undertaken by Krishi Vigyan Kendra, Undi as a Front Line Demonstration (FLD) on rice MCM 103 variety in five locations during Kharif for two consecutive years during 2023 & 2024, to assess the performance of rice variety MCM 103 on yield and economics of rice. The higher yield i.e., 5273, 5062 kg/ha was noticed with MCM 103 rice variety compared to MTU 7029 (4959 and 4875 kg/ha) during both the years of assessment. Net returns and B:C ratio were higher with MCM 103 rice variety (Rs. 46414, 44446 and 45430/ha and 2.16, 2.35 and 2.25) when compared to farmers practice (Rs. 37480, 39105 and 38293 /ha and 1.8, 2.01 and 1.90) during 2023, 2024 and in pooled data, respectively.

Key words: Economics, FLD, Rice, Saline tolerant, Yield

INTRODUCTION

Rice is a staple food for more than 65% of Indians and accounts to 40% of total food grain production, thus making it essential to food and livelihood security. In India, rice crop occupies an area of 478 lakh ha with a production of 1378 lakh tons and productivity of 2882 kg/ha. Whereas in Andhra Pradesh, it grows in an area of 19.2 lakh ha with a production of 73.41 lakh tons and productivity of 3822 kg/ha (Ministry of Agriculture & Farmers Welfare, GOI, 2023-24).

Drought, salinity, and flooding cause serious harm beyond economic injury and agricultural losses annually (Akpeji *et al*., 2021). However, salt stress has a significant impact on rice yield worldwide. Saline soils of India, Andhra Pradesh stands at 7th place with a share of 6.2% (Arora and Sharma, 2017).

In West Godavari district, paddy is the major crop grown during Kharif in an area of 84,891 ha, with a production and productivity of 4.2 lakh tons, 5002 kg/ha, respectively [Season & Crop Report, 2022-23]. One third of cultivable area in West Godavari district is affected by salinity.

Salinity is a major problem, especially in the Godavari delta area, because of land-use changes, aquaculture activities especially shrimp farming and seawater intrusion resulting in increasing salinity and impacting yields. Rice crop yield and quality is adversely effected by salinity during seedling and reproductive phases (Changappa *et al*., 2024). Studies indicate that salt-tolerant rice varieties can mitigate yield losses,

There is every need to demonstrate the performance of new fine grain rice types that

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can withstand salinity. KVKs are the grassroot organizations designed to promote technology by evaluating, refining, and demonstrating tested technology in a district's micro farming situation.

Hence, KVK has conducted FLD with MCM 103 rice, a fine grain, salt tolerant, non lodging medium duration variety in farmers fields of West Godavari district. With this background, the present investigation was undertaken with the specific objectives of demonstrating the performance of MCM 103 rice for salt tolerance, grain yield and economic gains.

MATERIAL AND METHODS

Trial was conducted in 05 locations every year thus making a total of 10 demonstrations in farmers fields of Matsyapuri, Kuppanapudi, Utada and Dirusumarru, Kalla, Komatigunta, Tundurru villages. Each FLD plot was 0.4 ha with black soils. Existing farmers practice was traditional variety MTU 7029. While MCM 103 rice variety (Salt tolerant, fine grain, non lodging, good cooking quality, moderately resistant to blast, sheath blight and WBPH) was assessed in demo plot. A total of 10 farmers were selected based on soil testing reports and their innovativeness in adopting latest technologies with the help of department officials and direct observation during field visits and interactive meetings. Trainings to selected farmers and group meetings were also organized on good agricultural practices in rice crop to providethe opportunities for other farmers to witness the benefits of demonstrated technology. The KVK Scientists visited the demonstrations plots and farmer's plot (control) on regular basis for close supervision and data collection during the entire programme. During two years, apart from yield data, economics were also recorded at the time of harvest. The data so recorded during two successive years was analyzed using descriptive statistics and ANOVA and the results were concluded at the respective levels of significance. pH and EC of demonstrated plots were mentioned in Table 1 & 2.

RESULTS AND DISCUSSION

Yield and yield attributes

MCM 103 rice variety recorded significantly higher yield i.e., 5273, 5062 kg/ha (Table 2) as compared to MTU 7029 variety (4959 and 4875 kg/ha) during Kharif, 2023 and 2024, respectively. The number of productive

Table 1. pH and EC in farmers fields of West Godavari district during Kharif 2023 & 2024.

S.No.	Farmer Name	Village	pH	EC
1	V. Srinivasa rao	Kalla	6.90	3.40
2	K. Venkateswara Rao	Komatigunta	7.25	3.98
3	D. Jeevaratnam	Tundurru	7.42	2.88
4	R. Suryanarayana	Kalla	7.26	3.89
5	S. Venkateswara Rao	Kallakuru	7.61	3.24
6	K. Paparao	Utada	7.47	3.48
7	K. ChallaRao	Kuppanapudi	7.76	4.83
8	G.Santha Raju	Dirusumarru	7.53	3.12
9	Ch. Venkateswara Rao	Matsyapuri	7.22	4.10
10	K. Bhanu Prakash	Rustumbada	7.26	3.42

Table 2. Performance of MCM 103 rice variety in farmers fields of West Godavari district during Kharif 2023 and 2024.

Year	No. of productive tillers/hill		No.of filled grains/ panice		Yield (Kg/ha)		Net Returns (Rs./ha)		B:C ratio	
	MCM 103	MTU 7029	MCM 103	MTU 7029	MCM 103	MTU 7029	MCM 103	MTU 7029	MCM 103	MTU 7029
2023	24	22	202	186	5273	4959	46414	37480	1.67	1.53
2024	22	20	248	232	5062	4875	44446	39105	1.61	1.53
Pooled	23	21	225	209	5168	4917	45430	38293	1.64	1.53

	Yield		Net returns	
Particulars	P Value	F Value	P Value	F Value
Varieties	0.000931*	19	0.001492*	19

*indicates significant at 1 percent level

tillers, filled grains per panicle were also more with MCM 103 compared to Swarna. The growth and yield performance of MCM 103 variety was good under salinity level of more than 3.5 dSm^{-1} compared to Swarna variety. The difference in yield might be due to the fact that genetic cause or responses of the particular genotype to the soil and might be reflected in yield attributes and yield of rice. The similar results were reported by Singh *et al.*, 2014, Samant, 2017 and Kumar *et al.*, 2023.

Net Returns and B: C ratio

The higher net returns (Rs. 46414,44446 and 45430/ha) and Benefit Cost ratio (2.16, 2.35 and 2.25) were recorded with MCM 103 rice variety when compared to farmers practice (Rs. 37480, 39105 and38293/ ha; 1.8, 2.01 and 1.90) during 2023, 2024 and in pooled data, respectively (Bajad*et al.*, 2017).

CONCLUSION

The study concluded that MCM 103 rice variety performed well in saline soils of West Godavari district in terms of yield, net returns and high benefit-cost ratio than Swarna. Thus, it has potential to be promoted on large scale in salt affected regions of the district.

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INFLUENCE OF ADJACENT AQUACULTURE ACTIVITIES ON SOIL PROPERTIES OF SANDY SOILS UNDER PADDY CULTIVATION IN GODAVARI DELTA.

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ABSTRACT

Soil salinization of agricultural lands around aqua ponds due to seepage of water from ponds was studied in the year 2017-2020. The ponds selected were aqua ponds with sandy texture with and without any trench. Soil samples(50 no.) were collected from 0 meters (outer side of the pond or trench bund) up to 50meters distance from the pond and 10cm to 30 cm depth and analysed for pH, EC, Organic carbon, available Nitrogen, Phosphorous, Potassium, Sodium and TDS etc. The results indicated that pH and electrical conductivity decreased with increase in distance from the pond upto50 m distance from the pond. Available Nitrogen, Phosphorus and Potassium increased with distance from the aquapond with shrimp upto 50 m. Seepage is more in case of a pond without any trench when compared to a pond with trench. Salinization due to seepage was observed to a long distance in case of sandy soils.

Key words: Aqua pond, SalinitySeepage,Soil fertility.

INTRODUCTION.

Aquaculture is the fastest growing food sector in coastal areas. In the past decades aquaculture around the world has been pursued only on the basis of economic costs without considering the social costs and negative impacts on the environment. Approximately 47% of the population lives in the coastal states and 60% of the labor force is occupied in agriculture (Marale and Mishra, 2011). Brackishwater shrimp farming is a popular practice due to an abundance of resources (12.4 lakh ha), and its high profit compared to the traditional farming common on the east coast of India. Shrimp, a major item of export, shares 51.35% of the total US dollar earnings in India. Since coastal populations survive mainly on marine resources, the overexploitation of essential resources has threatened the security and sustainability of the ecosystem (UNEP 2003; UNEP/GPA ,2006). Owing to huge profits from brackishwater shrimp culture, the conversion of rice fields to shrimp ponds has taken place on a large scale and the selling of agricultural land to shrimp growers at elevated prices has increased. These changes often take place in areas where income from rice farming is low, indebtedness is high, and limited off-farm employment opportunities exist.After e”10 years of the practice, many farms have been found to crash because of virus infection, the development of

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pathogens from shrimp and feed waste or infections in the pond that prevent further use. As a result, the farming is shifted to neighboring fields.In the process, more and more crop lands becomes shrimp ponds and the coastal farmland is more likely to become saline and unproductive in the near future. Salinisation of soil in nearby agricultural land is one of the major environmental issues in acquaculture areas. (Jayanthi *et al,* 2004).

The unplanned expansion of brackishwater shrimp farming has resulted in severe environmental degradation including water scarcity, increased salinity and health hazards, decreased land productivity and a loss of biodiversity that eventually exacerbated food insecurity and livelihood vulnerability (Rahman *et al*, 2013).The intrusion of salinity, the salinization of cropland and the decrease of soil fertility due to the unauthorized expansion of brackishwater shrimp farming are also reported from several locations across coastal areas (Hossain*et al*, 2013). Rice farms are favoured sites for conversion into aqua ponds because they pose several characteristics well suited for aquaculture (Siddique *et al,* 2012). Seepage of salt water into the adjacent agricultural lands from aquaculture ponds is well documented and sometimes it makes cultivation impossible. The salinity and sodicity of soil were found to be inversely proportional to the distance from the sea and aquaculture ponds. Thus , the present study focussed on the influence of adjacent aquaculture on soil properties of sandy soils under paddy cultivation.

MATERIAL AND METHODS

The aqua ponds (25 samples from villages of aquaponds without trench) and 25 samples from villages with trench) were selected from different farmers cultivating prawn with trench and without trench. The changes in soil properties were recorded by following the standard procedures mentioned below.The data on changes in soil properties were recorded from the aquaponds cultivated prawn without trench from the villages Bhatlamogaturu, Sriramapuram, Vissakoderu (Palakoderu Mandal), Kopparru and Saripalle. The yield and yield parameters of paddywere collected at a distance of 50m and to identify the changes in soil properties,soil samples were collected at a distance of 0,10, 20,30,40, 50m distance from the adjacent pond to the paddy field. The soil samples were analysed for pH, electrical conductivity, organic carbon and available NPKand TDS. The yield and yield parameters of paddy was recorded from the farmers cultivating shrimp with trench and the soil samples from the paddy fields cultivatedshrimp with trench were collected from Kuppanapudi ,Penumanchili, Ganapavaram, Penumantra and Attili villages were collected at distances of 0,5,10,20,30,40,50 m to identify the changes in soil properties. The collected soil samples were analyzed for the

S.No	Nutrient	Procedure	Scientists
1	pH	Soil and water 1: 2.5 ratio	Jackson 1973
2	Electrical conductivity	Soil and water 1: 2.5 ratio	Jackson 1973
3	Available N	Alkaline permanganate method	Subbaiah and Asija, 1956
4	Available P_2O_5	Olsens method	Olsen *et al,* 1954
5	Available K_2O	Neutral Normal ammonium acetate method	Muhr 1965

chemical properties viz pH, EC, OC, available NPKand TDS.Paddy cultivation with aquatic ponds growing prawns in sandy soils without trench was identified in five different villages Bhatlamogaturu, Sriramapuram ,Vissakoderu , Kopparru and Saripalle and the soil samples were analysed for different properties pH, electrical conductivity, available NPK, Sodium percentage and TDS at distances of 0,10,20,30,40 and 50m distance from the aquapond.

RESULTS AND DISCUSSION

Aquaponds without trench in prawn cultivation

The soil samples from the areas Bhatlamogaturu, Sriramapuram ,Vissakoderu , Kopparru and Saripallegrowing prawns without trench (5 samples from each village) were collected at different distances and analysed for different parameters.The results revealed that the pH and electrical conductivity decrease with increase in distance from the pond (0 – 50 m). The organic carbon status increased with increase in distance i.e from 5m to 50m. (0.35 - 0.42%). The influence of salinity decreased with increase in distance from the pond.Das *et al* (2017) also reported that salinity (TDS 4.93 to 203%), Na, Ca and Mg contents were also intensified with shrimp cultivation adjacent to paddy field. (Na: 1.11 to2.45,Ca: 0.39 to3.78andMg: 0.33 to 2.32 times).The available nutrients nitrogen (135-165 kg ha^{-1}) potassium (309-435 kg ha^{-1})and phosphorus (18.6-34.8 kgha^{-1}) contents were very low adjacent to aquatic pond and their availability increased with increase in distance from the pond (upto 50 m distance) shows that the influence of salinity decreased with the distance from the pond. These findings were supported by Das *et al*(2017) stated that the shrimp pond water was 1.66 to 1.84 times more salt stressed, and contained excess amounts of Na (2.11 to 3.35 times), organic carbon (1.33 to 3.46 times) and K (1.92 to 2.86 times) . Due to leaching of salts along with percolating water,the Na content of fields adjacent to aqua pond decreased from 188 ppm to 127 ppm.The potassium content of soil showed an increase from 309-435 kg ha^{-1} with an increase in distance from 5 to 70 m of aqua pond. This could be due to the decreased salt content (Na, Ca, Mg salts) in soil with the distance from the pond. A higher concentration of these was found adjacent to the aqua pond due to saturation of soil colloidal complex with these ions, thus resulting in a loss of potassium through leaching, thus available K_2O in soil was lower in the field neither to aqua ponds. Due to the lack of trench, the adjacent paddy field effected severely due to the salt stress existed in the pond and also due to the percolation and seepage losses the salt water entered into the paddy field and changes the properties of the soil which in turn impairs the yield of paddy.

Aquaponds with trench in prawn cultivation

Paddy cultivation with acquatic ponds growing prawns with trench was identified in five different villages Kuppanapudi, Penumanchili, Ganapavaram, Penumantra and Attili villages. The soil samples were collected, analysed and recorded the changes in soil properties at a distance of 0,10,20,30,40 and 50 m distance from the aquapond. The results revealed that the changes in soil properties not much varied due to the excavation of trench between the aquapond and the paddy field. The seepage water and the percolated water enter into the trench thus the soil properties were not impacted much and the paddy crop might not be secondary salinization due to

Table 1. Changes in soil properties with prawn cultivation without trench

S.No	Distance from pond	pH	EC	Organic carbon	Available nutrients Nitrogen Phosphorus Potassiu			Na	T.D.S	S
	(m)		dSm^{-1}	(%)	(kg/ha)			ppm	ppt	ppm
1	5 m	8.0	4.2	0.35	135	18.6	309	180	1.60	14
2	10 m	8.0	4.1	0.35	138	25.2	321	167	1.80	10
3	20 m	7.5	4.0	0.36	145	27.5	365	155	1.75	9
4	30 m	7.0	3.9	0.35	148	28.9	402	145	1.62	8
5	40 m	6.5	3.8	0.38	156	30.6	415	142	1.42	8
6	50 m	6.2	3.8	0.40	158	31.5	421	135	1.10	7
7	60 m	6.0	3.6	0.42	163	32.6	432	134	1.08	7
8	70 m	6.0	3.2	0.42	165	34.8	435	134	0.98	7

Table 2. Changes in soil properties with prawn cultivation with trench

S.No	Distance from pond	pH	EC	Organic carbon	Available nutrients Nitrogen Phosphorus Potassiu			Na	T.D.S	S
	(m)		dSm^{-1}	(%)	(kg/ha)			ppm	ppt	ppm
1	5 m	7.0	2.1	0.5	215	35.2	341	135	1.40	9
2	10 m	7.0	2.0	0.52	210	33.5	341	137	1.50	8
3	20 m	6.5	1.8	0.55	212	33.0	325	127	1.35	8
4	30 m	6.2	1.2	0.55	200	32.5	352	125	1.32	8
5	40 m	6.0	1.0	0.56	198	32.0	385	122	1.22	8
6	50 m	6.1	0.5	0.60	190	32.5	392	120	1.00	8
7	60 m	6.0	0.5	0.60	190	32.6	390	120	0.92	8
8	70 m	6.0	0.5	0.60	190	34.8	390	120	0.82	8

aquaponds.The aqua ponds with trench preserve the soil moisture and due to the soil moisture the salt content decreased and the pond without trench the seepage losses were more and the salts percolate to the adjacent paddy fields causes more salinity/sodicity in the paddy fields.

CONCLUSION

The distance between aqua pond and paddy field in sandy soils should necessarily be more than 50 m to reduce the impact of salinity on the adjacent paddy fields. Aquaculture without trench between paddy field and pond causes salinity problem and its impact reduces the yield of the crop and impaired soil health. Aquaculture with trench in between paddy crop and aquapond reduced the impact of salts on crop growth and also on soil health. Hence,the paddy cultivation can coexist successfully in coastal areas if there are buffer zones in between. The trench between the pond and paddy field is found to be helpful in preventing salinization of adjacent agricultural fields.

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PERFORMANCE EVALUATION OF MEDICINAL AND AROMATIC PLANTS IN HORTI-MEDICINAL AGROFORESTRY SYSTEM UNDER ARID REGIONS OF ANDHRA PRADESH

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ABSTRACT

A field experiment was conducted for evaluation of medicinal and aromatic plants in horti-medicinal agroforestry system under semi-arid regions of Andhra Pradesh during *kharif,*2021 and 2022 at AICRPDA, Agricultural Research Station, Ananthapur. The treatments consist of four main plots (Trees) of size 72X 36 m *viz.,* Simarouba, Custard apple, Jamun and Amla and three sub plots (Medicinal plants) of size 36 X 4 m *viz.,* Aswagandha, Senna, Nannari and Velvet bean. The experiment was conducted in split plot design with three replications. During 2021, Amla trees, recorded an average fruit yield of 8.0 kg per tree and Jamun fruit yield was 8 kg per tree. During 2022, Amla trees recorded an average fruit yield of 9.3 kg per tree, jamun average fruit yield was 7.1 kg per tree and custard apple average fruit yield was 0.7 kg per tree. The present study findings showed that, in semi-arid regions of Andhra Pradesh, all of the tested medicinal plants performed better when grown as sole crops as compared to different tree-based intercropping systems. Sub plot treatments *viz.,* medicinal plants intercropped in custard apple performed well (Mean leaf yield of Aswagandha was 1547 kg ha^{-1} , Aswagandha root dry weight was 87 kg ha^{-1} ; Senna leaf dry weight was 1674 kg ha^{-1} and velvet bean seed yield was 293 kg ha^{-1})compared to other trees.

Key words: Horti-medicinal agro forestry, Semi- arid regions, Yield and yield attributes

INTRODUCTION

Agriculture in the Scarce Rainfall zone of Andhra Pradesh is largely rainfed and highly susceptible to erratic monsoon patterns, prolonged dry spells and frequent droughts. These regions are characterized by low and uneven rainfall, high evapo-transpiration, and poor soil moisture retention, resulting in unstable crop yields, land degradation, and reduced farm incomes under conventional monocropping systems (Upadhyaya *et al.,*2021).Agroforestry is a land use option that increased livelihood security and reduced vulnerability to climate and environmental change. Arid regions like Ananthapur and Sri Sathyasai districts of Andhra Pradesh are characterized by low and uneven distribution of rainfall coupled with high evapo-transpiration losses, and frequent moisture stress, which limits the productivity,quality and

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sustainability of the conventional cropping systems. Dryland Horticulture offers a transformative approach to horticulture in arid and semi-arid regions addressing the challenges of water scarcity, poor soil and climate variability (Prakash Patil and Vani, 2025). Continuous dependence on field crops under dryland conditions has resulted in unstable yields, declining soil health, and increased vulnerability of farm livelihoods to climate variability. In this context, diversification of land-use systems through climate-resilient and resource-efficient approaches is essential for ensuring sustainable agricultural production in these fragile ecosystems.Horti-medicinal agroforestry systems, which integrate drought-tolerant horticultural species with medicinal and aromatic plants (MAPs), offer a promising alternative for semi-arid environments. Medicinal and aromatic plants such as Aswagandha, Senna, Nannari and Velvet bean are well adapted to moisture-limited conditions and possess high economic value, low input requirements, and growing demand from pharmaceutical, cosmetic and herbal industries. Their inclusion as intercrops or understory components in horticultural plantations enhances land productivity, improves resource-use efficiency and provides diversified income opportunities to small and marginal farmers. Agroforestry reduces dependence on external inputs, mitigates climate risks, and fosters ecological resilience. Scaling such sustainable models through research and adoption is critical for ensuring agricultural productivity, environmental conservation, and food security for future generations (Asha Ram *et al.,* 2025).Evaluation

Table 1. Package of practices followed for different medicinal plants

S.No.	Common Name	Seed Rate	Spacing	Fertiliser dose
	Horticulture/ tree plants (Main plots)			
1	Simarouba (*Simarouba glauca* DC.)	277 grafts ha^{-1}	6X6 m	60N +40P + 40K g/plant
2	Custard apple (*Annona squamosa* L.)	277 grafts ha^{-1}	6X6 m	250N+125P +125K g/plant
3	Jamun (*Syzygium cumini* L.)	277 grafts ha^{-1}	6X6 m	500N +250P+250K g/plant
4	Amla (*Phyllanthus emblica* L.)	277 grafts ha^{-1}	6X6 m	500N +250P+250K g/plant
	Medicinal plants (Sub plots)			
1	Aswagandha (*Withania somnifera)*	10 (kg ha^{-1})	30 x 10 cm	20N +30 P +20K Kg ha^{-1}
2	Senna (*Senna alexandria)*	10 (kg ha^{-1})	45 x 30 cm	40N +40 P +20K Kg ha^{-1}
3	Nannari (*Decalepis hamiltonii)*	12500 seedlings	45 x 45 cm	40N +50 P +40K Kg ha^{-1}
4	Velvetbean (*Mucuna pruriens)*	30 (kg ha^{-1})	60 x 60 cm	20N +40 P +20K

of performance of suitable medicinal and aromatic plants under horti-medicinal agroforestry systems is therefore crucial to identify compatible crop combinations that ensure optimum growth, yield and economic returns without adversely affecting the main horticultural component. Consequently, there is a growing need for resilient and sustainable land-use strategies that can withstand climatic and resource constraints. Since, many medicinal plant species prefer to grow under forest cover, agro-forestry offers a convenient strategy for their cultivation as well as conservation (Rao *et al*., 2004). Such systems also contribute to soil health improvement, microclimate moderation and long-term ecological sustainability. Hence, the present investigation aims to evaluate the performance of selected medicinal plants in horti-medicinal agroforestry systems under the dryland tracts of Andhra Pradesh, with a view to develop a climate-resilient and economically viable farming models.

MATERIAL AND METHODS

Field experiment was conducted during *kharif*, 2021 and 2022 at dryland farm of Agricultural Research Station, Ananthapur of ANGR Agricultural University of Andhra Pradesh, which is geographically situated in between 14.41^{0}N latitudes and 77.40^0 longitude and at an altitude of 350 m. above MSL.The treatments consist of four main plots (Trees) of size 72X 36 m *i.e.* Simarouba, Custard apple, Jamun and Amla and three sub plots (Medicinal plants) of size 36 X 4 m *i.e.* Aswagandha, Senna, Nannari and Velvet bean.The present experiment was conducted in split plot design with three replications.The package of practices followed for medicinal plants were furnished in Table 1.

Simarouba, Custard apple, Jamun and Amla were planted in 2010,with a spacing of 6x6 m in different blocks and which were 10 years old. The medicinal plants were sown as intercrop in between the rows of Simarouba, Custard apple, Jamun and Amla and also as sole crop. The soil is near neutral in soil reaction, low in organic carbon and nitrogen and high in phosphorous and potassium content. The experimental site comes under Class-VI as per land capability classification. An amount of 832 ,759 mm rainfall was received in 40, 41 rainy days during crop growing season of 2021 and 2022, respectively.

RESULTS AND DISCUSSION

Among the agroforestry trees higher stem girth was recorded with Jamun (61.5 cm), which was followed by Simarouba (58.5 cm). During 2021, out of 32 Amla trees, 19 trees came to fruiting (59%) and average fruit yield was 8.0 kg per tree. Similarly, 8 Jamun fruits came to fruiting and average fruit yield was 8 kg per tree. During 2022, out of 32 Amla trees, 19 trees came to fruiting (59%) and average fruit yield was 9.3 kg per tree.Out of 67 Jamun trees, 11 Jamun trees came to fruiting and average fruit yield was 7.1 kg per tree.Out of 80 Custard apple trees 75 trees came to fruiting and yielded 55 kg and average fruit yield was 0.7 kg per tree.The 6 years data (2010 to 2016) indicated that, the maximum yield was achieved by *Anacardium occidentale* with Proso millet followed by *Mangifera indica* with Finger millet (Dalvi *et al.,*2020).

Pooled mean data of two years (2021 and 2022) in the Aswagandha based horti-medicinal agroforestry system revealed that sole Aswagandha produced higher leaf dry matter (2378 kg ha^{-1}) and root dry matter (242 kg ha^{-1}) compared to intercropped systems (Table 2). Among the tree-based combinations, Aswagandha intercropped with custard apple produced comparatively higher biomass than other intercrops, indicating relatively lower competition effects. The reduction in biomass

Table 2. Performance of Ashwagandha under different agro-forestry systems

Treat-ments	Cropping System	2021		2022		Mean	
		Leaf dry wt.	Root dry wt.	Leaf dry wt.	Root dry wt.	Leaf dry wt.	Root dry wt.
		(Kg ha^{-1})					
T1	Sole Aswagandha	3075	65	1680	420	2378	242
T2	Simarouba+ Aswagandha	2258	445	374	89	1316	67
T3	Custard apple + Aswagandha	2564	53	530	112	1547	82
T4	Jamun + Aswagandha	1896	40	340	82	1118	61
T5	Amla + Aswagandha	2450	44	392	102	1421	73

Table 3. Performance of senna under different agro- forestry systems

Treatments	2021	2022	Mean
	Leaf dry wt. (kg ha^{-1})		
T1 Sole Senna	2675	2837	2756
T2 Simarouba+ Senna	2016	840	1428
T3 Custard apple + Senna	2359	989	1674
T4 Jamun + Senna	1848	656	1252
T5 Amla + Senna	2184	967	1575

Table 4. Performance of nannari under different agro-forestry systems

Treatments		2021	2022
		Root dry wt. (g plant^{-1})	
T1	Sole Nannari		916
T2	Simarouba + Nannari	No root yield was	15
T3	Custard apple + Nannari	recoded as crop was	18
T4	Jamun + Nannari	planted in 2021 only	21
T5	Amla + Nannari		33

Table 5. Performance of velvet bean under different agro-forestry systems

Treatments		2021	2022	Mean
		Seed yield (kg ha^{-1})		
T1	Sole Velvet bean	502	465	484
T2	Simarouba+ Velvetbean	335	176	256
T3	Custard apple + Velvet bean	370	215	293
T4	Jamun + Velvet bean	305	188	247
T5	Amla + Velvet bean	327	208	268

under tree-based systems could be attributed to competition for light, moisture, and nutrients. Supporting these findings, Kumar *et al.,* (2010) reported lower alkaloid content in Aswagandha grown under an amla-based cropping system compared to sole cropping, suggesting that tree interactions can influence both yield and quality parameters.In the Senna based horti-medicinal agroforestry system, sole cropping resulted in the highest leaf dry weight (2756 kg ha^{-1}), followed by Senna intercropped with custard apple (1674 kg ha^{-1}) (Table 3). The reduced leaf biomass under intercropping systems may be due to partial shading and below-ground competition imposed by tree components, which are known to affect photosynthetic efficiency and biomass accumulation in understory medicinal crops.

In the Nannari based system, root yield was not recorded during the first year (2021) as the crop was newly established. However, during the second year (2022), sole Nannari recorded the highest dry root yield (916 g $plant^{-1}$), followed by Nannari intercropped with Amla (33 g $plant^{-1}$) (Table 4). The substantial reduction in root yield under intercropping systems highlights the sensitivity of Nannari to competitive stress, particularly during root development stages.

Similarly, in the Velvet bean based horti-medicinal agroforestry system, the highest seed yield was recorded under sole cropping (484 kg ha^{-1}), followed by Velvet bean intercropped with custard apple (293 kg ha^{-1}) (Table 5). Lower yields in intercropped treatments may be attributed to reduced resource availability and altered microclimatic conditions under tree canopies.Overall, the results indicate that while sole cropping of medicinal plants maximized biomass and yield, certain tree-crop combinations, particularly with custard apple, showed relatively better compatibility. These findings emphasize the need for careful selection of tree species and spatial arrangements to minimize competition and enhance productivity in horti-medicinal agroforestry systems.

CONCLUSION

The study revealed that sole cropping of medicinal plants resulted in higher biomass and yield compared to intercropping in horti-medicinal agroforestry systems, due to reduced competition for resources. Among the tree components, Jamun showed better vegetative growth, while Amla and Jamun recorded satisfactory fruit yields. Among intercropping treatments, medicinal crops associated with Custard apple performed relatively better than other tree combinations, indicating higher compatibility. Overall, the results emphasize that careful selection of tree–crop combinations is essential to minimize competition and enhance productivity in horti-medicinal agroforestry systems.

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WEATHER-BASED REGRESSION ANALYSIS FOR PREDICTION AND VALIDATION OF GROUNDNUT LEAF MINER (*APROAEREMA MODICELLA*) INCIDENCE UNDER ARID ALFISOLS

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ABSTRACT

A study was conducted during 2020 to 2022 under arid alfisols at the Agricultural Research Station, Ananthapuramu, Andhra Pradesh.A Regression analysis of Groundnut Leaf Miner (GLM) moth catches with weather parameters revealed a significant positive correlation with Relative Humidity-I (RH-I) at 5 days lag (0.55*) and 6 days lag (0.59*) and Rainfall (RF) at 8 days lag (0.51*) and negative correlation with Wind velocity (Wv) (-0.51*).The leaf damage showed significant and positive correlation with Maximum Temperature (Tmax) (0.67*), Mean Temperature (Tmean) (0.53*),Evaporation (Evp) (0.72*) at 6 days lag and negative correlation with Relative Humidity-II (RH-II)(-0.68*) and Wv(-0.5*) at 5 days lag, and RH-I (-0.5*),Rf(-0.65*) at 6 days lag. RH-II at (-0.58*) at 7 days lag and 8 days lag RH-II (-0.55*) and Sun shine hours (Ssh) (-0.69*).No.of Live larvae/plant recorded significant positive correlation with Tmean(0.5*) and Rf(0.67*) at 9 days lag. and significant negative correlation with Rainfall (-0.5*) at 6 days lag and Wv(-0.79*) at 7 days lag and Minimum Temperature (Tmin) (-0.50*), Tmean(-0.55*) at 8 days lag and Tmax(-0.62*), Tmin(-0.65*), Tmean(-0.74*) and RH-I (-0.5*) at 9 days lag. The study showed that mean temperature was the strongest positive predictor of groundnut leafminer incidence, while higher maximum and minimum temperatures suppressed the pest. Morning humidity slightly favoured infestation, but higher afternoon humidity reduced it. These results highlight temperature and humidity as key weather drivers of leafminer outbreaks. With an R^2 of 0.97, the model explained most of the variation in pest incidence, though independent validation is needed to confirm its reliability.

Key words: Groundnut leaf Miner, Integrated Pest Management, Lagged weather effects, Pest Forecasting, Regression modelling,

INTRODUCTION

Groundnut is a widely cultivated oilseed crop of global significance, with India being one of the leading producers. Its productivity is largely affected by insect pest pressure and moisture stress, particularly under rainfed conditions. During 2020–21, India occupied the first position in terms of cultivated area (55.72 lakh ha) and ranked second in production with 102 lakh tonnes, achieving an average yield of 1831 kg ha{ ^{1} (Agricoop.nic.in). In Andhra Pradesh, groundnut was grown over 8.25 lakh

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hectares during 2021–22, producing 5.15 lakh tonnes with a mean productivity of 625 kg ha{ ¹, contributing about 5.03% to the national output (des.ap.gov.in). The state's average yield remains considerably lower than the national mean (Suneel Kumar *et al*., 2023).Several factors contribute to this yield gap, among which inadequate plant protection practices, especially under rainfed farming systems, play a crucial role. Among the insect pests affecting groundnut, the leaf miner, *Aproaeremamodicella* (Deventer), is regarded as one of the most destructive in Andhra Pradesh. This gelechiid moth, commonly referred to as the groundnut leaf miner (GLM), is an important oligophagous pest attacking groundnut, soybean, and a few other leguminous crops across South and Southeast Asia (Syobu*et al*. 2003). Therefore, the present investigation was undertaken to examine the effect of weather parameters on the seasonal incidence of this pest in rainfed groundnut, with a view to developing effective management strategies.

MATERIAL AND METHODS

A long-term investigation was undertaken to evaluate the relationship between pheromone trap catches, prevailing weather conditions, and the extent of damage caused by groundnut leaf miner (GLM) over the periods 2008–2016 and 2021–2023 at Ananthapuramuunder arid Alfisol conditions. The experiment was conducted during Kharif 2020–2022at the Agricultural Research Station, Ananthapuramu, Andhra Pradesh, using the groundnut variety Kadiri-6 (K-6). The crop was established in plots measuring 25 X 25 m, maintaining a spacing of 30 cm × 10 cm, with sowing carried out during the fourth week of July following recommended agronomic practices of ANGRAU, without adopting any plant protection measures. For pest observations, ten plants were randomly selected within a 1 m × 1 m quadrat in each experimental plot and tagged. Data on insect pests and their natural enemies were recorded at three-day intervals and summarized according to Meteorological Standard Weeks (MSW), beginning from 15 days after sowing (DAS) until crop harvest. The incidence of *Aproaeremamodicella* was quantified by counting the number of larvae on the tagged plants. The percentage of foliar damage was estimated based on the ratio of damaged leaves to total leaves per plant. Weather data were collected daily from the meteorological observatory, aggregated on a weekly basis, and subjected to correlation analysis with pest incidence using SPSS software.

Estimates of correlation were determined between the parameters of GLM and weather parameters. Regression models were determined to predict the adult mothsthrough weather parameters.Correlation only checks linear association.Regression diagnostics ensure that a regression model is valid, reliable and interpretable by testing assumptions, detecting problems and preventing false conclusions. Stepwise regression is a variable selection method used when more no. of predictors areavailable. It builds the regression model iteratively by adding or removing predictors based on statistical criteria.When predictors or response are time dependent, lagged variables are often introduced. Selecting correct lag order is critical to avoid underfitting or overfitting. Lag setting criteria here was based on the duration of larval period and life cycle of GLM Prediction of changes in different parameters was made and assessed the convergence of observed and simulated values. Predicted values were compared with observed values mainly through residual plots, fit statistics and influence diagnostics to check whether the regression model adequately represents the data and assumptions are satisfied.Based on the coefficient of determination (R^2), the models were assessed for their usefulness for prediction of adult moths over years.

RESULTS AND DISCUSSION

GLM adult moth catches

Analysis of GLM moth trap catches in relation to weather variables indicated a significant positive association with morning relative humidity (RH-I) at a lag of 5 days (r = 0.55*) and 6 days (r = 0.59*), as well as with rainfall at an 8-day lag (r = 0.51*). In contrast, wind velocity exhibited a significant negative correlation (r = “0.51*). These observations are in agreement with the findings reported by Radhika (2015).Stepwise regression analysis further supported these relationships, yielding the models: Y = “49.40 + 0.70 RH-I (R^2 = 0.31) at a 5-day lag, Y = “48.04 + 0.71 RH-I (R^2 = 0.35) at a 6-day lag, and Y = “42.84 + 2.65 Tmax + 0.19 Rf “ 4.94 Evp (R^2 = 0.50) at an 8-day lag(Table 1 & 2).

Leaf damage

The leaf damage showed significant and positive correlation with Tmax (0.67*), Tmean(0.53*), Evp(0.72*)at 6 days lagandnegative correlation with RH-II (-0.68*) and Wv(-0.5*) at 5 days lag, and RH-I (-0.5*), Rf(-0.65*)at 6 days lag. RH-II (-0.58*) at 7 days lag and 8 days lag RH-II (-0.55*) and Ssh(-0.69*)(Table3) The stepdown regression also revealed thatY=66.53-0.66RH-I-6.29Rf (R^2=0.73) at 6 days lag and Y=87.81-25.36Tmax-25.82Tmin+5089315.56Tmean-1.26RH-II (R^2=0.94) at 8 days lag (Table 7).

No.of webs/plant

No.ofwebs/plant showed significant positive correlation with Tmean(0.5*)at 6 days lag and Tmax(0.5*), Ssh(0.61*) at 7 days lag and significant negative correlation with Ssh(-0.5*) at 5 days lag, Rainfall(-0.5*)at 6 days lag and Tmin at 9 days lag (-0.5*). The step-down regression also revealed Y=-58.56-79.75 Tmax-82.82 Tmin+164. 19Tmean + 0.22Wv+0.35Rf(R^2=0.99) at 9 days lag (Table 4). The model was based on the huge data of ten years (2006 to 2016).

No.of Live larvae/plant

No.ofLive larvae/plant recorded significant positive correlation with Tmean(0.5*) and Rf(0.67*) at 9 days lag. and significant negative correlation with Rainfall (-0.5*) at 6 days lag and Wv(-0.79*) at 7 days lag and Tmin(-0.50*), Tmean(-0.55*) at 8 days lag and Tmax(-0.62*), Tmin(-0.65*), Tmean(-0.74*),RH-I (-0.5*) at 9 days lag. The step down regression also revealedY=-160.10-4.17Tmax +8.50Tmean+0.97RH-I-0.67RH-II+1.75Wv+0.47Rf (R^2=0.99) at 5 days lag and Y=-7.59-8.83Tmax-8.56Tmin+17.24Tmean+0.12RH-I-0.22RH-II(R^2=0.97) at 6 days lag and Y=65.24-143.44Tmax-143.25Tmin+284.54Tmean-0.07RH-I+0.42RH-II (R^2=0.99) at 9 days lag (Table 10). These results may be due to the coincidence of change in the instar I e., from larvae to pupa.No.of live pupae/plant has significant positive correlation with Tmax(0.58*) and Evp(0.52*) at 5 days lag and Evp(0.5*) at 7 days lag and significant negative correlation with RH-II (-0.5*) and Tmin(-0.71*) at 8 days lag and RH-I (-0.5*) at 9 days lag (Table7).

From this study, it is evident that temperature and relative humidity had a significant influence on leaf miner catches in kharif groundnut as reported by Dubey*et al*.(1995) who showed that high maximum and minimum temperatures of pre-monsoon period with low relative humidity, followed by continuous rains coupled with high maximum

Table 1. Correlation studies of GLM moth catches with weather parameters

S.No	Weather parameters	5 Days lag	6 Days lag	7 Days lag	8 Days lag	9 Days lag
1	T max	0.15	-0.03	0.09	-0.02	0.35
2	T min	-0.32	-0.27	-0.10	-0.10	0.007
3	Tmean	-0.04	-0.22	0.007	-0.06	0.31
4	RH-I	0.55*	0.59*	0.21	0.21	-0.13
5	RH-II	0.16	-0.14	0.09	0.10	0.05
6	Wind velocity	-0.51*	-0.42	-0.35	-0.21	0.009
7	Ssh	0.22	0.04	0.29	-0.01	0.16
8	Rainfall	0.01	-0.11	-0.03	0.51*	0.37
9	Rainy days	-0.05	-0.10	-0.03	0.30	0.13
10	Evaporation	0.26	0.08	-0.02	-0.34	-0.16

Table 2. Step down Regression equation of pheromone moth catches with weather parameters

GLM moth catches	Regression Equation	R^2 Value
5 days lag	Y=-49.40+0.70RH-I	0.31
6 days lag	Y=-48.04+0.71RH-I	0.35
8 days lag	Y=-42.84+2.65Tmax+0.19Rf-4.94Evp	0.50

Table 3. Populationdynamics of GLM (Leaf damage%) as influenced byweatherparameters

S.No	Weather parameters	5 Days lag	6 Days lag	7 Days lag	8 Days lag	9 Days lag
1	T max	0.09	0.67*	0.32	-0.18	0.16
2	T min	-0.32	-0.35	-0.07	-0.027	-0.01
3	Tmean	-0.07	0.53*	0.078	-0.15	0.06
4	RH-I	0.09	-0.5*	-0.42	-0.42	-0.37
5	RH-II	-0.68*	-0.38	-0.58*	-0.55*	-0.18
6	Wind velocity	-0.5*	-0.22	-0.18	-0.14	0.33
7	Ssh	-0.27	0.44	0.08	-0.69*	0.04
8	Rainfall	-0.11	-0.65*	-0.27	0.31	0.06
9	Rainy days	-0.14	0	-0.27	0	0.01
10	Evaporation	0.22	0.72*	0.15	-0.008	0.33

and minimum temperatures followed by monsoon break for a week or two, favoured the outbreak of the pest. Bagmare*et al.*(1995) also reported that maximum and minimum temperatures and sunshine hours had a positive correlation with GLM trap catches, while rainfall and relative humidity had negative influence. Further, Wheatley *et al.*, (1989)

Table 4.Population dynamics of GLM (Live larvae/plant) as influencedby weather parameters

S.No	Weather parameters	5 Days lag	6 Days lag	7 Days lag	8 Days lag	9 Days lag
1	T max	-0.31	0.21	0.21	-0.41	-0.62*
2	T min	0.32	0.17	0.06	-0.50*	-0.65*
3	Tmean	-0.11	0.5*	0.16	-0.55*	-0.74*
4	RH-I	-0.13	0.06	-0.09	-0.13	-0.5*
5	RH-II	0.07	0.10	-0.17	-0.11	0.002
6	Wind velocity	0.39	0.12	-0.79*	-0.19	-0.09
7	Ssh	-0.13	0.09	0.18	-0.11	-0.35
8	Rainfall	-0.03	-0.5*	-0.15	-0.21	0.67*
9	Rainy days	-0.23	0	-0.22	-0.22	0.27
10	Evaporation	-0.30	0.36	-0.15	-0.52*	-0.36

Table 5.Population dynamics of GLM (No.of webs/plant) as influenced by weather parameters

S.No	Weather parameters	5 Days lag	6 Days lag	7 Days lag	8 Days lag	9 Days lag
1	T max	-0.31	0.21	0.5*	0.27	0.26
2	T min	-0.00	0.17	0.19	-0.03	-0.50*
3	Tmean	-0.26	0.5*	0.36	0.19	-0.20
4	RH-I	0.05	0.06	-0.04	0.21	0.03
5	RH-II	-0.28	0.10	-0.09	-0.37	-0.10
6	Wind velocity	0.09	0.12	0.14	0.05	-0.01
7	Ssh	-0.5*	0.09	0.61*	0.33	0.42
8	Rainfall	-0.18	-0.5*	-0.33	-0.29	0.003
9	Rainy days	-0.35	0	-0.32	-0.32	0.42
10	Evaporation	-0.13	0.36	0.21	0.20	-0.02

observed that leaf miner *A.modicella* was most densely infected on the most drought stressed plants of groundnut where leaf surface temperatures were highest. On the contrary, significant positive correlations of morning and evening relative humidity and number of rainy days were found with pheromone trap catches of GLM (Das, 1999). Whereas rainfall showed a significant influence on leaf miner moth catches in the present study which was in conformity with the findings of Radhika(2015).Chaudhuri and Senapati(2004) also reported that the leaf miner incidence was significantly and positively correlated with minimum temperature as reported in this study during kharif. The current findings are also in accordance with Pazhanisamy and Hariprasad (2014) and Suneel Kumar *et al.*(2023) demonstrating the significant positive

Table 6. Population dynamics of GLM (Live pupae/plant) as influenced by weather parameters.

S.No	Weather parameters	5 Days lag	6 Days lag	7 Days lag	8 Days lag	9 Days lag
1	T max	0.58*	0.20	0.24	0.017	0.037
2	T min	-0.28	0.37	-0.13	-0.71*	-0.42
3	Tmean	0.35	0.40	0.07	-0.31	-0.26
4	RH-I	0.25	0.09	0.10	0.31	-0.5*
5	RH-II	-0.21	-0.5*	-0.32	-0.20	-0.19
6	Wind velocity	-0.27	-0.31	-0.35	-0.03	0.42
7	Ssh	0.41	0.21	0.34	0.12	0.38
8	Rainfall	-0.08	0.05	0.015	0.03	-0.09
9	Rainy days	0.02	0	0.014	0.01	-0.36
10	Evaporation	0.52*	0.24	0.5*	-0.08	0.17

Table 7. Stepdown regression equation for GLM asinfluenced by weather parameters

Time lag	Step down Regression equation	R^2 Value
Damage %		
6 days lag	Y=66.53-0.66RH-I-6.29Rf	0.73
8 days lag	Y=87.81-2544659.36Tmax-2544655.82Tmin+5089315.56Tmean-1.26RH-II	0.94
No of webs		
9 days lag	Y=-58.56-79.75Tmax-82.82Tmin+164.19Tmean+0.22Wv+0.35Rf	0.99
Live larvae/plant		
5 days lag	Y=-160.10-4.17Tmax+8.50Tmean+0.97RH-I-0.67RH-II+1.75Wv+0.47Rf	0.99
6 days lag	Y=-7.59-8.83Tmax-8.56Tmin+17.24Tmean+0.12RH-I-0.22RH-II	0.97
9 days lag	Y=65.24-143.44Tmax-143.25Tmin+284.54Tmean-0.07RH-I+0.42RH-II	0.99

association of minimum temperature with larval population of groundnut leaf miner.

CONCLUSION

Groundnut leafminer (GLM) moth catches and weather parameters revealed a significant positive correlation with Relative Humidity-I and Rainfall and negative correlation with Wind velocity.The leaf damage showed significant and positive correlation with Maximum temperature, Mean temperature, Evaporation and negative correlation with Relative Humidity-II.No.of Live larvae/plant revealed significant positive correlation with Tmean and Rf and significant negative correlation with rainfall and wind velocity. These results highlight temperature and humidity as key weather drivers of leafminer outbreaks, with an R^2 of 0.97, the model explained most of the variation in pest incidence, though independent validation is needed to confirm its reliability.

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DIRECT SEEDED RICE: A CLIMATE-SMART AND ECONOMICALLY VIABLE SUBSTITUTE FOR PUDDLED TRANSPLANTED RICE IN GUNTUR DISTRICT

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ABSTRACT

Direct seeding is becoming a key alternative transplanting in rice and has spread quickly in Andhra Pradesh, where unpredictable weather, fewer rainy days, lack of labor and higher production costs are common. This study looks at how changes in climate, such as variations in rainfall and temperature, recommend the use of Direct-seeded rice (DSR) as a farming method. DSR involves planting rice seeds directly into the field instead of growing them in water and then transplanting them. The results show that using DSR options greatly improves rice productivity and resilience, while also saving labor, water, and energy. It also helps get the next crop started 15 days earlier than the traditional puddled transplanted rice method. The study suggests that adopting DSR can help maintain food security and crop resilience even in tough weather conditions.

Key words: Direct Seeded Rice, Climate-smart agriculture, Economics, Rice cultivation, Resource conservation

INTRODUCTION

Agricultural production is likely to be affected by increasing temperatures, changes in rainfall pattern, and more frequent and severe weather events like floods and droughts (Prasanna,2014).To produce food sustainably, there needs to be a decrease in greenhouse gas emissions from farming and improved ability to handle the challenges brought by climate change. Globally, rice is grown on more than 164 million hectares, with about 90% of that area in Asia. In India, rice is grown on over 44 million hectares with an annual production of around 109 million tonnes. Although India is the largest in terms of area and the second largest in terms of production, it is not performing as well as other countries in terms of productivity. Rice is a vital crop in Andhra Pradesh, especially in the Guntur district. More than half of the cultivated land during the *kharif* season in Guntur is used for rice, which is grown on about 4.2 lakh hectares with a productivity of 2.2 tonnes per hectare. This productivity is lower than both the state and national averages, which is a big concern for farmers. Some of the main reasons for low rice yields in this area are the lack of reliable irrigation, delayed release of canal water, poor soil fertility, abiotic stress such as drought during the early growth stages and floods

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during later stages of the crop and emerging biotic stresses.The traditional method of growing rice by transplanting is labour intensive, needs a lot of tilling, and uses more energy, water, and labor. It also harms the soil structure. In transplanting, about 30 to 40 percent of the total cost of growing rice comes from important field operations. Because of decreasing benefits and lower productivity, farmers are still using this traditional method even in areas with good irrigation. To cut down on the need for labor and lower production costs, it's important to shift from manual transplanting to a better method that is scientifically sound, practical, cost-effective, and safe for the environment. Dry direct sowing uses less water and labor than manual transplanting. (Alam *et al*. 2019). Dry seeding is a cost-effective and environmentally friendly option compared to the traditional puddled transplanting method. Farmers are now moving from the old puddled transplanting system to modern methods like dry and wet direct sowing. (Pandey and Velasco 2002).This paper, thus, highlights the benefit of Direct sown rice over transplanting.

Major advantages of DSR

DSR offers several agronomic, economic, and environmental benefits over the conventional transplanted rice system:

* Reduction in labour requirement due to elimination of nursery raising and transplanting operations.
* Lower irrigation water consumption because puddling and continuous flooding are avoided.
* Reduced cost of cultivation through savings in labour and energy.
* Earlier crop maturity, enabling timely sowing of subsequent crops.
* Reduced methane emissions compared to flooded rice cultivation.
* Better suitability for mechanization and conservation agriculture practices.
* Lower production risk under water-scarce conditions.

Studies have shown that DSR can save 12–35% irrigation water and significantly reduce production costs while maintaining comparable yields. (Kumar and Ladha, 2011).

TYPES OF DIRECT SEEDED RICE

DSR systems can be broadly classified into three categories:

1. Dry Direct Seeded Rice

Dry seeds are drilled or broadcast into dry or moist soil after minimum tillage or zero tillage.

2. Wet Direct Seeded Rice

Pre-germinated seeds are sown on puddled or saturated soil.

3. Water Seeding

Sprouted seeds are broadcast into standing water.

Among these methods, dry DSR is becoming increasingly popular due to reduced labour and water requirements.

CROP MANAGEMENT UNDER DIRECT SOWN RICE SYSTEM

Crop management under Direct Sown Rice includes all activities from planting the seed to harvesting the crop. This covers choosing the right variety of rice, selecting the right field, deciding when to plant, how to plant, spacing between plants, using water, managing nutrients, controlling weeds, protecting the crop, and finally harvesting. In the Direct Sown Rice System, choosing the right location, soil type, leveling the land, and managing weeds are the most important factors. Establishing the crop quickly and making sure the plants grow fast helps reduce water loss and the number of weeds. This is done by planting the right number of seeds, using good quality rice varieties, and ensuring the seedlings are strong and healthy. This helps solve one of the biggest problems in Direct Sown Rice, which is weed growth.

WEED MANAGEMENT

Weeds are a big challenge for successful rice farming, especially in Direct Sown Rice (DSR). They compete with the rice plants not only for nutrients but also for space, light, and water throughout the growing season. Weeds are a bigger problem in DSR than in the traditional puddled transplanting method. This is because (1) young DSR seedlings are not as good at competing with weeds that come up at the same time, and (2) in both wet and dry DSR systems, the early growth of weeds is not controlled due to the lack of flooding. This has led to significant yield loss: 96% in dry DSR, 61% in wet DSR, and 40% in rice planted using machines, all because of uncontrolled weeds. Aerobic systems, like DSR, face more weed pressure than the continuously puddled transplanted rice (CPTR), where weeds are naturally controlled by the anaerobic environment created by flooded conditions (Singh *et al.,* 2013).The seedbed should be free from weeds and properly leveled before planting. To control existing weeds, herbicides like paraquat or glyphosate may be used. These herbicides are most effective when applied to weeds that are already growing.

Managing weeds is very important for high productivity in Direct Sown Rice. For DSR, a pre-plant herbicide such as glyphosate (a systemic herbicide) is applied at a rate of 10 mL per liter of water per hectare. Around 18 to 23 days after sowing, a mixture of pyrazosulfuron (20 grams of active ingredient per hectare) and bispyribac-sodium (25 grams of active ingredient per hectare) is applied. In mechanically transplanted rice, the same herbicides are used, but the pre-plant herbicides are not used. Choosing a rice variety that grows quickly, has strong early growth, and develops a dense canopy early can also help reduce weed problems. It is important to use clean paddy seeds and prepare the land using machines (Kumar and Ladha, 2011). Keeping the bunds (field boundaries) and irrigation canals clean is also necessary. Practices like off-season tillage (summer plowing) and stale seedbed sowing (which depends on the initial water availability) are also beneficial.Direct Sown Rice requires more nutrients and is more efficient in terms of water and carbon use compared to traditional methods (Jat *et al.,* 2020; Kaur and Singh, 2017). Puddled transplanted rice also leads to higher greenhouse gas emissions. In a study conducted in Punjab, direct seeding helped reduce the total global warming potential by about 33%. Puddled transplanted rice suffers from delays in growth and development after the puddling process. This can lead to poor rooting due to soil compaction and poor soil structure. The DSR method is more cost-effective, energy-efficient, and requires fewer inputs than traditional planting methods (Gangwar *et al*., 2008).

NUTRIENT MANAGEMENT

Rice farming now requires more intensive methods due to climate change, land degradation, and the rapid growth of cities. Factors like soil acidity, erosion, low organic matter, high costs and low use of nitrogen (N) fertilizers, low efficiency in N use, imbalanced fertilizer application, and infestations of insects, diseases, or weeds have led to significant N deficiency in upland rice farming. Even though rice uses more than 50% of all fertilizers produced worldwide, crop yields are stable and not profitable. The production of rice is now a major cause of water pollution, greenhouse gas emissions, algal blooms, and reduced soil productivity. Therefore, it is essential to regulate the amount of fertilizer used to ensure sustainable rice farming. The production of rice can be affected in terms of both quantity and quality by factors such as global climate change, extreme weather, water shortages, soil salinity, and low soil fertility (Pathak *et al*., 2018). The recommended fertilizer dose for upland rice is 90:60:60 (N:P:K) per hectare. For hybrid rice, the recommendation is 120–150 kg N, 60 kg P_2O_5, 60 kg K_2O, and 25 kg ZnSO4 (zinc sulfate) per hectare. ZnSO4 is also applied at 25 kg per hectare along with the second split of nitrogen. Research has shown that treatment involving Sesbania, farmyard manure (FYM), and vermicompost helped build up the highest amount of soil organic carbon and increased the rate of carbon sequestration (Pradhan *et al.,* 2015; Akhilesh and Nandan, 2016). Higher SOC levels were recorded when chemical fertilizers were combined with organic manure, compared to using fertilizers alone (Pathak *et al.,* 2011). Similarly, FYM used with or without fertilizers increased SOC compared to soil that was not fertilized (Moharana *et al.,* 2012).

CASE STUDY OF DSR IN GUNTUR DISTRICT

A comparative economic analysis of DSR and transplanted rice cultivation was conducted in Guntur district of Andhra Pradesh. Two farmers fields, each of 2 acres in Jonnalagadda village of Guntur district were studied. Vanga Naveen Reddy had taken up

Table 1. Comparison of Cost of Cultivation

Particulars	Transplanted Rice (Rs./ha)	Direct Seeded Rice (Rs./ha)
Land preparation	8,750	9,750
Labour	8,500	4,250
Seed cost	3,750	4,000
Water cost	14,000	11,000
Fertilizers & pesticides	9,500	9,500
Plant protection	8,500	8,500
Total cost	**53,000**	**47,000**

Table 2. Comparison of Yield and Returns

Parameter	Transplanted Rice	Direct Seeded Rice
Yield (q/ha)	67	66
Gross returns (Rs./ha)	1,21,605	1,19,790
Net returns (Rs./ha)	68,605	72,790
Benefit-Cost Ratio	1.2:1	1.5:1

DSR in two acres of land and Jonnala Srinivas Reddy from the same village had adopted transplanting method in his 2 acres land.The details and economics of both the methods is presented below.

Cost of Cultivation

The study indicated that DSR substantially reduced cultivation expenses compared to transplanted rice. Elimination of puddling and transplanting operations reduced labour and tillage costs.The total cultivation cost under DSR was approximately 11% lower than the transplanted method.

Yield and Returns

Although transplanted rice produced slightly higher grain yield, the difference was minimal. DSR recorded greater net returns and a better benefit-cost ratio due to lower input costs.The results clearly demonstrate that DSR can improve farm profitability while conserving resources.The average yield was considerably high in TR (67 q/ha) compared to DSR (66 q/ha)method of cultivation. The actual percentage yield difference is approximately 1.49%, with TR yielding more than DSR. The gross returns obtained were Rs.1,21,605 and Rs.1,19,790 per ha for TR and DSR of rice cultivation respectively. The net returns were higher in DSR (Rs.72,790/ha) than that of Transplanted rice (Rs.68,605/ha).This was due to high cost of cultivation in transplanted rice. The resultswere in line with the findings of Alam*et .al* 2019,whose resultsshowed that netreturns were higher in direct seeded rice when compared to transplanted method ofpaddy cultivation.

CONCLUSION

Direct Seeded Rice is emerging as a promising alternative to conventional puddled transplanted rice under changing climatic and economic conditions. The technology reduces labour dependence, irrigation water use, and greenhouse gas emissions while improving profitability.The findings from Guntur district indicate that DSR provides comparable yields with lower cultivation costs and higher net returns. It also enables timely sowing of subsequent crops and supports climate-resilient agriculture.However, successful adoption of DSR requires proper weed management, precision land levelling, and timely irrigation. Government support through extension services, farmer training, and mechanization assistance will be essential for wider adoption of DSR in Andhra Pradesh and similar rice-growing regions.

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MITIGATION PRACTICES FOR GREENHOUSE GAS EMISSIONS IN ANIMAL HUSBANDRY

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ABSTRACT

Animal husbandry significantly contributes to greenhouse gas (GHG) emissions, with livestock accounting for an estimated 7 to 18 percent of global anthropogenic emissions. Mitigation strategies targeting enteric methane (CH4) and management of manure are critical for lowering the environmental effect of animal production. This paper reviews current mitigation practices, including dietary strategies, feed supplements, manure management techniques, and climate-smart livestock management. Emphasizing the complex interactions between these practices, this review highlights the contribution of improving Animal performance and well-being as key strategies for GHG emission reduction. It also explores the capability for synergistic approaches to limit the emissions across multiple components of the animal production system.

Keywords: Enteric methane, Manure management, Mitigation practices, Animal health, Productivity.

INTRODUCTION

Animal production is a significant source of greenhouse gas (GHG) emissions, primarily in the form of methane (CH4) and nitrous oxide (N_2O). The contribution of livestock to global anthropogenic GHG emissions is estimated between 7 to 18 percent, depending on the methodology used by organizations like the IPCC, FAO, and EPA. To mitigate these emissions, it is essential to evaluate and implement effective practices within livestock management. This paper reviews mitigation strategies for reducing enteric CH4 and manure-related GHG emissions, examining the potential of dietary interventions, feed supplements, manure management, and climate-smart livestock practices.Emissions of greenhouse gases (GHGs) from the livestock segment primarily originate from digestive processes in herbivores, known as enteric fermentation, as well as from the storage and treatment of animal waste. Between 2005 and 2018, emissions from this sub-sector increased at a modest compound annual growth rate (CAGR) of approximately 0.01%, whereas a comparatively faster rise of around 0.07% was recorded during 2012–2018. Using the trend observed over 2005–2018, total emissions from livestock are expected to reach about 222.68 million tonnes of CO_2 equivalent by 2030.Dunkley, 2012 studied regarding the carbon footprint of poultry production farms,

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the study focused on assessing greenhouse gas (GHG) emissions-specifically carbon dioxide, methane, and nitrous oxide-under the control of poultry growers. A range of factors-such as the size of livestock populations, animal mass, feeding patterns, waste management systems, and regional terrain-significantly affect emission outcomes. (EPA, 2011) reviews U.S. greenhouse gas emissions from 1990 to 2009, identifying a net increase in total emissions over the two decades, The present analysis reviews historical emission trends, estimates future levels up to 2030, and proposes suitable mitigation strategies to curb emissions from the livestock sector primarily driven by energy-related CO_2

1.Enteric CH4 Mitigation Practices

Forage Quality and Digestibility.

Improving forage quality and digestibility is one of the most effective ways to reduce GHG emissions from ruminants. Increasing the digestibility of forage and enhancing the intake of digestible forages typically leads to a reduction in CH_4 production during rumen fermentation. Replacing grass silage with corn silage or legume silages can also lower CH_4 emissions due to their lower fiber content and the added benefit of reducing the need for synthetic nitrogen fertilizers. Legume integration into grass pastures in warm climates may offer a potential mitigation opportunity, though further research is needed to assess agronomic challenges and the comparative effects on N_2O emissions.

Broderick *et al.* (2002) compared ryegrass silage and alfalfa silage in a total mixed ration for lactating dairy cows. Although both diets had similar nitrogen and NDF levels, the alfalfa silage diet contained higher total and indigestible ADF. Cows fed alfalfa silage consumed about 50% more feed and produced 15% more milk, but feed efficiency was lower compared to the ryegrass silage diet. In contrast, fibre digestibility was about 50% higher with the grass silage diet. These results indicate that forage composition and digestibility influence feed intake, animal productivity, and potentially greenhouse gas emissions.

Feed Supplements

Several feed supplements can reduce enteric CH_4 emissions, including dietary lipids, concentrates, nitrates, ionophores, tannins, and direct-fed microbials. Lipid supplementation is effective, but economic feasibility and potential impacts on feed intake and animal health need to be considered. High-oil by-product feeds such as distiller's grains offer a viable option, though their higher fiber content may counteract the desired CH_4 reduction. The inclusion of concentrate feeds above 40 percent of dry matter intake decreases enteric CH_4 emissions per unit of animal product, depending on feed type and composition. Additionally, nitrates, ionophores, and tannins show moderate potential in mitigating CH_4 emissions, although their practical application is constrained by issues such as toxicity, feed intake reduction, or limited effects on productivity.

The main factor influencing emissions in the case of enteric fermentation is the quantity of animals; the larger the flock, the higher the emissions. Other factors that affect methane emissions include diet-related factors like the animals' average body weight, gross energy intake, and topographical variations (Department of Animal Husbandry & Dairying, 2018). It should be mentioned that bovines accounted for about 88% of the livestock subsector's emissions in 2018. Average bovine emissions accounted for 88% of these

Table1.Year wise data of Total Population of Indigenous cattle,CB cattle and Buffaloes

Cattle census (Yr) (Dept. of Animal Husbandry & Dairying, 2018)	Total Population of Indigenous cattle (in thousands)	Total Population of Cross-bred cattle (in thousands)	Total Population Buffalo of (in thousands)
1992	189,369	15,215	84,206
1997	178,782	20,099	89,918
2003	160,495	24,686	97,922
2007	166,014	33,086	105,342
2012	151,170	39,732	108,702
2019	141,763	51,410	109,852

emissions, emissions due to indigenous cattle (~41 %), buffaloes (42%) and the remaining crossbred cattle contributes 17%.

As indicated in Table 1, the population of indigenous cattle has shown a steady decline, falling from 189,369 thousand heads in 1992 to 141,763 thousand heads in 2019 (Department of Animal Husbandry & Dairying, 2019). This reduction contributed to an estimated mitigation of about 42.5 million tonnes of CO, equivalent emissions in 2018 when compared to 1992 levels. In this context, improving cattle productivity while reducing emission intensity and regulating the population of low-yielding breeds can serve as an effective mitigation approach, offering both environmental and socio-economic benefits. However, the natural decline in indigenous cattle numbers may reach a threshold beyond which further reduction is unlikely. Therefore, proactive policy measures and targeted interventions may be required to manage indigenous cattle populations within the broader rural economic framework.

2.Manure Management Mitigation Practices

Compared to enteric fermentation, methane emissions from manure management are often lower. Furthermore, the types of management systems that are employed have a substantial impact on the emissions of nitrous oxide from manure management. FAO (2010) shows that Emissions from manure management increased from 20.69 million tonnes CO_2e in 2012 to 20.90 million tonnes CO_2e in 2018, with a compound annual growth rate (CAGR) of 0.16 percent.

Diet and Manure Chemistry

Dietary adjustments significantly influence manure composition and GHG emissions. Decreasing protein levels in ruminant diets and balancing protein with rumen-degradable sources can reduce ammonia and N_2O emissions from manure. Low-protein diets for non-ruminants, supplemented with synthetic amino acids, also help mitigate N_2O and ammonia emissions. Grazing restrictions and optimizing fertilizer application on pasture can further reduce N_2O emissions, while improving manure storage systems, such as anaerobic digestion and composting, can reduce methane emissions.

Soil Fertility and Fertilizer Management

Optimizing manure application and improving soil management practices can reduce emissions from land-applied manure.

Forages with higher sugar content may reduce urinary nitrogen excretion, ammonia volatilization, and N_2O emissions. Additionally, cover cropping and urease inhibitors can help reduce N_2O emissions, although results are mixed and further research is required. Nitrification inhibitors show promise but can be expensive, limiting their adoption.

Effect on milk production

Scientific estimates suggest that nearly 20–30% of the plant and animal species evaluated to date could face a heightened risk of extinction if the global average temperature rises beyond the range of 1.5°C to 2.5°C. In the Indian context, climate change is expected to adversely affect dairy output, with projected reductions of about 1.6 million tonnes by 2020 and up to 15 million tonnes by 2050. More broadly, developing nations are likely to experience significant losses in livestock productivity, potentially declining by nearly one-fourth due to changing climatic conditions.In India, climate change is believed to reduce milk production by 1.6 MT&15 MT in 2020 & 2050 respectively (Upadhyay *et al*., 2008). Duetoclimate change, developing countries may lose 25 per cent of animal production (Thornton, 2010). Based on Garg *et al.* (2012), feeding balanced rations to lactating animals (cows/buffaloes) under field conditions increases milk yield by 4.5–6.2% and fat by 0.9–1.8 g/kg per animal.

3. Climate-Smart Livestock Management for Sustainable Farming

Enhancing Animal Productivity

Enhancing animal productivity is a highly effective strategy for reducing GHG emissions per unit of livestock product. Genetic improvements, balanced diets, and increased reproductive efficiency can significantly reduce emissions by increasing the output of individual animals while maintaining or reducing herd size. For instance, reducing the age at slaughter for beef cattle and optimizing nutrition can lower emissions intensity. Additionally, selecting animals with lower feed conversion ratios can help reduce the environmental footprint of livestock production.

Animal Health and Reproductive Management

Improved animal health, reduced morbidity, and increased productivity contribute to lower GHG emissions per unit of production. Reproductive management practices that improve conception rates, fecundity, and reduce embryo wastage can further enhance productivity while lowering emissions. A focus on increasing the productive lifespan of animals and reducing replacement rates is beneficial for reducing the total emissions from the livestock sector.

Interactions Among Mitigation Practices

The interactions among individual components of livestock production systems-such as feed, manure management, and animal health-are highly complex. For example, practices that mitigate enteric CH_4 emissions, such as dietary interventions, may inadvertently increase the fermentable substrates available for methane production during manure storage. Therefore, it is essential to consider the holistic impact of mitigation practices to avoid unintended consequences. Some practices, like improving animal health and productivity, offer synergistic benefits by reducing both enteric CH_4 and manure-related GHG emissions.

CONCLUSION

Improving the quality of forage and the efficiency of nutrient use remains one of the most effective methods for reducing GHG emissions per unit of animal product. Feed supplements, such as lipids, concentrates, and nitrates, show promise in reducing enteric CH_4 emissions, but their long-term effects and economic feasibility remain uncertain. Manure management practices also offer significant potential for reducing GHG emissions, but these must be carefully tailored to the specific context. Optimizing animal productivity, improving reproductive efficiency, and enhancing animal health are key strategies for mitigating GHG emissions. A systems-based approach that considers the complex interactions within livestock production systems is essential for effective and sustainable GHG mitigation.

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