Andhra Pradesh Journal of
Agricultural Sciences

Volume 11 **Number 3** **July – September, 2025**

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Andhra Pradesh J Agril. Sci : 11(3): 165-169, 2025

NUTRIENT UPTAKE AND YIELD OF SESAME (*Sesamum indicum* L.) AS INFLUENCED BY SEQUENTIAL APPLICATION OF HERBICIDES

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Date of Receipt: 07-07-2025 Date of Acceptance: 09-07-2025

ABSTRACT

Field experiment entitled "Weed management in *rabi* sesamum (*Sesamum indicum* L.)" was conducted in sandy loam soils during rabi 2024-25 at S.V. Agricultural College Farm, Tirupati in randomized block design (RBD) with three replications. The experiment comprised of ten treatments. Considering all the weed management approaches evaluated, the higher uptake of nitrogen, phosphorus and potassium by sesame crop, higher dry matter production and seed yield of sesame were recorded with hand weeding twice at 20 and 40 DAS which was comparable to pre-emergence application of pyroxasulfone 85% WG @ 125 g ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS. Significantly lower uptake of nutrients, lower dry matter production and seed yield of sesame were recorded with weedy check. The lowest weed dry weight and uptake of nitrogen, phosphorus and potassium by weeds were recorded with hand weeding twice at 20 and 40 DAS which was at par with pre-emergence application of pyroxasulfone 85% WG @ 125 g ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS. The nutrient loss due to weeds in unweeded check was 46.1, 18.7 and 35.5 kg ha^{-1} nitrogen, phosphorus and potassium, respectively.

KEYWORDS: Sesame, weeds, herbicides, hand weeding, nutrient uptake.

INTRODUCTION

Sesame, popularly referred to as til, is an annual herbaceous plant of tropical origin belonging to the Pedaliaceae family. Sesame stands as a major traditional oilseed crop widely grown in tropical and subtropical areas of Asia and Africa. Globally, India is the largest sesame producer where 15.31 lakh hectares of area is under sesame cultivation with 8.47 lakh tonnes production and 553 kg ha^{-1} productivity during 2023-24. In Andhra Pradesh, 0.31 lakh hectares of area is under sesame cultivation with an annual production of 0.11 lakh tonnes and productivity of 376 kg ha $^{-1}$ during 2023-24 (www.indiastat.com). Sesame contains 44-57% oil, 18-25% protein and 13-14% carbohydrate. 30.9 to 52.5% of sesame oil consists of oleic and linolenic acids, which make up the majority of the polyunsaturated fatty acids. Among the different biotic stress, weed infestation is the major problem in sesame production. The critical period for crop-weed competition of sesame is from 15 to 30 DAS (Venu *et al*., 2022). If weeds are kept unchecked during critical period, sesame yield may be reduced up to 70% (Bhavani *et al*., 2023). Mechanical weed management is difficult in sesame as it is sown by broadcasting and manual weeding which is adopted by most of the farmers adopt is labor intensive, expensive, back breaking, time taking practice and not possible to get labour in time for weeding. Hence, weed control using pre and post emergence at critical stages is essential to reduce yield losses caused by weeds.

MATERIAL AND METHODS

A field trial was conducted during rabi, 2024-25 at Dryland Farm of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The experimental field was characterized by sandy loam soil. Available nitrogen, phosphorus and potassium were 154, 26.3 and 185 kg ha^{-1}, respectively. The experiment was designed in a randomized block design with ten treatments and three replications. The treatments comprised of pre-emergence (PE) application of pyroxasulfone 85% WG @ 100 g ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS (T_1), pyroxasulfone 85% WG @ 125 g ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS (T_2), metolachlor 50% EC 500 g ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS (T_3), metolachlor 50% EC 750 g ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS (T4), imazethapyr 10% SL 20 g ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS (T_5), imazethapyr 10% SL 25 g ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS (T_6), pretilachlor 50% EC 500 g

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ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS (T_7), pendimethalin 30% EC 525 g hafb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS (T_8), hand weeding twice at 20 and 40 DAS (T_9) and weedy check (T_{10}). The variety 'Sarada' (YLM-66) was sown by broadcasting on January 3rd. The recommended fertilizer dose of 40:20:20 kg ha^{-1} of N, P_2O_5 and K_2O was applied. Pre-emergence and post emergence herbicides were applied at 1 and 20 DAS respectively by using spray fluid @ 500 l ha^{-1} with the help of knapsack sprayer fitted with flat fan nozzle. All other recommended agronomic practices were followed as per crop requirements. At harvest, composite plant samples of both the crop and associated weeds were collected from each plot. These samples were dried, ground finely, and nitrogen, phosphorus, and potassium content were analyzed following the standard procedures outlined by Jackson (1973). Nutrient uptake by the crop and weeds was calculated by multiplying the respective nutrient concentrations with their corresponding dry matter weights and expressed as kg ha^{-1}.

RESULTS AND DISCUSSION

Dry matter production of sesame was significantly influenced by the weed management practices. Hand weeding twice at 20 and 40 DAS (T_9) recorded significantly higher dry matter production of sesame which was at par with PE application of pyroxasulfone at 125 g ha^{-1} fb quizalofop-p-ethyl at 50 g ha^{-1} (T_2). This might be due to sustained weed suppression during critical period of crop-weed competition by these treatments and at later stages by the smothering effect of crop which allowed the crop to make better use of growth resources. Because of the intense competition for growth resources, weedy check (T_2) recorded lower dry matter production of sesame. Similar results were found with results of Venu *et al*. (2022) and Hota *et al*. (2024).

Weed management practices had a significant influence on nutrient uptake by sesame. Hand weeding twice at 20 and 40 DAS (T_9) resulted in higher uptake of N, P, and K by the sesame crop. This treatment was statistically at par with the PE application of pyroxasulfone at 125 g ha^{-1} fb quizalofop-p-ethyl at 50 g ha^{-1} (T2). These findings were consistent with the reports of Bhavani *et al*. (2023) and Giridhar (2024). The significant reduction in weed density and weed dry weight under these treatments created a weed-free environment, thereby enhancing crop growth and nutrient absorption. Nutrient uptake by the crop was positively correlated with both the nutrient content and dry matter production. Consequently, the increased uptake of N, P and K in these treatments was attributed to greater dry matter accumulation and higher nutrient concentrations in the plant tissues. The lower nutrient uptake by the crop in weedy check (T_{10}) was because of reduced dry matter production and limited nutrient acquisition caused by intense weed competition (Rajpurohit *et al*., 2017).

Hand weeding twice at 20 and 40 DAS (T_9) recorded the lowest total weed dry weight which was comparable with PE application of pyroxasulfone 125 g ha^{-1} fb quizalofop-p-ethyl 50 g ha^{-1} (T_2). Similar results were also reported by Patnaik *et al*. (2020) and Giridhar (2024). These treatments controlled the weeds upto critical stages of crop weed competition and later emerging weeds were controlled by smothering effect of crop. Significantly superior amount of total weed dry weight was recorded in weedy check (T_{10}) due to uncontrolled weed growth.

An inverse relationship between nutrient uptake by the crop and the associated weeds was found in this study. Lower uptake of nutrients by weeds was noticed in hand weeding twice at 20 and 40 DAS (T_9). This result was in line with results of Kamani *et al*. (2019). Manual removal of weeds at 20 and 40 DAS controlled the weeds and reduced its density and dry weight thus, resulted in lower nutrient uptake by weeds. This treatment was statistically comparable to the pre-emergence application of pyroxasulfone at 125 g ha^{-1} fb quizalofop-p-ethyl at 50 g ha^{-1} (T_2). This was due to, control of weeds for longer crop growth periods contributed to less density and dry weight of weeds and finally reduced the uptake of nutrients by weeds. These results were in conformity with Mruthul *et al*. (2015). Higher uptake of N, P and K by weeds was with weedy check (T_{10}), which was significantly higher than the remaining weed management practices due to uncontrolled weed growth. These results were similar with results of Bhaumik *et al*. (2023).

Among the various weed management practices, significantly higher seed yield of sesame was recorded with hand weeding twice at 20 and 40 DAS (T_9) which was at par with PE application of pyroxasulfone 125 g ha^{-1} fb quizalofop-p-ethyl 50 g ha^{-1} (T_2). This might be due to control of all type of weeds manually in hand weeding resulted in reduced competition for growth resources leading to efficient translocation of assimilates

Table 1. Dry matter production, seed yield and nutrient uptake by sesame at harvest as influenced by sequential application of herbicides

	Treatments	Dry matter production (kg ha^{-1})	Seed yield (kg ha^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1 :	Pre-emergence application of pyroxasulfone 85% WG @ 100 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	2710	850	53.0	32.2	58.0
T_2 :	Pre-emergence application of pyroxasulfone 85% WG @ 125 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	3367	984	60.6	36.0	63.6
T_3 :	Pre-emergence application of metolachlor 50% EC @ 500 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	2120	769	46.7	28.3	52.3
T_4 :	Pre-emergence application of metolachlor 50% EC @ 750 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	2209	792	47.3	28.6	53.0
T_5 :	Pre-emergence application of imazethapyr 10% SL @ 20 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	1961	771	45.5	27.8	51.2
T_6 :	Pre-emergence application of imazethapyr 10% SL @ 25 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	2789	867	54.9	32.6	58.8
T_7 :	Pre-emergence application of pretilachlor 50% EC @ 500 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	1513	714	39.8	24.2	46.5
T_8 :	Pre-emergence application of pendimethalin 30% EC @ 525 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	1402	706	38.1	23.1	45.8
T_9 :	Hand weeding twice at 20 and 40 DAS	3641	1030	62.1	37.7	66.0
T_{10} :	Weedy check	439	135	22.5	19.3	33.1
	SEm±	135.9	17.4	1.78	135.9	1.34
	CD (P = 0.05)	404	52	5.3	404	4.0

Table 2. Weed dry weight and nutrient uptake by weeds at harvest as influenced by sequential application of herbicides

	Treatments	Weed dry weight (kg ha^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1 :	Pre-emergence application of pyroxasulfone 85% WG @ 100 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	767	23.3	8.4	20.5
T_2 :	Pre-emergence application of pyroxasulfone 85% WG @ 125 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	470	16.7	6.1	14.0
T_3 :	Pre-emergence application of metolachlor 50% EC @ 500 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	891	28.6	9.9	24.6
T_4 :	Pre-emergence application of metolachlor 50% EC @ 750 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	884	27.5	9.7	23.6
T_5 :	Pre-emergence application of imazethapyr 10% SL @ 20 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	906	29.6	10.0	25.4
T_6 :	Pre-emergence application of imazethapyr 10% SL @ 25 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	743	22.8	8.2	20.0
T_7 :	Pre-emergence application of pretilachlor 50% EC @ 500 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	1029	35.7	11.6	28.7
T_8 :	Pre-emergence application of pendimethalin 30% EC @ 525 g ha^{-1} *fb* quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS	1040	36.2	11.8	29.3
T_9 :	Hand weeding twice at 20 and 40 DAS	422	14.9	5.2	13.1
T_{10} :	Weedy check	2615	46.1	18.7	35.5
	SEm±	35.5	1.20	35.5	0.94
	CD (P = 0.05)	105	3.6	105	2.8

from the source to the developing seed which ultimately reflected in the form of higher seed yield. Similar results were found with results of Hota *et al*. (2024). Reduction of weed density and dry weight by the sequential application of pre and post-emergence herbicides reduced weed competition for growth resources, allowing for more effective translocation of nutrients from the source to sink and led to increased seed yield. The significantly lower seed yield in the weedy check (T_{10}), was due to intense weed infestation, which led to heightened competition between the crop and weeds for essential growth resources.

Hand weeding twice at 20 and 40 DAS which was at par with pre-emergence application of pyroxasulfone 85% WG @ 125 g ha^{-1} fb quizalofop-p-ethyl @ 50 g ha^{-1} at 20 DAS resulted in higher dry matter production, seed yield, N, P and K uptake by sesame and the same weed management practices recorded lower weed dry weight and nutrient uptake by weeds on sandy loam soils.

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Andhra Pradesh J Agril. Sci : 11(3): 170-173, 2025

GROWTH, YIELD ATTRIBUTES AND YIELD OF FINGERMILLET (*Eleusine coracana* L. *Gaertn.*) AS INFLUENCED BY DIFFERENT LEVELS OF FERTILIZERS AND LIQUID BIOFERTILIZERS

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Date of Receipt: 18-07-2025 Date of Acceptance: 02-08-2025

ABSTRACT

A field experiment was conducted during *rabi,* 2024-25 at Dryland farm, S.V. Agricultural College, Tirupati campus of Acharya N. G. Ranga Agricultural University, Andhra Pradesh, India to study the effect of different levels of fertilizers and biofertilizers on productivity of finger millet. The experiment was laid out in randomized block design and replicated thrice. Among the different nutrient management practices tested, Application of 100% RDF + seed treatment with liquid biofertilizers + soil application of liquid biofertilizers (T_5) resulted in higher plant height, dry matter production, number of earheads m^{-2}, earhead weight (g), grain weight earhead^{-1} (g) and test weight (g), grain and straw yield (kg ha^{-1}) which was however comparable with application of 100% RDF + soil application of liquid biofertilizers (T_4). While they were found at their lowest with the absolute control (T_1) which was comparable with soil application of liquid biofertilizers (T_{10}).

KEYWORDS: Finger millet, liquid biofertilizer, seed treatment and soil application.

INTRODUCTION

Finger millet (*Eleusine coracana* L. Gaertn.), a staple crop in semi-arid and tropical regions, plays a significant role in food security, nutrition, and sustainable agriculture. Apart from its adaptability, finger millet is nutritionally superior to many other cereals, boasting high fiber (11.5 %), proteins (7.6 %), calcium (0.33%), iron (0.039%) and essential amino acids. In addition to these, lower glycemic index makes it highly suitable for diabetic patients. It has 10-fold higher calcium than brown rice, wheat and maize (Thapliyal and Singh, 2015.). Despite these advantages, maximizing its productivity remains a challenge, often requiring external nutrient supplementation. Traditional farming practices heavily rely on chemical fertilizers to improve yield. These factors compromise soil health, ultimately affects crop performance and sustainability. As the global focus shifts towards eco-friendly agricultural solutions, biofertilizers emerged as promising alternatives that foster soil health while ensuring optimal crop yield. Biofertilizers are substances that contain either latent or active strains of soil microorganisms, such as bacteria, algae or fungi, which improve the availability and uptake of nutrients by plants, leading to improved crop yields upto 10-40%. (Bhardwaj *et al.*, 2014). Liquid biofertilizers, in contrast to traditional carrier-based formulations, offer several advantages like higher cell counts, longer shelf life, ease of application, better storage and transport. They enhance nutrient availability, promote microbial activity, and improve soil biological properties, leading to better nutrient uptake, increased yield, and enhanced soil fertility. Seed treatment involves coating seeds with biofertilizer before sowing, which ensures early root colonization, better seedling vigor, and protection against soil-borne pathogens. Soil application, on the other hand, enriches the rhizosphere directly, enhancing nutrient mobilization and microbial activity around the root zone during critical stages of crop growth. Understanding the most effective method of application could significantly improve crop productivity, nutrient use efficiency and soil sustainability. However, limited studies were carried out on the effect of liquid biofertilizers with chemical fertilizers in finger millet. Hence, the present experiment was conducted to study the effect of different levels of fertilizers and liquid biofertilizers on productivity of finger millet.

MATERIAL AND METHODS

The field experiment was conducted at Dryland farm, S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University which is geographically situated at 13.5°N latitude and 79.5°E

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longitude, with an altitude of 182.9 m above the mean sea level, in the Southern Agro-Climatic Zone of Andhra Pradesh. The soil of experimental field was sandy loam in texture, neutral in soil reaction, low in organic carbon (0.4%) and available nitrogen (207 kg ha^{-1}), medium in available phosphorus (24.3 kg ha^{-1}) and available potassium (213 kg ha^{-1}). The experiment was laid out in randomized block design and replicated thrice. The treatments consisted of ten treatments absolute control (T_1), application of 100% RDF (T_2), application of 100% RDF + seed treatment with liquid biofertilizers (T_3), application of 100% RDF + soil application of liquid biofertilizers (T_4), application of 100% RDF + seed treatment with liquid biofertilizers + soil application of liquid biofertilizers (T_5), application of 75% RDF (T_6), application of 75% RDF + seed treatment with liquid biofertilizers (T_7), application of 75% RDF + soil application of liquid biofertilizers (T_8), application of 75% RDF + seed treatment with liquid biofertilizers + soil application of liquid biofertilizers (T_9) and soil application of liquid biofertilizers (T_{10}). A total rainfall of 424 mm was received in 17 rainy days during the crop growing period. The recommended dose of fertilizers in finger millet is 60-30-20 kg N, P_2O_5, K_2O ha^{-1}. The fertilizers were applied as per the treatments seed treatment with liquid biofertilizers (Azospirillum, PSB and KSB) was done by mixing 10 ml of each bioinoculants to 1 kg of seed and dried for 10-15 min under shade before sowing. For soil application of liquid biofertilizers (Azospirillum, PSB and KSB), 1.25 l ha^{-1} of each microbial inoculant was mixed in 500 kg of well decomposed FYM and applied as basal dose. The variety 'Vakula 'was transplanted with the spacing 22.5 cm x 10 cm. All the other practices were adopted as per the recommendations of ANGRAU. The data were subjected to analysis of variance procedures as outlined for randomized block design as suggested by Panse and Sukhatme (1985). Statistically significance was tested by F-value at 5 % level of probability and critical difference was worked out where ever the effect was significant.

RESULTS AND DISCUSSION

Growth parameters

Application of 100% RDF + seed treatment with liquid biofertilizers + soil application of liquid biofertilizers (T_5) resulted in higher plant stature at harvest which was however comparable with application of 100% RDF + soil application of liquid biofertilizers (T_4), whereas for the dry matter production, it differed significantly. The lowest plant stature and dry matter production were recorded with the soil application of liquid biofertilizers (T_{10}) and absolute control (T_1) without any significant disparity between them in the order of descent (Table 1). Integration of liquid biofertilizers with 100% RDF resulted in more balanced nutrient profile. Besides these, application of liquid biofertilizers also resulted in production of plant growth-promoting hormones such as auxins, gibberellins, and cytokinin's that stimulate cell division and elongation. As a result, plant grows taller and exhibit more vigorous above ground growth. Thus, administration of liquid biofertilizers along with 100% RDF resulted in enhanced photosynthetic efficiency, profuse tillering and overall plant growth, ultimately leading to greater dry matter production, as evidenced by the findings of Yadav *et al*., (2025) and Sukanya *et al*., (2023).

Yield parameters

The treatment comprising application of 100% RDF + seed treatment with liquid biofertilizers + soil application of liquid biofertilizers (T_5) resulted in higher earhead weight, grain weight $earhead^{-1}$ which was however comparable with application of 100% RDF + soil application of liquid biofertilizers (T_4), whereas for the number of earheads m^{-2}, they differed significantly. Soil application of liquid biofertilizers (T_{10}) and absolute control (T_1) were comparable with one another in registering the lowest number of earheads m^{-2} over the rest of the treatments. This was attributed to the readily available nutrients during critical growth stages with integrated application of chemical fertilizers and biofertilizers, aided in better root growth, development, enhanced uptake and translocation of nutrients. Consequently, the improved nutrient status and biological activity resulted in more efficient photo assimilates partitioning towards sink from source. The present results were in accordance with the findings of Kejiya *et al*., (2019), Deepti *et al*., (2022) and Ahiwale *et al*., (2011).

Test weight of finger millet was not significantly influenced by different levels of fertilizers and liquid biofertilizers. Yet with no marked differences, higher test weight of finger millet was recorded with the application of 100% RDF + seed treatment with liquid biofertilizers + soil application of liquid biofertilizers (T_5), while the minimum test weight was registered with absolute control (T_1). These findings were in conformity with the findings of

Table 1. Growth, Yield attributes and yield of finger millet as influenced by different levels of fertilizers and liquid biofertilizers.

Treatment	Plant height at harvest	Dry matter production at harvest	Number of earheads m^{-2}	Earhead weight (g)	Grain weight $earhead^{-1}$ (g)	Test weight (g)	Grain yield	Straw yield
T_1 : Control	40.8	2736	36.7	4.2	2.8	2.7	807	1533
T_2 : 100% RDF	84.6	6287	77.0	7.7	5.6	2.9	2050	3298
T_3 : 100% RDF + Seed treatment with liquid biofertilizers	88.4	6543	82.7	7.9	5.8	2.9	2215	3610
T_4 : 100% RDF+ Soil application of liquid biofertilizers	94.9	6946	84.6	8.2	6	2.9	2375	3895
T_5 : 100% RDF + Seed treatment with liquid biofertilizers + Soil application of liquid biofertilizers	98.6	7601	92.3	8.4	6.1	2.9	2692	4576
T_6 : 75% RDF	72.2	4565	63.2	6.2	4.5	2.8	1573	2516
T_7 : 75% RDF + Seed treatment with liquid biofertilizers	73.8	5027	68.4	6.4	4.8	2.8	1698	2767
T_8 : 75% RDF + Soil application with liquid biofertilizers	82.5	5219	70.9	6.7	5	2.8	1783	2941
T_9 : 75% RDF + Seed treatment with liquid biofertilizers + Soil application of liquid biofertilizers	83.7	5875	75.0	7	5.1	2.8	1996	3393
T_{10} : Soil application of liquid biofertilizers	46.1	2945	40.1	4.3	3	2.7	864	1641
SEm ±	3.00	205	2.51	0.24	0.18	0.13	67	106
CD (P=0.05)	8.9	610	7.4	0.7	0.5	NS	200	315

Gangothri *et al*., (2023) and Senthamil *et al*., (2021).

Yield

The highest grain and straw yield of finger millet were obtained with the application of 100% RDF + seed treatment + soil application of liquid biofertilizers (T_5) which was significantly superior over the rest of the treatments. This might be due to the combination of fertilizers and biofertilizers which together optimized nutrient availability and plant uptake throughout the growing season, led to improved root development, increased nutrient use efficiency. Additionally, the dual application of biofertilizers (seed + soil) maximized their benefits, as microbes worked in tandem with chemical fertilizers to reduce nutrient losses and promote balanced plant nutrition which resulted in the increased photosynthetic rate, enhanced biomass production coupled with better partitioning of photosynthates from source to sink, there by enhanced morphological characters *i.e.,* plant height, leaf area and dry matter production that in turn reflected in higher straw yield of finger millet. Ultimately culminating in higher grain and straw yield of finger millet. These findings were in line with the findings of Sukanya *et al*., (2023) and Deepti *et al,*., (2022).

Absolute control (T_1) recorded significantly lower grain yield which was at par with soil application of liquid biofertilizers (T_{10}). From this it was proved that chemical fertilizers could not be replaced by biofertilizers alone and they should be integrated with any organic matter or chemical fertilizers to function effectively.

Application of 100% RDF + Seed treatment with liquid biofertilizers + Soil application of liquid biofertilizers in finger millet significantly increased the crop growth performance, yield attributes and yield over the rest of the treatments tried in sandy loam soils of Southern Agro- climatic zone of Andhra Pradesh.

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Andhra Pradesh J Agril. Sci : 11(3): 174-178, 2025

IMPACT OF CONJUNCTIVE USE OF ORGANIC AND INORGANIC FERTILIZERS ON NUTRIENT AVAILABILITY IN SOIL, YIELD AND YIELD ATTRIBUTES OF MAIZE (*Zea mays* L.)

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Date of Receipt: 07-07-2025 Date of Acceptance: 10-07-2025

ABSTRACT

An investigation was carried on "Impact of conjunctive use of organic and inorganic fertilizers on nutrient availability in soil, yield and yield attributes of maize (*Zea mays* L.)" during kharif 2024 at wet land farm of S.V. Agricultural College, Tirupati. The experiment was carried out in randomized block design with three replications consisting of ten treatments with 75% and 100% RDF along with poultry manure, FYM and microbial inoculum (*Azospirillum*, PSB and KSB). Data indicated that application of 100% RDF + Soil application of liquid biofertilizers *viz., Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_5) resulted in the highest grain yield and stover yield. Yeild attributes like cob length, number of kernels per row, number of kernel rows per cob were found to be highest with application of 100% RDF + soil application of liquid biofertilizers viz., *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_5). The highest available nutrients *viz.,* N, P, K were noticed with application of 100% RDF + Soil application of liquid biofertilizers *viz., Azospirillum*, PSB and KSB @ 1.25 litres each (T_5).

KEYWORDS: Liquid Biofertilizers, kernel, yield, growth.

INTRODUCTION

Maize belongs to family Gramineae and popularly known as corn. Maize is the third most consumed cereal after rice and wheat. It is commonly called as the queen of cereals due to its high genetic yield potential compared to the other cereals. Maize is cultivated on nearly 190 million hectares in about 165 countries, which have a wide diversity of soil, climate, biodiversity, and management practices. India stands at sixth position in productivity with 3 metric ton per hectare. Maize is primarily grown in the Kharif season nearly contributing 85 per cent of cultivation during this season. In India major producing states of maize are Maharashtra, Madhya Pradesh and Karnataka. Among the maize-producing states, Andhra Pradesh ranks 13th in cultivation area with 2.91 lakh hectares and is estimated to produce 19.04 lakh tonnes contributing to 5.34% of India's total production, with a productivity of 6543 kg ha^{-1} (Maize Outlook Report, ANGRAU).

Maize is highly nutrient exhaustive crop requires higher amounts of both macro and micro nutrients to obtain higher yields. Inorganic fertilizers are costly and its continuous usage causes nutrient imbalance, lowers the nutrient use efficiency, deteriorates soil properties and causes drastic fall in soil fertility. Therefore, conjunctive use of fertilizers *i.e.,* chemical fertilizers, organic manures and biofertilizers together in crop production is gaining importance for sustainable food production. It helps to achieve higher crop productivity, prevents soil degradation thus helping to meet future food supply.

MATERIAL AND METHODS

A field experiment entitled" Impact of conjunctive use of organic and inorganic fertilizers on nutrient availability in soil, yield and yield attributes of maize (*Zea mays* L.)" was conducted during kharif, 2024 on sandy clay loam soils of wetland farm of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University. Geographically situated at 13°36'55.3"N latitude and 79°22'20.2"E longitude with an altitude of 182.9 m above mean sea level, which falls under Southern Argo Climatic Zone of Andhra Pradesh.

The experiment was laid out in randomized block design with three replications consisting of ten treatments. The field was ploughed and given pre-sowing irrigation. The field was divided into 30 different plots of 6m x 5m size. FYM and poultry manure are applied seven days before sowing. The pretreated seed of variety Kaveri 50 was sown by dibbling method in between the

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Table.1. Influence of fertilizers, biofertilizers and organic manures on yield and yield attributes

Treatments	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{1})	Cob length (cm)	Number of kernels rows cob^{-1}	Number of kernels row^{-1}
T_1 : Control	2016	2456	8.5	8.5	15.1
T_2 : 100% RDF	4626	5497	16.1	16.1	29.6
T_3 : FYM @ 10 t ha^{-1}	2736	3156	10.0	10.0	17.8
T_4 : Poultry Manure @ 2 t ha^{-1}	3096	3575	11.6	11.6	20.4
T_5 : 100% RDF + Soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 lit ha^{-1} each	4956	5875	17.3	17.3	31.8
T_6 : 75 % RDF + Soil application of liquid biofertilizers *Azospirillum,* PSB and KSB @ 1.25 lit ha^{-1} each	3560	4275	13.1	13.1	23.1
T_7 : 75% RDF + FYM @ 10 t ha^{-1}	3950	4725	14.5	14.5	25.7
T_8 : 75% RDF + Poultry Manure @ 2 t ha^{-1}	4250	5025	14.8	14.8	26.9
T_9 : 75% RDF + FYM@ 10 t ha^{-1} + Soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 lit ha^{-1} each	4688	5526	16.2	16.2	30.1
T_{10} : 75% RDF + Poultry Manure@ 2 t ha^{-1} + Soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 lit ha^{-1} each	4813	5702	16.6	15.9	31.3
S.Em±	118	130.3	0.44	0.40	0.83
CD @ 5%	349	387	1.3	1.2	2.5

rows by using maize seed at the rate of 8 kg per hectare with a spacing of 60cm x 20cm on 25th July, 2024. RDF (Recommended dose of fertilizer) of NPK for maize was 200:60:50 kg ha^{-1}. Nitrogen was applied in the form of urea in two splits, first split at the time of sowing and second split at 30 DAS. Phosporus was applied in the form of SSP and potassium as MOP as a basal dose. Regular biometric observations were recorded at periodic intervals of 30 DAS, 60 DAS, 90 DAS and at harvest stages. Yield attribute parameters were recorded just before harvesting of crop.

The initial and post-harvest soil samples were collected from the experimental field and analysed for soil texture by International pipette method as described by Piper (1966), pH and EC by Conductometry as described by Jackson (1973), organic carbon percent by Wet digestion method as described by Walkley and Black (1934), N by Alkaline permanganate method as described by Subbiah and Asija (1956), P_2O_5 by Olsen's extraction as described by Olsen *et al*., (1954), K_2O by Neutral normal ammonium acetate as described by extraction Jackson (1973).

RESULTS AND DISCUSSION

Data depicted in Table.1. showed high kernel yield and stover yield were recorded with the application of 100 % RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_5) which was on par with application of 75 % RDF + poultry manure @ 2 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T10), 75 % RDF + FYM @ 10 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_9) and 100 % RDF (T_2). The lowest kernel yield was recorded in the control (T_1). Combining of fertilizers with biofertilizers improved nitrogen and phosphorus availability to maize. This led to better root growth, nutrient uptake, and plant development. Overall, the integration resulted in higher kernel and stover yields. (Jat *et al*., 2014).

Yield attributes like highest cob length, number of kernels per row, number of kernel rows per cob were highest with the application of 100 % RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_5) which was on par with application of 75 % RDF + poultry manure @ 2 t ha^{-1} + soil application of liquid biofertilizers Azospirillum, PSB and KSB @ 1.25 litres ha^{-1} each (T_{10}), 75 % RDF + FYM @ 10 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_9) and 100 % RDF (T_2). The lowest yield attributes were recorded in the control (T_1). The improvement in yield traits under integrated use of fertilizers with biofertilizers might be due to higher absorption of nutrients responsible for increased photosynthate accumulation and high biomass production and finally resulting in increase in the yield components. (Naik *et al*., 2020).

Available nitrogen, phosphorous and potassium as depicted in Table.2. were found to be highest with the application of 100 % RDF + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_5) which was on par with application of 75 % RDF + poultry manure @ 2 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T10), 75 % RDF + FYM @ 10 t ha^{-1} + soil. Application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_9) and 100 % RDF (T_2). The lowest available nitrogen, phosphorous and potassium were recorded in the control (T_1).

The reason for high nutrient content in 75 % RDF + poultry manure @ 2 t ha^{-1} + soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T_{10}) might be due to the addition of organic matter through the manures & added biofertilizers resulted in increase in microbial population that regulates soil temperature, soil moisture and humus content in soil. This might have created favourable soil environment for microbes favouring their rapid multiplication and ultimately increasing nutrient availability. (Sudhakar *et al*., 2019. Combined application of organic and inorganic sources reduces will definitely improve soil nutrient status. (Maish *et al*., 2018)

It can be concluded that , integrated application of inorganic fertilizers, organic manures and biofertilizers played an important role in improving the N,P and K availability to the plants. Combined application of 100% RDF + Soil application of liquid biofertilizers *viz., Azospirillum*, PSB and KSB @ 1.25 litres ha^{-1} each (T5) resulted in highest yield and yield attributes.

Table 2. Effect of conjunctive use of fertilizers, biofertilizers & organic manures available nutrients N, P_2O_5 and K_2O (kg ha^{-1}) of soils after harvest

Treatments	Available Nutrients (kg ha^{-1})		
	N	P_2O_5	K_2O
T_1 : Control	160	28.4	160
T_2 : 100% RDF	231	44.9	233
T_3 : FYM @ 10 t ha^{-1}	176	31.7	183
T_4 : Poultry Manure @ 2 t ha^{-1}	189	35.0	174
T_5 : 100% RDF + Soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 lit ha^{-1} each	242	47.3	245
T_6 : 75 % RDF + Soil application of liquid biofertilizers *Azospirillum,* PSB and KSB @ 1.25 lit ha^{-1} each	202	38.2	197
T_7 : 75% RDF + FYM @ 10 t ha^{-1}	215	38.5	219
T_8 : 75% RDF + Poultry Manure @ 2 t ha^{-1}	219	41.7	211
T_9 : 75% RDF + FYM@ 10 t ha^{-1} + Soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 lit ha^{-1} each	233	44.9	239
T_{10} : 75% RDF + Poultry Manure@ 2 t ha^{-1} + Soil application of liquid biofertilizers *Azospirillum*, PSB and KSB @ 1.25 lit ha^{-1} each	240	46.8	234
S.Em±	3.7	1.04	3.9
CD @ 5%	11	3.0	12

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Andhra Pradesh J Agril. Sci : 11(3): 179-183, 2025

EVIDENCE OF AGRITOURISM ACTIVITIES IN ALLURI SITHARAMARAJU DISTRICT OF ANDHRA PRADESH

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Date of Receipt: 10-07-2025 Date of Acceptance: 17 -07-2025

ABSTRACT

Agritourism documentation was carried out in Alluri Sitharama Raju district of Andhra Pradesh. The study was conducted in the year 2025 focusing on agritourism activities in Chintapalli and Araku Valley Mandals of the district. Among the varied agritourism activities of the farmers in the district, five agritourism farms were selected and observations were made on various agritourism activities they established. The observations revealed that large farmer had a comprehensive agritourism establishment with diverse activities of agritourism, value-added product, and proper marketing activities. The farms cultivate a diverse range of crops *viz.,* strawberry, broccoli, carrot, green peas, chrysanthemum, and marigold as agritourism activities. Three medium farmers partially implemented the concept, offering visitor facilities and direct farm-gate sales. Whereas, one small farmer with a half-acre plot provided basic facilities to tourists and earned income from entry fees and direct product sales. The findings show a range of agritourism models, from extensive, integrated operations by large farmers to more basic, entry-level efforts of agritourism.

KEYWORDS: Agritourism activities by farmers, Alluri Sitharama Raju district.

INTRODUCTION

Agritourism provides a distinctive rural gateway and offer city dwellers a look at agricultural life. By converting farm land into recreational hubs for facilitating the Agri visitors, it provides a steady source of supplemental revenue. Though participate in real agricultural tasks like ploughing fields and milking cows, picking of own fruit and vegetables visitors gain experience of agriculture activities. The concept of agritourism includes education about farming, rural living and also assisting urban dwellers in de-stressing and re-energizing to connect with nature. Visitors not only visit and get experience the agricultural activities and also purchase agri produce at farm gate. Alluri Sitharama Raju district by its initials as ASR district is in the Indian state of Andhra Pradesh, named after Alluri Sitarama Raju, a revolutionary in the Indian independence movement who hailed from the region. Agritourism in the ASR district focuses on offering visitors an opportunity to experience rural life, often in a natural and serene setting. Here are some of the popular agri-tourism activities one can find in the ASR district are: farm stays and rural immersion, culinary experiences, educational opportunities, cultural and adventure activities. In this work an attempt was made to document various activities of agritourism prevailed in Alluri Sitharama Raju district of Andhra Pradesh.

MATERIAL AND METHODS

The information for case study was collected from agritourism farms in and around Araku Valley and Chintapalli areas were taken for case study purpose. A total of five agritourism farms. Observations were recorded with focused discussion with the individual agritourism farms using a common format for overall documentation of agritourism farm activities that were being carried out.

RESULTS AND DISCUSSION

I. Agritourism farm: Andhra Strawberry Farm, Lambasingi vi llage in Chintapalli mandal.

The Andhra strawberry farm was established in 2017 by Sri K. Satyanarayana, operates as a fully dedicated agritourism enterprise across 12 acres in Lambasingi village, Chintapalli mandal. The farm cultivates a diverse range of crops *viz.,* strawberry, broccoli, carrot, green peas, chrysanthemum, and marigold. The revenue received by collecting entry fee from the visitors, collecting accommodation charges and other visiting charges from filmmakers, video makers, photographers etc. Accommodation facilities available was five air conditioned and non-air conditioner rooms. A comprehensive culinary offered include vegetarian meals, multiple non-vegetarian biryani options, locally

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Photographs : Andhra Strawberry farm, Lammasingi village in Chintapalli mandal

available bamboo cooked non-vegetation dishes, fish curry, and millet-based dishes. This farm also prepared various value-added products *viz.,* strawberry milkshakes, dried strawberries, and strawberry jam to sell directly to visitors. The agritourism farm also engaged in marketing of their farm produce and products by supplying to urban retailers in Visakhapatnam, Kakinada, and Vijayawada cities The farm had been visited by over 3000 visitors annually and made total revenue of Rs. 25,00,000 annually. The farm also providing employment to rural youth and women in his village. Future strategic development plans of the farm were construction of a green houses for growing high value flower and fruit crops. (Anthony *et al*., 2016).

II. Agritourism farm: Jannani organic strawberry farm, Likiveedi village in Chintapalli mandal

The Jannani organic strawberry farm was founded in the year 2021 by Sri K. Satyanarayana, utilizes 10 acres in Likiveedi village, Chintapalli mandal, for partial agritourism activities. Beyond cultivation of strawberry, papaya, broccoli, lettuce, watermelon, and golden berry, the farm integrates livestock (hen and sheep). No entrance fee being collected but possibility to implement as demand escalates. Visitors can have accommodation in AC and non-AC rooms which are available. It provides a variety of vegetarian and non-vegetarian dishes, alongside millet-based options. Agri-products are sold include strawberries, strawberry milkshakes, golden berry dry fruits, strawberry jam, and strawberry cream/honey/chocolate dips. Marketing channels are robust, involving direct sales to shopkeepers in Hyderabad, Vijayawada, and Visakhapatnam and supply to large retailers. Publicity is generated through word-of-mouth, YouTube, social media, and traditional press. Tourist attractions nearby include Chervulavanam view point. With an impressive turnover of 22 lakhs, Mr. K. Satyanarayana has turned farming in to a Agri business model. The future plans focus on value addition to strawberries, creating products like chocolates and sweets, and establishing an organic coffee store on-site to diversify revenue streams. (Suvarna *et al*.,2019).

III. Agritourism farm: Sri Bhavani organics farm, Araku village in Dimriguda mandal

Sri Bhavani Organics, established in 2019 by Mr. Jaswanth, holding on 2 acres land in Araku village,

Photographs : Jannani organic strawberry farm, Likiveedi village in Chintapalli mandal

Dimriguda mandal, engaging in partial agritourism. The main focus of the farm is on millets, niger, sunflower, and paddy, additionally by livestock (hen, cows, ducks). The farm is located near to bus and railway stations of Araku. The farm currently not collecting entrance fees for visitors but plans to do so upon the establishment of a honey museum. Stay, food services and combo packages are not available for the tourists in the farm. Publicity on the farm is generated through conventional and digital media, in addition to direct engagement with regular customers. Nearby tourist spots include the Tribal Museum, Araku Pinery, Padmapuram Gardens, and coffee/chocolate factories. The farm specializes in selling various honey products such as Multifloral, Niger Floral, Rose Petal, and Forest Honey, along with all types of millets. Marketing is diversified, encompassing direct sales to shopkeepers in multiple cities (Vijayawada, Visakhapatnam, Rajahmundry, Hyderabad). Direct supply to major retailers and online platforms (Amazon, Flipkart). Similar to other cases mentioned above, this farm also not having membership in business associations or with A.P. Tourism and has no insurance coverage. The primary future objective is to establish a honey museum to enhance profitability. (Anita, 2014).

IV. Agritourism farm: Amma Cottage (Knowledge Park) in Araku valley village

Amma Cottage also known as Knowledge Park, founded in 2003 by Sri Raghu Phani spann ing in 15 acres in Araku village. Over 22 years of rich experience in cultivation, the farm produces paddy, millets, niger, and banana, along with poultry and cows. The farm provides a significant accommodation for tourists with a capacity of 10 rooms and is located very near to Araku Valley bus and railway stations. The farm charges entry fees based on visitor. The food menu is covering with vegetarian full meals, various non-vegetarian biryanis, fish curry, and millet-based dishes. Distinctively, the farm offers hands-on farming experiences for an additional fee, with a penalty system for visitor-induced damages. Comprehensive training courses are provided in apiculture, sericulture, mushroom cultivation, and value addition. Marketing is achieved through direct sales to shops in major cities, direct supply to large retailers and online platforms. Widespread publicity on farm activities are given via digital and traditional media. Nearby attractions include the Tribal and Coffee Museums, Padmapuram Gardens, and Sunkarameta coffee plantation with rental vehicle services. The farm sells processed agri-products like ragi flour, ragi biscuits, millets, honey, mushroom, and silk, primarily through direct marketing to shops or export. A key differentiator in this farm is the exhibition of medicinal plantations, 5000 varieties of seeds, mushroom, apiculture, sericulture units, a fish gallery, a snake gallery, and a kids' recreation zone, all accessible with an entry fee. Mr. Raghu phani now earn over 55 lakhs annually, hosts over 5400 visitors annually and providing employment to 12 rural youth. Despite its advanced offerings, the farm is not affiliated with any business associations or with A.P. Tourism limits the farm from coverage of insurance. The future plan of the farm involves building a function hall for the conduction of agriculture-related conferences, workshops, or training sessions to expand business operations. (Laxman *et al*.,2024).

Photographs: Sri Bhavani organics, Araku village in Dimriguda mandal

Photographs: Amma cottage (Knowledge Park) in Araku valley village

Photographs: Pallavi sunflower garden, Dimriguda village in Araku valley mandal

V. Agritourism farm: Pallavi Sunflower Garden, Dimriguda village in Araku Valley mandal

Sri P. Ramu established Pallavi Sunflower Garden, in 2019 which represents an early-stage agritourism initiative in half-acre land holding in Dimriguda village, Alluri Sitharama Raju district. The primary crops cultivated by the farm includes sunflower, maize, groundnut, radish, beans, millets, mirchi, and brinjal, supported by cows, goats, and poultry farming. The farm is situated near Araku Valley bus and railway stations and charges entry fees for various visitor categories (general public, foreign tourists, filmmakers, students, pre-wedding shoots) to explore the premises. However, it currently does not offer accommodation, food, hands-on experiences, training, or combo packages. The farm sells minimal quantities of raw agricultural produce such as maize cobs, groundnuts, millets, mirchi, radishes, and beans directly to visitors. Marketing is primarily conducted through direct farm gate sales and participation in the Araku Rural Haat (weekly market), supplemented by word-of-mouth, YouTube, social media, and traditional press. Unique to this farm is the arrangement of umbrellas and photogenic spots within the field to enhance visitor attraction. Nearby tourist spots include Padmapuram Gardens, Sunkarameta coffee plantation, and the Tribal Museum. The farm cannot facilitate the coverage of insurance because of not having membership in business associations or A.P. Tourism. Farming of strawberry to increase profitability is the future plan of the farm. (Rohit *et al*., 2020).

This study alternates that agritourism in Alluri Sitharama Raju district spans a spectrum from integrated, large-scale ventures offering accommodation, hands-on experiences, and robust marketing, to small-scale projects focusing on basic tourism and direct sales. While these initiatives successfully combine agriculture and tourism to generate additional income and employment. Systematic documentation highlights the diversity and evolving nature of agritourism models in the region, underscoring both the opportunities and the need for capacity-building to realize its full potential.

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Andhra Pradesh J Agril. Sci : 11(3): 184-189, 2025

ASSESSMENT OF GENETIC VARIABILITY AND CORRELATION STUDIES FOR YIELD IMPROVEMENT IN SESAME (*Sesamum indicum* L.)

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Date of Receipt: 13-02-2025 Date of Acceptance: 11-03-2025

ABSTRACT

A study was conducted in 44 sesame accessions to analyze genetic variability and character association for yield improvement in sesame. Analysis of variance indicated the existence of significant genotypic differences among the genotypes. High GCV and PCV were observed for seed yield per plant, harvest index and number of capsules per plant. High heritability coupled with high genetic advance as percent of mean was observed for number of primary branches, seed yield per plant, number of capsules per plant, harvest index and height to first capsule indicating the influence of additive and gene action. Seed yield per plant showed positive association with number of capsules per plant, harvest index, oil content and number of primary branches.

KEYWORDS: Sesame, PCV, GCV, heritability, genetic advance as per cent mean, correlation.

INTRODUCTION

Sesame (*Sesamum indicum* L., 2n = 26), an ancient oilseed crop, a member of the Pedaliaceae family and also known as the "Queen of Oilseeds," is recognized for its nutritional value and diverse applications. The seeds are rich in proteins, lipids, and lignin-like compounds, offering health benefits such as antioxidant properties, cholesterol reduction, and protection against cardiovascular diseases (Wei *et al*., 2022). Sesame seeds enhance plasma g-tocopherol and vitamin E activity, which may prevent aging-related diseases, and are incorporated in foods like bread, cookies, and tahini (Elleuch *et al*., 2011).

In India, it occupied in an area of 10.39 lakh hectares with 4.29 lakh tonnes of production and productivity of 413 kg/ha (Indiastat,2024). Variation in climatic and edaphic conditions affects sesame yield, the major constraints identified in growing sesame are instability in yield, lack of wider adaptability and non-synchronous maturity etc. Therefore, there is a need to exploit the existing genetic variability in sesame for developing high yielding varieties. Besides this, for understanding the mode of inheritance of the yield components, the correlation among them and the association between each component and yield is necessary for intelligent choice of breeding procedures for evolving high yielding varieties. (Robinson *et al*., 1951 and Johnson *et al.,* 1955).

The present investigation was conducted to study the phenotypic and genotypic variability among the genotypes and to estimate genetic advance, correlation coefficient among the component characters on yield of sesame.

MATERIAL AND METHODS

The experiment was conducted with 44 accessions including 40 advanced breeding lines and four checks *viz.,* YLM 66, Swetha til, TKG 22 and G Til 10 in a randomized block design (RBD) with two replications at the Regional Agricultural Research Station (RARS), Tirupati during Rabi 2023-24. Each breeding line was sown in two rows of three meters length with a spacing of 30 cm between the rows and 15 cm distance between the plants within the row. List of forty advanced breeding lines along with four checks utilized are given in Table.1

(C): Check

Observations were recorded for all the characters separately on randomly chosen five competitive plants in each replication except days to 50% flowering and days to maturity which will be taken on plot basis. The characters studied are *viz.,* days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, SCMR (SPAD Chlorophyll meter reading), SLA (Specific Leaf Area) ($cm2g^{-1}$), height to the first capsule (cm), distance between the internodes (cm), number of capsules per plant, capsule length (cm),

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Table. 1: List of genotypes under study

S. No	Breeding Line	S. No	Breeding Line	S. No	Breeding Line	S. No	Breeding Line
1.	TPTS-4146	12.	TPTS-4201	23.	TPTS-4248	34.	TPTS-4278
2.	TPTS-4148	13.	TPTS-4204	24.	TPTS-4249	35.	TPTS-4280
3.	TPTS-4158	14.	TPTS-4208	25.	TPTS-4253	36.	TPTS-4281
4.	TPTS-4159	15.	TPTS-4211	26.	TPTS-4259	37.	TPTS-4283
5.	TPTS-4167	16.	TPTS-4223	27.	TPTS-4260	38.	TPTS-4284
6.	TPTS-4172	17.	TPTS-4232	28.	TPTS-4263	39.	TPTS-4285
7.	TPTS-4193	18.	TPTS-4233	29.	TPTS-4264	40.	TPTS-4299
8.	TPTS-4197	19.	TPTS-4234	30.	TPTS-4267	41.	YLM 66 (C)
9.	TPTS-4198	20.	TPTS-4238	31.	TPTS-4273	42.	Swetha Til(C)
10.	TPTS-4199	21.	TPTS-4239	32.	TPTS-4276	43.	TKG 22 (C)
11.	TPTS-4200	22.	TPTS-4243	33.	TPTS-4277	44.	G Til 10 (C)

number of seeds per capsule, 1000 seed weight (g), seed yield per plant (g), harvest index (%) and oil content (%).

Mean, range and coefficient of variation were also estimated. Genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were estimated according to Burton (1952) while heritability in broad sense (h_2bs) was estimated according to Burton and Devane (1953); genetic advance (GA) and genetic advance as percent of mean (GAM) were calculated by Johnson *et al*., (1955a) and correlation coefficient analysis by Robinson *et al*., (1951).

RESULTS AND DISCUSSION

The numerical data collected on quantitative characters were statistically analyzed and analysis of variance (Table 2) showed highly significant differences among the genotypes under study for all the 15 traits indicating the presence of considerable genetic variability among the experimental material under study. The PCV was greater than GCV for all the characters suggesting that the performance of entries was influenced by the environment. The characters, seed yield per plant, harvest index and number of capsules per plant exhibited high GCV and PCV suggesting sufficient amount of variation among the advanced breeding lines and the selection would be effective for further improvement of the traits. The above results are in accordance with findings of Patil and Lokesha (2018), Kumar *et al*., (2022), Patel *et al*., (2022), and Kumari and Shah (2023). Estimates of genetic parameters for yield and yield attributing traits in forty-four accessions of sesame are given in Table. 3.

High heritability coupled with high genetic advance as per cent mean were recorded for number of primary branches (h_2bs: 94.40%; GAM: 40.02%), seed yield per plant (h_2bs: 92.50%; GAM: 55.02%), number of capsules per plant (h2bs: 86.86%; GAM: 47.49%), harvest index (h2bs: 85.79%; GAM: 50.27%) and height to first capsule (h2bs: 70.20%; GAM: 24.69%) indicating the preponderance of additive gene action. Therefore, phenotypic selection would be more effective for improvement of these characters. Patel *et al*., (2022) and Kumar *et al*., (2022) had reported similar results.

The traits number of capsules per plant (rp = 0.804**; rg = 0.910**), harvest index (rp = 0.754**; rg = 0.874**), oil content(rp = 0.31**; rg = 0.347**) and number of primary branches (rp = 0.220*; rg = 0.225*) recorded positive significant association with seed yield per plant at both phenotypic and genotypic levels indicating that these characters play an important role in selection for the improvement of seed yield per

Table 2. Analysis of variance for yield and yield attributing traits in forty four entries of sesame

S. No.	Characters	Mean sum of squares		
		Replications (df : 1)	Treatments (df : 43)	Error (df : 43)
1.	Days to 50% flowering	0.01	8.86**	3.85
2.	Days to maturity	25.10	20.59**	6.73
3.	Plant height (cm)	130.41	170.86**	35.06
4.	Number of primary branches	0.03	1.23**	0.03
5.	SCMR (SPAD Chlorophyll meter reading)	2.056	28.165**	10.248
6.	SLA (Specific Leaf Area) (cm^2 g^{-1})	555.16	679.15**	155.46
7.	Height to first capsule (cm)	26.73	38.56**	6.75
8.	Distance between the internodes (cm)	0.004	0.17**	0.05
9.	Number of capsules per plant	0.910	489.449**	34.48
10.	Capsule length (cm)	0.001	0.06**	0.02
11.	Number of seeds per capsule	55.682	49.71**	21.19
12.	1000 seed weight (g)	0.01	0.19**	0.014
13.	Seed yield per plant (g)	0.200	13.204	0.539
14.	Harvest index (%)	90.558**	103.976**	7.952
15.	Oil content (%)	4.98	34.53**	1.36

*Significant at 5% level; ** Significant at 1% level.

plant (Table 4). These results were in harmony with the findings of Abate et al. (2015), Saravanan *et al*., (2020) and Patel *et al*., (2022).

In contrast distance between the internodes (rp = -0.242*; rg = -0.315**) and SLA (Specific leaf area) (rp = -0.220*; rg = -0.277**) exhibited significant negative correlation with seed yield per plant indicating the role of these traits is important for improving seed yield per plant in sesame. Similar results were earlier reported by Hemanth *et al*., (2022) and Kumari and Shah (2023). Non-significant positive association of oil content (rp = 0.12; rg = 0.062) was observed with seed yield per plant. Similar results were earlier reported by Patel *et al*., (2022) in (Table. 4)

High heritability coupled with high genetic advance as per cent mean were recorded for number of primary branches, seed yield per plant, number of capsules per plant, harvest index and height to first capsule indicating the preponderance of additive gene action. In correlation studies, the traits *viz.,* number of capsules per plant, harvest index, oil content and number of primary branches recorded positive significant association with seed yield per plant indicating that these characters play an important role in selection for the improvement of seed yield per plant.

Table 3. Estimates of genetic parameters for yield and yield attributing traits in forty four accessions of sesame

S. No.	Character	Mean	Range		Variance		Coefficient of variation		Heritability (Broad sense) %	Genetic advance (GA)	Genetic advance as percent of mean (%)
			Min.	Max.	Genotypic	Phenotypic	Genotypic	Phenotypic			
1	Days to 50% flowering	37.83	33.00	41.00	2.51	6.35	4.18	6.66	39.43	2.05	5.41
2	Days to maturity	80.19	75.00	85.00	6.93	13.66	3.28	4.61	50.72	3.86	4.816
3	Plant height (cm)	92.87	62.80	108.50	67.90	102.96	8.87	10.93	65.95	13.78	14.84
4	Number of primary branches	3.86	1.00	5.20	0.60	0.63	19.99	20.57	94.50	1.55	40.03
5	SCMR(SPAD Chlorophyll meter reading)	38.08	31.50	46.70	8.96	19.21	7.86	11.51	46.64	4.21	11.06
6	Specific leaf area ($cm^2 g^{-1}$)	140.53	98.38	185.28	261.84	417.30	11.52	14.54	62.75	26.40	18.79
7	Height to first capsule (cm)	27.88	19.05	36.80	15.90	22.66	14.31	17.08	70.20	6.88	24.69
8	Distance between the internodes (cm)	2.60	2.16	3.51	0.06	0.11	9.60	12.65	57.70	0.39	15.01
9	Number of capsules per plant	60.98	38.80	91.30	227.52	261.93	24.74	26.54	86.86	28.96	47.49
10	Capsule length (cm)	2.84	2.50	3.20	0.02	0.04	5.40	7.00	60.51	0.25	8.58
11	Number of seeds per capsule	62.14	50.50	74.00	14.26	35.45	6.08	9.58	40.22	4.93	7.94
12	1000 seed weight (g)	3.08	2.43	4.10	0.08	0.10	9.45	10.20	85.97	0.56	18.03
13	Harvest index (%)	26.30	14.57	40.97	48.01	55.96	26.35	28.44	85.79	13.22	50.27
14	Oil content (%)	46.12	33.80	53.14	16.59	17.94	8.83	9.19	92.43	8.07	17.49
15	Seed yield per plant (g)	9.07	5.08	14.25	6.34	6.86	27.77	28.88	92.50	4.99	55.02

Table 4. Phenotypic (r_p) and genotypic (r_g) correlation coefficients among yield and yield attributing traits in forty four sesame accessions

Trait		DM	PH	NPB	SCMR	SLA	HFC	DBI	NCPP	CL	NSPC	TSW	HI	OC	SYP
DFF	r_p	0.19*	0.22*	0.324**	-0.109	-0.025	0.43**	0.005	0.098	0.194*	0.06	0.021	0.017	-0.124	0.024
	r_g	0.074	0.517**	0.508**	-0.146	-0.223*	0.892**	0.15	0.24*	0.258*	0.255*	0.019	0.151	-0.225*	-0.023
DM	r_p	1	0.161*	-0.327**	0.084	-0.334**	-0.158*	-0.086	0.21*	-0.097	0.098	0.046	0.234*	-0.005	0.106
	r_g	1	0.242*	-0.428**	0.272*	-0.514**	-0.16*	-0.288*	0.335**	-0.309**	-0.111	0.04	0.451**	0.065	0.128
PH	r_p		1	-0.003	-0.022	0.016	0.417**	0.071	0.227*	0.365**	0.132	0.107	0.194*	-0.162*	0.176
	r_g		1	-0.049	-0.102	0.068	0.539**	0.172*	0.225*	0.387**	-0.007	0.151	0.191*	-0.214*	0.218*
NPB	r_p			1	0.084	0.003	0.445**	-0.043	0.344**	0.137	0.134	0.133	0.072	-0.005	0.220*
	r_g			1	0.122	0.048	0.485**	-0.027	0.388**	0.161*	0.191*	0.152	0.08	-0.005	0.225*
SCMR	r_p				1	-0.22*	-0.169*	-0.128	0.559**	-0.109	0.011	0.467**	0.554**	0.137	0.656**
	r_g				1	-0.277*	-0.15	0.003	0.879**	-0.25*	-0.101	0.726**	0.845**	0.236*	0.731**
SLA	r_p					1	0.069	0.093	-0.278*	0.201*	-0.029	-0.009	-0.252*	-0.109	-0.184*
	r_g					1	0.23*	0.136	-0.358**	0.365**	-0.038	0.000	-0.289*	-0.174*	-0.237*
HFC	r_p						1	0.371**	-0.012	0.281*	0.11	-0.028	0.01	0.000	-0.002
	r_g						1	0.522**	0.025	0.411**	0.132	-0.061	0.049	0.012	-0.062
DBI	r_p							1	-0.255*	0.064	-0.03	-0.157*	-0.064	0.132	-0.242*
	r_g							1	-0.434**	0.287*	0.118	-0.284*	-0.149	0.133	-0.315**
NCPP	r_p								1	-0.048	-0.068	0.493**	0.632**	0.116	0.804**
	r_g								1	-0.057	-0.016	0.559**	0.706**	0.140	0.910**
CL	r_p									1	0.344**	-0.032	-0.107	0.008	-0.070
	r_g									1	0.529**	-0.067	-0.107	0.002	-0.079
NSPC	r_p										1	-0.173*	-0.169*	0.040	-0.086
	r_g										1	-0.236*	-0.288*	0.071	-0.177
TSW	r_p											1	0.55**	0.037	0.664**
	r_g											1	0.665**	0.062	0.727**
HI	r_p												1	0.191*	0.754**
	r_g												1	0.205*	0.874**
OC	r_p													1	0.120
	r_g													1	0.114

*Significant at 5% level; ** Significant at 1% level.

DFF : Days to 50% flowering; HFC : Height to first capsule (cm); CPP : Number of capsules per plant; TSW : 1000 seed weight; DM : Days to maturity; PH: Plant height (cm); CL : Capsule length (cm); OC : Oil content (%); SCMR : SPAD Chlorophyll meter reading; NPB : Number of primary branches; SPC : Number of seeds per capsule; SYP : Seed yield per plant (g); SLA : Specific Leaf Area (cm^2 g^{-1}); DBI : Distance between the internodes (cm); HI : Harvest index (%)

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Andhra Pradesh J Agril. Sci : 11(3): 190-196, 2025

ASSESSMENT OF SEASONAL INCIDENCE OF SUCKING PESTS AND NATURAL ENEMIES IN SUNFLOWER (*Helianthus annuus* L.) AND THE CORRELATION WITH WEATHER FACTORS

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Date of Receipt: 10-07-2025 Date of Acceptance: 28-07-2025

ABSTRACT

A sunflower hybrid (KBSH-44) was sown on second fortnight of October at Regional Agricultural Research Station, Nandyal, Andhra pradesh during rabi, 2024-25. The seasonal incidence of sucking pests *viz.,* leafhopper (*Amrasca biguttula biguttula*), whitefly (*Bemisia tabaci*), thrips (*Thrips palmi*) and natural enemies were observed in sunflower hybrid KBSH-44 during rabi, 2024-25. The incidence of sucking pests *viz.,* leafhopper, whitefly and thrips was first appeared 15 days after germination. Peak incidence of sucking pests was recorded in 51st and 2nd standard week. The correlation studies on leafhopper, whitefly and thrips showed negative correlation with maximum temperature, minimum temperature, sunshine hours and wind velocity, but positive correlation with rainfall, morning and evening relative humidity. Natural enemies like spiders and ladybird beetles positively correlated with wind velocity, morning and evening humidity, while negatively correlated with maximum temperature, minimum temperature, rainfall and sunshine hours.

KEYWORDS: Sunflower, Sucking pests, Natural enemies, Weather parameters.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) popularly known as "surajmukhi" family Asteraceae. It is native to southern parts of USA and Mexico (Heiser, 1951). Sunflower is one of the important edible oilseed crop grown in the world after soybean and groundnut. Sunflower oil is a rich source of linoleic acid (64 per cent) which helps in washing out cholesterol deposition in the coronary arteries of heart and thus good for heart patients. In India, during 2023-24, sunflower was cultivated on an area of 1.51 lakh ha with 1.72 lakh tonnes of production and 1144 kg ha^{-1} of productivity (indiastatagri 2024). In Andhra Pradesh, sunflower was cultivated on an area 0.04 lakh ha with 0.038 lakh tonnes of production and 886 kg ha^{-1} of productivity in 2023-24 (indiastatagri 2024). The principal states in India that cultivate sunflower include Karnataka, Andhra Pradesh, Maharashtra, Orissa, Bihar, Haryana, Punjab, Tamil Nadu and West Bengal. Among these states, Karnataka ranks first and Andhra Pradesh ranked eighth in terms of sunflower production and area. In Andhra Pradesh, Kurnool district is one of the prominent sunflower growing area, where the crop is largely cultivated under rainfed conditions during late kharif and as irrigated crop during rabi and summer seasons. Insect pests infestation is one of the major constraint for sunflower production. In India more than 50 insect species have been recorded to damage the crop at different growth stages and nine are major pests. Meteorological variables play a vital role in multiplication and distribution of insect pests, which directly influence the abundance of natural enemies (Zafar *et al*., 2013). To formulate an effective, economic and sustainable pest management strategy for a specific agro- ecosystem, complete knowledge on abundance and distribution of pest in relation to weather factors is a basic requirement (Patel and Shekh, 2006). In India, the major sucking insect pests include leafhopper (*Amrasca biguttula biguttula* Ishida) and whitefly, (*Bemisia tabaci*) are of major economic importance (Basappa, 2004). Many thrips species that are associated with crop are also acting as vectors for transmitting sunflower necrosis virus and other viral diseases. Sucking insect-pest of sunflower cause 44 per cent of yield losses (Kakakhel *et al*., 2000). The incidence of sucking pest on sunflower crop varied due to several factors like planting time, variety and most important abiotic factors. Different abiotic factors like temperature, humidity and rainfall plays an important role on the incidence and population dynamics of sucking pests. Hence, in the present

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investigation, seasonal incidence of sucking pests and natural enemies and the effect of different meteorological parameters like maximum and minimum temperature, morning and evening relative humidity, rainfall on development and survival of the insect pests and natural enemies was studied.

MATERIAL AND METHODS

The field experiment was carried out at Regional Agricultural Research Station farm, Nandyal (15027'N and 78028'E), Andhra Pradesh. The soil of experimental field is black cotton, with pH 8.3 and EC 0.26 ds m^{-1}. The sunflower hybrid KBSH-44 was sown during second fortnight of October in a plot measured 50 sqm with the spacing of 60 cm between the rows and 30 cm within the row. Application of manure and fertilizer at recommended dose as per package of practices and intercultural operations such as thinning, weeding etc. were done at proper time.

Methods of observations

After one week of germination, observations on sucking insect pests were recorded on weekly basis till harvesting of the crop. Ten plants from plot were randomly selected and tagged. Sucking insect pests such as leafhopper, whitefly and thrips were recorded from six leaves per plant, two each from upper, middle and lower canopy of the plant.

Meteorological Data: The weather data was obtained from the Department of Agricultural Meteorology, Regional Agricultural Research Station, Nandyal for the crop period November to January during rabi, 2024-25. The daily weather data *viz.,* maximum and minimum temperature, the morning and evening relative humidity, the rainfall, wind velocity and the bright sunshine hours were recorded by the weather station, installed in the research area. Correlation and regression analyses were used to find out the influence of climatic factors- on the seasonal incidence of sucking pests.

Statistical Analysis: The weekly averaged data of seasonal incidence of sucking pests and natural enemies were subjected to correlation and regression analysis with weather parameters following standard procedure. Multiple regression was worked out between insect pests and weather factors. The significance level was set at $p < 0.05$.

RESULTS AND DISCUSSION

During the period of investigation, the population of insect pest was fluctuating and present throughout the crop season. Population buildup of insect pests and the influence of several weather parameters on their population were presented in the Table 1.

Simple correlation and regression equation of sucking pests and their natural enemies with maximum and minimum temperature, morning and evening relative humidity, rainfall, sunshine hours and wind velocity are presented in the Table 2 and Table 3.

Leafhopper

Leafhopper was observed during 47th SMW and maximum population (3.53 per 6 leaves per plant) was observed during the 51st SMW *i.e.* 3rd week of December (Table 1). The results are in accordance with mean incidence of leafhopper ranging from 0.25 to 1.65 per 6 leaves per plant in sunflower was reported during 43rd and 45th SMW by Geetha and Hegde (2018). Ghante *et al*. (2020) noticed the peak population of leafhopper observed during 3rd SMW (January). Similarly, the results were obtained by Darandale *et al*. (2015) who stated that, jassids incidence started to appear from 2nd week of December and peak population of jassids recorded during 4th week of January in niger crop.

Leafhopper population was negatively correlated with maximum temperature(r=-0.523), sunshine hours(r=-0.378) and wind velocity(r=-0.004), whereas positively correlated with rest of the weather parameters (Table 2). Similar results were obtained by Bhura et al. (2020) who reported negative correlation between leafhopper population and maximum temperature. The results are in contrary with the findings of Yadav *et al*. (2022) who reported negative correlation between leafhopper population and maximum and minimum temperature, rainfall and evening relative humidity. The present results are in conformity with the findings of Kumar and sharma (2023) who reported leafhopper population was showed significant positive correlation with evening relative humidity and rainfall. Shambhavi *et al*. (2023) who reported that leafhopper population positively correlated with morning and evening relative humidity in castor crop. Similar results were obtained by Sharma *et al*., (2023) who reported negative correlation between leafhopper population and evening relative humidity, wind speed. The findings were consistent with those observed in previous studies by Nayak *et al*., (2022) who reported that jassids negatively correlated with maximum and minimum temperature in sunflower

Table 1: The data on seasonal incidence of sucking insect pests of sunflower during rabi, 2024-25

S. No.	Standard meteorological Week	Period	Mean no. of leafhoppers/6 leaves	Mean no. of whiteflies/6 leaves	Mean no. of thrips/6 leaves	Mean no. of spiders /plant	Mean no. of lady bird beetle /plant
1.	45	05 - 11 Nov	0.00	0.00	0.00	0.00	0.00
2.	46	12 - 18 Nov	0.00	0.00	0.00	0.00	0.00
3.	47	19 - 25 Nov	0.33	1.10	0.12	0.00	0.00
4.	48	26 Nov - 02 Dec	0.40	1.18	0.15	0.20	0.20
5.	49	03 - 09 Dec	0.56	1.25	0.33	0.40	0.50
6.	50	10 - 16 Dec	3.20	1.82	0.45	0.80	0.10
7.	51	17 - 23 Dec	3.53	1.90	0.55	1.90	1.35
8.	52	24 - 31 Dec	2.85	1.75	0.50	1.20	1.20
9.	1	01 - 07 Jan	1.20	1.30	1.00	0.60	1.10
10.	2	08 - 14 Jan	1.10	1.20	1.20	0.10	0.30
11.	3	15 - 21 Jan	0.30	1.10	0.50	0.20	0.20
12.	4	22 - 28 Jan	0.10	0.00	0.46	0.00	0.00

Table 2. Correlation of abiotic factors with sucking pests and natural enemies of sunflower

Weather parameters	Correlation coefficient ('r' values)				
	Leafhopper	Whitefly	Thrips	Spiders	Lady bird beetle
Maximum temperature (ºC)	-0.523	-0.768*	-0.611*	-0.507	-0.498
Minimum temperature (ºC)	0.052	-0.163	-0.543	-0.012	-0.157
Rainfall (mm)	0.500	0.354	0.021	0.188	-0.178
Sunshine hours (h)	-0.378	-0.534	-0.044	-0.386	-0.300
Wind velocity (km/h)	-0.004	-0.014	0.258	0.080	0.147
Morning Relative humidity (%)	0.553	0.522	0.628*	0.299	0.269
Evening Relative humidity (%)	0.541	0.576	0.014	0.401	0.232

N = 12; * : Significant at 0.05%

crop.

The multiple linear regression equation for leafhopper is Y=47.51-2.749 X_1 +1.986 X_2 +0.039 X_3 +0.034X4 -2.328 X5 +0.251 X6 -0.413 X_7 indicated one unit increase in maximum temperature, wind velocity and evening relative humidity caused increase in leafhopper population by 2.749, 2.328 and 0.413 units. Leafhopper population was collectively influenced by the weather factors to the extent of 76.1 percent (Table 3).

Whitefly

Whitefly was observed during 47th SMW *i.e.* last week of November, 2024 and active until 4th SMW *i.e.* last week of January. Highest population (1.90 per 6 leaves per plant) was observed during the 51st SMW *i.e.* 3rd week of December (Table 1). Similarly, Jadhao *et al*. (2015) who reported that peak incidence of whitefly recorded during 09th SMW (2.7 nymphs per leaf).

The Population of whitefly significantly negative correlation with maximum temperature(r=-0.768) and non-significantly negative correlation with minimum temperature(r=-0.163), sunshine hours(r=-0.534) and wind velocity(r=-0.014), while positive correlation with rest of the weather parameters (Table 2). Whiteflies found to have non-significant correlation with weather factors (Solanki and Jha 2018). Similarly, the results are also in agreement with Vishwakarma *et al*., (2023) who reported that population of whitefly in niger crop and showed negative correlation with maximum temperature, minimum temperature, morning and evening relative humidity, while positive correlation with rainfall, wind speed. The same results were conformed with Panday *et al*., (2019) who reported that positive correlation between whitefly population and minimum temperature and sunshine hours in niger crop. Similar, to the present study Sharma *et al*., (2023) who reported that whitefly population positively correlation with morning relative humidity. The results were in close agreement with Bhura *et al*., (2020) who reported positive correlation between whitefly population and evening relative humidity and minimum temperature. The findings were in accordance with Nayak *et al*., (2022) who reported that whitefly population negatively correlated with maximum and minimum temperature in sunflower crop.

The multiple linear regression equation for whitefly is Y=8.54 -0.571 X_1 +0.177 X_2 -0.174 X_3 +0.061 X_4 -0.711 X_5 +0.073 X_6 +0.009 X_7 revealing that an unit increase in maximum temperature, rainfall and wind velocity will increase in whitefly population by 0.571, 0.174 and 0.711 units. Collectively influence of weather factors on population of whitefly was to the tune of 86.3 per cent (Table 3).

Thrips

Thrips population was observed during 47th SMW and active until 4th SMW. Maximum population of thrips (1.20 per 6 leaves per plant) was observed during

Table 3. Regression equation for sunflower insect pest population and weather parameters

Pest	Regression Equation	R^2 value (%)
Leafhopper	$Y = 47.51-2.749 X_1 + 1.986 X_2 + 0.039 X_3 + 0.034 X_4 - 2.328 X_5 + 0.251 X_6 - 0.413 X_7$	0.761
Whitefly	$Y = 8.54-0.571 X_1 + 0.177 X_2 - 0.174 X_3 + 0.061 X_4 - 0.711 X_5 + 0.073 X_6 + 0.009 X_7$	0.863
Thrips	$Y = 4.649-0.322 X_1 + 0.092 X_2 - 0.136 X_3 + 0.080 X_4 - 0.077 X_5 + 0.048 X_6 - 0.009 X_7$	0.753

X_1 : Maximum temperature, X_2 : Minimum temperature, X : Rainfall, X_4 : Sunshine hours, X_5 : Wind velocity, X_6 : Morning relative humidity, X_7 : Evening relative humidity

2nd SMW (Table 1). The findings were consistent with those observed in previous studies by Ahir *et al*., (2017) who reported thrips attained peak during 2nd week of September. Similarly, to the present study Sharmila *et al*., (2020) reported that peak population of thrips observed during 36th SMW (6.61 thrips per plant).

Thrips population was significantly positive correlation between morning relative humidity (r=0.628) and non-significantly positive correlation with rainfall (r=0.021), wind velocity (r=0.258) and evening relative humidity (r=0.014), whereas negative correlation with maximum temperature (r=-0.611), minimum temperature (r=-0.543) and sunshine hours (r=-0.044) (Table 2). The results were in close agreement with Vijaykumar *et al*., (2022) who reported that thrips population positively correlated with evening relative humidity and negatively correlated with maximum and minimum temperature, rainfall. The same results were conformed with Saritha *et al*., (2020) who reported thrips population negatively correlated with rainfall and humidity. Similarly, Ram *et al*., (2025) who reported that thrips population negatively correlated with sunshine hours, wind velocity and morning and evening relative humidity. The results are conformity with the findings of Ahir *et al*., (2017) who reported that thrips population negatively correlated with temperature and positively correlated with relative humidity.

The multiple linear regression equation for thrips is $Y = 4.649 -0.322 X_1 + 0.092 X_2 -0.136 X_3 + 0.080 X_4 - 0.077 X_5 +0.048 X_6 -0.009 X_7$ revealing that an unit increase in maximum temperature, rainfall, wind velocity and evening relative humidity will increase in thrips population by 0.322, 0.136, 0.077 and 0.009 units. Collectively influence of weather factors on population of thrips was to the tune of 75.3 per cent (Table 3).

Natural enemies

Spider

Spider population was observed during 48th SMW and highest population (1.90 per plant) was observed during 51st SMW (Table 1). Spider population was negative correlation with maximum temperature(r=-0.507), minimum temperature(r=-0.012) and sunshine hours(r=-0.386) and positive correlation with rest of the weather parameters (Table 2). The results were in close agreement with Vijaykumar *et al*., (2022) who reported that spider population negatively correlation with maximum temperature and positively correlated with rainfall morning and evening relative humidity. The results are conformity with the findings of Nayak *et al*., (2022) who reported spider showed negative correlation with maximum relative humidity and minimum relative humidity.

Lady bird beetle

Lady bird beetle was observed during 48th SMW and was found to be active until 3rd SMW. Maximum population (1.35 per plant) was observed during 51st SMW (Table 1). Rambihari *et al*., (2015) noticed the peak activity of ladybird beetle on soyabean during 2nd week of August and September with 0.4 grub and adult per plant. Lady bird beetle was found to have non-significantly positive correlation with wind velocity(r=0.147), morning(r=0.269) and evening relative humidity(r=0.232) and Negative correlation with rest of the weather parameters (Table 2). Similarly, Gocher and Ahmad (2019) who reported that positive correlation between ladybird beetle and relative humidity. The results were in close agreement with Kashyap *et al*., (2018) who reported ladybird beetle positively correlated with rainfall. The findings were consistent with those observed in previous studies by Vijaykumar *et al*., (2022) who reported that coccinellid population was negative correlation with minimum temperature, maximum temperature, rainfall, morning and evening relative humidity. The findings were consistent with those observed in previous studies by Suyal *et al*., (2018) who reported Coccinella septempunctata exhibited a positive correlation with evening relative humidity.

The incidence of sucking pest *viz.,* leafhopper, whitefly, thrips was first appeared 15 days after germination. Peak incidence of sucking pests was recorded in 51st and 2nd standard week. The correlation studies on leafhopper, whitefly and thrips showed negative correlation with maximum temperature, minimum temperature, sunshine and wind velocity, but positive correlation with rainfall, morning and evening relative humidity. Natural enemies like spiders and ladybird beetles positively correlated with wind velocity, morning and evening humidity, while negatively correlated with maximum and minimum temperature, rainfall and sunshine hours.

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IMPACT OF PLANT GROWTH REGULATORS ON PHOTOSYNTHESIS AND YIELD PARAMETERS IN HIGH DENSITY PLANTING SYSTEM OF COTTON

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Date of Receipt: 10-07-2025 Date of Acceptance: 26-08-2025

ABSTRACT

A field experiment was conducted during Kharif 2024 at RARS, Nandyal to study the impact of plant growth regulators on photosynthesis and yield Parameters in high-density of cotton. The Bt cotton hybrid Navneeth-BG II was grown under three different spacings (90 × 60 cm, 90 × 30 cm, and 90 × 15 cm) and with four treatments including control, detopping at 20th node, mepiquat chloride at 50% squaring, mepiquat chloride at 50% squaring and 50% flowering applications. Results showed that wider spacing improved physiological traits like photosynthesis and stomatal conductance, while closer spacing produced higher seed cotton and lint yields due to higher plant population. Application of mepiquat chloride, especially at 50% squaring, enhanced boll number, yield, and source–sink balance. The combination of closer spacing and mepiquat chloride at 50% squaring proved most effective for maximizing yield and improving physiological efficiency under high-density planting.

KEYWORDS: Bt-cotton, Detopping, HDPS, Mepiquat Chloride, Navneeth BG II.

INTRODUCTION

Cotton is one of the most commercially valuable natural fibre crops, cultivated in over 70 countries worldwide. Owing to its economic significance, it is often referred to as “White Gold” and the “King of Fibre Crops.” In addition to its fibre, cotton is also valued for its oil and as a source of feed for poultry and livestock. The genus Gossypium, belonging to the Malvaceae family, comprises more than 50 species, among which four are widely cultivated. The diploid species (Gossypium herbaceum and Gossypium arboreum) have a chromosome number of (2n = 2x = 26), while the tetraploid species (Gossypium hirsutum and Gossypium barbadense) have (2n = 4x = 52). Among them, (*Gossypium hirsutum* L.) is the most dominant, being an allo-tetraploid and a major contributor to the global textile industry. In India, cotton is cultivated in an area of about11.8 million hectares, yielding around 25million bales (170kg each) with a productivity of 461 kg/ha. Where as in Andhra Pradesh, the crop covers 4.22 lakh hectares with a production of 7.37 lakh bales and an average yield of 297 kg/ha (AICRP on Cotton Annual Report, 2025).

Light interception plays a vital role in photosynthesis and biomass accumulation in crop growth. High- density planting often limits light availability, especially in the lower canopy, reducing photosynthetic efficiency, while low-density planting underutilizes light. Compact canopies with proper spacing improve light capture and yield. Plant growth regulators have been utilized to analyze their impact on cotton and studies indicated that PGRs enhance yield by increasing the retention of photosynthesis in developing bolls. In developed nations, PGRs are widely used to improve cotton production by regulating plant growth, thereby enhancing lint yield and fibre quality. Among the Plant growth regulators used widely, mepiquat chloride (1,1-dimethylpiperidinium chloride) is extensively utilized to manage plant architecture, regulate growth, and hasten maturity under high planting densities. This growth regulator helps maintain a balance between vegetative and reproductive growth in cotton plants and offsets the effects of excessive nitrogen by reducing overall plant height and lateral branch length. Optimizing spacing and using growth regulators are key strategies to enhance light use efficiency, yield, and fibre quality in cotton.It also improves gross canopy photosynthesis and promotes the development of thicker leaves with reduced surface area. Application of mepiquat chloride has also been shown to increase the number of bolls per unit area under high plant density, enhance boll retention on lower sympodia, and promote synchrony in boll maturation in cotton.

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MATERIAL AND METHODS

The experiment was conducted at Regional Agricultural Research station, Nandyal, which is situated in scarce rainfall Agro-Climatic Zone of Andhra Pradesh at 15o29 Northern latitude and 78o29 Eastern latitude with an elevation of 211.76m above mean sea level. The statistical design adopted for the experimentation was Split-Plot design, with three replications. The main plots were three crop geometry *viz.,* 90 cm x 60 cm (M_1), 90 cm x 30 cm (M_2) and 90 cm x 15 cm (M_3). The sub plots consisted of *viz.,* S_1: control, S_2: Dettoping at 20th node, S_3: Mepiquat chloride @ 45ppm at 50% squaring, S_4: Mepiquat chloride @ 45ppm at 50% squaring and 50% flowering. The test hybrid used was Navneeth BG II (*Gossypium hirsutum* L.), a high-yielding Bt cotton hybrid.

1. Gas exchange parameters

Leaf gas exchange measurements were estimated using portable photosynthetic system (model CI-340). Totally, three measurements were taken at a constant flow rate of 5 mmol min-1 with a reference CO_2 concentration of 380 µmolmol^{-1} and photosynthetic flux density of 1000 µmolm^{-2}s^{-1}.The readings were taken between 10.00 hours to 12.30 hours. Photosynthetic rate, Transpiration rate, Stomatal conductance were measured at flowering stage of the crop using the Photosynthetic system.

2. Yield and its attributes

Number of bolls per plant, Boll weight (g), Number of sympodia per plant were averaged from the five randomly selected plants from each plot. Seed cotton yield *i.e* Seed cotton was picked from the plants in the net plot area and weighed. The yield obtained from five tagged plants was also added to this and expressed as seed cotton yield in kg ha^1. Lint yield is the cumulative yield lint from three canopy levels pickings in each treatment plot was weighed and expressed in kg ha^{-1}.

RESULTS AND DISCUSSION

Gas exchange parameters

Photosynthetic rate in cotton was significantly influenced by plant spacing and growth regulator treatments. (Table: 1) The widest spacing (90 × 60 cm) recorded the highest rate (34.75 µmol CO_2 m^{-2} s^{-1}), while the closest spacing (90 × 15 cm) showed the lowest (28.26 µmol CO_2 m^{-2}s^{-1}), indicating that wider spacing improved light interception and canopy aeration. Among growth regulator treatments, mepiquat chloride @ 45 ppm at 50% squaring (S_3) resulted in the highest photosynthetic rate (31.89 µmol CO_2 m^{-2} s^{-1}), likely due to its role in creating compact canopies and enhancing source-sink balance. Reddy *et al*., (2017) and Bibi *et al*., (2008), observed that improved photosynthesis with wider spacing and mepiquat chloride application.

Transpiration rate was significantly influenced by both spacing and growth regulator treatments. (Table: 1) The widest spacing (M_1) showed the highest transpiration rate (5.63 mmol H_2O m^{-2} s^{-1}), while the closest spacing (M3) had the lowest (4.61), likely due to denser canopies increasing humidity and reducing vapor pressure deficit. Among sub-plot treatments, S_3 Mepiquat chloride @ 45 ppm at 50% squaring (S_3) recorded the highest transpiration (5.45), while the lowest was in S_4 (4.97), possibly due to reduced leaf area and enhanced stomatal control from double mepiquat chloride application. Hebbar *et al*., (2020), reported improved water use efficiency with mepiquat chloride through lower leaf area and transpiration.

Stomatal conductance was significantly affected by both spacing and growth regulator treatments. (Table: 1). The highest conductance was observed in the widest spacing (M_1: 591.1 mmol H_2O m^{-2} s^{-1}), while the lowest was in the closest spacing (M_3: 482.7), suggesting that wider spacing improved light availability and air flow, supporting optimal stomatal function. Among treatments, S_3 (Mepiquat chloride at 50% squaring) recorded the highest conductance (546.3), whereas the control (S_1) had the lowest (530.9). The application of mepiquat chloride likely contributed to better stomatal regulation and gas exchange. Hussain *et al*., (2019), reported that mepiquat chloride enhances stomatal conductance by improving plant water relations and reducing stress.

Yield attributing parameters

Seed cotton yield was significantly affected by both plant spacing and growth regulator treatments. (Table: 2). The highest yield was recorded under the closest spacing (M3: 1943 kg ha^{-1}), attributed to higher plant density compensating for lower individual plant productivity. Among growth regulator treatments, S_3 (mepiquat chloride @ 45 ppm at 50% squaring) produced the highest yield (1988 kg ha^{-1}), while the control (S_1) recorded the lowest (1715 kg ha^{-1}). Mepiquat chloride

Table: 1 Influence of plant spacing and growth regulator on gas exchange parameters in cotton.

Parameters	Photosynthetic Rate (µmol CO_2 m^{-2} s^{-1})	Transpiration rate (mmol H_2O $m^{-2}s^{-1}$)	Stomatal conductance (mmol H_2O $m^{-2}s^{-1}$)
Main plots (Different spacings)			
M_1 : 90 ×60 cm	34.75	5.63	591.1
M_2 : 90 × 30 cm	31.39	5.45	548
M_3 : 90 × 15 cm	28.26	4.61	482.7
S.E(m)±	0.16	0.02	0.97
CD(P=0.05)	0.63	0.11	3.81
CV(%)	1.77	1.84	0.61
Subplots (Treatments)			
S_1 : Control	30.39	5.33	530.9
S_2 : Dettoping at 20th node	30.89	5.23	535.3
S_3 : Mepiquatchloride @ 45 ppm at 50% squaring	31.89	5.45	546.3
S_4 : Mepiquatchloride @ 45 ppm at 50% squaring and 50% Flowering	31.28	4.97	540.0
S.E(m)±	0.16	0.03	1.88
CD(P=0.05)	0.48	0.10	5.58
CV (%)	1.54	1.97	1.03

likely enhanced assimilate partitioning to reproductive organs by suppressing excessive vegetative growth. Reddy *et al*., (2019) and Venkateswarlu *et al*., (2015), reported yield benefits from closer spacing and mepiquat chloride application in high density planting systems. Lint yield was significantly influenced by both plant spacing and growth regulator treatments. (Table: 2). The highest yield was observed in the closest spacing M_3: (729 kg ha^{-1}), highlighting the benefit of high-density planting for maximizing output. Among the sub-plot treatments, S_3 (mepiquat chloride @ 45 ppm at 50% squaring) recorded the highest lint yield (705 kg ha^{-1}), likely due to improved boll retention and increased boll numbers. Patil *et al*., (2018), reported increased lint yield with mepiquat chloride due to enhanced sink strength.

The number of sympodia per plant, was significantly influenced by plant spacing and growth regulator treatments. (Table 2) Closer spacing (M_3) recorded the highest number of sympodia (22.2), suggesting that higher plant density promoted reproductive branching. Among treatments, S_4 (split application of mepiquat chloride at squaring and flowering) showed the highest number (23.4), indicating its effectiveness in canopy management and enhancing fruiting branch development. Saleem *et al*., (2017), noted that growth retardants like mepiquat chloride improve sympodial branching by regulating internode elongation. Boll weight was negatively affected by increasing plant density, with the widest spacing (M_1) recording the highest boll weight (6.2 g), while the closest spacing (M_3) had the lowest (5.5 g), likely due to reduced assimilate availability per boll. (Table: 2). Among growth regulator treatments, S_3 (mepiquat chloride at squaring) showed the highest boll weight (6.1 g), indicating improved source-sink balance and efficient boll filling. Ramegowda *et al*., (2014), reported enhanced boll weight with mepiquat chloride application due to better allocation of photosynthesis.

The number of bolls per plant was significantly influenced by both spacing and plant growth regulator treatments. (Table 2). The highest boll count was recorded under the closest spacing (M_3: 38.9), highlighting the advantage of high-density planting in maximizing total

Table 2. Influence of plant spacing and growth regulator on yield attributing characters in cotton

Parameters	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Number of sympodia per plant	Boll weight (gm)	Number of Bolls per plant
Main plots (Different spacings)					
M_1 : 90 ×60 cm	1723	537	20.9	6.2	24.6
M_2 : 90 × 30 cm	1853	622	21.5	5.8	27.3
M_3 : 90 × 15 cm	1943	729	22.2	5.5	38.9
S.E(m)±	16.05	9.7	0.14	0.39	1.02
CD(P=0.05)	63.0	38.1	0.57	1.56	4.01
CV(%)	3.02	5.3	2.36	2.35	11.7
Subplots (Treatments)					
S_1 : Control	1715	568	21.5	5.6	28.0
S_2 : Dettoping at 20th node	1792	600	19.8	5.7	29.7
S_3 : Mepiquatchloride @ 45 ppm at 50% squaring	1988	705	22.4	6.1	33.0
S_4 : Mepiquatchloride @ 45 ppm at 50% squaring and 50% Flowering	1864	645	23.4	5.9	30.3
S.E(m)±	17.9	10.4	0.31	0.45	0.95
CD(P=0.05)	53.2	31.1	0.94	1.35	2.83
CV (%)	2.91	4.98	4.43	2.32	9.44

boll production per unit area. Among PGR treatments, S_3 (mepiquat chloride at 50% squaring) recorded the highest number of bolls per plant (33.0), suggesting that mepiquat chloride improved boll retention and reduced shedding. Khan *et al*., (2016), reported that closer spacing combined with mepiquat chloride application increased boll number by enhancing effective fruit set and retention.The results clearly demonstrated that high-density planting and application of mepiquat chloride at 45 ppm during flowering significantly improved key yield parameters in cotton. While boll weight was slightly lower under dense spacing, the overall gains in boll number, lint yield, and seed cotton yield compensated effectively. The combination of optimized plant population and canopy regulation using PGRs is a viable strategy to improve productivity in HDPS cotton cultivation. The study confirms that wider spacing and the use of mepiquat chloride at 50% flowering significantly improved gas exchange parameters in cotton. These findings emphasize the potential of optimized plant architecture and growth regulator use to enhance photosynthesis and water use efficiency under High-DensityPlanting System. Strategic manipulation of canopy structure through spacing and PGRs can lead to better physiological performance and potentially higher yield in cotton crop.

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Andhra Pradesh J Agril. Sci : 11(3): 202-205, 2025

ESTIMATES OF VARIABILITY, HERITABILITY AND GENETIC ADVANCE IN BROWNTOP MILLET

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Date of Receipt: 08-07-2025 Date of Acceptance: 26-07-2025

ABSTRACT

The present study aimed to assess the genetic variability, heritability, and genetic advance for nine yield and yield-attributing traits in 30 genotypes of brown top millet (*Brachiaria ramosa* (L.) Stapf.) maintained at Agricultural Research Station, Perumallapalle during Rabi 2024-25. Significant differences among genotypes were observed for all traits, indicating substantial genetic variability in the material studied. High genotypic and phenotypic coefficients of variation were recorded for number of productive tillers per plant and grain yield per plant, suggesting ample scope for improvement through selection. Traits such as test weight, number of productive tillers per plant, harvest index and grain yield per plant exhibited high heritability coupled with high genetic advance as a percentage of mean, indicating the predominance of additive gene action and the effectiveness of phenotypic selection for these traits. The findings highlight productive tillers per plant, grain yield, harvest index and test weight as ideal targets for genetic improvement in brown top millet breeding programmes. Integrating variability measures with heritability and genetic gain estimates is emphasized for formulating effective breeding strategies.

KEYWORDS: Brown top Millet, GCV, PCV, Heritability and Genetic Advance.

INTRODUCTION

Bracharia ramosa (L.) Stapf. or *Urochola ramosa* (L.) is a minor millet originated from Southeast Asia (Sheahan, 2014). It was first domesticated in southern India and belongs to the family Poaceae and sub-family Panicoideae. Brown top millet is a self-pollinated crop with a chromosome number of 2n=4x=32. It is locally known as "Andukora" or pedda sama in Telugu and korlle or karlaki in Kannada. The crop is commonly called browntop millet because of its dark brown tinge on its seeds. It is also known as signal grass. Taxonomically, it is represented by var. ramosa and var. pubescens (Basappa *et al*.,1987).

Genetic variability is a key prerequisite for genetic improvement in plant breeding. Knowledge on the extent of variability existing in a crop species for different traits is crucial, because it serves as the basis for effective selection. To obtain a realistic indication of genetic variation in any trait, phenotypic variability must be partitioned into heritable and non-heritable components. The potential genetic gain from a selection process may be evaluated using estimations of heritability along with genetic advance. The aim of this research was to estimate the degree of variation among different yield and yield attributing traits and identify the best suitable lines for increasing the grain yield of brown top millet.

MATERIALS AND METHODS

The current study was carried out at Agricultural Research Station, Perumallapalle during rabi, 2024-25. The experimental material constituted 30 brown top millet genotypes and the experiment was conducted in Randomized Block Design with three replications and every entry was sown in three rows with a spacing of 45 cm x 10 cm. Timely management of recommended package was done during the crop period. Observations were noted for plant height, the number of productive tillers per plant, days to 50% flowering, panicle length, days to maturity, test weight, fodder yield per plant, grain yield per plant and harvest index.

RESULTS AND DISCUSSIONS

Analysis of variance was carried out for nine yield and yield attributing traits *viz.,* plant height, number of productive tillers per plant, days to 50% flowering, panicle length, days to maturity, fodder yield, test weight, grain yield and harvest index is represented in Table.1 The results revealed significant differences among the studied genotypes for all the traits which indicate the

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Table 1. Analysis of variance for yield, yield components in 30 browntop millet

S. No.	Characters	Mean Sum of Squares		
		Replications (df : 1)	Treatments (df : 29)	Error (df : 29)
1.	Plant Height (cm)	11.51	120.56**	21.89
2.	Number of productive tillers per plant	2.82	15.09**	1.12
3.	Days to 50% flowering	2.01	3.73**	0.56
4.	Panicle length (cm)	0.57	4.10*	1.98
5.	Days to maturity	0.41	3.94**	0.76
6.	Test weight (g)	2.70	9.77**	1.28
7.	Fodder yield per plant (g)	27.5	57.98**	6.94
8.	Grain yield per plant (g)	5.64	7.64**	0.94
9.	Harvest index (%)	0.06	0.49**	0.02

presence of substantial amount of genetic variability in the material investigated.

High GCV was recorded for number of productive tillers per plant (27.66) followed by grain yield per plant (25.37). Moderate GCV was recorded for harvest index (19.54) followed by test weight (13.87) and fodder yield per plant (10.06) and remaining triats showed low values (Table-2).

High PCV was recorded for number of productive tillers per plant (29.80) followed by grain yield per plant (28.71) and harvest index (22.04). Moderate PCV was recorded for test weight (14.42) followed by panicle length (13.74), fodder yield per plant (11.48) and Plant height (11.06).

High GCV and PCV was recorded for traits like grain yield per plant (GCV: 25.37 %; PCV: 28.71 %) and number of productive tiller per plant (GCV: 27.66%; PCV: 29.80 indicating the presence of ample amount of variation among the genotypes. Thus, simple selection would be effective for further improvement of these traits. These results are in accordance with Rahul *et al.*, (2024) in browntop millet for number of productive tillers per plant. Ayesha *et al.*, (2019) in foxtail millet; Priya *et al.*, (2022) and Rahul *et al.*, (2024) in browntop millet for grain yield per plot.

The traits like test weight (92.53%), number of productive tillers per plant (86.17%), harvest index (78.61%), grain yield per plant (78.07%), fodder yield per plant (76.77%) showed high estimates of heritability. Moderate estimates of heritability was recorded for days to 50% flowering (73.59%), plant height (69.26%), days to maturity (67.66%) and panicle length (34.93%).

Higher estimates of genetic advance as percentage of mean were recorded for number of productive tillers per plant (52.88%) followed by grain yield per plant (46.19%), harvest index (35.69%) and test weight (27.48%). Moderate estimates of GAM were recorded for plant height (15.77%) and fodder yield (18.16%).

High estimates of heritability and genetic advance as percentage of mean were recorded for test weight (h^2_{bs}: 92.53, GA: 27.48%), number of productive tillers per plant (h^2_{bs} : 86.17, GA: 52.88 %), harvest index (h^2_{bs} : 78.61, GA:35.69%) and grain yield per plant (h^2_{bs} : 78.07, GA:46.19%). High estimates of indicates the predominance of additive gene action. Therefore, phenotypic selection would be more effective for improvement of these traits. These results are in agreement with Yadav *et al.*, (2024) in foxtail millet; Patel *et al.*, (2018) in little millet; Rahul *et al.*, (2024) in browntop millet for number of productive tillers per plant and grain yield per plant; Smita *et al.*, (2016) and Patel *et*

Table 2. Mean, range, variability, heritability (broad sense) and genetic advance as per cent of mean of the characters

S. No	Character	Mean	Range		Coefficient of variation		Heritability (broad sense) (%)	Genetic advance as % of mean
			Minimum	Maximum	GCV (%)	PCV (%)		
1.	Plant height (cm)	76.33	54.00	94.45	9.20	11.06	69.26	15.77
2.	Number of productive tillers per plant	9.56	4.78	15.10	27.66	29.80	86.17	52.88
3.	Days to 50% flowering	57.55	54.00	60.00	2.19	2.55	73.59	3.86
4.	Panicle length (cm)	12.70	9.64	15.50	8.12	13.74	34.93	9.88
5.	Days to maturity	87.98	84.50	90.50	1.43	1.74	67.66	2.43
6.	Test weight (g)	3.51	2.46	4.25	13.87	14.42	92.53	27.48
7.	Fodder yield per plant (g)	20.47	16.55	24.39	10.06	11.48	76.77	18.16
8.	Grain yield per plant (g)	7.22	3.65	12.43	25.37	28.71	78.07	46.19
9.	Harvest index (%)	25.85	14.20	38.38	19.54	22.04	78.61	35.69

al. (2018) in little millet for test weight and Katara *et al*. (2019) for harvest index in little millet.

The results highlight that traits *viz.,* number of productive tillers per plant, grain yield per plant, harvest index and test weight exhibit considerable genetic variability, high heritability coupled with significant genetic advance, making them ideal traits for improvement through selection. These findings underscore the importance of integrating variability measures with heritability and genetic gain estimates to formulate effective breeding strategies.

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Andhra Pradesh J Agril. Sci : 11(3): 206-211, 2025

BIOFERTILIZER SUPPLY CHAIN: RISKS AND CHALLENGES

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Date of Receipt: 14-07-2025 Date of Acceptance: 22-08-2025

ABSTRACT

The transition toward sustainable agriculture has increased the adoption of biofertilizers as an eco-friendly alternative to chemical fertilizers in paddy cultivation. This study investigates the biofertilizer supply chain originating from the Regional Agricultural Research Station (RARS), Tirupati, and evaluates associated risks using a hybrid approach of Petri Nets and Failure Mode Effects and Criticality Analysis (FMECA). Two key distribution pathways were assessed: Pathway 1 (via Krishi Vigyan Kendras and DAATT Centres) and Pathway 2 (direct supply to farmers). Petri Net models were used to visualize supply flows, while FMECA identified and ranked potential failure modes based on their severity, occurrence and detection difficulty. The most critical risks included delays in input supply at the production level (RPN = 336), limited rural supply centres (RPN = 280), and distribution inefficiencies through intermediaries (RPN = 224). Comparative analysis revealed that Pathway 2 was more efficient and resilient, offering better quality control, reduced delivery delays and improved farmer outreach. The study concludes that direct distribution, combined with expanded supply infrastructure and targeted farmer training, can significantly enhance biofertilizer adoption and support sustainable rice production in Andhra Pradesh..

KEYWORDS: Biofertilizers, Supply Chain, Petri Nets, FMECA, Risk Analysis.

INTRODUCTION

Agriculture remains one of the most vital human activities, essential for ensuring food security and sustaining livelihoods. Among food crops, rice (*Oryza sativa* L.) holds a critical role as the staple food for more than half of the global population, especially in Asia. In India, rice production has shown a consistent upward trend, with an estimated output of 13.78 lakh tonnes in 2023–24, an increase of over 20 lakh tonnes from the previous year (Ministry of Agriculture and Farmers Welfare, 2023). Projections indicate that global rice production needs to reach 3.9 billion tonnes by 2030 and over 4.1 billion tonnes by 2050 to meet the growing food demand (Garai *et al*., 2013; Mohanty *et al*., 2013). To address this challenge, the agricultural sector has increasingly relied on inputs such as chemical fertilizers and pesticides to enhance productivity. However, the excessive use of such inputs poses significant environmental risks and threatens long-term soil health and ecosystem stability. In response, there is a growing emphasis on integrated nutrient management strategies that combine chemical inputs with sustainable alternatives like biofertilizers. Biofertilizers enhance crop yields, improve soil fertility, and reduce environmental harm, making them an essential component of sustainable rice production.

India has significantly ramped up biofertilizer production in recent years. In 2020–21, the country produced 1,34,323 tonnes of solid carrier-based biofertilizers and 26,442 kilolitres of liquid biofertilizers. These numbers increased to 1,69,379 tonnes and 2,32,934 kilolitres respectively in 2021–22 (Khurana & Kumar, 2022). Notably, South India, including Andhra Pradesh, contributes a major share to this production. In Andhra Pradesh, ANGRAU (Acharya N.G. Ranga Agricultural University) plays a pivotal role in the biofertilizer supply chain by producing and distributing biofertilizers to farmers at affordable prices under initiatives like RKVY (Rashtriya Krishi Vikas Yojana). ANGRAU produces and markets seven types of biofertilizers through schemes like NFSM and NMOOP, with a total production capacity of 650 MT (solid) and 600 MT (liquid) annually. These biofertilizers are distributed through a supply chain that originates from RARS (Regional Agricultural Research Station), Tirupati, reaching farmers across the state.

MATERIAL AND METHODS

Petri nets Frame Work

In this study, a hybrid framework combining Petri Nets (PN) and Failure Mode Effects and Criticality Analysis (FMECA) was employed to model, simulate and analyse risks in the supply chain network of biofertilizers

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originating from RARS, Tirupati. This approach was chosen due to its capacity to effectively handle dynamic, concurrent, and distributed systems, particularly under conditions of uncertainty and disruption, as commonly observed in agricultural supply chains.

Petri Nets are a powerful modelling tool that represent systems both graphically and mathematically, making them particularly suitable for understanding the flow of materials and information. A Petri Net consists of places, transitions, and tokens. In the supply chain context:

- Places (represented as circles) correspond to conditions or system states such as inventory availability, transportation status, or farmer-level delivery.
- Transitions (represented as bars or rectangles) indicate events or activities such as dispatching, delivery, or restocking.
- Tokens are dynamic elements used to simulate the movement of goods or information, enabling real-time analysis of concurrency and workflow.

The PN model provides a visual and analytical framework that captures the sequence and interdependence of supply chain activities. Its strength lies in modelling asynchronous and parallel events while also allowing for simulation of disruption scenarios.

This model was developed to track the biofertilizer flow from production at ANGRAU to delivery to farmers. It enables continuous monitoring and highlights disruptions such as delays in transport, supply shortages or increased demand. The model facilitates decision-making by providing real-time system status and impact assessment of different risk scenarios.

Risk Analysis Using FMECA

To complement the Petri Net model and enhance risk analysis, the Failure Mode Effects and Criticality Analysis (FMECA) method was integrated. FMECA is a widely recognized technique in reliability engineering, used to identify, evaluate and prioritize potential failure modes in a system. It provides a structured approach to anticipate possible failures in the supply chain and design mitigation strategies accordingly.

The FMECA process in this study followed four main steps:

1. Risk Identification: The potential risks in the biofertilizer supply chain such as production delays, poor storage conditions or inadequate transportation were identified through field observations and stakeholder interviews.

2. Risk Assessment: Each identified failure mode was evaluated using three parameters:

Severity (S): The seriousness of the effect of the failure.

Occurrence (O): The likelihood of the failure happening.

Detection (D): The likelihood of the failure being detected before it impacts the supply chain.

3. Risk Prioritization: The three factors were multiplied to calculate the Risk Priority Number (RPN) using the formula:

$$RPN_i = S_i \times O_i \times D_i$$

where,

RPN_i is the risk priority number for the ith subsystem,

S_i is the severity index,

O_i is the probability of occurrence, and

D_i is the detection difficulty.

Higher RPN values indicate more critical risks requiring immediate attention. This step allowed for the identification of bottlenecks and vulnerabilities in the system, directing focus toward high-impact failure modes.

4. Risk Mitigation and Monitoring: For risks with high RPN values, mitigation strategies were proposed, such as improving storage conditions, optimizing transportation schedules or increasing communication efficiency among supply chain actors. The model also supports ongoing risk monitoring, enabling dynamic response to emerging threats.

RESULTS AND DISCUSSION

The supply chain of biofertilizers from the Regional Agricultural Research Station (RARS), Tirupati, is a crucial component in promoting sustainable agriculture in Andhra Pradesh. This supply chain has been analysed as part of ANGRAU's initiative to encourage the adoption of biofertilizers among paddy farmers. The study focuses on two primary distribution pathways: one involving intermediary agencies (Pathway 1) and the

Table 1. Application of FMECA to the Pathway 1 of supply chain process

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
Entity/ Process Step	Potential failure/ Error model	Potential effect(s) of failure	Severity Index (S)	Potential cause(s) of failure	Probability of occurrence (O)	Detection/ current controls	Detection score (D)	Risk Priority Number (RPN)
Biofertilizers Production level	Quality control	Harmful effect on crops	5	Ineffective microbial cultures, Improper testing	6	Implement batch testing	6	180
	Lack of storage	Biofertilizers degrade, ineffective application, financial loss to farmers	7	Lack of temperature control, poor ventilation, improper monitoring	6	Periodic stock checks, manual temperature monitoring	5	210
	Lack of timely availability of inputs in Production	Increasing operational costs, Delay in production	8	Quality issues, weather condition, lack of skilled persons	7	Quality control checkpoints, hiring skilled persons	6	336
Intermediary agencies	Storage problems	Biofertilizers degrade, ineffective application, financial loss for farmers	7	Lack of temperature control, poor ventilation, improperMonitoring	6	Periodic stock checks, manual temperature monitoring	4	168
	Delay in supply	Reduced crop yield and productivity	8	Farmers mis -application of biofertilizers and forced to use chemical fertilizers	7	Farmer grievance mechanisms and Periodic review meetings on supply progress	4	224
	Transportation problems	Lower quality and reduced viability	7	packaging failures, mechanical strain, or damage on rural roads	6	Sturdypackaging, damage resistant containers, and utilizing suitable transport options	5	210
Farmers	Limited supply centres	Interruptions in supply of biofertilizers	7	Timely supply of biofertilizers is not available	7	Increase of supply centres in rural areas	5	245
	Technical Guidance	Inappropriate usage of biofertilizers	6	Insufficient farmer trainings	7	Conduct Field demonstrations and training programmes	4	168
	Do not show Immediate results	No profit maximization	8	Slow impact of microbial activity in soil	6	Applying the biofertilizers at right time and right quantity	3	144

other involving direct sales to farmers (Pathway 2). To understand the interactions and flow of biofertilizers, a Petri Net model was developed, and a comprehensive risk assessment using Failure Mode, Effects and Criticality Analysis (FMECA) was conducted.

Flow of Biofertilizer Supply Chain

The supply chain is structured into two main channels:

Pathway 1

RARS → Intermediary Agencies (KVK's, DAATT Centres) → Farmers

Pathway 2

RARS → Farmers (Direct supply, no intermediaries)

Brief view of Pathways

Pathway 1: The supply of biofertilizers begins at the Regional Agricultural Research Station (RARS). RARS provides biofertilizers directly to Krishi Vigyan Kendras (KVK's) and DAATT Centres. These act as authorized distribution points in the supply chain. From the KVK's and DAATT Centres biofertilizers are further distributed to farmers engaged in paddy cultivation.

Pathway 2 : Some farmers visit RARS and directly buy the biofertilizers for cultivation of paddy without any intermediaries.

Places: RARS (production), Farmers (end-users)

Transition: Intermediary agencies (KVKs, DAATT Centres) present in Pathway 1

Arcs: Represent the transfer of biofertilizers between stages.

Risk Identification and Analysis

To identify key risks in the supply chain, stakeholder interviews were conducted and FMECA tables were developed for both pathways. Each subsystem (production, intermediary agencies, and farmers) was analysed for potential failure modes, their effects, causes, severity, occurrence, detection difficulty and recommended mitigation measures. The Risk Priority Number (RPN) was used to rank the criticality of each failure mode.

From Table 1, in pathway 1, the biofertilizer supply chain involves three key stakeholders: the production unit, intermediary agencies (KVKs and DAATT Centres) and farmers. At the production level, the most critical failure mode was the lack of timely input supply (RPN = 336), caused by supplier delays, weather variability and labour shortages. This was followed by inadequate storage (RPN = 210) and quality control failures (RPN = 180), which can compromise microbial viability and crop outcomes. At the intermediary level, significant risks included delays in supply (RPN = 224), transportation issues due to poor packaging and road conditions (RPN = 210) and suboptimal storage environments (RPN = 168), all of which reduced the effectiveness and timely

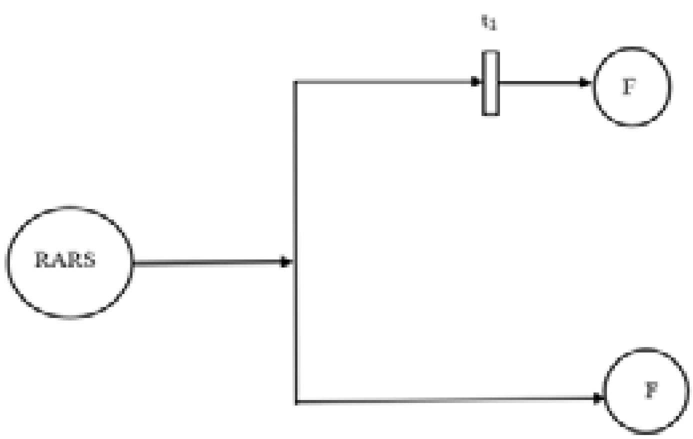

Fig. 1. Graphical representation of petri nets supply chain of biofertilizers in RARS, Tirupati district of Andhra Pradesh.

Table 2 Application of FMCEA to the pathway 1 of supply chain process

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
Entity/ Process Step	Potential failure/ Error mode	Potential effect(s) of failure	Severity Index (S)	Potential cause(s) of failure	Probability of Occurrence(O)	Detection/current controls	Detection score (D)	Risk Priority Number (RPN)
Biofertilizers Production level	Quality control	Harmful effect on crops	5	Ineffective microbial cultures, Improper testing	6	Implement batch testing	6	180
	Lack of storage	Biofertilizers degrade, ineffective application, financial loss for farmers	7	Lack of temperature control, poor ventilation, improper monitoring	6	Periodic stock checks, manual temperature monitoring	5	210
	Lack of timely inputs	Increasing operational costs, Delay in production	8	Supplier disruptions, weather variability, lack of skilled persons	7	Quality control checkpoints, hiring skilled persons	6	336
Farmers	Limited supply centres	Interruptions in supply of biofertilizers	8	Timely supply of biofertilizers is not available	7	Increase of supply centres in rural areas	6	280
	Technical Guidance	Inappropriate usage of biofertilizers	5	Insufficient farmer trainings	6	Conduct Field demonstrations and Training programmes	3	168
	Slow results	No profit maximization	8	Slow impact of microbial activity in soil	6	Applying the biofertilizers at right time	3	144
	Locational Barrier	Delay in rate of adoption of biofertilizers	7	Lack of information on availability of biofertilizers	5	Implement mobile input vans	5	175

availability of biofertilizers. At the farmer level, limited access to supply centres (RPN = 245) was the most pressing issue, alongside insufficient technical guidance (RPN = 168) and the perception of delayed results (RPN = 144). Overall, the highest risks in this pathway stem from production delays and access constraints, while moderate risks related to storage, transportation, and farmer awareness can be mitigated through infrastructure improvements, supply chain coordination, and farmer training initiatives. These findings are similar with Ahu *et al*. (2016) study revealed critical failure modes such as supplier delivery delays and lack of skilled manpower. These risks had high Risk Priority Numbers (RPNs), indicating significant impacts on supply chain performance.

From Table 2, in pathway 2, the biofertilizer supply chain involves only two key stakeholders: the production unit (RARS, Tirupati) and farmers, making it a more streamlined model. At the production level, the critical risks mirrored those in Pathway 1, with the most severe being delays in input supply (RPN = 336), followed by inadequate storage (RPN = 210) and quality control failures (RPN = 180), all of which impact the quality and availability of biofertilizers. At the farmer level, the most pressing issue was limited access to supply centres (RPN = 280), which restricts timely procurement. Other moderate risks included lack of technical guidance (RPN = 168), slow or delayed results from application (RPN = 144) and locational or awareness barriers (RPN = 175). Despite these risks, Pathway 2 proved to be more effective than Pathway 1. Direct distribution from the production unit ensured better quality control, reduced intermediary-induced delays, and allowed for more efficient farmer training and technical support. This integrated system enhanced both product reliability and farmer adoption. Overall, the simplified structure and direct engagement with farmers made Pathway 2 more robust and sustainable model for biofertilizer supply. These findings are similar with Shanks *et al*., (2020).

This study assessed the supply chain of biofertilizers from the Regional Agricultural Research Station (RARS), Tirupati, using a combination of Petri Net modelling and Failure Mode Effects and Criticality Analysis (FMECA). Two distribution pathways were evaluated: one involving intermediary agencies such as KVKs and DAATT Centres (Pathway 1), and another involving direct distribution to farmers (Pathway 2). The most critical failure identified in both pathways was the delay in the availability of raw inputs at the production stage (RPN = 336), followed by storage and quality control issues. In Pathway 1, risks extended further down the chain, with significant problems including delays at intermediary agencies (RPN = 224), limited supply centres (RPN = 245) and inadequate technical guidance for farmers (RPN = 168), all contributing to reduced accessibility and adoption of biofertilizers.

In contrast, Pathway 2 demonstrated greater efficiency and resilience due to its simplified structure, involving only the production unit and farmers. While it shared similar production-level risks, the absence of intermediaries reduced potential delays and maintained better product quality. Direct engagement between RARS scientists and farmers improved technical guidance and adoption outcomes. The most pressing issue in this model remained the limited number of supply points (RPN = 280), though this can be addressed through mobile distribution units and local depots. Overall, the findings suggest that Pathway 2 is a more robust model for biofertilizer distribution, offering improved reliability, better farmer support and higher potential for sustainable agricultural impact in Andhra Pradesh.

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Andhra Pradesh J Agril. Sci : 11(3): 212-217, 2025

OPTIMIZING PHOSPHORUS NUTRITION IN GROUNDNUT THROUGH NANO DAP BASED FOLIAR FEEDING

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Date of Receipt: 26-07-2025 Date of Acceptance: 01-08-2025

ABSTRACT

A field experiment was conducted at Agricultural Research Station, Kadiri, during Rabi, 2024-25 to evaluate the effect of nano DAP on the growth and yield of groundnut. The experiment consists of 50% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS (T_1), 50% recommended dose of P_2O_5 + Two sprays of Nano-DAP at 30-35 and 50-55 DAS (T_2), 75% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS (T_3), 75% recommended dose of P_2O_5 + Two sprays of Nano-DAP at 30-35 and 50 -55 DAS (T_4), 100% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS (T5), 100% recommended dose of P_2O_5 + Two sprays of Nano-DAP at 30-35 and 50-55 DAS (T_6), Foliar application of Nano-DAP @ 2.5 ml l -1 twice at 30-35 and 50-55 DAS (T_7), 100% RDP (40 kg P_2O_5 ha^{-1}), (T_8) and Absolute control (T_9). This experiment was laid out in RBD with nine treatments and three replications. Various levels of nano DAP treatments were evaluated. Among the tested treatments application of 100% recommended dose of P2O5 along with two sprays of Nano-DAP@ 2.5 ml l-1 at 30-35 and 50-55 DAS (T_6) recorded Significantly higher plant height, leaf area index, dry matter production and yield attributes pod and haulm yield. The results indicates that improved phosphorus availability and uptake efficiency due to the synergistic effect of soil-applied phosphorus and foliar-feed nano DAP. The nano form of DAP likely ensured better nutrient absorption through the foliage, reduced nutrient losses and enhanced physiological activity, contributing to better vegetative growth and reproductive development.

KEYWORDS: Foliar nutrition, nano DAP, groundnut.

INTRODUCTION

Groundnut is the king of vegetable oilseed crops. It is the 4th most important source of edible oil and 3rd most important source of vegetable protein in India. It is a versatile legume oil seed crop, belong to Leguminaceae family and originated in Brazil. Groundnut plays an important role in meeting the demand of edible oil across the world and is popularly named as monkey nut, earth nut, unpredictable legume and energy capsule. India is the top producing nation in the world accounting to about 39.3 % area, with 27.3 % production. In India it is cultivated over 4.9 m ha in India, with a production of 9.25 m ha and with an average productivity of 1893 kg ha^{-1}. Andhra Pradesh produces around 0.6 million tonnes from an area of 0.59 million ha, with productivity of 1011 kg ha^{-1}(Directorate of Economics and Statistics, Andhra Pradesh, 2022-2023). Groundnut seed contains 47-50% oil, 26% protein and 11.5 % of starch (Noubissié *et al*. 2012). Groundnut oil, valued for its sweet flavour, is commonly used in cooking and to improve groundnut yield and quality the use of nano DAP has shown great potential. Nano DAP supplies essential nutrients nitrogen (N) and phosphorus (P) in nano-sized particles, which enables more efficient absorption and utilization by plant cells through foliar application. Unlike conventional DAP, nano DAP ensures precise and efficient nutrient delivery, minimizing losses caused by leaching, fixation or volatilization. When applied during key growth stages nano DAP significantly enhances photosynthesis, root growth, and flowering, thereby promoting healthier plants and improved crop productivity. This experiment was conducted with a focus on improving soil health by minimizing excessive chemical fertilizer inputs and enhancing nutrient balance in the cropping system. The use of nano DAP, due to its higher efficiency and lower application rate helps to reduce the environmental footprint of phosphorus fertilization particularly by mitigating the risk of eutrophication of water bodies caused by phosphorus runoff. Additionally, the improved nutrient use efficiency leads to cost savings for farmers and contributes to the reduction of soil and environmental pollution, supporting the goals of sustainable agriculture.

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MATERIAL AND METHODS

Experimental Details

Experimental site

The experiment was conducted at the Agricultural Research Station, Kadiri during Rabi, 2024- 25. The soils of the experimental site are sandy loam in texture, neutral pH (7.0) and non-saline (EC: 0.42 dSm-1), low in organic carbon (0.27 %) and available nitrogen (206.62 kg ha^{-1}), medium in available phosphorus (36.5 kg ha^{-1}) and potassium (232.15 kg K_2O ha^{-1}).

Statistical analysis of results

The field experiment was conducted in a Randomized Block Design (RBD) involving nine treatments and three replications with a plot size of 4.5 m × 5.0 m. The collected data were statistically analysed using the analysis of variance (ANOVA)for Randomized Block Design as suggested by Panse and Sukhatme (1985). Statistical significance was tested with 'F' value at five per cent level of probability. Critical difference (CD) for the significant source of variation was calculated at five per cent level of significance. The treatmental differences those were non-significant were denoted by "NS". The treatments consisted of 50% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS (T_1), 50% recommended dose of P_2O_5 + Two sprays of Nano-DAP at 30-35 and 50-55 DAS (T_2), 75% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS (T_3), 75% recommended dose of P_2O_5 + Two sprays of Nano-DAP at 30-35 and 50 -55 DAS (T_4), 100% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS (T_5), 100% recommended dose of P_2O_5 + Two sprays of Nano-DAP at 30-35 and 50-55 DAS (T_6), Foliar application of Nano-DAP @ 2.5 ml l -1 twice at 30-35 and 50-55 DAS (T_7), 100% RDP (40 kg P_2O_5 ha^{-1}), (T_8) and Absolute control (T_9). Recommended dose of fertilizer (30:40:50 kg of N: P2O5: K2O ha^{-1}). Seeds of groundnut (Kadiri -6) were sown in 22.5 × 10.0 cm spacing with ridge and furrow method.

RESULTS AND DISCUSSION

Growth Attributes

Plant height (cm)

P_2O_5 along with two foliar sprays of nano DAP 2.5 ml l-1 at 30-35 and 50-55 DAS (T_6) recorded maximum plant height at harvest compared to other treatments tried (Table 1). The significant variation in plant height across treatments indicates that phosphorus, particularly when supplemented with foliar application of nano DAP, promotes early vegetative growth. The increase in plant height can be attributed to the role of phosphorus in enhancing cell division and cell expansion, along with stimulation of biological activity of photosynthetic pigments and enzymes, thereby improving biomass accumulation and potentially contributing to better yield attributes. Similar observations were recorded by Chinnappa *et al*. (2023). The absolute control (T_9) noticed shortest plants of groundnut at harvest.

Leaf area index

The leaf area index (Table 1) was recorded higher with the application 100 % recommended P_2O_5 along with two foliar sprays of nano DAP 2.5 ml l-1 at 30-35 and 50-55 DAS (T_6) at harvest and however it was on par with application of 100% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS (T_5). Due to a combination of enhanced nutrient uptake, improved root and leaf development, better photosynthesis, and increased plant resilience can be observed. The efficient and sustained nutrient release provided by nano-DAP, along with other nutrients provides plants with the resources they need to expand their leaf area, which in turn supports greater photosynthetic capacity and overall plant productivity. Basal fertilizer to the soil and as foliar application had a positive influence on leaf area index. Similar findings were observed with Mahachandramuki *et al*. (2023). The absolute control (T_9) noticed a minimum leaf area index at harvest.

Dry matter accumulation

Dry matter accumulation was higher (Table 1) with application of 100% recommended P_2O_5 along with two foliar sprays of nano DAP 2.5 ml l-1 at 30-35 and 50-55 DAS (T_6) was on par with 100% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS (T_5) Significant increase in dry matter was due to increased photosynthesis, which transforms sunlight, CO_2 and water into glucose and other key compounds that boost overall biomass.

Nano fertilizers results in better absorption of nano nutrients and photosynthetic activity. Both will enhance vegetative growth due to proper supply of nutrients and accumulation of dry matter in leaves, the photosynthetic

Table 1. Growth parameters of groundnut as influenced by different levels of phosphorus and nano DAP

Treatments	Plant height (cm)	Leaf area index	Dry matter production (kg ha^{-1})
T_1 : 50% recommended dose of P_2O_5 + One spray of nano-DAP at 30-35 DAS	25.67	2.10	6481
T_2 : 50% recommended dose of P_2O_5 + Two sprays of nano-DAP at 30-35 and 50-55 DAS	26.63	2.12	6528
T_3 : 75% recommended dose of P_2O_5 + One spray of nano-DAP at 30-35 DAS	28.93	2.47	7425
T_4 : 75% recommended dose of P_2O_5 + Two sprays of nano-DAP at 30-35 and 50-55 DAS	30.13	2.48	7425
T_5 : 100% recommended dose of P_2O_5 + One spray of nano-DAP at 30-35 DAS	34.67	2.81	8326
T_6 : 100% recommended dose of P_2O_5 + Two sprays of nano-DAP at 30-35 and 50-55 DAS	35.10	2.92	8371
T_7 : Foliar application of nano-DAP @ 2.5 ml l^{-1} twice at 30-35 and 50-55 DAS	21.13	1.78	5599
T_8 : 100% RDP (40 kg P_2O_5ha^{-1})	30.80	2.48	7444
T_9 : Absolute control	20.83	1.76	5550
SEm±	1.149	0.100	87.6
CD (P=0.05)	3.47	0.30	265

Table 2. Pod yield and haulm yield of groundnut as influenced by different levels of phosphorus and nano DAP

Treatments	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1 : 50% recommended dose of P_2O_5 + One spray of nano-DAP at 30-35 DAS	1978	3292
T_2 : 50% recommended dose of P_2O_5 + Two sprays of nano-DAP at 30-35 and 50-55 DAS	1989	3384
T_3 : 75% recommended dose of P_2O_5 + One spray of nano-DAP at 30-35 DAS	2189	3812
T_4 : 75% recommended dose of P_2O_5 + Two sprays of nano-DAP at 30-35 and 50-55 DAS	2247	3902
T_5 : 100% recommended dose of P_2O_5 + One spray of nano-DAP at 30-35 DAS	2721	4619
T_6 : 100% recommended dose of P_2O_5 + Two sprays of nano-DAP at 30-35 and 50-55 DAS	2738	4753
T_7 : Foliar application of nano-DAP @ 2.5 ml l^{-1} twice at 30-35 and 50-55 DAS	1767	2702
T_8 : 100% RDP (40 kg P_2O_5ha $^{-1}$)	2421	4079
T_9 : Absolute control	1581	2512
SEm±	98.5	151.7
CD (P=0.05)	304	458

area remains active for longer period and was responsible for growth of plant in terms of dry matter. Application of nutrients in combination increased the supply of required required nutrients for growth and development which resulted in higher dry matter accumulation in the reproductive parts and formation of higher sink capacity. Nano DAP was helpful for efficient nutrient transportation that enhances nutrient availability directly to plant tissues, promoting better growth (Khandare *et al*., 2024). The absolute control (T_9) noticed least dry matter production at harvest.

Yield Attributes

Pod yield (kg ha^{-1})

Response of nano DAP has significant effect on pod and kernel yield of groundnut (Table 2). Higher pod and haulm yield (2738 and 4753 kg ha^{-1}) of groundnut was recorded with application of 100 % recommended dose of P_2O_5 along with two foliar sprays of nano DAP 2.5 ml l-1 at 30-35 and 50-55 DAS (T_6), which was comparable with application of 100% recommended dose of P_2O_5 + One spray of Nano-DAP at 30-35 DAS (T_5). The increase in pod yield of groundnut with phosphorus and nano DAP application might be due to enhanced nutrient use efficiency, improved root and shoot growth, better flowering and pod formation and overall healthier plant development. Nano DAP boosts phosphorus availability and uptake, leading to better yields with lower input costs and supports optimal growth and metabolic processes such as photosynthesis which promotes the accumulation and translocation of photosynthates to the plant economic parts, resulting in higher yields and better translocation of assimilates to the reproductive parts leds to higher pod yield. Similar results were reported by Sagar *et al*. (2021). The absolute control (T_9) recorded lower pod yield of groundnut.

Haulm yield (kg ha^{-1})

Among the various treatments evaluated (Table 2) Application of 100 % recommended P_2O_5 along with two foliar sprays of nano DAP 2.5 ml l-1 at 30-35 and 50-55 DAS (T_6) recorded higher haulm yield of groundnut which was comparable with 100% recommended dose of P_2O_5 along with one foliar spray of nano DAP at 30–35 DAS (T_5). The positive effects of phosphorus and nano DAP on haulm yield might be due to pronounced role of nitrogen and phosphorus in cell elongation and photosynthesis leds to higher growth parameters and higher haulm yield. Similar findings were reported with Rajput *et al*. (2022) and Mallikarjuna (2021). The application of nutrients such as nitrogen, phosphorus through foliar nutrition may boost protoplasmic components, which are crucial for physiological processes like chlorophyll and protein synthesis, ultimately leading to increase in haulm yield. The lowest haulm yield was recorded with absolute control (T_9) due to limited availability of nutrients.

Application of 100% recommended dose of P_2O_5 as basal combined with two foliar sprays of Nano DAP @ 2.5 ml l^{-1} at 30-35 and 50–55 days enhanced the plant height, leaf area index and dry matter production. Significantly higher pod yield and haul yield was recorded with same treatment. By improving efficiency and sustainability, nano DAP aligns with modern agricultural goals and offers a pathway toward more productive and eco-friendly farming systems.

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Andhra Pradesh J Agril. Sci : 11(3): 218-225, 2025

SURVEY FOR THE INCIDENCE OF SUCKING PEST COMPLEX AND VIRAL DISEASES OF SUNFLOWER IN Y.S.R KADAPA AND KURNOOL DISTRICTS OF ANDHRA PRADESH

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Date of Receipt: 08-07-2025 Date of Acceptance: 26-07-2025

ABSTRACT

A roving survey was carried out in sunflower cultivating areas of Y.S.R Kadapa and Kurnool districts of Andhra Pradesh during rabi, 2024 to know the incidence of sucking pests complex and incidence of viral diseases in sunflower. From the selected districts, different mandals, *viz.,* Thondur, Jammalamadugu, Peddamudiyam, Pattikonda, Yemmiganur and Nandavaram were surveyed randomly for the incidence of sucking pests and viral diseases at crop growth period. Results revealed that whitefly and leafhopper population were more when compared to thrips. The highest mean number of whitefly population per six leaves was recorded in mandal of Thondur (8.69) during the month of January in Y.S.R Kadapa district and followed by Jammalamadugu (8.36). The highest mean number of leafhopper population was recorded in mandal of Jammalamadugu (9.20) during the month of January in Y.S.R Kadapa district and followed by Peddamudiyam (8.78). The highest mean number of thrips population was recorded in mandal of Peddamudiyam (6.79) during the month of January in Y.S.R Kadapa district and followed by Jammalamadugu (6.01). The incidence of viral disease was recorded highest in Thondur mandal with 15.16 % and 12.59 % of leaf curl and necrosis diseases in Y.S.R Kadapa district respectively and among two districts surveyed the highest mean number of whiteflies, thrips and leafhopper population were noticed in Y.S.R Kadapa district. Highest incidence of leaf curl and necrosis i.e, 16.67 % and 12.57 % were observed in Nandavaram mandal of Kurnool district.

KEYWORDS: Sunflower, Sucking pest, whitefly, thrips, leafhopper, viral disease, leafcurl, necrosis.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an annual oilseed crop primarily grown for its edible oil and seeds in temperate and subtropical climates worldwide and native to North America. Sunflower seeds contain different micronutrients, macronutrients, saturated and unsaturated fatty acids, vitamins like B_1 and minerals (Skoric *et al*., 2008). Sunflower oil majorly contains 59% linoleic acid (polyunsaturated omega-6), 30% oleic acid (monounsaturated omega-9), 6% stearic acid and 5% palmitic acid (Avni *et al*., 2016). One of the reasons for this is the occurrence of serious insect pests and viral diseases. Sunflower is attacked by nearly 250 species of insects (Basappa and Santha Lakshmi Prasad, 2005). Thrips Thrips palmi (Karny), leafhoppers Amrasca biguttula biguttula (Ishida), whiteflies Bemisia tabaci (Gennadius) are the major sucking pests contributing to yield loss. Thrips attack tender plant parts, result in stunted growth in addition to transmission of the necrosis disease (Chander Rao, 2002). Leaf hoppers (Amrasca biguttula biguttula) suck sap (Jayewar *et al*., 2018) leading to hopper burn symptoms. Recently, whitefly Bemisia tabaci emerged as a new pest and as a vector of leaf curl begomovirus.

In the recent past, another viral disease caused by a begomovirus has been observed in Northern Karnataka, producing leaf curl symptoms mainly on Sunbreed-275 and KBSH-44 upto 40% and 10% respectively (Govindappa *et al*., 2011). Similar kind of disease symptoms were also observed in Aruna and Swathi hybrids of sunflower predominantly grown in Kurnool district in the past two years where in the disease incidence of 85-90% was recorded. The prominent symptoms are small size and malformed leaves, leaf and veinal thickening, enations and upward leaf curling, emerging leaves exhibits yellow discolouration and severe reduction in leaf size. The early infected plants are stunted with no ear head emergence (Venkataramanamma *et al*., 2022). The disease significantly affects the plant height, head diameter, seed weight and oil percentage (Deepa *et al*., 2015). As per the third advanced estimates of 2023-24 (DES), the acreage under sunflower came down drastically to 1.58 lakh ha^{-1} with estimated production of 1.69 lakh tonnes (ICAR-IIOR Annual Report of Sunflower, 2023-24). In

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India, during 2023-24, sunflower was cultivated in an area of 1.51 lakh ha with 1.72 lakh tonnes of production and 1144 kg ha^{-1} of productivity. Sunflower is grown in all the three cropping seasons - kharif, rabi and summer in Andhra Pradesh. sunflower was cultivated on an area 0.04 lakh ha with 0.038 lakh tonnes of production and 886 kg ha^{-1} of productivity in 2023-24. (https://www.indiastatagri.com/).

MATERIAL AND METHODS

A roving survey was conducted to record the incidence of sucking pest complex in major sunflower growing areas of Andhra Pradesh during rabi season, 2024-2025. The districts covered under this study were Y.S.R. Kadapa and Kurnool districts of Andhra Pradesh during rabi from December 2024 to March 2025. From each district, three mandals and five villages from each mandal were selected based on the sunflower area. From each Village, the survey was undertaken in five farmer fields. In each location five plants were selected randomly in a field. Whitefly, thrips and leafhoppers population were counted in sunflower crop by counting the number of nymphs and adults on six leaves *i.e.,* two at bottom, two at middle and two at the top per plant during vegetative stage to flowering stage. In order to study the symptoms of the disease, healthy sunflower plants and sunflower leaf curl infected plants were compared during roving survey from different locations. The symptoms exhibited by the diseased plants were recorded in various stages of crop growth.

Per cent disease incidence (PDI)

The incidence of the disease was recorded during the survey on naturally infected plants by using following equation as suggested by Wheeler (1969). The zigzag pattern is followed to collect required data in which ten randomly selected plants were evaluated at each location.

$$\text{PDI} = \frac{\text{Total number of plants infected}}{\text{Total number of plants observed}} \times 100$$

RESULTS AND DISCUSSION

Whiteflies (*Bemesia tabaci*): The results of the survey conducted during 2024-25, revealed that, the mean population of whiteflies in different mandals in Y.S.R Kadapa district ranged between 3.25 to 8.14 whiteflies/6 leaves during December to March months and in Kurnool district the mean population ranged from 3.59 to 7.26 whiteflies / 6 leaves (Table 2 & Figure 1). Similar results were observed Kumari *et al*., (2023) on pulses in farmers field from second fortnight of June 2020 and 2021 to first fortnight of October 2020 and 2021 in Mahendergarh, Rewari and Gurugram districts of Haryana. The population whitefly (7.71 whitefly/plant), was more abundant in Gurugram district as compared to Mahendragarh and Rewari districts. Overall survey studies revealed that sucking pest population and its incidence depends on various climatic factors, it's geographic allocation, genotypes and farmer's cultivation practices.

Thrips (Thrips spp.): The mean population of thrips in different mandals in Y.S.R Kadapa district ranged between 3.03 to 5.98 thrips / 6 leaves during December to March months and in Kurnool district mean population ranged from 2.40 to 4.96 thrips / 6 leaves (Table 2 & Figure 1).

Table 1. Locations selected for survey of sucking insect pests on sunflower at Y.S.R Kadapa and Kurnool district of A.P.

S. No.	District	Mandal	Latitude	Longitude
1.	Y.S.R Kadapa	Peddamudiyam	14.870284°	78.397261°
2.		Jammalamadugu	14.823664°	78.321410°
3.		Thondur	14.588736°	78.299753°
4.	Kurnool	Pattikonda	15.377954°	77.435401°
5.		Nandavarm	15.561037°	77.251354°
6.		Yemmiganur	15.824382°	77.530134°

Table 2. Occurrence of sucking pest complex on sunflower in Y.S.R Kadapa and Kurnool district of Andhra Pradesh during *rabi*, 2024-2025

S. No.	District	Mandal	Mean No. of nymphs or adults / 6 leaves / plant											
			December, 2024			January, 2025			February, 2025			March, 2025		
			W	T	L.H	W	T	L.H	W	T	L.H	W	T	L.H
1.	Y.S.R Kadapa	Peddamudiyam	6.33	5.58	5.85	7.36	6.79	8.78	5.14	4.01	5.35	2.99	2.73	4.08
2.		Jammalamadugu	6.27	5.19	7.27	8.36	6.01	9.20	4.89	3.93	5.77	2.98	2.86	4.69
3.		Thondur	5.89	4.46	7.31	8.69	5.15	8.18	4.53	4.34	5.35	3.77	3.50	3.80
		Mean	**6.16**	**5.08**	**6.81**	**8.14**	**5.98**	**8.72**	**4.85**	**4.09**	**5.49**	**3.25**	**3.03**	**4.19**
4.	Kurnool	Pattikonda	5.89	4.02	6.48	7.98	4.82	8.18	5.19	3.24	5.35	4.19	2.44	3.33
5.		Nandavarm	6.33	3.77	5.85	6.42	4.79	5.25	5.83	3.19	4.26	2.99	2.32	3.44
6.		Yemmiganur	6.01	4.40	6.30	7.38	5.27	8.46	4.89	2.83	4.66	3.58	2.43	3.32
		Mean	**6.08**	**4.06**	**6.21**	**7.26**	**4.96**	**7.30**	**5.30**	**3.09**	**4.76**	**3.59**	**2.40**	**3.36**
	Overall mean		**6.12**	**4.57**	**6.51**	**7.70**	**5.47**	**8.01**	**5.08**	**3.59**	**5.13**	**3.42**	**2.72**	**3.78**
	SE(m)±													
	CD (P=0.05)													
	CV (%)													

W : Whitefly (*Bemesia tabaci*)
T : Thrips (*Thrips* spp.)
L.H : Leafhopper (*Amrasca biguttula biguttula*)

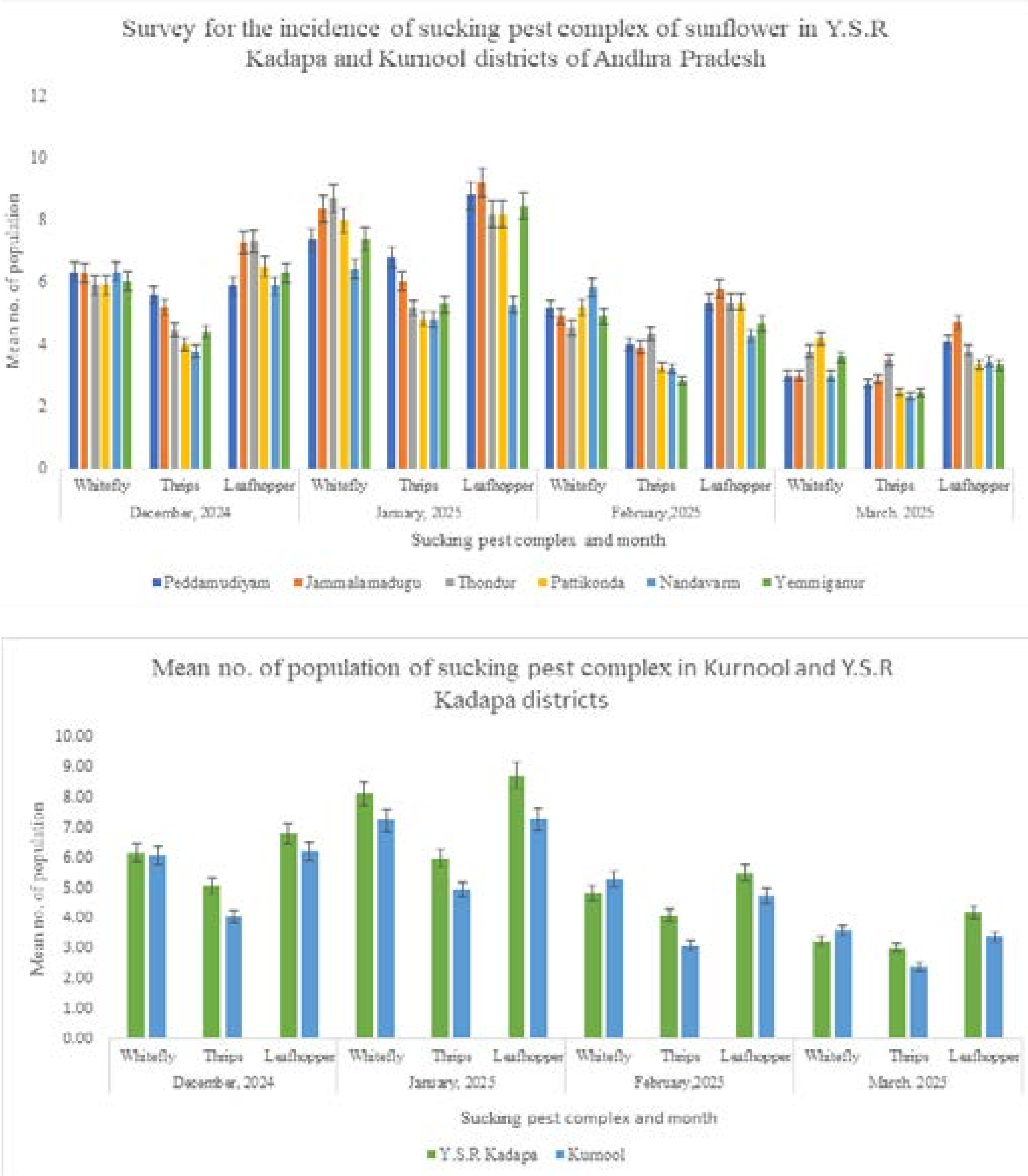
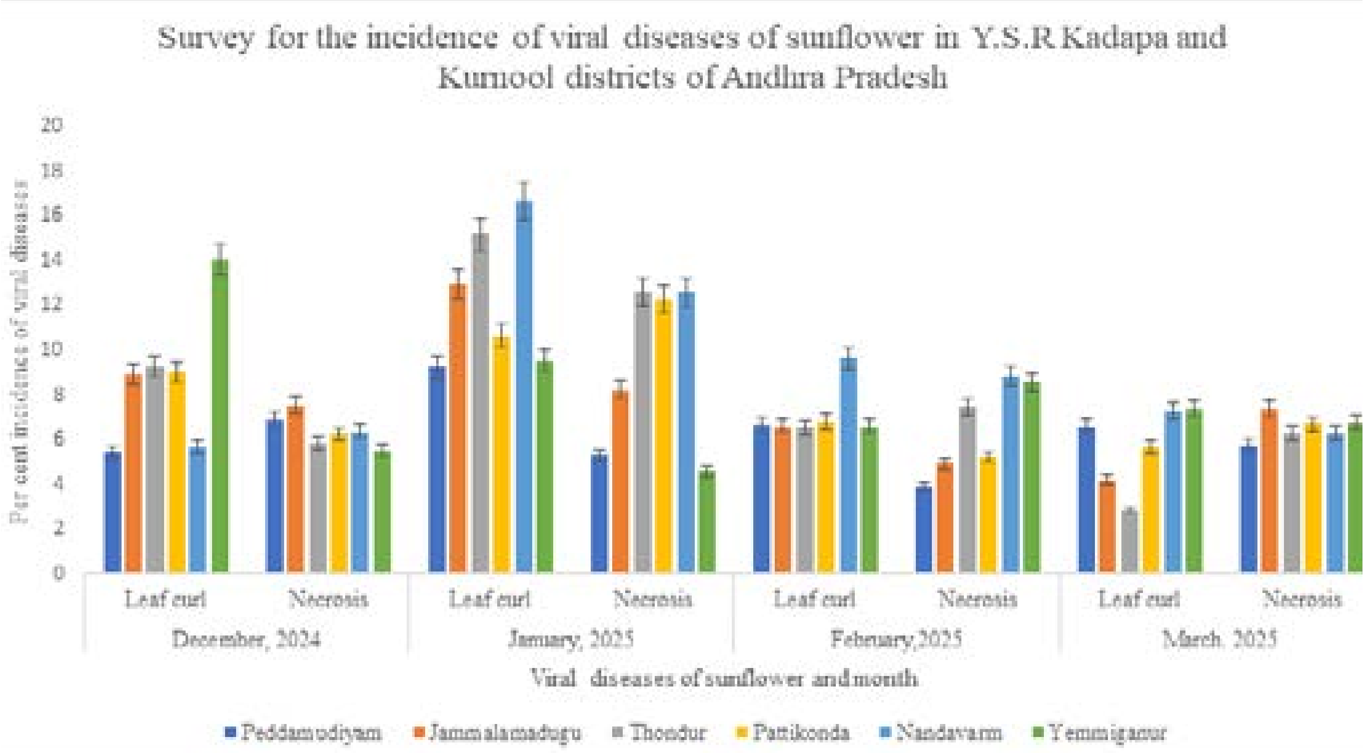


Fig. 1. Survey for the incidence of sucking pest complex in sunflower at Kurnool and Y.S.R Kadapa districts of A.P.

Table: 3 Incidence of viral diseases of sunflower in Y.S.R Kadapa and Kurnool district of Andhra Pradesh during *rabi,* 2024-2025

S. No.	District	Mandal	Diseases of sunflower							
			December, 2024		**January, 2025**		**February, 2025**		**March, 2025**	
			Leaf curl	**Necrosis**	**Leaf curl**	**Necrosis**	**Leaf curl**	**Necrosis**	**Leaf curl**	**Necrosis**
1.	Y.S.R Kadapa	Peddamudiyam	5.45	6.91	9.23	5.33	6.67	3.93	6.62	5.79
2.		Jammalamadugu	8.91	7.57	12.95	8.24	6.62	4.92	4.23	7.36
3.		Thondur	9.26	5.86	15.16	12.59	6.56	7.48	2.84	6.29
		Mean	**7.87**	**6.78**	**12.45**	**8.72**	**6.62**	**5.44**	**4.56**	**6.48**
4.	Kurnool	Pattikonda	9.03	6.26	10.68	12.24	6.81	5.26	5.65	6.71
5.		Nandavarm	5.67	6.37	16.67	12.57	9.66	8.87	7.31	5.67
6.		Yemmiganur	14.06	5.51	9.53	4.59	6.59	8.58	7.36	6.77
		Mean	**9.59**	**6.05**	**12.29**	**9.80**	**7.69**	**7.57**	**6.77**	**6.38**
	Overall mean		8.73	6.42	12.37	9.26	7.16	6.51	5.67	6.43
	SE ± (m)									
	CD(P=0.05)									
	CV (%)									



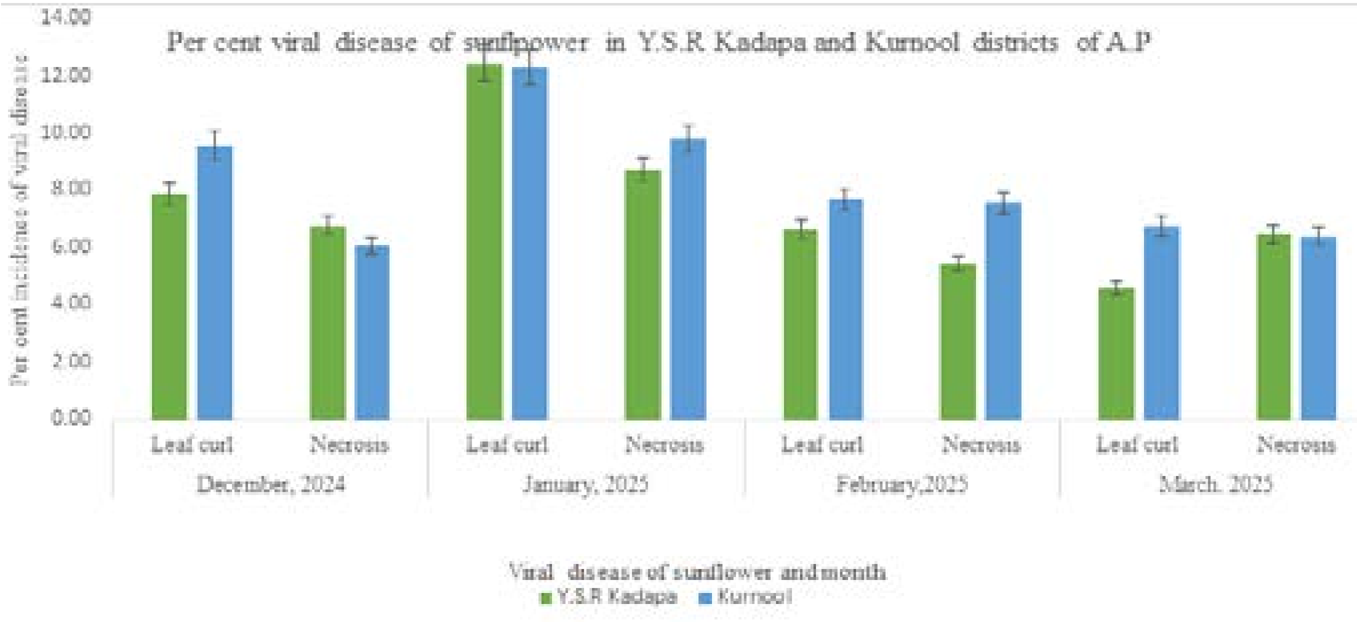


Fig. 2. Per cent viral disease incidence of sunflower in Y.S.R Kadapa and Kurnool districts of Andhra Pradesh

The results are in confirmity with the findings of Nayak *et al*., (2022) who studied on seasonal abundance of insect pests in sunflower in the Western Undulating zone of Odisha during 2019-2020. The sucking pest of thrips appeared at early growth stage of sunflower and continued to build up and attained the peak during 50-51 MW with highest population of 1.80 / leaf.

Leafhoppers (*Amrasca biguttula biguttula*): The mean population of leafhopper in different mandals in Y.S.R Kadapa district ranged between 4.19 to 8.72 leafhopper / 6 leaves during December to March month and in Kurnool district the mean population ranged from 3.36 to 7.30 leafhopper / 6 leaves (Table 2 & Figure 1).

Similar results were observed by Kumari *et al*. (2023) on pulses in farmers field from second fortnight of June 2020 and 2021 to first fortnight of October 2020 and 2021 in Mahendergarh, Rewari and Gurugram districts of Haryana. The population of leafhopper (6.96 leafhopper/plant) was more abundant in Gurugram district as compared to Mahendragarh and Rewari districts.

The present information on the status and diversity of the sucking insect pests of sunflower crop eco systems in Y.S.R Kadapa and Kurnool districts will help to formulate the priority research strategies by researchers. The knowledge on sucking insect pest scenario in sunflower crop ecosystems will also help the extension workers and farmers in deciding the judicious use of insecticides.

Viral disease of leaf curl (Transmitted- whitefly): The per cent incidence of leaf curl viral disease in different mandals in Y.S.R Kadapa district ranged between 4.56 to 12.45 % during December to March months and in Kurnool district the per cent incidence of leaf curl viral disease ranged from 6.77 to 12.99 % (Table 3 & Figure 2).

Similar results were observed Deepa *et al*., (2015) and the experiment was carried out to assess the crop loss due to sunflower leaf curl virus (SuLCV) disease. The crop loss assessment in terms of growth and yield components was recorded at first appearance of symptoms of SuLCV at 30 days to 90 days during the crop growth. The SuLCV disease infection in sunflower significantly affected the plant height (72.60 to 157 cm), size of the head (8.60 to 18.78 cm), 100 seed weight (2.20 to 6.32 g), oil content (31.24% to 38.26%), and weight of seeds/10 heads (77.20 to 372.2 g) as compared to the healthy control plants. In the plants, first appearance of symptoms at 30 DAS was recorded the seed yield loss of 79.25 per cent.

Viral disease of necrosis (Transmitted- Thrips): The per cent incidence of necrosis viral disease in different mandals in Y.S.R Kadapa district ranged between 6.48 to 8.72 % during December to March months and in Kurnool district the per cent incidence of necrosis viral disease ranged from 6.05 to 9.80 % (Table 3 & Figure 2).

The results are in confirmity with the findings of Bestar (2004) who reported that sunflower necrosis virus disease was prevalent in all the sunflower fields visited. The incidence ranged, 1 per cent at Dambal (Gadag) to 65 per cent at Navalgund and Devikoppa (Dharwad). Incidence and severity were higher in the fields grown with ITC-Zeneca sunflower hybrid (PAC-36). Maximum disease was observed in Dharwad district and minimum was recorded at Gadag district.

The results are in confirmity with the findings of Lokesh *et al*., (2008) who conducted a survey to know the sunflower necrosis virus disease and stated that the disease was prevalent in all the sunflower fields with the maximum necrosis disease incidence of 24 per cent in 2005. The highest incidence of necrosis of 22 per cent and high mean thrips numbers 2.42 per five plants was observed on KBSH-1 in Bagepalli taluk in 2006. However, least incidence of necrosis disease was observed in Bangalore (4%), and Shimoga (4%) followed by HD Kote (6%) and Honnalli (6%) during September 2006 and concluded that the disease and the thrips vectors were least during rabi months whereas, it were more in kharif sown crops.

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Andhra Pradesh J Agril. Sci : 11(3): 226-232, 2025

PHYSIOLOGICAL EFFICIENCY OF GROUNDNUT VARIETIES UNDER RAINFED CONDITIONS

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Date of Receipt: 18-07-2025 Date of Acceptance: 21-07-2025

ABSTRACT

A field experiment titled "Physiological Efficiency of Groundnut Varieties Under Rainfed Conditions" was conducted during kharif 2024, using a Randomized Block Design (RBD) with ten groundnut varieties and three replications. The present study assessed physiological efficiency and yield performance of ten groundnut genotypes under rainfed conditions. Parameters such as SPAD Chlorophyll Meter Reading (SCMR), Specific Leaf Area (SLA), Crop Growth Rate (CGR), Relative Growth Rate (RGR), and Net Assimilation Rate (NAR) were recorded at different growth stages. Significant variations among physiological and yield traits were observed across the varieties. Kadiri Lepakshi and Nithyaharitha recorded higher SCMR, indicating better early photosynthetic capacity. Kadiri-6 showed higher SLA and CGR, while Visishta recorded the highest early-stage RGR. Himani and Kadiri Lepakshi exhibited strong NAR during pod-filling. Kadiri Lepakshi also recorded the highest pod yield (3333.3 kg ha-^{1}), highlighting its physiological efficiency and yield potential under rainfed conditions.

KEYWORDS: SPAD Chlorophyll Meter Readings (SCMR), Relative Growth Rate (RGR), Crop Growth Rate (CGR), Net Assimilation Rate (NAR)

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a globally significant oilseed crop, cultivated over an estimated 373 lakh hectares with a total production of 559 lakh tonnes and an average yield of 1,656 kg ha^{-1} (FAOSTAT, 2024). In India, the crop covers 48.80 lakh hectares, producing approximately 102.89 lakh tonnes with a productivity of 1,847.4 kg ha^{-1}. In Andhra Pradesh, the crop is cultivated across 3.66 lakh hectares, yielding about 3.56 lakh tonnes with an average productivity of 1,141 kg ha^{-1} (ANGRAU 2024).

Globally, about 50% of groundnut production is used for oil extraction, 37% for direct consumption, and 12% for seed purposes. Groundnut kernels are a rich source of nutrition, containing high levels of fats (40–50%), proteins (20–28%), and carbohydrates (10–20%), along with essential vitamins and minerals (Sharma *et al*., 2019). Crop Growth Rate (CGR) is directly associated with pod yield, indicating the genotype's efficiency in converting intercepted light into biomass. Elevated CGR during the critical reproductive phases facilitates improved peg development and enhanced pod formation. Similarly, Relative Growth Rate (RGR) indicates initial seedling vigour and rate of early canopy establishment, significantly influencing peg penetration and survival. Varieties exhibiting higher RGR demonstrate vigorous early growth, leading to enhanced peg strength and better pod retention under field conditions. Net Assimilation Rate (NAR), a key indicator of net photosynthetic efficiency, directly influences assimilate availability for reproductive structures such as pegs and pods. Increased NAR during the mid-pod filling stage has been shown to improve kernel growth and pod final weight (Kumari et *al*., 2022). Thus, integrating these growth indices offers a physiological basis for selecting high-yielding groundnut varieties adapted to specific agro ecological environments like rainfed systems of Andhra Pradesh.

MATERIAL AND METHODS

The experiment entitled "Physiological Efficiency of Groundnut Varieties Under Rainfed Conditions" was conducted during kharif, 2024 of dryland farm, S.V. Agricultural College, Tirupati. Ten groundnut varieties were sown in a Randomized Block Design (RBD) with three replications.

Treatments: Groundnut varieties

T_1 – Himani

T_2 – Kadiri- 6

T_3 - Konark

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T_4 – Pragati

T_5 – Visishta

T_6 - Kadiri Lepakshi

T_7 - Dharani

T_8 – Nithyaharitha

T_9 – Dheeraj

T_{10} – Narayani

PHYSIOLOGICAL TRAITS

Observations were recorded for all 10 varieties separately from randomly chosen five competitive plants of each variety for all the three replications. The details of the data recorded were as follows.

SPAD Chlorophyll Meter Reading (SCMR)

SPAD (Soil Plant Analytical Development) Chlorophyll Meter Readings were recorded using Minolta chlorophyll meter (model SPAD 502). The SPAD readings were recorded for the leaf from top of each representative plant, between 10.00 AM to 12.00 Noon of the day by keeping on the different position of the leaf in the slot of the meter head and their average of readings was considered as the value of single plant. The readings of five tagged plants per each plot were averaged and considered as SPAD chlorophyll meter reading for each plot.

Specific Leaf Area (SLA)

Specific leaf area is the mean area of leaf displayed per unit leaf weight. It is the ratio between leaf area to leaf dry weight and expressed in cm2 g^{-1}.

$$\text{SLA} = \frac{\text{Leaf area}}{\text{Leaf dry weight}} \ (\text{cm}^2\ \text{g}^{-1})$$

Crop Growth Rate (CGR)

Crop growth rate indicates the dry matter production by a plant community per unit area per unit time. It is used for the determination of production efficiency of a crop. It was estimated using the formula provided by Watson (1952) and expressed in gm^{-2} day-1.

$$\text{CGR} = \frac{1}{\text{P}} \times \frac{\text{w}_2 - \text{w}_1}{\text{t}_2 - \text{t}_1} \ (\text{g m}^{-2}\text{day}^{-1})$$

where,

W_1 and W_2 = dry weights at two sampling times t_1 and t_2, respectively.

t_2 and t_1 = sampling time in days

P = ground area occupied by plant (m_2).

Relative Growth Rate (RGR)

Relative Growth Rate (RGR) is the rate of dry matter increase per unit of existing dry matter per unit time. It was estimated using the formula provided by Blackman (1969).

$$\text{RGR} = \frac{\log_e \text{w}_2 - \log_e \text{w}_1}{\text{t}_2 - \text{t}_1} \ (\text{g g}^{-1}\text{day}^{-1})$$

where,

W_1 and W_2 = dry weights at two sampling times t_1 and t_2, respectively.

Loge W_2 = natural logarithm of dry weight at sampling time t_2

Loge W_1 = natural logarithm of dry weight at sampling time t_1

t_2 and t_1 = sampling time in days

Net Assimilation Rate (NAR)

Net Assimilation Rate (NAR) is the rate of increase in leaf dry weight per unit area of leaf per unit time. NAR is calculated using the formula by Williams (1946) and results are expressed in mg cm^{-2} day^{-1}.

$$\text{NAR} = \frac{\text{w}_2 - \text{w}_1}{\text{t}_2 - \text{t}_1} \times \frac{\log_e \text{A}_2 - \log_e \text{A}_1}{\text{A}_2 - \text{A}_1} \ (\text{mg cm}^{-2}\text{day}^{-1}$$

where,

Loge A_2 - Natural log of leaf area at stage 2

Loge A_1 - Natural log of leaf area at stage 1

A_2 & A_1 - Leaf area of whole plant at stage 2 & 1 respectively

W_2 & W_1 - Dry weight of the whole plant at stage 2 & 1 respectively

t_2 - t_1 - Time interval between the two stages.

Pod yield (kg ha^{-1})

Pods harvested from net plot area were separated from haulms and sundried till constant weight attained and expressed as kg $ha^{-1.}$

RAINFALL DATA DURING THE CROP GROWTH PERIOD

Rainfall pattern during the crop growth period (19-6-2024 to 30-10-2024), was recorded at the Meteorological Observatory, S.V. Agricultural College, Tirupati (Fig 1).

During the crop growth period, a total amount of 386.6 mm of rainfall was received in 21 rainy days as against the decennial mean -4.61 mm received in 1.75 rainy days for the corresponding period.

Fig.1 Standard week wise Rainfall pattern during the crop growth period of groundnut (19-06-2024 to 30-10-2024).

2. RESULTS AND DISCUSSION

The results revealed, significant difference measured for all the measured traits and presented in Table.1 These growth parameters provide valuable insights into the efficiency of biomass accumulation and resource utilization during different stages of crop development.

SPAD Chlorophyll Meter Readings (SCMR)

SCMR is the indication of light-transmittance characteristics of leaf dependent on the leaf chlorophyll content. SCMR values were recorded at 40, 60, and 80 days after sowing (DAS) to assess chlorophyll content and photosynthetic efficiency in various groundnut genotypes. The results revealed significant differences among the varieties (Table 1).

At 40 DAS, Kadiri Lepakshi and Nithyaharitha recorded the highest SCMR (46.05), indicating better chlorophyll content and early growth, while Narayani (38.00) and Kadiri-6 (38.93) showed the lowest values (Kumar et *al*., 2019). At 60 DAS, Dharani (42.39) and Narayani (41.76) led, reflecting strong photosynthetic activity, whereas Pragati and Kadiri-6 had lower values (Badigannavar *et al*., 2002). At 80 DAS, Kadiri Lepakshi and Nithyaharitha again showed the highest SCMR (38.03), suggesting delayed senescence, while Kadiri-6 (30.46) and Himani (31.19) recorded the lowest, indicating early chlorophyll decline.

Specific Leaf Area (SLA)

Specific Leaf Area (SLA), ratio of leaf area to its dry weight, is an indicator of leaf thickness, SLA was measured at 20, 40, 60, and 80 days after sowing (DAS), showing significant genotypic variation (Table 1).

At 40 DAS, Kadiri-6 (270.2 cm^2g^{-1}), Narayani (268.2 cm^2g^{-1}), and Visishta (254.8 cm^2g^{-1}) recorded the highest SLA, suggesting larger leaf area and improved light capture, while Pragati showed the lowest (226.9 cm^2g^{-1}), indicating thicker leaves. At 60 DAS, Narayani (240.6 cm^2g^{-1}), Kadiri-6 (235.1 cm^2g^{-1}), and Visishta (232.4 cm^2g^{-1}) maintained high SLA, reflecting active leaf expansion, whereas Dharani (205.5 cm^2g^{-1}) had the lowest. At 80 DAS, Dheeraj (194.8 cm^2g^{-1}) recorded highest SLA, followed by Konark and Nithyaharitha, indicating ongoing photosynthesis. Pragati (166.8 cm^2g^{-1}) and Himani (165.2 cm^2g^{-1}) had the lowest SLA, suggesting early senescence. A higher SLA at later growth stages supports better pod filling (Badigannavar et *al*., 2002; Singh *et al*., 2014).

Crop growth rate (CGR)

CGR denotes the rate of dry matter accumulation per unit land area, recorded in groundnut varieties at different crop growth stages 20-40 DAS, 40-60 DAS, 60-80 DAS during kharif (Table 1).

During the early vegetative stage, Kadiri-6 and Pragati recorded the highest CGR (10.0 g m^{-2} day^{-1}), indicating strong early biomass buildup, followed by Dheeraj, Visishta, and Narayani. Konark had the lowest CGR (8.00 g m^{-2} day^{-1}), suggesting slower canopy development. At the peak growth stage, Dheeraj (11.00 g m^{-2} day^{-1}), Visishta (10.90 g m^{-2} day^{-1}), and Narayani (10.80 g m^{-2} day^{-1}) showed vigorous biomass accumulation, while Konark again had the lowest (10.00 g m^{-2} day^{-1}). During the reproductive phase, Kadiri-6 led with the highest CGR (12.00 g m^{-2} day^{-1}), supporting effective pod development. In contrast, Konark (7.50 g m^{-2} day^{-1}) and Nithyaharitha (7.90 g m^{-2} day^{-1}) had the lowest, indicating reduced growth due to early senescence (Badigannavar *et al*., 2002).

Relative Growth Rate (RGR)

Relative Growth rate (RGR) measures the growth rate of a plant relative to its existing biomass. It also reflects the efficiency of assimilate (photosynthate) utilization and distribution during different growth stages. The RGR values of various groundnut varieties at different stages are presented in (Table 1).

At 20–40 DAS, Visishta (0.050 g g^{-1} day^{-1}), Dheeraj (0.049 g g^{-1} day^{-1}), and Himani (0.048 g g^{-1} day^{-1}) showed the highest RGR, reflecting strong early growth, while Konark (0.042 g g^{-1} day^{-1}) had the lowest. During 40–60 DAS, Dharani (0.040) and Nithyaharitha (0.039 g g^{-1} day^{-1}) led, indicating efficient dry matter production.

Table 1. Physiological efficiency of groundnut varieties at different growth stages

Variety	SPAD chlorophyll readings (SCMR)			Specific leaf area (SLA) (cm^2g^{-1})			Crop growth rate (CGR) ($g\ m^{-2}day^{-1}$)			Relative growth rate (RGR) ($g\ g^{-1}day^{-1}$)			Net assimilation rate (NAR) ($g\ cm\ day^{-1)}$)		
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS	20-40 DAS	40-60 DAS	60-80 DAS	20-40 DAS	40-60 DAS	60-80 DAS	20-40 DAS	40-60 DAS	60-80 DAS
Himani	41.37	40.04	31.19	252.1	223.6	165.2	8.5	10.2	9.0	0.048	0.032	0.031	0.037	0.049	0.033
Kadiri -6	38.93	39.13	30.46	270.2	235.1	180.2	10.0	10.5	12.0	0.044	0.036	0.029	0.039	0.041	0.023
Konark	42.44	39.70	36.72	240.1	224.0	194.6	8.0	10.0	7.5	0.042	0.032	0.029	0.03	0.041	0.021
Pragati	43.1	39.29	35.55	226.9	212.6	166.8	10.0	10.7	8.2	0.047	0.038	0.026	0.034	0.039	0.025
Visishta	41.71	39.82	33.36	254.8	232.4	178.2	9.3	10.9	8.4	0.05	0.038	0.027	0.035	0.052	0.026
Kadiri Lepakshi	46.05	40.23	38.03	244.8	218.4	184.2	8.9	10.6	8.1	0.046	0.032	0.026	0.033	0.045	0.032
Dheeraj	39.38	40.06	32.19	238.3	206.2	194.8	9.5	11.0	8.7	0.049	0.038	0.030	0.034	0.047	0.028
Nithyaharitha	46.05	41.48	38.03	234.1	214.6	188.2	8.7	10.3	7.9	0.043	0.039	0.036	0.031	0.043	0.021
Dharani	41.33	42.39	35.16	236.6	205.5	178.4	9.0	10.4	8.0	0.045	0.04	0.041	0.032	0.037	0.024
Narayani	38.00	41.76	36.00	268.2	240.6	180.4	9.2	10.8	8.5	0.047	0.031	0.042	0.037	0.036	0.030
MEAN	**41.83**	**40.39**	**34.66**	**246.6**	**221.3**	**181.1**	**8.11**	**10.54**	**8.63**	**0.046**	**0.036**	**0.032**	**0.034**	**0.043**	**0.026**
SEm	1.283	0.304	0.818	2.698	2.563	1.955	0.100	0.146	0.125	0.001	0.002	0.004	0.002	0.003	0.002
CV%	5.313	1.305	3.949	18.800	10.810	10.480	1.830	2.401	2.513	4.626	11.102	19.552	8.274	10.29	14.474
CD(5%)	3.813	0.904	2.430	8.018	7.615	5.808	0.290	0.434	0.372	0.004	0.007	0.011	0.005	0.008	0.007

Table 2. Pod yield of groundnut varieties

S. No.	Variety		Pod yield (kg ha^{-1})
1.	Himani		2500.9
2.	Kadiri-6		2012.4
3.	Konark		2476.8
4.	Pragati		1802.6
5.	Visishta		2489.2
6.	Kadiri Lepakshi		3333.3
7.	Dheeraj		1780.7
8.	Nithyaharitha		2534.4
9.	Dharani		1668.1
10.	Narayani		2010.4
		Mean	**2260.9**
		SEm	227.7
		CV%	23.641
		CD (%)	676.7

Narayani (0.031 g g^{-1} day^{-1}) and Himani (0.032) showed reduced growth, likely due to assimilate diversion to reproductive parts. At 60–80 DAS, Narayani (0.042 g g^{-1} day^{-1}) and Dharani (0.041 g g^{-1} day^{-1}) maintained the highest RGR, whereas Pragati and Kadiri Lepakshi (both 0.026 g g^{-1} day^{-1})) had the lowest, possibly due to onset of senescence. Sustained RGR during pod-filling is essential for better yield (Badigannavar *et al*., 2002).

Net Assimilation Rate (NAR)

Net Assimilation Rate (NAR) indicates the efficiency with which a plant converts light into dry matter per unit leaf area. It is a key measure of photosynthetic efficiency. A decline in NAR often points a slower growth and less effective use of assimilates. NAR values recorded at different crop stages are shown in (Table 1).

At 20–40 DAS, Kadiri-6 (0.039 g cm^{-2} day^{-1}), Himani, and Narayani (0.037 g cm^{-2} day^{-1}) showed the highest NAR, indicating efficient early photosynthesis and canopy growth, while Konark had the lowest (0.030 g cm^{-2} day^{-1}). During 40–60 DAS, Visishta (0.052 g cm^{-2} day^{-1}), Himani (0.049 g cm^{-2} day^{-1}), and Dheeraj (0.047 g cm^{-2} day^{-1}) maintained high NAR, reflecting strong biomass conversion, whereas Dharani and Narayani had lower values. At 60–80 DAS, Himani (0.033 g cm^{-2} day^{-1}) and Kadiri Lepakshi (0.032 g cm^{-2} day^{-1}) led, showing sustained photosynthesis under stress. Konark and Nithyaharitha (0.021 g cm^{-2} day^{-1}) recorded the lowest, possibly due to onset of senescence (Badigannavar *et al*., 2002).

Pod Yield

Among the varieties Kadiri Lepakshi had recorded the highest pod yield (3333.3 kg ha^{-1}), followed by

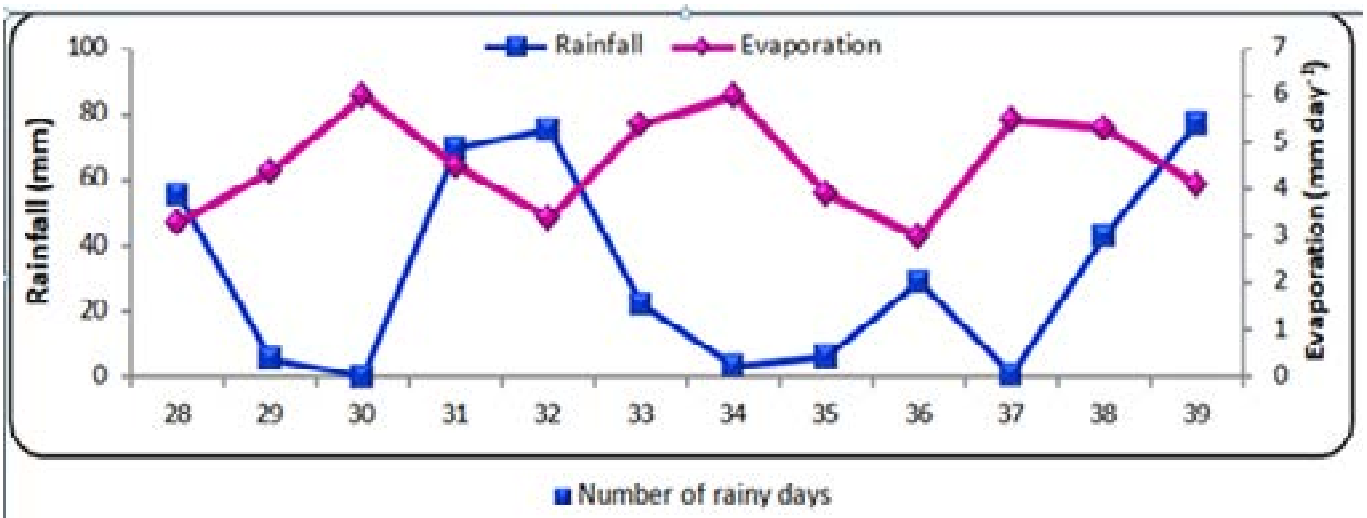

Fig. 1. Standard week wise Rainfall pattern during the crop growth period of groundnut (19-06-2024 to 30-10-2024).

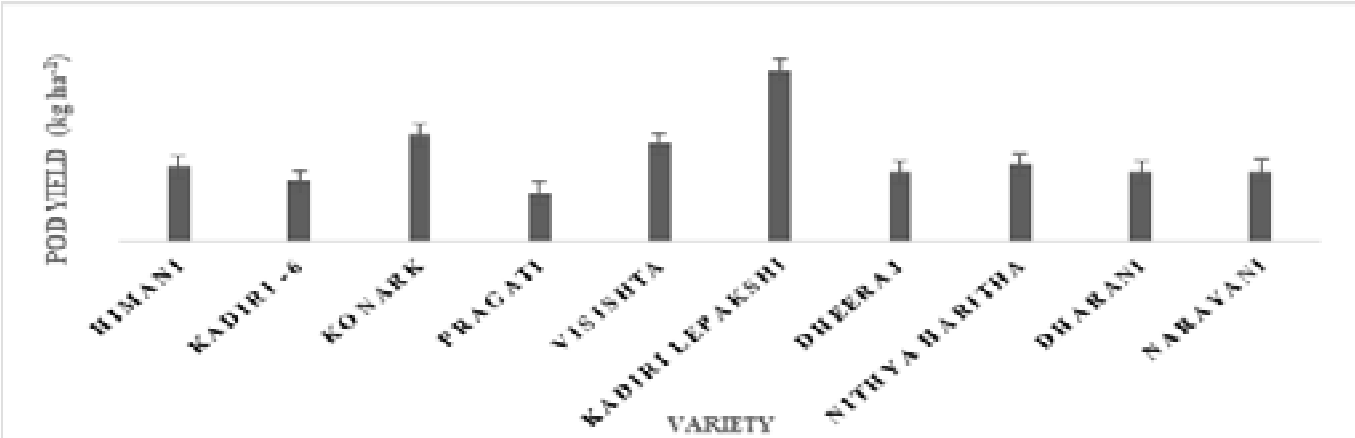

Fig. 2. Pod yield of groundnut varieties.

Nithyaharitha (2534.4 kg ha^{-1}), Himani (2500.9 kg ha^{-1}) and Visishta (2489.2 kg ha^{-1}), These varieties were statistically on par, indicating efficient source-sink management. Pod yield data are presented in Figure2 and Table 2 .

The study highlights significant variation in physiological traits among ten groundnut genotypes cultivated under rainfed conditions. Traits such as SCMR, SLA, CGR, RGR, and NAR played key roles in influencing biomass accumulation, canopy development and pod formation. Varieties like Kadiri Lepakshi, Nithyaharitha, Himani, and Visishta consistently recorded superior performance across several growth indices. High SCMR and NAR values supported efficient photosynthesis, while optimal SLA and CGR contributed to better growth and yield. Varieties with higher RGR showed vigorous early establishment, aiding subsequent peg development. Stable physiological performance during critical growth stages enhanced pod filling and final yield. Kadiri Lepakshi stood out with the highest pod yield, making it a promising variety for rainfed cultivation. Overall, the integration of these growth parameters helps in identifying high-yielding and stress-resilient groundnut varieties.

FUTURE STUDIES

Identifying QTLs/genes associated with high SCMR, optimal SLA, and efficient NAR, to integrate these traits through marker assisted selection or genomic selection approaches.

Combining the best performing genotypes with optimized agronomic practices (plant density, nutrient management, mulching, foliar sprays) to further enhance yield potential under rainfed cultivation.

Monitoring how these traits respond to progressive climate variability, to design breeding strategies for climate smart groundnut varieties.

LITERATURE CITED

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Andhra Pradesh J Agril. Sci : 11(3): 233-238, 2025

EFFICACY OF AZADIRACHTIN AND NANO SILICA FORMULATIONS AGAINST PULSE BEETLES, CALLOSOBRUCHUS MACULATUS

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Date of Receipt: 08-07-2025 Date of Acceptance: 26-07-2025

ABSTRACT

The present study evaluated the bio efficacy of Azadirachtin (10,000 ppm), silica and nano silica formulations against the pulse beetle, *Callosobruchus maculatus* (Fabricius), a key pest of stored pulses. Among the treatments, Azadirachtin (10,000 ppm) demonstrated the highest efficacy, recording 100% mortality by the 7th day, with the lowest LC_{50} (0.16%) and LT_{50} (1.39 days), indicating rapid and potent action. Silica and nano silica exhibited moderate but delayed mortality, requiring higher concentrations and longer exposure. Spinosad, used as a chemical check, also showed significant toxicity. The results suggest that Azadirachtin is a promising eco-friendly alternative for the sustainable management of C. *maculatus* in storage systems.

KEYWORDS: *Callosobruchus maculatus*, Azadirachtin, Nano silica, Silica, Spinosad, Stored product pests, Biopesticides.

INTRODUCTION

Pulses are nutrient rich edible seeds of leguminous crops, valued for their high protein, fibre and essential nutrients, making them a key part of the vegetarian diet of Indians. India leads the world in pulses production, contributing 38% to the global area and 28% to total production, with an estimated 24.25 million metric tons produced in 2024 (FAOSTAT, 2023–24). Andhra Pradesh ranks among the top 10 states, producing 3.33 lakh tons in the year 2024 (www. Statista. com). Despite their importance, pulses suffer significant losses due to insect pests, both in the field and during storage. Among these, the pulse beetle, *Callosobruchus* spp. is the most destructive storage pest, infesting a wide range of pulses. Infestation starts in the field and continues till post-harvest. The hidden infestation of pulse beetle causes severe quantitative and qualitative losses, making its management critical for safe storage of pulses for long duration.

The increasing development of insecticide resistance among storage pests, along with the presence of harmful residues in food and the environment, has significantly restricted the reliance on chemical insecticides and fumigants. As a result, there is a growing need to explore natural pesticide alternatives that are easily accessible, eco-friendly, and safe for non-target organisms, without compromising the market value of stored grains.

Essential oils derived from various plant species exhibit ovicidal, larvicidal and repellent activities against a wide range of insect pests and are considered eco-friendly alternatives to conventional pesticides (Isman, 2000; Cetin *et al*., 2004). Neem-based products have shown potential as natural grain protectants due to their ovicidal, larvicidal, and repellent actions, offering a sustainable approach for managing storage pests under tropical conditions (Saxena *et al*., 2018). Silica and Nano silica based formulations are emerging as effective bio pesticides for stored grain pest management. They are p hysiosorbed by the insect’s cuticular lipids, which results in considerable injury and the insect's death (Barik *et al*., 2008). According to Saw *et al*., 2023, Silica nano particles act as an ecofriendly biopesticide for killing the target insect pest and improve plant resistance to insect pests.

Hence the present study was carried out to evaluate the efficacy of bio pesticides like Neem oil, Silica, Nano silica along with chemical check Spinosad against pulse beetle, C. *maculatus*.

MATERIAL AND METHODS

The present investigation was carried out at Department of Entomology, S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural university, Andhra Pradesh, India during 2024-25.

Commercial neem formulation, Neem azal (10,000 ppm) and Spinosad (Tracer 45% SC) were purchased from local market in Tirupati were used for bio assay studies.

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Silica and nano silica formulations were synthesized at Nano technology lab, Institute of Frontier Technology, Regional Agricultural Research station, Tirupati.

Maintenance of pulse beetle culture

The pulse beetle adults collected from pulse storage godown of Regional Agricultural Research Station, Tirupati, Andhra Pradesh were maintained at laboratory, Department of Entomology, S.V. Agricultural College, Tirupati under ambient conditions at 25+ 2°C and 75% RH. For mass multiplication, about ten pairs of adult pulse beetles were released into plastic containers containing 500-gram green gram seed and the mouth of the container was covered with muslin cloth and secured with a rubber band. The jars were kept undisturbed till the emergence of F1 adults. The pulse beetles were mass multiplied and the freshly emerged beetles were used for the bioassay studies.

Synthesis of Silica Nanoparticles

Nano silica particles were synthesised using Sol-gel method (Bokov *et al*., 2021). Tetraethyl ortho silicate (TEOS) and CH_3COOH (acetic acid glacial) were mixed using a magnetic stirrer for 30 min and rinsed with double-deionised water (DI-water) and allowed to dry in air at room temperature. Then the mixture was made into fine powder and decomposed in air by keeping it in a preheated muffle furnace for 90 min at 600°C.

Dynamic Light Scattering Spectroscopy (DLS for Size and Zeta Potential Measurements of nano particles). Dynamic light scattering (DLS) was performed using particle sizing system, Horiba Nanoparticle analyzer at a wavelength of 633 nm from a 4.0 mW, solid-state He-Ne laser at a scattering angle of 170°. Intensity average, volume average and number average diameters were calculated from the auto correlation function using Malvern's Zeta sizer Nano 4.2 software utilizing a version of the CONTIN algorithm.

Bioassay studies against C. maculatus

The efficacy of bio pesticides were evaluated against pulse beetle adults using diet incorporation method. Each biopesticide was tested at 5 different concentrations and the adult mortality percentage was calculated at different time intervals at 1, 3, 5, 7 and 15 days after treatment. Different concentrations of Azadirachtin (10,000 ppm) (0.1, 0.25, 0.5, 0.6 and 1.0 per cent) were prepared using distilled water as a solvent by serial dilution method. Silica and nano silica were also taken at five different concentrations (1.5, 2, 5, 7.5 and 10 g kg^{-1}). Spinosad was taken at 0.003, 0.005. 0.01, 0.03 and 0.05 per cent. 20 grams of green gram seed was thoroughly mixed with required concentrations of bio pesticides and was kept in plastic containers to achieve equal distribution and the containers were shaken manually for 5 minutes and allowed to shade dry for 24 hours. Freshly emerged Twenty pulse beetle adults were released into each plastic container and the experiment was replicated four times. The containers were closed with muslin cloth for sufficient ventilation and kept under ambient conditions in the laboratory at at 25+ 2°C and 75% RH. The pulse beetle adult mortality counts were taken after 1, 3, 5, 7 and 15 days after exposure.

Based on adult pulse beetle mortality, LC50, LC90 and LT50 values were calculated using probit analysis using the SPSS statistical package for determining their effectiveness against C. maculatus.

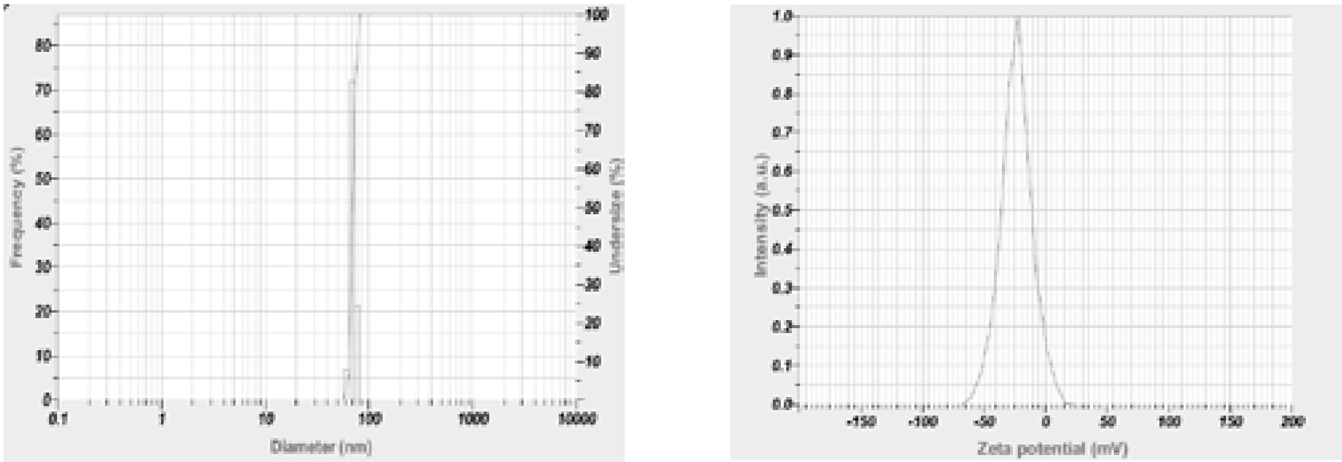
RESULTS AND DISCUSSION

Dynamic Light Scattering technique used to measure the hydrodynamic diameter (HDD) of the particles, showed that nano silica particles have mean size of 69.4 nm and the zeta potential was also measured and recorded as -23.4 mV for nano silica (Fig 1).

Among different biopesticides, Azadirachtin (10,000 ppm) demonstrated the highest effectiveness, causing 90 % mortality at 0.6 % concentration by 5th day and 100 % by 7th day at 0.6% and 1.0% concentrations and 100% mortality in all the treatments by 15th day. This was further supported by its lowest LC_{50} value (0.16%) and shortest LT_{50} (1.39 days), indicating both high potency and rapid action.

Silica showed a moderate and delayed response, with low initial mortality at 1st day (5%) at lower concentrations but notable increase was observed by 5th and 7th day, especially at higher concentrations (7.5–10 g/kg), where mortality reached 100%. LC_{50} value of 2.19 g/kg, and LT_{50} of 2.58 days of silica indicating that higher doses and longer exposure are required for effective control. The likely mode of action is through abrasion and desiccation, leading to slow but cumulative mortality.

Nano Silica exhibited the slowest action among the three treatments. Mortality remained low to moderate until 5th day (32.5% -87.5%) and on 7th day mortality



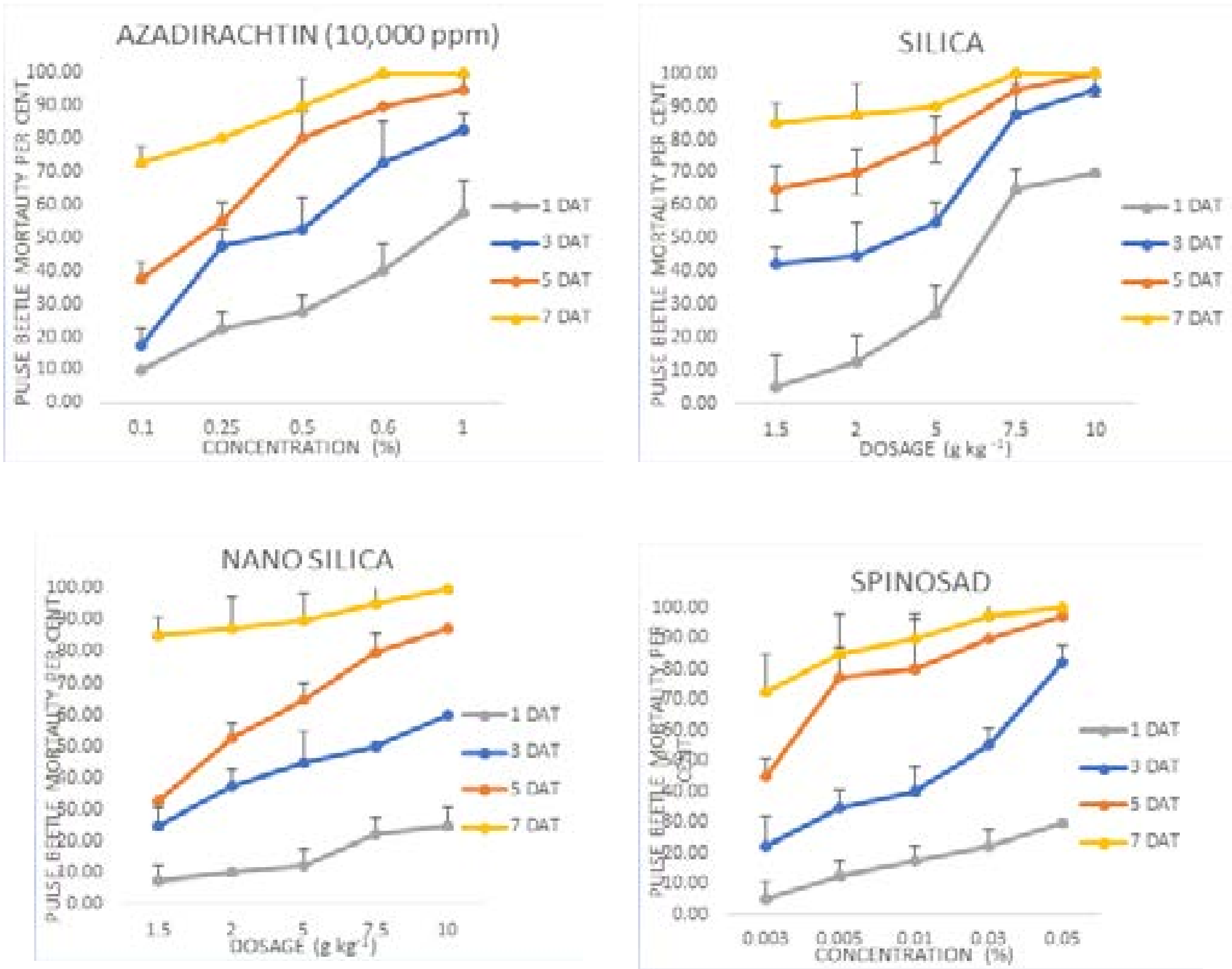


Fig.1 Dynamic light scattering for particle size and zeta potential of nano silica using nano particle analyser

Table 1. Probit analysis (LC_{50} and LC_{90}) of biopesticides against pulse beetle, *C. maculatus*

Treatment	LC_{50} value (% or g kg^{-1})	Fiducial limits		LC_{90} value (% or g kg^{-1})	Regression equation	Chi square value	Intercept ± SE	Slope ± SE
		Upper	Lower					
Azadirachtin (10,000 ppm)	0.16%	0.24	0.08	0.75%	y = 1.58 + 2.04x	5.88	1.58 ± 0.11	2.04 ± 0.19
*Silica	2.19 g kg^{-1}	3.41	0.81	9.76 g kg^{-1}	y = -0.73 + 2.14x	10.81	-0.73 ± 0.12	2.14 ± 0.20
Nano silica	2.40 g kg^{-1}	3.43	1.28	13.75 g kg^{-1}	y = -0.66 + 1.73x	5.48	-0.66 ± 0.12	1.73 ± 0.19
*Spinosad	0.01%	0.03	0.006	0.18%	y = -2.51 + 1.18x	9.67	-2.51 ± 0.28	1.18 ± 0.13

LC_{50} values were calculated after 5 DAT for azadirachtin and nano silica

*LC_{50} of silica, and spinosad were calculated after 3 DAT

Silica and Nano silica were taken in g kg^{-1}

Table 2. Probit analysis (LT_{50}) of biopesticides against pulse beetle, *C. maculatus*

Treatment	LT_{50} (days)	Fiducial limits(days)		Regression equation	Chi square value	Intercept ± SE	Slope ± SE
		Upper	Lower				
Azadirachtin @ 0.6%	1.39	2.09	0.61	y = -0.29 + 2.13x	9.20	-0.29 ± 0.12	2.13 ± 0.23
Silica @ 5 g kg^{-1}	2.58	2.88	2.27	y = -1.18 + 2.88x	1.74	-1.18 ± 0.14	-1.18 ± 0.23
Nano silica@ 5 g kg^{-1}	3.01	4.25	1.87	y = -1.25 + 2.68x	10.88	-1.25 ± 0.14	2.68 ± 0.22
Spinosad @ 0.03%	2.06	3.07	1.07	y = -0.94 + 3.16x	13.44	-0.94 ± 0.13	3.16 ± 0.23

LT: Lethal time

reached around 90-100% at higher concentrations.100 % mortality was observed in all the treatments by the 15th day. The LC_{50} was 2.40 g/kg, and LT_{50} was 3.01 days, reflecting lower toxicity and slow releasing effect.

The chemical check Spinosad was also found effective against pulse beetles with 90% mortality was seen after five days of treatment at 0.03% and 100% at 0.05%. LC_{50} was 0.01% and LT_{50} was 2.06 days.

These findings are line with Rajasri and Rao (2012) who reported that commercially available neem formulations viz., Econeem plus®, Neemindia ® and Neemazal ® found effective control of pulse beetle, C. chinensis in stored Bengal gram.

The present findings are in line with Rajasri *et al*., (2014) studied efficacy of neem formulations on pulse beetle and reported that all the commercial neem formulations *viz.,* Econeem plus®, Neemindia ® and Neemazal ® were effective against C. chinensis in stored black gram up to 15 months of storage.

In similar lines, Arora *et al*., (2018) evaluated toxicity *viz.,* neem and clove oil against adults of Tribolium castaneum at different concentrations *viz.,* 10, 15, 20 and 25% of neem oil and clove oil. The clove oil resulted in 100% mortality at the higher concentration (25%) after 48 hours of treatment. The neem oil revealed only 86.9 per cent mortality at higher dose (25%) after a period of 48 hours after treatment.

Mondal *et al*., (2018) tested the efficacy of Spinosad against pulse beetle, C. chinensis using diet incorporation method and contact toxicity method. The LC50 value is found to be around 95 ppm after 72 hours which is almost same as the findings of the current study.

Rani *et al*., (2022) studied the efficacy of essential oils like neem-azal, clove oil and acorus oil different concentrations against red flour beetle, Tribolium castaneum. Neem-azal at 2.0 per cent was found to be effective with LC50 value of 1.11 per cent and LT50 value of 2.4 days followed by acorus oil 15.0 per cent with LC50 value of 16.43 and LT50 value of 4.30 days against Tribolium larvae.

Based on LC50, LC90 and LT50, among the different treatments tested, Azadirachtin (10,000 ppm) found be very effective against pulse beetle. The safer and ecofriendly bio pesticides are recommended for the control of pulse beetle and reduce the risk of chemical residues in stored grains, promoting sustainable management.

Acknowledgement:

I am highly thankful to Acharya N.G. Ranga Agricultural University, Guntur and Indian Council of Agricultural Research, New Delhi for all the facilities extended during the period of my post-graduation programme and for the financial assistance provided during my post-graduation.

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Andhra Pradesh J Agril. Sci : 11(3): 239-242, 2025

INFLUENCE OF TRANSPLANTING WINDOW ON PHOTO SENSITIVE RICE VARIETIES DURING RABI SEASON

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Date of Receipt: 11-07-2025 Date of Acceptance: 17-07-2025

ABSTRACT

A field experiment was conducted during *rabi*, 2024-25 at Agricultural Research Station, Nellore, Andhra Pradesh. The experiment was laid out in split-plot design and replicated thrice. The treatments consist of five dates of transplanting *viz.,* II F.N of November (D_1), I F.N of December (D_2), II F.N of December (D_3) I F.N of January (D_4) and II F.N of January (D_5) assigned to main plots, three varieties RNR 15048, KNM 1638 and NLR 34449 allotted to sub plots. Among the varied dates of transplanting tried, higher plant height and dry matter production at harvest was recorded with II F.N of December (D_3) whereas, crop transplanted during II F.N of November (D_1) registered lower plant height and dry matter production. Incase, of leaf area index the crop transplanted during I F.N of January recorded higher leaf area index. With respect to varieties NLR 34449 (V_3) recorded recoded higher leaf area index and dry matter production whereas, RNR 15048 (V_1) recorded higher plant height.

KEYWORDS: Rice, times of transplanting, varieties.

INTRODUCTION

Over half of the world's population depends on rice (*Oryza sativa* L.), making it a staple meal. These days, rice (*Oryza sativa* L.) is progressively taking the lead in global dietary patterns. For hundreds of millions of people in Africa and Latin America, as well as the rural population in subtropical and tropical Asia, it is their primary source of income. The world's rice cultivated area is 168 million hectares. India ranks first in the world with an area of 47.9 million hectares under rice cultivation with production of 137.5 million tonnes and the average productivity of 3155 kg ha^{-1} (www.indiastatistica.com, 2024-25). In Andhra Pradesh, rice crop is grown in 2.16 million hectares of area with production of 7.49 million tonnes and productivity of 3896 kg ha^{-1} (www.angrau.ac.in,2025). Timely planting plays a crucial role in ensuring the attainment of superior yield-attributing parameters and ultimately higher grain yield. In contrast, delayed transplanting often leads to a reduction in growth and yield components such as leaf area, number of productive tillers and test weight. This is primarily due to a shortened growth duration and suboptimal environmental conditions during critical growth stages. Photo and thermo-sensitive rice varieties possess physiological traits that cause their growth and reproductive development to respond significantly to variations in day length (photoperiod) and temperature.

MATERIAL AND METHODS

The field experiment was conducted at Agricultural Research Station, Nellore of Acharya N.G. Ranga Agricultural University which is geographically situated at 14.27°N latitude and 79.59°E longitude with an altitude of 20m above mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh. The soil of experimental field was clay loam in texture, alkaline in soil reaction, medium in organic carbon (0.62%), low in available nitrogen (188 kg ha^{-1}), medium in available phosphorus (43 kg ha^{-1}) and available potassium (231 kg ha^{-1}). The experiment was laid out in split-plot design and replicated thrice. The treatments consisted of five dates of transplanting *viz.,* II F.N of November (D_1), I F.N of December (D_2), II F.N of December (D_3) I F.N of January (D_4) and II F.N of January (D_5) assigned to main plots, three varieties RNR 15048, KNM 1638 and NLR 34449 allotted to sub plots. A total rainfall of 65.4 mm received in 2 rainy days during the crop growing period. All the other recommended practices were adopted as per the recommendations.

RESULTS AND DISCUSSION

Plant height at harvest was influenced by the times of transplanting and the varieties. The crop transplanted during the II fortnight of December (D_3) registered higher plant height than all other transplanting dates, which was

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Table 1. Plant height (cm), leaf area index (cm^2) and dry matter production (kg ha^{-1}) at harvest of rice varieties as influenced by times of transplanting

Treatments	Plant height	Leaf area index	Dry matter production
Main plots: Times of transplanting (5)			
D_1 : II F.N of November	75.7	1.35	13116
D_2 : I F.N of December	79.5	1.60	14508
D_3 : II F.N of December	85.1	1.83	16189
D_4 : I F.N of January	83.1	2.11	15345
D_5 : II F.N of January	82.9	2.01	13744
SEm±	1.36	0.040	418.9
CD (P = 0.05)	4.5	0.10	1388
Sub plots: Varieties (3)			
V_1 : RNR 15048	84.4	5.85	13516
V_2 : KNM 1638	82.2	6.17	14466
V_3 : NLR 34449	77.2	6.66	15759
SEm±	0.79	0.062	301.0
CD (P = 0.05)	2.3	0.18	894
Times of transplanting (D) × Varieties (V)			
V at D			
SEm±	2.36	0.073	725.6
CD (P = 0.05)	5.5	NS	NS
D at V			
SEm±	1.99	0.06	691.1
CD (P = 0.05)	6.2	NS	NS

on par with I fortnight of January (D_4), II fortnight of January (D_5) and I F.N of December (D_2). The lowest plant height was observed in the crop transplanted during II F.N of November (D_1). Among the varieties tested RNR 15048 (V_1) registered higher plant height at harvest which was on par with KNM 1638. While the shortest plant height was recorded with the variety NLR 34449 (V3). With regard to interaction effect RNR 15048 transplanted during II fortnight of December (D_3V_1) was on par with the variety KNM 1638 transplanted during II fortnight of December (D_3V_2). The lowest plant height was recorded with the variety NLR 34449 transplanted during II fortnight of November (D_5V_3) The higher plant height of the variety RNR 15048 (V_1) might be due to the genetic character of the variety and higher photosynthetic efficiency. These results were similar to those obtained by Anil and Siddi (2020), Nizamani *et al*., (2014) and Suleiman *et al*., (2014) who observed that plant height differed significantly among the varieties.

Among all times of transplanting, the crop transplanted during I F.N of January (D_4) recorded significantly the highest leaf area index at harvest, it was followed by the crop transplanted during II fortnight of December (D_5) and it was on par with crop transplanted during II F.N of December (D_3) followed by the crop transplanted during II F.N of December (D_2) and II F.N of November (D_1) .While the crop transplanted during II F.N of November (D_1) recorded significantly the lowest leaf area index. With respect to varieties RNR 15048 (V_1) and NLR 34449 (V_3) recorded higher leaf area index followed by KNM 1638 (V_2). Higher leaf area index recorded across the dates of transplanting might be due to vigorous growth habit, higher tillering ability and greater leaf production potential were noticed in NLR 34449 (V_3) rice variety. With regard to interaction effect, at harvest was found to be non-significant.

Dry matter production of rice at harvest was significantly influenced by times of transplanting and varieties. Among varied times of transplanting, significantly higher dry matter production of rice was recorded when the crop transplanted during II fortnight of December (D_3) which was statistically on par with I fortnight of January (D_4). Significantly the lower dry matter production was recorded at II fortnight of November (D1).

Significantly highest dry matter production was registered with variety NLR 34449 (V_3) followed by KNM 1638 (V_2). Significantly the lowest dry matter production was recorded in RNR 15048 (V_1). These findings were in line with Sharma *et al*., (2018)

Interaction effect between times of transplanting and varieties on dry matter production at harvest was found to be statistically not significant. Dry matter accumulation in the plant is a reliable indicator of overall growth, as it integrates various growth parameters over time. Significantly the highest dry matter accumulation was recorded with the crop transplanted during II fortnight of December (D_3), which may be attributed to timely transplanting that allowed optimal temperature, interception of solar radiation, along with optimum day length, better vegetative growth under favourable conditions. These factors collectively promote the

Table 2. Plant height (cm) of rice varieties at harvest as influenced by times of transplanting

Times of transplanting \ Varieties	V_1: RNR 15048	V_2: KNM 1638	V_3: NLR 34449	Mean
D_1 : II F.N of November	78.4	77.4	71.4	75.7
D_2 : I F.N of December	81.5	79.4	77.5	79.5
D_3 : II F.N of December	92.1	87.5	75.6	85.1
D_4 : I F.N of January	84.6	83.0	81.8	83.1
D_5 : II F.N of January	85.2	83.8	79.8	82.9
Mean	84.4	82.2	77.2	
			SEm±	**CD (P = 0.05)**
D			1.36	4.5
V			0.79	2.3
V at D			2.36	5.5
D at V			1.99	6.2

synthesis and efficient translocation of photosynthates to vegetative organs, thereby contributing to increased biomass.

Among the varieties evaluated, NLR 34449 (V_3) exhibited significantly the highest dry matter accumulation. This superior performance may be attributed to its inherent genetic potential for enhanced photosynthetic efficiency, leading to an increased source capacity and more efficient translocation of photosynthates to the sink. Variations in dry matter accumulation among the different varieties could be attributed to their genetic potential as well as differences in height and growth rates. The results were in-line with the findings of Anil and Siddi (2020) and Dileep *et al*., (2018).

Among all dates of transplanting the crop transplanted during II fortnight of December recorded significantly higher plant height and dry matter production whereas, the lowest plant height, leaf area index and dry matter production was recorded with the crop transplanted during II fortnight of November. Among varieties RNR 15048 recorded significantly higher plant height. NLR 34449 recorded higher leaf area index and dry matter production.

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Andhra Pradesh J Agril. Sci : 11(3): 243-248, 2025

SURVEY FOR THE VARIABILITY OF ALTERNARIA SPP. INCITING LEAF BLIGHT OF SUNFLOWER IN ANDHRA PRADESH

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Date of Receipt: 07-05-2025 Date of Acceptance: 08-06-2025

ABSTRACT

This study assessed the incidence of Alternaria leaf blight in sunflower crops across major growing regions of Andhra Pradesh during the 2023–24 Rabi season. Surveys conducted in five districts revealed notable variability in Percent Disease Incidence (PDI), ranging from 18.5% to 49.6%. The highest incidence was observed in Tirupati village of Chittoor district (49.6%), while the lowest was recorded in Mudigguba village of Ananthapur district (18.5%). The disease was more severe in sunflower hybrids than in open-pollinated varieties, with the hybrid 'NDSH 1012' showing high susceptibility, particularly during the flowering stage. PDIs varied across black and red soils, indicating that soil characteristics may influence disease severity. These results highlight the importance of adopting region-specific management strategies, including the use of resistant varieties such as 'Advanta' and 'Kaveri', timely interventions during the flowering period and appropriate soil management practices. Utilizing localized PDI data for planning can significantly improve disease control and enhance sunflower productivity in Andhra Pradesh.

KEYWORDS: *Alternaria* leaf blight, Survey, Percent disease index.

INTRODUCTION

Sunflower is one of the most important edible oilseed crops grown worldwide after soybean and groundnut. The crop has grown in popularity due to its short maturity period, high oil quality, photo-insensitivity, and drought tolerance. The word "Helianthus" is derived from greek word 'Helios' meaning 'sun' and 'anthos' meaning 'flower'. According to Agricultural statistics at a glance (2021-2022), In india sunflower is cultivated in 0.22 million hectares with a production of 0.23 million tonnes and productivity of 1023 kg/ha. The major sunflower producing states are Karnataka (0.12 million hectares) and Maharastra (0.02 million hectares).

The major composition of sunflower oil is linoleic acid (polyunsaturated fat) and oleic acid (mono-saturated fat). Sunflower oil contains 5% palmitic acid, 6% stearic acid, 30% oleic acid (monounsaturated omega-9) and 59% linoleic acid (polyunsaturated omega-6) (Avni *et al*., 2016)

The sunflower crop is attacked by number of pests and diseases right from germination to harvest causes huge loss to the growers. The important sunflower affecting diseases are leaf spot, leaf blight., etc.

Sunflower is infected with so many fungal, bacterial, viral diseases. Among fungal diseases, leaf spot causes yield loss. Among the biotic stresses for successful sunflower production, susceptibility to the leaf spot and leaf blight diseases is one of the major constraint.

Alternaria leaf spot is the most common foliar disease on sunflower. This disease can affect the sunflower plants in all growing stages such as emergence, leaves, stems and flowering. The disease causes direct yield loss by reduction in the number of seeds per head (16–65%) and thousand-seed weight (15–79%). Symptoms of the disease are dark brown, oval to circular spots with pale margins and halo. In severe infection, lesions become irregular by coalescing, leading to blight, defoliation and death of the plant.

The loss due to Alternaria spp. is proportionate to the disease intensity and varies considerably depending on the stage of the plant growth at which disease occurs. It is essential to undertake survey and surveillance of the disease in every year which helps us to know the rhythmic changes in regional severity and status of the disease. Hence in this study, a roving survey has been made to document the disease severity in major districts of Andhra Pradesh, india.

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MATERIAL AND METHODS

Survey for the incidence of sunflower leaf blight disease in Andhra Pradesh and collection of infected leaf samples.

Roving survey was conducted to record the incidence of Alternaria leaf blight disease on sunflower in major growing areas of Andhra Pradesh (A.P.) during Rabi season during 2023-24. The districts covered under this study are Ananthapuramu, Chittoor, Kurnool, Prakasam, Kadapa and Nandyal from Andhra Pradesh (Table 1). The leaf blight incidence in different sunflower varieties and hybrids cultivated in those districts were recorded along with data on various stages of crop growth and the percent disease incidence (PDI) were used.

Per cent disease incidence =

$$\frac{\text{Number of diseased plants}}{\text{Total number of plants}} \times 100$$

RESULTS AND DISCUSSION

The information on hybrids, soil types, stage of the crop, latitude, longitude and percent disease incidence in these areas were collected and calculated the details are given in Table1.

In Ananthapuram district, the survey included five villages among them Kadiri village of Kadiri mandal, the isolate code AKK from the Ganga Kaveri hybrid at the vegetative stage observed in black soil recorded a PDI of 48.5%. The second isolate, B. Papuru village in Narpala mandal, with isolate ABPN from the Ganga Kaveri hybrid at vegetative stage observed in black soil, recorded a PDI of 29.0%. The third isolate at Bandlapalli village in Narpala mandal, with the code ABN isolate from Ganga Kaveri hybrid at the young stage observed in red soil, recorded a PDI of 45.2%. At Mudiguba village in Mudigubba mandal with the AMM isolate from the Advanta hybrid at the seedling stage observed in black soil recorded a PDI of 18.5%. The fifth isolate atgv d, Belguppa village in Belguppa mandal with the ABB isolate from Advanta at the flowering stage observed in black soil, recorded a PDI of 43.2%.

In Kurnool district, the survey included Veldurthi village of Veldurthi mandal with the isolate KVV from Advanta hybrid at the flowering stage observed in black soil, recorded a PDI of 48.1%.

In Kadapa district,the survey included four villages of four mandals among them Sirigapalli village in Jammalamadugu mandal with isolate KSJ from the Zaneka hybrid at the flowering stage were observed in black soil, recorded a PDI of 29.6%. At Dhobudupalli village in Kondapuram mandal with isolate KDK from Zaneka hybrid at the flowering stage were observed in black soil, recorded a PDI of 42.3%. At Murgampalli village in Tadipatri mandal with isolate KMT from Zaneka hybrid at the flowering stage were observed in black soil, recorded a PDI of 30.5%. The fourth isolate at Bondala Dinne village in Tadipatri from Zaneka hybrid at the flowering stage were observed in black soil, recorded a PDI of 40.1%.

In Nandyal district, five Villages of five Mandals were surveyed. Among them Nandyal village in Nandyal mandal with isolate NNN from the NDSH 1012 hybrid at the flowering stage observed in black soil, recorded a PDI of 48.1%. The second, isolate at Pamulapadu village in Pamulapadu mandal with isolate NPP from NDSH 1012 hybrid at the flowering stage observed in black soil, recorded a PDI of 50.5%. The third, isolate at Rudravaram village in Rudravaram mandal with isolate NRR from NDSH 1012 hybrid at the flowering stage observed in black soil, recorded PDI of 30.6%. At Kambala Palli village in Pamulapadu mandal with isolate NKP from NDSH 1012 hybrid at the flowering stage observed in black soil, recorded a PDI of 21.3%. The fifth, isolate at Kokkarancha village in Kothapalle mandal with isolate NKK from NDSH 1012 hybrid at the flowering stage observed in black soil, recorded a PDI of 28.4%.

In Chittoor district, the survey included five villages of five mandals *i.e.,* Tirupati, Nagari, M.Kuthuru, Vellavadi, and Buagraharam villages. The first Tirupati village with isolate CTT isolate from KBSH-44 hybrid at the flowering stage were observed in red soil, had recorded a PDI of 49.6%. The second, isolate at Nagari village with isolate CNN from KBSH-53 hybrid at the vegetative stage observed in black soil, recorded a PDI of 36.8%. The third, isolate at M.Kuthuru village in Palamaner mandal with isolate CMP from KBSH-53 hybrid at the seedling stage observed in black soil, recorded a PDI of 27.2%. The fourth, isolate at Vellavadi village in Nagari mandal with isolate CVN from KBSH-53 hybrid at the vegetative stage observed in black soil, recorded a PDI

Table 1. Survey details and sunflower leaf blight disease incidence in Andhra Pradesh

S. No.	Isolate -Codes	State	District	Village	Mandal	Latitude	Longitude	Variety	Stage of crop	Soil type	PDI *
1	AKK	Andhra pradesh	Ananthapur district	Kadiri	Kadiri	13.99°	77.96°	Ganga kaveri	Vegetative stage	Black soil	48.5 (44.16)**
2	ABPN	Andhra pradesh	Ananthapur district	B.papuru	Narpala	15.60°	77.90°	Ganga kaveri	Vegetative stage	Black soil	29.0 (32.60)
3	ABN	Andhra pradesh	Ananthapur district	Bandlapalli	Narpala	15.6°	77.93°	Ganga kaveri	Young stage	Black soil	45.2 (42.27)
4	AMM	Andhra pradesh	Ananthapur district	Mudigubba	Mudigubba	15.57°	77.89°	Advanta	Seedling stage	Black soil	18.5 (25.49)
5	ABB	Andhra pradesh	Ananthapur district	Belguppa	Beluguppa	15.59°	77.93°	Advanta	Flowering stage	Black soil	43.2 (41.11)
6	KVV	Andhra pradesh	Kurnool district	Veldurthi	Veldurthi	15.55°	77.92°	Advanta	Flowering stage	Black soil	48.1 (43.93)
7	KSJ	Andhra pradesh	Kadapa district	Sirigapalli	Jammalamadugu	14.88°	78.11°	Zaneka	Flowering stage	Black soil	29.6 (32.98)
8	KDK	Andhra pradesh	Kadapa district	Dhobudupalli	Kondapuram	14.90°	78.12°	Zaneka	Flowering stage	Black soil	42.3 (40.59)
9	KMT	Andhra pradesh	Kadapa district	Murgampalli	Tadipatri	14.90°	78.12°	Zaneka	Flowering stage	Black soil	30.5 (33.54)
10	KBT	Andhra pradesh	Kadapa district	Bondala dinne	Tadipatri	14.90°	78.12°	Zaneka	Flowering stage	Black soil	40.1 (39.31)
11	NNN	Andhra pradesh	Nandyal district	Nandyal	Nandyal	15.46°	78.47°	NDSH 1012	Flowering stage	Black soil	28.9 (32.54)
12	NPP	Andhra pradesh	Nandyal district	Pamulapadu	Pamulapadu	15.82°	78.49°	NDSH1012	Flowering stage	Black soil	50.5 (45.31)
13	NRR	Andhra pradesh	Nandyal district	Rudravaram	Rudravaram	15.82°	78.49°	NDSH 1012	Flowering stage	Black soil	30.6 (33.60)
14	NKP	Andhra pradesh	Nandyal district	Kambala palli	Pamulapadu	15.84°	78.47°	NDSH 1012	Flowering stage	Black soil	21.3 (27.50)
15	NKK	Andhra pradesh	Nandyal district	Kokkarancha	Kothapalle	15.84°	78.47°	NDSH 1012	Flowering stage	Black soil	28.4 (32.22)
16	CTT	Andhra pradesh	Chittoor district	Tirupati	Tirupati	13.328°	79.81°	KBSH-44	Flowering stage	Red soil	49.6 (44.79)
17	CNN	Andhra pradesh	Chittoor district	Nagari	Nagari	13.327°	79.61°	KBSH-53	Vegetative stage	Black soil	36.8 (37.37)

Cont...

Table 1. Cont...

S. No.	Isolate -Codes	State	District	Village	Mandal	Latitude	Longitude	Variety	Stage of crop	Soil type	PDI *
18	CMP	Andhra pradesh	Chittoor district	M.kuthuru	Palamaner	13.328°	79.61°	KBSH-53	Seedling stage	Black soil	27.2 (31.45)
19	CVN	Andhra pradesh	Chittoor district	Vellavadi	Nagari	13.32°	79.61°	KBSH-53	Vegetative stage	Black soil	22.8 (28.54)
20	CBN	Andhra pradesh	Chittoor district	Buagraharam	Nagari	13.61°	79.37°	KBSH-53	Star buding stage	Black soil	38.7 (38.49)
21	PCP	Andhra pradesh	Prakasam district	Chenam palli	Pullalacheruvu	16.06°	79.39°	Kaveri	Flowering stage	Red soil	32.6 (34.84)
22	PKP	Andhra pradesh	Prakasam district	Komarolu	Pullalacheruvu	16.08°	79.35°	Kaveri	Flowering stage	Red soil	29.1 (32.66)
23	PPK	Andhra pradesh	Prakasam district	punugodu	Kanigiri	16.14°	79.66°	Kaveri	Flowering stage	Red soil	30.0 (33.23)
24	PNP	Andhra pradesh	Prakasam district	naidupalem	Pullalacheruvu	15.41°	79.56°	Kaveri	Flowering stage	Red soil	39.2 (38.78)
25	PBK	Andhra pradesh	Prakasam district	Bomireddi palli	Kanigiri	15.39°	79.58°	Kaveri	Flowering stage	Red soil	40.1 (39.31)
										PDI MEAN	35.23
										C.D at 5%	2.15
										SE(m)	1.71
										C.V	3.72
										SE(d)	0.36

* Mean of three replications
** Figures in parentheses are Angular transformed value

of 22.8%. The fifth, isolate at Buagraharam village in Nagari mandal with isolate CBN from KBSH-53 hybrid at the star budding stage observed in black soil, recorded a PDI of 38.7%.

In Prakasam district, the survey included five villages of five mandals *i.e.,* Chenam Palli, Komarolu, Punugodu, Naidupalem, and Bomireddi Palli villages. Among them Chenam Palli village in Pullalacheruvu mandal with isolate PCP from the Kaveri hybrid at the flowering stage observed in red soil, recorded a PDI of 32.6%. The second, isolate at Komarolu village in Pullalacheruvu mandal with isolate PKP from Kaveri hybrid at the flowering stage observed in red soil with recorded a PDI of 29.1%. The third, isolate at Punugodu village in Kanigiri mandal with isolate PPK from Kaveri hybrid at the flowering stage observed in red soil, recorded a PDI of 30.0%. The fourth, isolate at Naidupalem village in Pullalacheruvu mandal with isolate PNP from Kaveri hybrid at the flowering stage observed in red soil a PDI of 39.2%. The fifth, isolate at Bomireddi Palli village in Kanigiri mandal with isolate PBK from Kaveri hybrid at the flowering stage observed in red soil, recorded a PDI of 40.1%.

A survey conducted across several districts in A. P. revealed significant variation in the PDI for Alternaria leaf blight. The 'NDSH 1012' hybrid showed high susceptibility (50.5%), especially during the flowering stage, consistently exhibiting higher PDI compared to seedling and vegetative stages. Both black and red soil types displayed varying PDI (between varying, 0.9%), indicating that soil properties influence disease severity. The highest disease incidence was observed in Pamulapadu village (50.5%) of Nandyal district, while the lowest was recorded in Mudigubba village (18.5%) of Ananthapuramu district. Average disease incidences of 36.8% and 39.2% were noted in Nagari village of Chittoor district and Naidupalem village of Prakasam district, respectively. The disease was more severe (49.6%) in variety KBSH 44 in Chittoor compared to other varieties. Implementing targeted interventions, particularly during the flowering stage, selecting resistant hybrids like Advanta and Kaveri. Based on PDI data will enhance disease control and improve sunflower crop health in A. P.

The present results were in agreement with the findings of Singh *et al*., (2019) observed that field surveys were undertaken during two consecutive cropping seasons (2015-16 and 2016-17) in the initial study revealed higher illness incidence in both states. Throughout both farming seasons, Karnataka consistently had higher disease indicators than Maharashtra. Interestingly, district Dharwad in Karnataka has the highest mean disease incidence during both Alternaria leaf spot and Fusarium wilt (55.41% and 41.42%, respectively) among all surveyed districts. Kgatle *et al*., (2019) conducted study to identify the causative agent, prevalence and geographical distribution of ALB in South Africa's major sunflower production areas. Surveys were carried out at commercial sunflower production fields and commercial cultivar trials throughout the growing seasons 2012/13, 2013/14 and 2014/15. Between 90 and 120 days following planting, the plants were surveyed and ALB-symptomatic leaves were taken. Alternaria alternata was identified as the major ALB pathogen in all fields. Similarly, Prasad *et al*. (2020) examined the sunflower leaves with dark specks caused by leaf blight were gathered from 117 farms throughout nine Indian states during the rainy and spring seasons of 2009-10, 2010-11 and 2011-12. Similarly, Ajith *et al*., (2023) who surveyed in six major sunflower growing regions of northern Karnataka, including Gadag, Vijayapura, Bagalkote, Belagavi, Bellary and Haveri, during Kharif 2022 and Rabi 2022-23. The survey data revealed that leaf blight was prevalent across all growing locations, showing significant variations in severity based on location, season, cultivated hybrids, soil type and crop growth stage.

The average Percent Disease Incidence (PDI) observed across all surveyed locations during the Rabi 2023–24 season is 35.23%, representing the overall disease burden as calculated from the arithmetic mean of all sampled sites. A difference between two means, whether between varieties, locations, or treatments is considered statistically significant at the 5% level if it exceeds 2.15, indicating a true difference unlikely to have occurred by chance. Conversely, if the difference is 2.15 or less, it is deemed not statistically significant, suggesting the variation may be due to random sampling error rather than a genuine effect.

The study underscores the significant impact of Alternaria leaf blight on sunflower cultivation in A.P. The variability in disease incidence across different regions, soil types, and crop stages highlights the need for region-specific management strategies. The findings suggest that targeted interventions, particularly during the flowering stage, and the selection of resistant hybrids like 'Advanta' and 'Kaveri' are crucial for effective disease management. The significant variability in disease index across different regions, hybrids, and soil types underscores the importance of developing region-specific interventions. Selecting resistant hybrids, implementing appropriate soil management practices, and focusing on critical growth stages like flowering can enhance disease control and improve sunflower yields. The findings contribute valuable insights into the epidemiology of Alternaria leaf blight and offer a foundation for future research and management practices.

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The Editor-In-Chief gratefully acknowledges the help rendered by the following Editorial board members and Referees in reviewing the manuscripts for the Volume 11(3): 2025.

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