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PRODUCTION POTENTIAL OF SWEET CORN AS INFLUENCED BY ORGANIC MANURES AND FOLIAR NUTRITION

J. RAGHAVENDRA*, Y. REDDI RAMU, G. KRISHNA REDDY, SK. NAFEEZ UMAR AND V. CHANDRIKA

Department of Agronomy, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

A field experiment was conducted at dryland farm of S.V. Agricultural College, Tirupati, during *kharif*, 2023 on sandy loam soils. The experiment was laid down in FRBD and replicated thrice, assessed the effects of organic manures and foliar nutrition on sweet corn (variety Tang 75). The treatments included three organic manure combinations: M_1 (Green manuring with sunhemp + 50% N through FYM + biofertilizer consortium), M_2 (Green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium), and M_3 (Green manuring with sunhemp + 25% N through FYM + 25% N through poultry manure + biofertilizer consortium), and three foliar sprays: F_1 (Seaweed extract @ 1%), F_2 (Waste decomposer), and F_3 (Panchagavya @ 5%). Results revealed that the application of M_2 significantly enhanced green cob and green fodder yields compared to other treatments, among the foliar sprays, F_1 achieved the highest yields, while F_3 was statistically on par to F_2. Treatment M_2 also notably improved nitrogen, phosphorus, and potassium uptake, as well as soil microbial populations (bacteria, fungi, and actinomycetes). Statistically M_1 and M_3 treatments were on parity with each other. Seaweed extract (F_1) resulted in the greatest nutrient uptake, whereas waste decomposer (F_2) and panchagavya (F_3) were comparable but less effective in nutrient enhancement compared to F_1. Post-harvest soil analysis showed that M_1 had the highest levels of available nutrients, followed by M_3 and M_2. Based on an economic analysis, M_2 had the best benefit-cost ratio, as well as the highest gross and net returns.

KEYWORDS: Sweet corn**,** Organic Manures, Foliar Sprays, Biofertilizer consortium, Green manure crop, Gross Returns, Benefit-Cost Ratio.

INTRODUCTION

Maize is known as "queen of cereals," is crucial for global agriculture due to its high productivity and versatile uses. Cultivated across 208.87 million hectares worldwide, it produces 1210.23 million tonnes, representing 37 per cent of global grain output (FAO, 2021). In India, maize is grown on 9.9 million hectares, yielding 30 million tonnes with a productivity rate of 6105 kg h^{-1} (IndiaStat, 2024). Among its varieties, sweet corn is distinguished by its elevated sugar content, a result of genetic mutations that enhance sweetness, particularly when harvested at 18 to 21 days post-pollination (Creech, 1965). Its popularity has surged due to urban demand for nutritious, sweet-tasting food. Organic farming has become a key alternative to synthetic inputs, emphasizing sustainable practices. Organic methods, such as the use of farmyard manure, poultry manure, and green manures like sunhemp, are integral to maintain the soil fertility and achieving sustainable yields. Poultry manure, rich in nitrogen, phosphorus, and potassium, and biofertilizers like Azospirillum and phosphate-solubilizing bacteria, further enhance soil health and crop growth (Mohamed *et al*., 2010; Garg and Bahla, 2008; Vamsi *et al*., 2023).

Additionally, foliar applications, including seaweed extracts, waste decomposer, and panchagavya, improve crop vigor and productivity. This study aims to evaluate the effects of various organic manures and foliar treatments on sweet corn's yield, nutrient uptake, soil microbial status, and economic returns, providing valuable insights into sustainable organic practices for sweet corn production.

MATERIAL AND METHODS

A field experiment was conducted during the *kharif* season of 2023 at the College Farm of S.V. Agricultural College, Tirupati campus, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India. The soil at the experimental site was sandy loam with a pH of 6.9, an electrical conductivity (EC) of 0.13 dS m^{-1}, and low organic carbon (0.29%). Available nitrogen, phosphorus, and potassium were 176.0, 27.2, and 259.0 kg ha^{-1}, respectively. Initial microbial counts were 21.7 $\times 10^6$ CFU g^{-1} for bacteria, 9.5 $\times 10^4$ CFU g^{-1} for fungi, and 9.8 $\times 10^3$ CFU g^{-1} for actinomycetes.

The experimental design was randomized block design with factorial concept replicated thrice. Treatments were divided into two factors: organic manures and

*Corresponding author, E-mail: justsrs@gmail.com

organic foliar sprays. Three organic maanure treatmnts *i.e.* M_1 (green manuring with sunhemp + 50% N through FYM + biofertilizer consortium), M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium), and M_3 (green manuring with sunhemp + 25% N through FYM + 25% N through poultry manure + biofertilizer consortium). Four foliar spray treatments included F_1 (seaweed extract @ 1%), F_2 (waste decomposer), and F_3 (panchagavya @ 5% [260 l ha^{-1}]). Biofertilizer consortium (Azospirillum + PSB + KSB) was applied at 1.25 l ha^{-1}, and foliar sprays were administered at the knee-high stage and tassel initiation. Recommended doses of fertilizers (120-50-40 kg N, P_2O_5, and K_2O ha^{-1}) were supplied through organic manures based on equivalent nitrogen content.

Green cob yield was determined by weighing the harvested cobs from the net plot and expressing the results in kg ha^{-1}. Following the harvest of green cobs, the remaining plants were cut back to the base, and the green fodder was weighed from the net plot and also expressed in kg ha^{-1}.

Plant samples of crop were collected from all the plots at harvest and these samples were dried, ground into fine powder and used for estimation of nitrogen, phosphorus and potassium. Nutrient uptake by crop was calculated by using the formula

Nutrient uptake (kg ha^{-1}) =

$$\frac{\text{Drymatter production (kg ha}^{-1}) \times \text{Nutrient content (\%)}}{100}$$

Microbial populations in the soil were assessed using the serial dilution plate count method (Pramer and Schmidt, 1965). Bacteria were enumerated on Nutrient Agar (NA), fungi on Potato Dextrose Agar (PDA), and actinomycetes on Actinomycetes Isolate Agar (AIA). For nutrient uptake analysis, plant samples were collected at harvest, oven-dried, powdered, and analyzed for nitrogen, phosphorus, and potassium content. Nitrogen content was estimated using the micro-Kjeldahl method (AOAC, 1960), phosphorus by the vanado-molybdo phosphoric acid method (Jackson, 1973), and potassium using flame photometry (Jackson, 1973).

Soil samples were collected before planting and after harvest, air-dried, powdered, and sieved for analysis. Available nitrogen, phosphorus, and potassium were measured using methods outlined by Subbiah and Asija (1956), Olsen *et al.* (1954), and Jackson (1973), respectively.

The total cost of cultivation and gross returns were calculated based on input costs and market prices, with net returns determined by subtracting the cost of cultivation from gross returns. The benefit-cost ratio was computed to evaluate the economic viability of the treatments.

RESULTS AND DISCUSSION

Sweet corn yield, post-harvest soil nutrient status, nutrient uptake, soil microbial population and economics as influenced by different organic manures and foliar sprays are discussed under the following headings

Green Cob Yield

The green cob yield of sweet corn was significantly affected by the organic manures and foliar sprays used, although the interaction between them was not statistically significant. Among the organic manures, M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium) resulted in the highest green cob yield (5634 kg ha^{-1}), which was significantly superior to all other treatments. The next best treatment was M_3 (green manuring with sunhemp + 25% N through FYM + 25% N through poultry manure + biofertilizer consortium), which was comparable to M_1 (green manuring with sunhemp + 50% N through FYM + biofertilizer consortium). The superior yield from poultry manure M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium) can be attributed to the higher concentration of macro and micronutrients and a steady nutrient release throughout the crop period. Poultry manure increases humic acid production, which forms water-soluble chelated phosphorus, facilitating easier phosphorus release to the crop, enhancing green cob yield. These findings are consistent with those of Jagadeesha *et al*. (2010), Sangeetha *et al*. (2013), Prakash *et al.* (2018), Priya and Satyamoorthi (2019), Aravind *et al.* (2020). Regarding foliar sprays, the highest green cob yield was achieved with F_1 (seaweed extract @ 1%), followed by F_3 (panchagavya @ 5% [260 l ha^{-1}]) which was comparable to the F_2 (waste decomposer). Increase in green cob yield was observed with seaweed extract compared to panchagavya due to natural growth hormones, cytokinins, and auxins present in seaweed extract stimulate cell division and elongation, leading to robust plant growth and larger cobs. Additionally, seaweed extract enhances the plant's stress resistance, resulting in healthier plants and higher yields. These findings are consistent with those of Gumpula *et al*. (2022) and Simha *et al*. (2023).

Table 1. Green cob yield and green fodder yield (kg ha^{-1}) of sweet corn as influenced by organic manures and foliar sprays

Treatments	Green cob yield (kg ha^{-1})	Green fodder yield (kg ha^{-1})
Organic manures (M)		
M_1 : Green manuring with sunhemp + 50 % N through FYM + biofertilizer consortium	5634	12126
M_2 : Green manuring with sunhemp + 50 % N through poultry manure + biofertilizer consortium	6112	13161
M_3 : Green manuring with sunhemp + 25 % N through FYM + 25% N through poultry manure + biofertilizer consortium	5724	12323
SEm±	102	223.5
CD (P = 0.05)	307	670
Foliar sprays (F)		
F_1 : Seaweed extract @ 1%	6280	13521
F_2 : Waste decomposer	5562	11978
F_3 : Panchagavya @ 5% (260 l ha^{-1})	5628	12111
SEm±	102	223
CD (P = 0.05)	307	670
Organic manures (M) × Foliar sprays (F)		
SEm±	177	387
CD (P = 0.05)	NS	NS

Green fodder yield

Among the organic manures, treatment M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium) produced the highest green fodder yield (12126 kg ha^{-1}), significantly surpassing all other treatments. The next best treatment was M_3 (green manuring with sunhemp + 25% N through FYM + 25% N through poultry manure + biofertilizer consortium), which was comparable to M_1. The highest green fodder yield observed with M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium) might be due to the better availability of NPK and beneficial micronutrients in poultry manure, enhancing plant activity and resulting in higher dry matter production, thus leading to greater green fodder yield. These findings align with those of Gawade *et al.* (2013), Pallavi *et al*. (2016), and Reddy *et al.* (2021). Additionally, the organic source's nutrient availability increased due to the release of organic acids during decomposition, aiding in the mineralization of native soil nutrients and enhancing their availability to plants. Similar results were reported by Kharche *et al.* (2020). Regarding foliar sprays, the highest green fodder yield was achieved with treatment F_1 (seaweed extract @ 1%) followed by F_3 (panchagavya @ 5% [260 l ha^{-1}]), which was comparable to F_2 (waste decomposer). The significant increase in green fodder yield associated with seaweed extract application may be attributed to enhanced nutrient uptake by the maize plant, and the presence of macro and micro-elements and plant growth regulators (especially cytokinins, IAA, and GA)

Table 2. Nutrient (NPK) uptake (kg ha^{-1}) by sweet corn at harvest as influenced by organic manures and foliar sprays

Treatments	Nitrogen	Phosphorus	Potassium
Organic manures (M)			
M_1 : Green manuring with sunhemp + 50 % N through FYM + biofertilizer consortium	140	19.0	142
M_2 : Green manuring with sunhemp + 50 % N through poultry manure + biofertilizer consortium	153	20.6	155
M_3 : Green manuring with sunhemp + 25 % N through FYM + 25% N through poultry manure + biofertilizer consortium	143	19.3	145
SEm±	2.8	0.37	2.88
CD (P = 0.05)	8.4	1.1	8.6
Foliar spray (F)			
F_1 : Seaweed extract @ 1%	157	21.2	159
F_2 : Waste decomposer	139	18.0	141
F_3 : Panchagavya @ 5% (260 l ha^{-1})	142	18.9	142
SEm±	2.8	0.4	2.9
CD (P = 0.05)	8.0	1.1	9.0
Organic manures (M) × Foliar sprays (F)			
SEm±	4.9	0.6	5.0
CD (P = 0.05)	NS	NS	NS

responsible for larger leaf area index (LAI), higher dry matter production, and ultimately higher green fodder yield. These findings are consistent with those of Gumpula *et al.* (2022) and Simha *et al.* (2023).

Nutrient (NPK) uptake at harvest

Among the organic manures, treatment M_2 resulted in the highest nutrient uptake, significantly superior to all other treatments. The next best treatments were M_3 (green manuring with sunhemp + 25% N through FYM + 25% N through poultry manure + biofertilizer consortium) and M_1 (green manuring with sunhemp + 50% N through FYM + biofertilizer consortium) which were on par with each other. The higher nutrient uptake observed with poultry manure M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium) can be attributed to its production of more humic acid, forming water-soluble chelated phosphorus. This helps in the gradual release of phosphorus in the rhizosphere, providing a steady supply of soluble nutrients and minimizing nutrient fixation and precipitation. Adequate nutrient supply resulted in higher nutrient uptake and better yield. These findings are consistent with Hossain *et al.* (2010), Sangeetha *et al.* (2013), Prakash *et al.* (2018), and Nayak *et al.* (2020). The application of poultry manure releases nutrients slowly into the soil solution, matching the sweet corn's absorption pattern. Devegowda (1997) also reported that poultry manure contains higher concentrations of macro and micronutrients, contributing to greater nutrient availability and uptake than farmyard manure. Among the foliar sprays, the highest nutrient uptake was observed with treatment F_1 (seaweed extract @ 1%) followed by F_3 (panchagavya @ 5% [260 l ha^{-1}]), which was comparable to F_2 (waste decomposer). The increase in nutrient uptake with seaweed extract foliar spray can

Table 3. Post-harvest soil available nitrogen, phosphorous and potassium (kg ha^{-1}) of sweet corn as influenced by organic manures and foliar sprays

Treatments	Available N	Available P_2O_5	Available K_2O
Organic manures (M)			
M_1 : Green manuring with sunhemp + 50 % N through FYM + biofertilizer consortium	241	31.6	224
M_2 : Green manuring with sunhemp + 50 % N through poultry manure + biofertilizer consortium	231	30.4	185
M_3 : Green manuring with sunhemp + 25 % N through FYM + 25% N through poultry manure + biofertilizer consortium	240	31.8	214
SEm±	3.6	0.48	3.69
CD (P = 0.05)	11	1.4	11.0
Foliar spray (F)			
F_1 : Seaweed extract @ 1%	241	31.6	219
F_2 : Waste decomposer	238	31.2	212
F_3 : Panchagavya @ 5% (260 l ha^{-1})	240	31.5	224
SEm±	3.68	0.48	3.69
CD (P = 0.05)	NS	NS	NS
Organic manures (M) × Foliar sprays (F)			
SEm±	6.3	0.8	6.4
CD (P = 0.05)	NS	NS	NS

be attributed to beneficial microorganisms and plant growth-stimulating substances in the extract, enhancing the biological efficiency of crop plants and improving the source-sink relationship. This likely contributed to greater nutrient absorption and translocation (NCOF, Ghaziabad).Higher NPK uptake might also result from the sufficient release of nutrients through mineralization at a constant level, which increased nutrient uptake under the improved soil environment created by the cumulative effect of organic sources (Nayak *et al.,* 2019).

Post-harvest soil nutrient status

Among the treatments, the highest post-harvest soil available nitrogen, phosphorus, and potassium were recorded with treatment M_1 (green manuring with sunhemp + 50% N through FYM + biofertilizer consortium). The next best treatment was M_3 (green manuring with sunhemp + 25% N through FYM + 25% N through poultry manure + biofertilizer consortium), which was comparable to M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium). The mineralization of organic manures and the release pattern of nutrients into the soil solution vary according to their sources. The enhanced nitrogen status of the soil might be due to increased rhizosphere microorganisms' activity, facilitated by the incorporation of poultry manure, which converts bound nitrogen into an inorganic form. Consequently, the application of poultry manure enhances nitrogen availability and uptake by the crop, potentially leading to lower nitrogen levels in the soil post-harvest compared to other manures. These results align with the findings of Banerjee *et al.* (2013) and Nayak *et al.* (2020). During the decomposition of organic manures, various acids are produced,

Table 4. Post-harvest soil microbial population of sweet corn as influenced by organic manures and foliar sprays

Treatments	Bacteria (No. × 10^7 CFU g^{-1})	Fungi (No. × 10^4 CFU g^{-1})	Actinomycetes (No. × 10^3 CFU g^{-1})
Organic manures (M)			
M_1 : Green manuring with sunhemp + 50 % N through FYM + biofertilizer consortium	39	18.6	15.3
M_2 : Green manuring with sunhemp + 50 % N through poultry manure + biofertilizer consortium	43	20.0	17.0
M_3 : Green manuring with sunhemp + 25 % N through FYM + 25% N through poultry manure + biofertilizer consortium	41	19.1	15.9
SEm±	0.81	0.36	0.31
CD (P = 0.05)	2.4	1.1	0.9
Foliar spray (F)			
F_1 : Seaweed extract @ 1%	45	20.8	17.2
F_2 : Waste decomposer	40	18.1	15.3
F_3 : Panchagavya @ 5% (260 l ha^{-1})	42	18.6	15.6
SEm±	0.8	0.37	0.31
CD (P = 0.05)	2.43	1.10	0.9
Organic manures (M) × Foliar sprays (F)			
SEm±	1.4	0.6	0.5
CD (P = 0.05)	NS	NS	NS

which solubilize phosphate-bearing minerals, activate phosphatase, and lower phosphorus fixation, thereby increasing phosphorus availability. This reduction in phosphorus fixation and increased availability are supported by the findings of Rana *et al.* (2015), Nayak *et al.* (2020), Chaudhary *et al.* (2021), and Ahmed and Tripathi (2022). Organic manures not only supply nutrients but also serve as food for microorganisms, encouraging their multiplication, which improves nutrient mineralization in the soil, enhancing soil fertility and productivity. Basavarajappa et al. (2002) reported similar observations, indicating that the use of organics increases both yield and soil health. In general, organic manures improve soil health by increasing the number of soil microorganisms, which in turn transform non-available plant nutrients into available forms (Yawalkar *et al.,* 1992). The results clearly indicate that wherever nutrient uptake increased, there was a corresponding decrease in the status of available nutrients in the soil post-harvest (Jagadeesha *et al.*, 2018). The influence of foliar sprays and their interactions was not statistically traceable.

Post-harvest soil microbial population

Higher post-harvest soil microbial populations, including the total count of bacteria, fungi, and actinomycetes, were recorded with treatment M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium) which showed a significant difference compared to other treatments. The next best treatment was M_3 (green manuring with sunhemp +

Table 5. Gross returns, net returns (₹ ha^{-1}) and benefit-cost ratio of sweet corn cultivation as influenced by organic manures and foliar sprays

Treatments	Gross return	Net return	Benefit-cost ratio
Organic manures (M)			
M_1 : Green manuring with sunhemp + 50 % N through FYM + biofertilizer consortium	102264	40521	1.66
M_2 : Green manuring with sunhemp + 50 % N through poultry manure + biofertilizer consortium	110949	52409	1.89
M_3 : Green manuring with sunhemp + 25 % N through FYM + 25% N through poultry manure + biofertilizer consortium	103908	43517	1.72
SEm±	1864	1868	0.03
CD (P = 0.05)	5589	5599	0.10
Foliar spray (F)			
F_1 : Seaweed extract @ 1%	113993	48967	1.76
F_2 : Waste decomposer	100977	43409	1.74
F_3 : Panchagavya @ 5% (260 l ha^{-1})	102152	44071	1.75
SEm±	1864	1868	0.03
CD (P = 0.05)	5589	5599	0.1
Organic manures (M) × Foliar sprays (F)			
SEm±	3229	3235	0.06
CD (P = 0.05)	NS	NS	NS

25% N through FYM + 25% N through poultry manure + biofertilizer consortium), which was comparable to M_1 (green manuring with sunhemp + 50% N through FYM + biofertilizer consortium). The increased microbial populations with poultry manure application are likely due to its richness in macro and micronutrients, along with plant growth-promoting substances, humus-forming microbes, and nitrogen fixers. Poultry manure enhances enzymatic and microbial activities, improving soil fertility. It also increases biological activities in the soil, thereby encouraging microbial population growth. These findings align with those of Sharma *et al.* (2017) and Ammaan *et al.* (2019). Foliar sprays such as seaweed extract, panchagavya, and waste decomposer contain beneficial microorganisms along with plant growth-stimulating substances and nutrients, promoting microbial colonization in the rhizosphere (NCOF, Ghaziabad).

Gross Returns

Significantly the highest gross returns (₹ 110949 ha^{-1}) were realized by M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium) over the rest of the treatments tried. It is obvious that realization of higher gross returns was the result of higher green cob and green fodder yield. The next best treatment was green manuring with M_3 (green manuring with sunhemp + 25% N through FYM + 25% N through poultry manure + biofertilizer consortium), which was on par with M_1 (green manuring with sunhemp + 50% N through FYM + biofertilizer consortium). Among different foliar sprays, significantly the highest gross returns were recorded with application of F_1 (seaweed extract @ 1%). The next best treatment was F_3 (panchagavya @ 5% [260 l ha^{-1}]), which was on par with green manuring with F_2 (waste decomposer).

Net Returns

Significantly the highest net returns (₹ 52409 ha-1) were realized by M_2 over the rest of the treatments tried. The next best treatment was M_3 (green manuring with sunhemp + 25% N through FYM + 25% N through poultry manure + biofertilizer consortium), which was on par with M_1 (green manuring with sunhemp + 50% N through FYM + biofertilizer consortium). Among different foliar sprays, significantly the highest net returns were recorded with application of F_1 (seaweed extract @ 1%). The next best treatment was F_3 (panchagavya @ 5% [260 l ha^{-1}]), which was on par with green manuring with F_2 (waste decomposer).

Benefit-Cost Ratio

Significantly the highest benefit-cost ratio (1.89) was noticed with M_2 (green manuring with sunhemp + 50% N through poultry manure + biofertilizer consortium) compared to other treatments. The next best treatments were green manuring with M_3 (green manuring with sunhemp + 25% N through FYM + 25% N through poultry manure + biofertilizer consortium) and M_1 (green manuring with sunhemp + 50% N through FYM + biofertilizer consortium) with no significant disparity between them.

Among the foliar sprays, significantly the highest benefit-cost ratio was noticed with F_1 (seaweed extract @ 1%). Treatment F_3 (panchagavya @ 5% [260 l ha^{-1}]) and F_2 (waste decomposer) were the next best treatments with no significant difference between them.

In conclusion, the present study revealed that green manuring with sunhemp + 50 per cent N through poultry manure (60 kg ha^{-1}) + soil application of *Azospirillum*+ PSB+ KSB @1.25 l ha^{-1} each along with foliar application of seaweed extract @ 1 per cent twice at knee high and tassel initiation stage was found to be the most promising and economically viable organic nutrient management practice for enhancing the productivity, uptake of nutrients as well as sustaining the soil microbial health of organic sweet corn.

LITERATURE CITED

Ahmed, M and Tripathi, S.K. 2022. Effect of integrated use of vermicompost, FYM and chemical fertilizers on soil properties and productivity of wheat (*Triticum aestivum* L.) in alluvial soil. *The Journal of Phytopharmacology*. 11(2): 101-106.

Ammaan, M., Akila, A., Muthukrishnan, M., Nivedhaa, M.A., Rahul, A., Rishi, B., Sowmya, S.P., Sumithra, S., Deepthi, S and Theradimani, M. 2019. Effect of organic manures and biofertilizers on soil microbial population in amaranth (*Amaranthus blitum*). *International Journal of Current Microbiology and Applied Sciences*. 8(6): 700- 704.

AOAC. 1960. *Official Methods of Analysis of the Association Official Agricultural Chemists*, 9th edn. Washington. D.C.

Aravind, A.S., Kumar, S.N., Hemalatha, M and Paramasivan, M. 2020. Influence of organic supplements on growth and yield of finger millet (*Eleusine coracana* L.). *Journal of Pharmacognosy and Phytochemistry*. 9(3): 1564-1567.

Banerjee, S., Ghosh, M., Pal, S.K., Mazumdar, D and Mahata, D. 2013. Effect of organic nutrient management practices on yield and economics of scented rice *Gobindabhog*. *Oryza*. 50(4): 365-369.

Basavarajappa, R., Prabhakar, A.S and Halikatti, S.I. 2002. Effect of tillage, organics, nitrogen and their interactions on yield attributes and yield of foxtail millet (*Setaria italica*) under shallow *Alfisol* during rainy season. *Indian Journal of Agronomy*. 47: 390-397.

Chaudhary, M.G., Malav, J.K., Vala, Y.B and Desai, N.A. 2021. Influences of different organic sources and seaweed extract on quality, nutrient content, uptake, soil fertility status and soil microbial population after harvest of summer greengram (*Vigna radiata* L.). *The Pharma Innovation Journal*. 10(11): 1390-1394.

Creech, R.G., 1965. Genetic control of carbohydrate synthesis in maize endosperm. *Genetics.* 52(6): 1175.

Devegowda, G. 1997. Poultry manure excreta and other wastes as a source of organic manures. *Training Course on Organic Farming*, UAS, GKVK, Bangalore. 7-11.

FAO. 2020-21. Quarterly bulletin of statistics food and Aricultural Organisation (https://www.fao.org/statistics/en*)*.

Garg S and Bahla G.S. 2008. Phosphorus availability to maize as influenced by organic manures and fertilizer P associated phosphatase activity in soils. *Bioresour Technol.* 99(13): 5773–5777.

Gawade, M.B., Mahadkar, U.V and Jagtap, D.N. 2013. Effects of organic manures, sources and levels of fertilizers on yield attributes and yield of finger millet (*Eleusine coracana* G.). *International Journal of Agricultural Sciences*. 9(2): 795-798.

Gumpula, P.K and Dawson, J. 2022. Effect of crop geometry and seaweed (*kappaphycus* & *gracilaria*) extract on growth and yield of baby corn (*Zea mays*). *International Journal of Plant & Soil Science*. 34(21): 672-677.

Hossain, A.T.M.S., Rahman, F., Saha, P.K and Solaiman, A.R.M. 2010. Effects of different aged poultry litter on the yield and nutrient balance in boro rice cultivation. *Bangladesh Journal of Agricultural Research*. 35(3): 497-505.

https://www.indiastat.com

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice-Hall of India Pvt. Ltd., New Delhi. 134-204.

Jagadeesha, N., Reddy, V.C., Krishnamurthy, N and Sheshadri, T. 2010. Effect of organic manures on productivity of finger millet and redgram inter cropping system under protective irrigation. *International Journal of Agricultural Sciences*. 6(2): 453-455.

Kharche, P.P., Bhondave, T.S and Sawant, A.C., 2020. Effect of organic source of nitrogen on growth, yield and economics of baby corn. *Current Journal of Applied Science and Technology.* 39(16): 66-75.

Mohamed AM, Sekar S and Muthukrishnan P (2010) Prospects and potential of poultry manure. *Asian Journal of Plant Sciences* 9: 172–182.

Nayak, H.V., Ramu, Y.R, Chandrika, V and Reddy, P.V.R.M. 2020. Integrated nutrient management for enhancing growth and productivity of maize (*Zea mays* L.). *Andhra Pradesh Journal of Agricultural Sciences.* 7(1): 9-12.

Nayak, H.V., Ramu, Y.R, Chandrika, V and Reddy, P.V.R.M. 2020. Integrated nutrient management for enhancing growth and productivity of maize (*Zea mays* L.). *Andhra Pradesh Journal of Agricultural Sciences.* 7(1): 9-12.

Nayak, P., Reddy, A.P.K., Sunitha, N and Madhuri, K.V.N. 2019. Optimising the organic, inorganic and biofertiliser needs for sustained productivity of maize (*Zea Mays* L.). *International Journal of Current Microbiology and Applied Sciences.* 8(4): 1203-1209.

NCOF,Ghaziabad.https://ncof.dacnet.nic.in/Training_manuals/Training_man uals_in_English/Waste Decomposer-Eng.pdf

Pallavi, C., Joseph, B., Khan, M.A.A and Hemalatha, S. 2016. Effect of integrated nutrient management on nutrient uptake, soil available nutrients and productivity of rainfed finger millet. *International Journal of Science, Environment and Technology*. 5(5): 2798-2813.

Prakash, P., Sharanappa and Nagaraju. 2018. Effect of different establishment methods and organic nutrient sources on yield, yield attributes and economics of finger millet (*Eleusine coracana* (L.) Gaertn). *International Journal of Environmental Sciences & Natural Resources*. 12(3): 56-60.

Pramer, D and Schmidt, E.L. 1965. *Experimental Soil Microbiology*. Burgess Publishing Co., Minneapolis.

Priya, G and Sathyamoorthi, K. 2019. Influence of organic manures on the growth and yield of foxtail millet [*Setaria italica* (L.) Beauv]. *Chemical Science Review and Letters*, 8(29): 114-117.

Rana, M., Raverkar, K.P., Pareek, N., Chandra, R and Singh, D.K. 2015. Impact of bio-dynamic preparations and panchagavya in organically managed cropping systems comprising legumes on soil biological health. *Legume Research-An International Journal*. 38(2): 219-228.

Reddy, R and Prathima, T. 2023. Effect of liquid biofertilizers on productivity, quality and soil biota of fodder sorghum. *International Journal of Environment and Climate Change.* 13(10): 3665-3671.

Reddy, R.K., Singh, R and Khan, W. 2021. Performance of organic sources and biofertilizers on growth and yield of finger millet (Eleusine coracana L.). *International Journal of Current Microbiology and Applied Sciences*. 10(3): 2017-2023.

Sangeetha, S.P., Balakrishnan, A and Devasenapathy, P. 2013. Influence of organic manures on yield and quality of rice (Oryza sativa L.) and blackgram (Vigna mungo L.) in rice-blackgram cropping sequence. *American Journal of Plant Sciences.* 4: 1151-1157.

Sharma, R.K., Sharma, S.K and Balyan, J.K. 2017. Productivity and profitability of Indian mustard under different organic nutrient management practices in Semi-arid region*. Journal of Oilseed Brassica*. 1(1): 89-94.

Simha, K.J and Debbarma, V. 2023. Influence of seaweed sap and zinc on growth and yield of baby corn (*Zea mays* L.). *International Journal of Plant & Soil Science*. 35(16): 251-260.

Sree, G.R. 2022. Nutrient management practices for organic finger millet (*Eleusine coracana* (L.) Gaertn.). *M.Sc. (Ag.) Thesis*. Acharya N.G. Ranga Agricultural University, Guntur, Andhra Pradesh.

Subbiah, B.V and Asija, G.L. 1956. A rapid procedure for determination of available nitrogen in soil. *Current Science*. 25: 259-260.

Swaminathan, C., Swaminathan, V and Vijayalakshmi, K. 2007. Panchagavya-boon to organic farming, *International Book, Distributing Co.* 181-195.

Vamsi, Y., Reddy, S.T., Reddy, M.R and Prathima, T. 2023. Effect of liquid biofertilizers on productivity, quality and soil biota of fodder sorghum. *International Journal of Environment and Climate Change.* 13(10): 3665-3671.

Yawalkar, K.S., Agarwal, J.P and Bokde, S. 1992. *Manures and fertilizers. Kapoor Art Press.* 29-77.

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CHARACTERIZATION OF GRAIN IRON AND ZINC CONTENT IN LITTLE MILLET GENOTYPES

U. MADHURI*, L. MADHAVI LATHA, P. SHANTHI, SK. NAFEEZ UMAR AND M. REDDI SEKHAR

Department of Genetics and Plant Breeding, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

Micronutrient deficiency is a common cause of most of the human diseases. Little millet is an important climate-resilient crop and a rich source of micronutrients, particularly iron and zinc, thus can be helpful to combat iron and zinc malnutrition. Little millet has many health-promoting factors. Identifying and selecting nutrient-rich genotypes within populations is vital for improving the crop's nutritional value. This process involves evaluating and screening various genotypes for their nutrient content, such as protein quality and mineral composition. In this field experiment, 40 genotypes were evaluated in 3 replications in randomized block design. Maximum iron content was observed for the genotype, CLMV-1 (9.85mg) and PPS 164 (9.85mg) whereas the minimum was observed in PPS145 (6.23mg) with general mean of 7.23mg. The genotypes PPS 99 (8.76mg), PPS 165 (8.23mg), PPS 179 (8.21mg), PPS 118 (7.87mg), PPS 147 (7.78mg) and PPS 126 (7.77mg), recorded significantly higher iron content per 100g of grain. Maximum zinc content was observed for the genotype CLMV-1 (4.08mg) whereas the minimum was observed in PPS156 (1.87mg) with general mean of 2.84mg. The genotypes PPS 164 (3.88 mg), PPS 180 (3.78mg), PPS 113 (3.77mg), PPS 149 (3.56mg), PPS 163 (3.45mg), PPS 147(3.44mg), PPS 109 (3.42mg), PPS 179 (3.26mg) recorded significantly higher zinc content per 100g of grain.

KEYWORDS: Little millet, micronutrients, iron content, zinc content and nutrient rich genotypes.

INTRODUCTION

Iron (Fe) and zinc (Zn) are the most essential micronutrients for human growth and development, especially for infants. Micronutrient malnutrition has been identified as one of the most severe human health-related problems around the world. Iron deficiency is the most noticeable of these having 9th rank, whereas zinc deficiency is at 11th rank among the top twenty risk factors, which contribute to global disease burden. Although there are many adequate sources for these nutrients, still insufficiency is an issue mainly in poor. So, it is important to find the low-cost cereals having high iron and zinc content along with other essential nutrients. Millets may be a viable answer to this issue.

Little millet (*Panicum sumatrense* Roth ex Roem. & Schult.) is one of the most important small millet crops and is popularly known as sama, samo, vari or kutki belongs to the Poaceae family (Ganapathy *et al*. 2016). It is quick-growing, short-duration and hardy crop that can withstand drought and waterlogging to a certain degree. It was domesticated in the Eastern Ghats of India occupying a major portion of the diet amongst the tribal people and spread to Sri Lanka, Nepal, and Myanmar. In India, its cultivation is mostly confined to the tribal belt of Madhya Pradesh, Chattisgarh and Andhra Pradesh (Natesan *et al*. 2020). Little millet is considered as best nutri-cereal as it is nutritionally rich, as 100 g of seed contains high protein (7.70 g), zinc (3.70 mg), iron (9.30 mg), magnesium (114.00 mg), calcium (17.00 mg), phosphorus (220.00 mg), carbohydrate (76.70 g), fat (4.79 g), calories 329 kcal, minerals (1.50 g), fiber (7.60 g) (Nandini *et al*. 2016). Little millet grain is a low glycemic index food that is also rich in dietary fiber. Identifying and selecting nutrient-rich genotypes within populations is vital for improving the crop's nutritional value.

MATERIAL AND METHODS

Forty genotypes of little millet were evaluated in three replications under randomized block design at the Agriculture Research Station, Perumallapalle, Tirupati.

The experiment is conducted to identify the high-yielding genotypes with significant amounts of Fe, and Zn content**.**

Procedure for extraction of micronutrients

One gram of sample was taken into a 100 ml conical flask and 10 ml of a di-acid mixture of HNO_3 and $HClO_4$ in the ratio of (9:4) was added and kept for

*Corresponding author, E-mail: madhuriuppada05@gmail.com

overnight digestion. The sample with diacid is kept on a heat hot plate. The contents were then heated at a higher temperature until the production of NO_2 fumes ceased. Later the contents were evaporated until 3 to 5 ml digest was obtained but not to dryness. The completion of digestion is confirmed when the liquid becomes colourless. After cooling the flask, 50 ml of double distilled water was added to the digest and transferred into a 100 ml volumetric flask with the Whatmann no:1 filter paper and the volume was made up to 100 ml with double distilled water. Then, the iron and zinc content in the samples was determined with the help of an Atomic Absorption Spectrophotometer (AAS) (Lindsay and Norvell., 1978).

RESULTS AND DISCUSSION

Micronutrient analysis of grain was performed in forty little millet genotypes to determine iron and zinc concentration. Iron and zinc content of little millet genotypes was presented in Table 1. The elemental analysis of little millet results depicted significant variation in iron concentrations ranging from 6.34 mg/100g to 9.85 mg/100g whereas zinc content ranging from 1.87 mg to 4.08 mg/100g. Maximum iron content was observed for the genotype CLMV-1 (9.85mg) and PPS 164 (9.85mg) whereas the minimum was observed in PPS 145 (6.23mg) with general mean of 7.23mg. The genotypes PPS 99 (8.76mg), PPS 165 (8.23mg), PPS 179 (8.21mg), PPS 118 (7.87mg), PPS 147 (7.78mg) and PPS 126 (7.77mg), recorded significantly higher iron content per 100g of grain. Genotypes PPS145 (6.23mg), PPS 120 (6.24mg) PPS 151 (6.29 mg) and PPS 133 (6.33 mg) recorded lower iron content per 100g of grain. Maximum zinc content was observed for the genotype CLMV-1 (4.08mg) whereas the minimum was observed in PPS 156 (1.87mg) with general mean of 2.84mg. The genotypes PPS 164 (3.88 mg), PPS 180 (3.78mg), PPS 113 (3.77mg), PPS 149 (3.56mg), PPS 163 (3.45mg), PPS 147(3.44mg), PPS 109 (3.42mg), PPS179 (3.26mg) recorded significantly higher zinc content per 100g of grain.

The genotypes were grouped into three categories, high, medium and low based on their iron and zinc content using mean and standard deviation values. Classification of little millet genotypes based on iron and zinc content was presented in Table 2.

The genotypes were grouped into 3 classes i.e. low, medium and high based on the grain iron and zinc content of forty genotypes of little millet. Five genotypes

Table 1. Iron and zinc content of little millet genotypes (in mg/100g)

S. No	Genotype	Iron Content (mg/100g)	Zinc Content (mg/100g)
1	PPS 99	8.76	2.88
2	PPS 105	7.24	2.66
3	PPS 107	7.55	2.37
4	PPS 108	7.34	3.23
5	PPS 109	6.86	3.42
6	PPS 113	7.56	3.77
7	PPS 114	6.87	2.86
8	PPS 118	7.87	2.88
9	PPS 120	6.23	2.44
10	PPS 123	7.34	1.08
11	PPS 125	6.30	1.87
12	PPS 126	7.77	2.44
13	PPS 127	7.28	2.29
14	PPS 133	6.33	3.24
15	PPS 134	6.37	3.29
16	PPS 138	7.23	3.29
17	PPS 140	6.87	2.24
18	PPS 142	7.77	2.88
19	PPS 144	7.36	2.29
20	PPS 145	6.23	3.23
21	PPS 147	7.78	3.44
22	PPS 149	6.67	3.56
23	PPS 151	6.29	2.57
24	PPS 152	7.35	2.83
25	PPS 156	7.25	1.77
26	PPS 157	7.36	1.78
27	PPS 159	6.29	2.75
28	PPS 160	7.33	2.77
29	PPS 163	6.87	3.45
30	PPS 164	9.85	3.88
31	PPS 165	8.23	2.77
32	PPS 166	7.24	2.88
33	PPS 168	7.74	1.79
34	PPS 171	6.86	1.88
35	PPS 172	7.67	1.82
36	PPS 179	8.23	3.26
37	PPS 180	7.34	3.76
38	CLMV-1	9.85	4.08
39	OLM-203	8.43	3.87
40	BL-6	8.29	3.77
	Mean	**7.40**	**2.83**
	SD	**0.85**	**0.71**

Table 2. Classification of little millet genotypes based on iron and zinc content

Category	Iron	Zinc
Low (< Mean-SD)	**(<6.55%)** PPS 120, PPS 125, PPS 133, PPS 134, PPS 145, PPS 151 and PPS 159	**(<2.12%)** PPS 123, PPS 125, PPS 156, PPS 157, PPS 168, PPS 171 and PPS 172.
Medium (Mean-SD-Mean + SD)	**(6.55%-8.25%)** PPS 105, PPS 107, PPS 108, PPS 109, PPS 113, PPS 114, PPS 118, PPS 123, PPS 126, PPS 127, PPS 138, PPS 140, PPS 142, PPS 144, PPS 145, PPS 147, PPS 149, PPS 152, PPS 156, PPS 157, PPS 160, PPS 163, PPS 165, PPS166, PPS 168, PPS 171, PPS 172, PPS 179 and PPS180.	**(2.12%-3.54%)** PPS 99, PPS 105, PPS 107, PPS 108, PPS 109, PPS 114, PPS 118, PPS 126, PPS 127, PPS 133, PPS 134, PPS 138, PPS 140, PPS 142, PPS 144, PPS 145, PPS 147, PPS 149, PPS 151, PPS 152, PPS 159, PPS 160, PPS 163, PPS 165, PPS166 and PPS 120
High (> Mean + SD)	**(>8.25%)** PPS 99, OLM-203, BL-6, CLMV-1 and PPS164.	**(>3.54%)** BL-6, OLM-203,CLMV-1, PPS 180, PPS 164, PPS 149 and PPS 113.

fall under high iron content (>8.25mg/100g), twenty-eight fall under medium (6.55-8.25mg/100g), and seven fall under the low category (<6.55mg/100g). Seven genotypes fall under high zinc content (>3.54mg/100g), twenty-six fall under medium (2.12-3.54mg/100g) and seven fall under the low category (<2.12mg/100g). This variation of iron and zinc content in little millet grains is nearly consistent with results obtained by Manimozhi *et al*. 2015, Kundagol *et al*. 2015, Singane *et al*. 2018, Kaushal *et al*. 2023 and Panda *et al*. 2024.

The study revealed significant variation in iron and zinc content among different little millet genotypes. Genotypes such as CLMV-1 and PPS 164 were rich in both iron and zinc, making them excellent candidates for breeding programs aimed at enhancing the nutritional value of millet. In contrast, genotypes like PPS 145 (low in iron) and PPS 156 (low in zinc) could benefit from genetic selection or agronomic improvements. This analysis provides valuable insights for selecting genotypes with optimal micronutrient content, which is crucial for combating nutritional deficiencies in populations that depend on little millet as a staple food.

LITERATURE CITED

Ganapathy, K.N. 2017. Genetic improvement in little millet. *Millets and Sorghum: Biology and Genetic Improvement.* 170-183.

Kaushal, L., Thakur, R., Anjani, K and S.K. Singh. 2023. Biochemical characterization of grain iron and zinc content in little millet (*Panicum sumatrance* Roth Ex Roem and Schult.) genotypes. *Electronic Journal of Plant Breeding*. 10(2): 566- 569.

Kundgol, N.G., Kasturiba B., Math, K.K., Kamatar, M.Y and Usha, M. 2013. Impact of decortication on chemical composition, antioxidant content and antioxidant activity of little millet landraces. *International Journal of Engineering Research and Technology*. 2: 1705-1720.

Lindsay, W.L and Norvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of American Journal*. 42: 421-428

Manimozhi S.V., Nirmalakumari, A and Senthil, N. 2015. Genetic diversity for zinc, calcium and iron content of selected little millet (*Panicum sumatrance* Roth Ex Roem and Schult.) genotypes. *Journal of Nutrition and Food Sciences* 5(417): 2.

Nandini, C., Sujata, B., Krishnappa, M and Aruna, Y.R. 2016. Genetic variability, heritability, genetic advance and character association studies in F_3 generation of cross JK-8 × Peddasame (purple late) in little millet (*Panicum sumatrense* Roth Ex Roem and Schult.). *Asian Journal of Bio Science*. 11(2): 244-249.

Natesan, S., Venugopalan, G., Selvamani, S.B and Angamuthu, N. 2020. Characterization of little millet (*Panicum sumatrense* Roth Ex Roem and Schult.) varieties using morphological descriptors. *Journal of Phytology*. 12: 29-34.

Panda, D., Muni, P., Panda, A., Lenka, K.C and Parida, P.K. 2024. Nutritional and nutraceutical richness of neglected little millet (*Panicum sumatrense* Roth Ex Roem and Schult.) genotypes from Eastern Ghats of India: implications for breeding and food value. *Planta*. 259(2): 37.

Singane, S., Gomashe, S., Ganapathy, K.N and Patil, J.V. 2018. Genetic variability and association analysis for grain yield and nutritional quality in little millet. *Journal of Bioresource*. 9(6): 596-600.

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FAUNISTIC STUDIES ON ECONOMICALLY IMPORTANT LEPIDOPTERANS IN DIFFERENT FIELD CROPS OF TIRUPATI DISTRICT

P. PRAVALLIKA*, M.S.V. CHALAM, E. CHANDRAYUDU, P. LAVANYA KUMARI AND M. RAJASRI

Department of Entomology, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

A study was conducted in the Department of Entomology, S.V. Agricultural College, Tirupati during the year 2023-2024, on the chaetotaxy of larva and genital characters of adults. Larvae were collected from different field crops such as rice, sugarcane, maize, sorghum, ragi, groundnut, cotton, pulses and oilseeds. The collected larvae were brought to the laboratory and the taxonomic characters were studied in detail. Some of the larvae were reared until the adult emergence followed by dissection of genitalia in order to identify them easily. All these lepidopteran larvae were described based on the morphological characters and chaetotaxy of thoracic and abdominal segments especially 3rd abdominal segment and arrangement of crochets on the ventral prolegs. External morphology and genital characters *viz.,* uncus, gnathos, tegumen in male genitalia and ovipositor, bursa copulatrix and apophyses of female genitalia. The photographs of head capsule, thorax, abdominal segments, depiciting the setal formula, crochets and genitalia were taken.

KEYWORDS: Chaetotaxy, Crochets, Genitalia, Noctuidae.

INTRODUCTION

Lepidoptera is the order of insects which includes butterflies and moths. It is one of the most diverse groups of insects, with around 1,80,000 species described worldwide. Most lepidopteran larvae are plant feeders and nectar feeding as adults, and they are a prominent element of terrestrial ecosystems, functioning as herbivores, pollinators and prey, as well as being one of the most damaging groups of pests to agriculture (Reiger *et al.* 2009). Major crops like Paddy, Sugarcane, Maize, Groundnut, Pulses *etc*., are infested by a number of Lepidopteran pests. Majority of the Lepidopteran pests which causes economic loss mainly feed on the plant parts like foliage, buds, blossoms, roots, stems causing considerable crop loss. The family Noctuidae of Lepidoptera is probably the largest macrolepidopteran family with more than 25,000 described species (Heppner, 1991). This family is economically important as it includes a number of serious pests of field crops, vegetables, ornamental plants *etc.* The species belonging to genera *Spodoptera, Helicoverpa, Mythimna etc*. cause heavy losses to different crops during their larval stages.

The knowledge on biology and accurate identification of a pest allows formulation of the management strategies effectively. Larval stages of these lepidopterous pests are economically significant as they are the damaging stages. Species affecting any crop is the first and foremost step in Integrated Pest Management. The identification of adult stage is easy but the destructive larval stages poses considerable difficulties in their identification. Accurate identification of a pest species affecting any crop is the and foremost step in Integrated Pest Management.

MATERIAL AND METHODS

The larvae belonging to the order Lepidoptera of Family Noctuidae infesting different field crops like rice, maize, sugarcane, sorghum, ragi, cotton, pulses and oilseeds were collected. The collected larvae were taken to the laboratory. Some of the larvae were reared for emergence of adults. The collected larvae were killed with K.A.A.D mixture (kerosene-1 part, 95% ethyl alcohol-7 parts, dioxan-1 part and glacial acetic acid-2 parts). The killed larvae were immersed in 10 per cent solution of potassium hydroxide for maceration overnight, washed in water and passed through different grades of alcohol *viz.,* 60, 80, 95 per cent consecutively for about 10-15 minutes to facilitate dehydration. The digested soft tissues were removed with the help of a pair of blunt needles and the specimens were transferred to clove oil for clearing. A 1:1 mixture of phenol + xylol was used to retain the specimens until the slides are prepared with Canada balsam permanently. The photographs of head capsule, thorax, abdominal segments, depicting the setal formula, crochets were taken with the help of photographic attachment in Olympus trinocular stereo zoom microscope.

*Corresponding author, E-mail: ponnapravallika12@gmail.com

Genitalia of adults (male and female) were dissected using the technique described by Clark (1941) and Kirti and Gill (2005) with little modification. Dried and preserved specimens were used for the study of genitalia. Before dissection of genitalia, adults were photographed. Then the abdomen was detached from thorax with the help of a fine needle. The abdomen was then transferred to a test tube containing a few milliliters of 10 per cent caustic potash (KOH). This was heated slowly in a water bath till the convection currents were observed in the solution and then it was kept for cooling. After cooling, the abdomen was transferred to a glass cavity dish containing 10% alcohol and the macerated soft tissues were pressed out with the help of a pair of bent needles mounted on plastic handles. After repeated washings in water, the genitalia is detached by cutting out intersegmental membrane. The genitalia which was dissected is then dehydrated in absolute alcohol for proper visualance of all the parts of genitalia. Later the dehydrated genitalia were mounted on a glass slide using coverslip with DPX mountant. These permanent slides were kept in hot air oven for drying. After the study, the dissected genitalia were preserved in slide boxes.

RESULTS AND DISCUSSION

In the present study species of family Noctuidae belonging to order Lepidoptera were collected *viz.,* Tobacco caterpillar, *Spodoptera litura;* Gram pod borer *Helicoverpa armigera,* Castor semilooper, *Achaea janata,* Fall army worm *Spodoptera frugiperda;* Cotton spotted bollworm, *Earias vittella;* ragi pink stem borer, *Sesamia inferens;* Rice climbing cutworm, *Mythimna separata.*

A. Tobacco caterpillar, *Spodoptera litura* (Fabricius) (Plate 1)

Description of larvae: Colour of the larvae is generally brown, occasionally with a greenish blue shade. Larvae have a bright yellow or orange middorsal line, but also possess a less conspicuous subdorsal line marked by yellow or orange spots or dashes.

Chaetotaxy of prothorax and mesothorax

Prothorax: Prothoracic shield much chitinized, dark extended up to the margin of XD_2. Dorsal setae D_1 and D_2, Anterior dorsal setae XD_1 and XD_2 are distinct and present on prothoracic shield. Lateral setae L_1 and L_2 present. Microscopic seta MV_1 and ventral seta V_1 present. Subventral setae SV_1 and SV_2 distinct.

Mesothorax: Dorsal setae D_1 and D_2 and subdorsal setae SD_1 and SD_2 distinct. Lateral setae L_1, L_2 and L_3 present. Microscopic setae MV_1 and MV_2 present. Subventral seta SV_1, ventral seta V_1 distinct.

Abdomen: Abdomen ten segmented. Abdominal legs are fleshy, paired non-segmented which are called prolegs exists on 3rd, 4th, 5th, 6th and on last segments. Eight pairs of spiracles present on first to eight abdominal segments.

Chaetotaxy of 3rdabdominal segment: Third abdominal segment is with dorsal setae D_1 and D_2. Subdorsal seta SD_1 distinct. Lateral setae L_1, L_2 and L_3 present below the spiracle. Ventral seta V_1 present and subventral setae SV_1, SV_2 and SV_3 distinct.

Crochets: Uniordinal mesoseries type of crochets are observed on abdominal prolegs.

Description of Adult: Adult moth is robust and large sized with dark wavy white markings on forewings and hindwing white in colour having a brown patch along its margin. In male genitalia, uncus is long and slightly curved in apical half, gradually narrowing toward pointed apex. Tegumen inverted V-shaped nearly equal to the length of uncus. In female genitalia, lobes of the ovipositor small, broad and setosed sparsely.

B. Gram pod borer, *Helicoverpa armigera* (Hubner) (Plate 2)

Description of larvae: Larvae is greenish in colour with coloured longitudinal stripes or dark grey lines present laterally on the body.

Chaetotaxy of prothorax and mesothorax

Prothorax: Prothoracic shield much chitinized and extended up to the margin of SD_1. Dorsal setae D_1 and D_2 longer and anterior dorsal seta XD_1, subdorsal setae SD_1 and SD_2 distinct. Lateral setae L_1 and L_2 present above the spiracle. Ventral seta V_1 and microscopic setae MV_1, MV_2 present. Subventral setae SV_1 and SV_2 present.

Mesothorax: Microscopic seta MV_1 present. Dorsal setae D_1 and D_2 and subdorsal setae SD_1 and SD_2 present. Lateral setae L_1 and L_2 distinct.

Abdomen: Abdomen ten segmented. Abdominal legs are fleshy, paired non-segmented which are called prolegs exists on 3rd, 4th, 5th, 6th and on last segments. Eight pairs of spiracles present on first to eight abdominal segments.

Chaetotaxy of 3rd abdominal segment: Dorsal setae D_1, D_2 and subdorsal seta SD_1 distinct. Dorsal setae A1-A8 inserted on large conical chalazae, those of A1,

A2 or A8 often larger than the rest. Lateral seta L_1 and L_2 below the spiracle and ventral seta V_1 present.

Crochets: Biordinal mesoseries type of crochets are observed on abdominal prolegs.

Description of Adult: Adult moths are robust and medium to large sized. Head is reddish brown in colour with greenish compound eyes. Forewings with 7-8 blackish spots on the margin and a broad, irregular, brown transverse band. Hindwings pale-straw coloured with a broad dark-brown border containing a paler patch, with yellowish margins. In male genitalia, uncus is singular and curved. Vesica without cornuti and with a terminal hook, surrounded by circlet of spines. In female genitalia, lobes of ovipositor are narrow, long and densely setose. Valve is longitudinally bifurcated and is elongated.

C. Castor semilooper, *Achaea janata* (Linnaeus) (Plate 3)

Description of larvae: Caterpillar is long and smooth, brownish to bluish grey in colour with black head. A red spot is present on the black loop which is formed due to the non-functional first pair of prolegs. Anal tubercles are red and prominent.

Chaetotaxy of prothorax and mesothorax

Prothorax: Prothoracic shield much sclerotized and extended upto the margin of SD_1. Subdorsal setae SD_1, SD_2 and Dorsal setae D_1, D_2 distinct. Above the spiracle, Lateral setae L_1 and L_2 present. Ventral seta V_1 distinct. Subventral setae SV_1, SV_2 and microscopic setae MV_1 and MV_2 present.

Mesothorax: Subdorsal setae SD_1 and SD_2 and Dorsal setae D_1 and D_2 distinct. Lateral setae L_1, L_2 and L_3 present. Ventral seta V_1 distinct.

Abdomen: Abdomen ten segmented. Abdominal legs are fleshy, paired non-segmented which are called prolegs exists on 4^{th}, 5^{th}, 6^{th} and on last segments. Eight pairs of spiracles present on first to eight abdominal segments.

Chaetotaxy of 3rd abdominal segment: Dorsal setae D_1 and D_2 distinct. Around the spiracle, Lateral setae L_1, L_2 and L_3 present. Subventral seta SV_1 distinct.

Crochets: Uniordinal lateropenellipse type of crochets are observed on abdominal prolegs.

Description of Adult: Adult moth can be identified by the presence of an oblique white postmedial band on forewing. The hindwings are black with a medial white band and three large white spots on the outer margin. In male genitalia, uncus curved and strongly bifurcated with a well defined gnathos. In female genitalia, ovipositor lobes are smooth and elongated.

D. The Fall army worm, *Spodoptera frugiperda* (J. E. Smith) (Plate 4)

Description of larvae: Larvae are yellowish, greenish or brownish in colour with white longitudinal stripes. Head black, brown and orange in colour, inverted Y shaped yellow band along the fronto- clypeal suture along the ecdysial line. Raised spots very prominent on the dorsal surface of mature larvae. Dots or spots are arranged in the form of square shape on the abdomen.

Chaetotaxy of prothorax and mesothorax

Prothorax: On first thoracic segment SD_1 and SD_2 setae present on a joint pinaculum ventral to thoracic shield. On prothoracic shield dorsal setae XD_1, XD_2 and dorsal setae D_1, D_2 present. L_1 and L_2 setae are hair like and situated on ventral margin of spiracular line. But the L_3 setae is about half the length of L_1 and L_2.

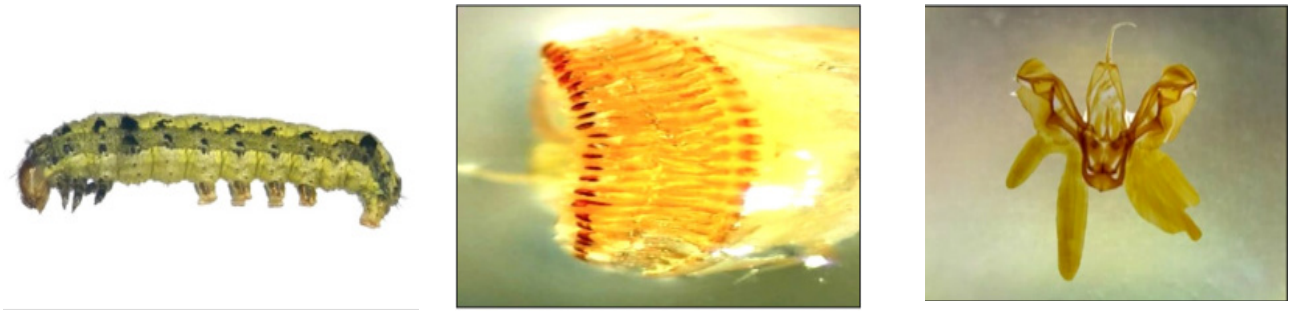
Mesothorax: On meso and meta thoracic segments dorsal setae D_1, D_2 and sub dorsal setae SD_1 and SD_2 present. Lateral setae L_1, L_2, L_3 present. Sub ventral setae SV_1 situated on spiracular line. Spiracles are absent on meso and meta thoracic segments.

Abdomen: Abdomen ten segmented. Abdominal legs are fleshy, paired non-segmented which are called prolegs exists on 3^{rd}, 4^{th}, 5^{th}, 6^{th} and on last segments. Eight pairs of spiracles present on first to eight abdominal segments.

Chaetotaxy of 3^{rd} abdominal segment: Third abdominal segment is with dorsal setae D_1 and D_2 that are arranged in trapezoidal pattern. Subdorsal setae SD_1 present just above to the spiracle. Lateral setae L_1, L_2 and L_3 present. Subventral setae SV_1, SV_2, SV_3 distinct.

Crochets: Uniordinal mesoseries heteroideous type of crochets are observed on abdominal prolegs.

Description of Adult: Adult moth can be identified by the presence of distinct white patch at the apex of forewing and posses orbicular spot which is oval, cream-colored with a dull brown center, outlined in black. Dark grey spindle-shaped spots along the outer margin. Hindwings are Semi-hyaline. In male genitalia, uncus curved towards the apex, slender, and gradually narrowed

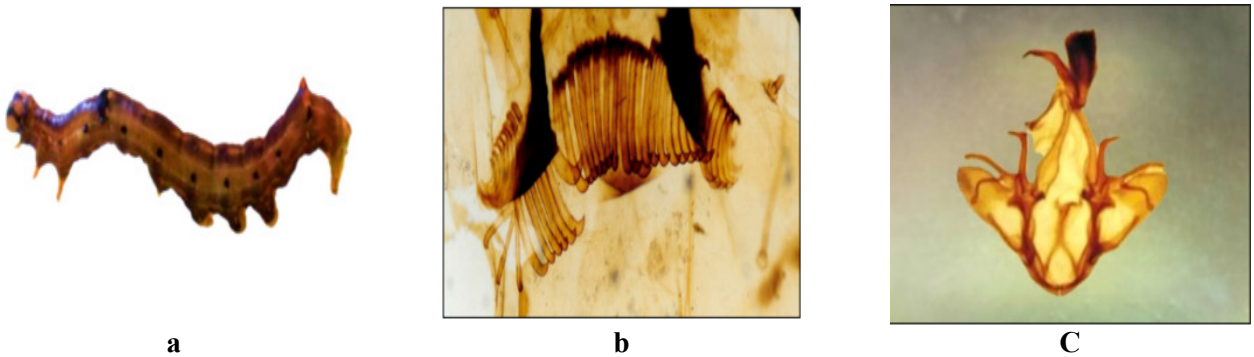


a **b** **c**

Plate 1 (a-c). ***Spodoptera litura*** **(Fabricius), a. Larva b. Crochets c. Male genitalia**

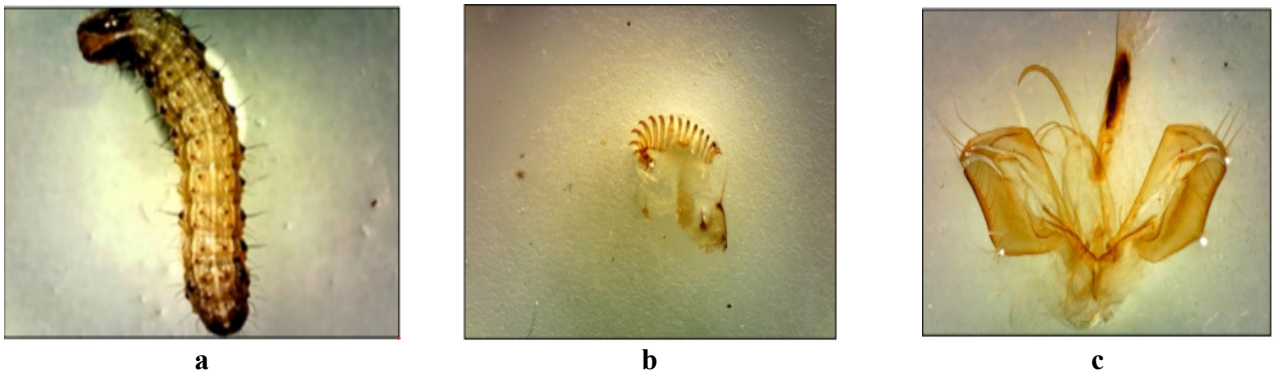
a **b** **c**

Plate 2 (a-c). ***Helicoverpa armigera*** **(Hubner), a. Larva b. Crochets c. Male genitalia**



a **b** **C**

Plate 3 (a-c). ***Achaea Janata*** **(Linnaeus), a. Larva b. Crochets c. Male genitalia**



a **b** **c**

Plate 4 (a-c). ***Spodoptera frugiperda*** **(J. E. Smith), a. Larva b. Crochets c. Male genitalia**

to a pointed apex. Tegumen is slightly sclerotized and inverted V shaped. Female genitalia characterized by elongate ventral plate of ostium bursa.

E. Cotton spotted bollworm, *Earias vittella* (Fabricius) (Plate 5)

Description of larvae: Larvae is brownish in colour. A longitudinal white stripe is present on the dorsal side of the body and orange maculae all over the body. On pinaculae few setae are present.

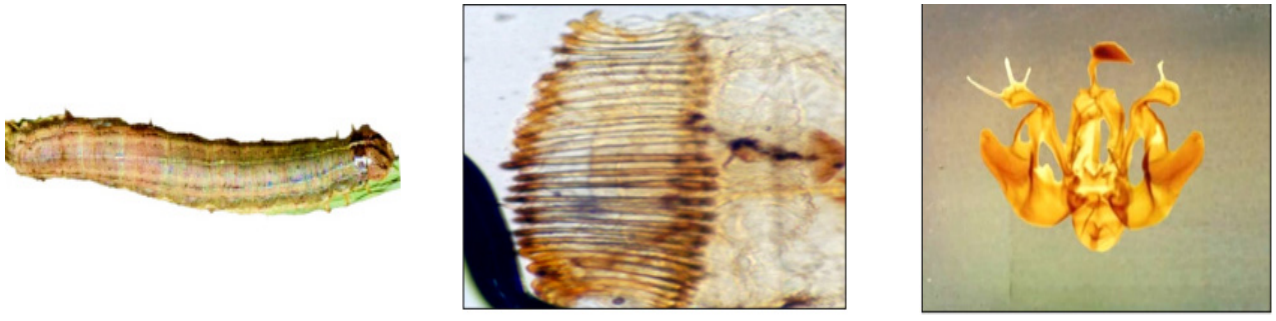
Chaetotaxy of prothorax and mesothorax

Prothorax: Prothoracic shield much sclerotized and dark which is extended upto XD_2. Dorsal setae D_1, D_2 and anterior dorsal setae XD_1 and XD_2 are distinct. Microscopic seta MXD_1 is present. Above the spiracle lateral setae L_1, L_2 and L_3 are present. Ventral seta V_1 and subventral setae SV_1 and SV_2 present.

Mesothorax: Microscopic setae MXD_1, MXD_2 and Dorsal setae D_1 and D_2 distinct. Subdorsal setae SD_1 and SD_2 are also present. Lateral setae L_1, L_2 and L_3 are

a **b** **c**

Plate 5 (a-c). ***Earias vittella*** **(Fabricius), a. Larva b. Crochets c. Male genitalia**



a **b** **c**

Plate 6 (a-c). ***Mythimna separata*** **(Walker), a. Larva b. Crochets c. Male genitalia**

a **b** **C**

Plate 7 (a-c). ***Sesamia inferens*** **(Walker), a. Larva b. Crochets c. Male genitalia**

present above the spiracle. Microscopic setae MV_1, MV_2 and MV_3 distinct. Ventral seta V_1 and subventral setae SV_1 and SV_2 present.

Abdomen: Abdomen ten segmented. Abdominal legs are fleshy, paired non-segmented which are called prolegs exists on 3rd, 4th, 5th, 6th and on last segments. Eight pairs of spiracles present on first to eight abdominal segments.

Chaetotaxy of 3rd abdominal segment: Third abdominal segment with subdorsal setae SD_1 and SD_2 present above the spiracle. Dorsal seta D_1 positioned anterodorsally from D_2. Lateral seta L_1 present nearer to the spiracle. Subventral setae SV_1 and SV_2 distinct.

Crochets: Uniordinal mesoseries type of crochets are observed on abdominal prolegs.

Description of Adult: Adult moth can be identified by the presence of pale whitish with a broad greenish band running from the base to the apical margin on forewings. The hindwings are whitish in colour. In male genitalia, uncus is bifid and the gnathos is absent. Valvae are rectangular with a well-developed cucullus. In female genitalia, ovipositor lobe is large and densely setose.

F. Rice climbing cutworm, *Mythimna separata* (Walker) (Plate 6)

Description of larvae: The larvae have two dark brown and white lateral stripes and a central dark brown line. Larvae dirty pale brown in colour and the head is greyish brown in colour

Chaetotaxy of prothorax and mesothorax:

Prothorax: Much sclerotized prothoracic shield present which is dark and extended upto the ventral margin XD_1, MXD_1 and XD_1 lie in the same vertical line. Dorsal setae D_1, subdorsal setae SD_1 and SD_2 distinct. Two lateral setae L_1 and L_2 located anterior to the spiracle on the same vertical line. Subventral setae SV_1 and SV_2 distinct.

Mesothorax: The same vertical line is occupied by the dorsal setae D_1 and D_2 and the subdorsal setae SD_1 and SD_2. Subventral seta SV_1 distinct and away from L_1.

Abdomen: Abdomen ten segmented. Abdominal legs are fleshy, paired non-segmented which are called prolegs exists on 3rd, 4th, 5th, 6th and on last segments. Eight pairs of spiracles present on first to eight abdominal segments.

Cheatotaxy of 3rd abdominal segment: Third abdominal segment is with distinct dorsal seta D_1 and D_2. Above the spiracle subdorsal setae SD_1 present. Lateral setae L_1 present below the spiracle, away from L_1. Sub ventral setae SV_1 distinct.

Crochets: Uniordinal uniserial type of crochets are observed on both abdominal and prolegs.

Description of Adult: Adult moth can be identified by forewing with a distinctive kidney-shaped (reniform) spot and a circular (orbicular) spot near the center. Hindwings are whitish to pale grey, with darker veins and a slightly darker fringe along the edges. In male genitalia, uncus very short and tegumen inverted U-shaped. In female genitalia, ductus bursae sclerotized and abruptly curved dorsally with many longitudinal striae.

G. Ragi pink stem borer, *Sesamia inferens* (Walker) (Plate 7)

Description of larvae: Caterpillar is soft and pinkish brown in colour. Head is small and reddish to dark brown in colour with prothoracic shield.

Chaetotaxy of prothorax and mesothorax

Prothorax: Prothoracic shield much chitinized, dark extended upto the ventral margin of XD2, dorsal setae D1 distinct, Lateral setae L1 and L2 present. Subventral setae SV1 distinct, Ventral setae V1, V2 and V3 are present.

Mesothorax: Dorsal setae D1 distinct and lies in pinaculum. Lateral setae L1 present in a vertical line below D1.

Abdomen: Abdomen ten segmented. Abdominal legs are fleshy, paired non-segmented which are called prolegs exists on 3rd, 4th, 5th, 6th and on last segments. Eight pairs of spiracles present on first to eight abdominal segments.

Chaetotaxy of 3rd abdominal segment: Third abdominal segment is with dorsal setae D1 and D2 that are arranged in trapezoidal pattern. Subdorsal setae SD1 present just above to the spiracle. Lateral setae L1, L2 and L3 present. Subventral setae SV1, SV2, SV3 distinct.

Crochets: Uniordinal mesoseries heteroideous type of crochets are observed on abdominal prolegs.

Bhattacherjee and Gupta (1971), Adamski and Brown (1987), Ahola (1986) and Chatterjee (1967) conducted chaetotaxy studies of various lepidopteran larvae and stressed the need for chaetotaxic and genital studies aiding in identification of economically important lepidoptera larvae which are in line with present studies.

In this study external morphology and chaetotaxy of larvae, external morphology of adults and genital characters of adults were explored for accurate

identification of lepidopteran larvae associated with major field crops in Tirupati district.

LITERATURE CITED

Ahola, M. 1986. Larvae of European *Polia ochsenheimer* (Lepidoptera: Noctuidae), with proposals on a subgeneric division and phylogeny. *Entomologica Scandinavica.* 17(1): 55-74.

Adamski, D and Brown, R.L. 1987. A new Nearctic Glyphidocera with descriptions of all stages (Lepidoptera: Blastobasidae; Symmocinae). Proceedings of the *Entomological Society of Washington.* 89(2): 329-343.

Arunasri, M. 2006. Taxonomic studies on the different Lepidopteran larvae of economic importance in Guntur District. *M.Sc. (Ag.) Thesis*, Acharya N.G. Ranga Agricultural University, Hyderabad.

Bhattacherjee, N.S and Gupta, S.L. 1971. Identity of lepidopterous pests infesting wheat crop at Delhi. *Indian Journal of Entomology.* 33 (4): 435-451.

Chatterjee, S.N. 1967. The identity of *Spodoptera mauritia* (Guenee), *Spodoptera pecten* (Guenee) and *Spodoptera abyssinia* (Guenee). (Lepidoptera: Noctuidae) based on a comparative study of the male and female genitalia. *Indian National Science Academy.* 35 (1): 45-58.

Clark, G.J.F. 1941. The preparation of slides of the genitalia of Lepidoptera. *Bulletin of Brooklyn Entomological Society*. 36-53.

Heppner, J.B. 1991. Faunal regions and diversity of Lepidoptera. *Tropical Lepidoptera.* 2: 1-85.

Kirti, J.S and Gill, N.S. 2005. Taxonomic studies on Indian species of genus Maruca (Walker) (Lepidoptera: Pyralidae: Pyraustinae). *Zoos Print Journal*. 20(7): 1930-1931.

Regier, J.C., Zwick, A and Cummings, M.P. 2009. Toward reconstructing the evolution of advanced moths and butterflies (Lepidoptera: Ditrysia) an initial molecular study. *Evolutionary Biology*. 9: 280–300.

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AN ANNOTATED CHECKLIST OF CYPERCEAE, ERIOCAULACEAE AND POTAMOGETONACEAE OF CHHATTISGARH

A.K. VERMA, O.N MAURYA, SANJAY MISHRA AND KUMAR AVINASH BHARATI

Department of Botany, Siddharth University, Kapilvastu, Siddharth Nagar-272202.

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ABSTRACT

Tropical forests of Chhattisgarh are known for rich floristic diversity and many important protected forests of central India. An updated annotated checklist is provided for the family Cyperaceae, Eriocaulaceae, and Potamogetonaceae of Chhattisgarh It has breen prepared with the help of herbarium specimens housed in BSA and relevant literatures pertaining to the floristic diversity of the state. A total of 118 taxa (species, subspecies and varieties), representing 15 genera under 3 families are provided in the present communication. Family Cyperaceae has 104 taxa, Eriocaulaceae has 13 taxa and Potamogetonaceae has 5 taxa. At generic level remarkable diversity has been recorded in *Cyperus* (37 species and one variety) and *Fimbristylis* (21 species and one subspecies). The distribution of taxa is highest in Raipur (75 taxa), followed by Bilaspur (70 taxa), Bastar (64 taxa), Surguja (48 taxa), Raigarh (47 taxa), Dantewada (44 taxa), etc.

KEYWORDS: Angiosperm; Monocotyledons; Flora; Diversity; Ecosystem.

INTRODUCTION

Chhattisgarh is a state in central India with an area of 1,35,194 sq. km. The state was created on 1st November 2000 from Madhya Pradesh; it is 9th largest state by area and 7th most populous state of the India. Chhattisgarh shares boarder with Uttar Pradesh in north, Madhya Pradesh in northwest, Maharashtra in southwest, Jharkhand in northeast, Odisha to east, Andhra Pradesh and Telangana in south. It has diverse geography, ranging from hilly terrains to plains with variation in climatic condition. Most of the southern and northern part has hilly terrain and central part is fertile plain. The state has the 3rd largest forest by area in India with many national parks and Achanakmar-Amarkantak Biosphere Reserve.

Forest cover of Chhattisgarh is 46% of its total area; it is dominated by *Shorea robusta* and *Tectona grandis*. According to Champion and Seth (1968) forests of Chhattisgarh may be classified into 3 types: (1) Tropical moist deciduous, (2) Tropical dry deciduous, (3) Montane subtropical.

The tropical moist deciduous forest is dominated by mainly deciduous species, subdominant and lower storey are mostly evergreen. Top canopy is not very dense with abundance of climbers and epiphytes. *Tectona grandis, Terminalis alata, Haldiana cordifolia, Pterocarpus marsupium, Gmelina arborea, Terminalia chebula, Anogeissus latifolia, Mitragyna parvifolia, Bridelia retusa, Syzygium cumini, etc*. are top canopy species. The second storey is comprises of *Grewia tiliifolia, Mallotus philippensis, Cleistanthus Collins, Semecarpus anacardium, Kydia calycina, Kydia calycina, Bauhinia malabarica, Wendlandia heynei, Syzgium cumini, Millusa tomentosa, Dillenia pentagyna*. Third storey consists of *Ixora arborea, Helicteres isora, Petalidium barlerioides, Grewia hirsute, Woodfordia fruiticosa, Clerodendrum serratum, Phoenix acaulis, Eranthemum purpurascens, Andrographis paniculata, etc*. Common climbers are *Bauhinia vahlii, Ichnocarpus frutescens, Erycibe paniculata, Smilax zeylanica, Millettia extensa, Combretum roxburghii, Dioscorea hispida, etc*. Forth storey is found in moist mixed deciduous forest mainly consist of *Blepharis maderaspatensis, Desmodium pulchellum, Arvea lanata, Indigofera linnaei, etc*.

Tropical dry deciduous forest is mixed with deciduous trees like, *Shorea robusta, Terminalia alata, Terminalia bellirica, Buchanania lanzan, Diospyrous melanoxylon, Mallotus philippensis, Ptercarpus marsupium, Accacia catechu, Lannea coromandelica, Boswellia serrata, Anogeissus latifolia, Butea monosperma, Sterculia urens, Lagerstroemia parviflora, Aegel marmelos*, *etc*. In third storey *Indigofera cassioides, Woodfordia fruticosa, Flemingia semialata, Ixora arborea*, etc. are frequently found. Second storey consists of *Gardenia turgida, Flacourtia indica, Balanites aegyptiaca, Ziziphus xylopyra*, *etc*. *Butea superba, Bauhinia vahlii, Cansjera rheedii, Calycopteris floribunda, Cryptolepis buchanani, Cocculus hirsulus, Tinospora cordifolia, Ventilago denticulate, etc.* are common climbers.

*Corresponding author, E-mail: avinash.bharati@bsi.gov.in

Table 1: Enumeration of the taxa of the family Cyperaceae, Eriocaulaceae and Potamogetonaceae

S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
			Cyperaceae	
1	**Actinoscirpus grossus** (L.f.) Goetgh. & D.A.Simpson	Sept.– Dec.	Bastar, Raipur, Surguja	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
2	Bolboschoenus maritimus (L.) Palla	May– Jun.	Bastar, Raipur	Bastar, 21.02.1985, G.P. Roy, 42318 (BSA)
3	**Bulbostylis barbata** (Rottb.) C.B. Clarke	Sept.– Dec.	Bilaspur, Dantewada, Dhamtari, Durg, Jashpur, Korba, Raigarh, Raipur, Rajnandgaon, Surguja	Bilaspur, 09.05.2015, A.P. Tiwari, 75424 (BSA); Durg, 26.08.1978, P.C. Pant, 29245 (BSA); Jaspur, 11.04.2016, A.P. Tiwari, 197(BSA); Raipur, D.M. Verma, 05.06.1976, 23910 (BSA); Raigarh, 28.09.1974, N.C. Rathkrishnan, 21196 (BSA); Rajnandangaon, 26.08.1978, P.C. Pant 29245 (BSA); Surguja, G. Sengupta, 21.08.1974, 20548 (BSA)
4	**Bulbostylis densa** (Wall.) Hand.-Mazz.	Sept.	Raipur	Raipur, 14.08.1976, D.M. Verma, 24844 (BSA)
5	**Carex baccans** Nees	Sept.	Bastar	Bastar, 13.02.1963, G. Panigrahi & C.M. Arora, 6837 (BSA)
6	**Carex cruciata** Wahlenb.	Sept.	Bastar, Bilaspur, Jashpur, Korba, Raigarh, Raipur, Surguja	Bastar, 23.05.1983, G.P. Roy & S.K. Dixit, 3513 (BSA); Bilaspur, S.K. Murti, 16.07.1973, 19177 (BSA); Raigarh, 08.02.1974, N.C. Rathkrishnan, 19769 (BSA); Raipur, 09.08.1976, D.M. Verma, 24719 (BSA); Jashpur, 18.06.2013, A.P. Tiwari, 73121 (BSA); Surguja, 26.06.2013, A.P. Tiwari, 73187 (BSA)
7	**Carex filicina** Nees	Sept.	Bastar	Bastar, 17.09.2002, A.K. Jha, 56160 (BSA)
8	**Carex myosurus** Nees	Jan.–Mar.	Bastar	Bastar, 24.11.1984, G.P. Roy, 42157 (BSA)
9	**Carex phacota** Spreng.	Feb.–Mar.	Bastar, Surguja	Bastar, 25.04.1965, G. Panigrahi & C.M. Arora, 8962 (BSA)
10	**Carex teres** Boott	Apr.-May.	Bastar	Specimen not available (recorded on the basis of N.P. Singh *et al.*, l.c).
11	**Carex speciosa** Kunth	Sept.– Jan.	Bastar, Dhamtari, Raipur, Surguja	Bastar, 28.11.1972, G. Sengupta, 15968 (BSA); Raipur,03.06.19/72, DM Verma, 17526 (BSA)
12	**Carex stramentitia** Boott ex Boeckeler	Apr.– Jun.	Bastar	Specimen not available (recorded on the basis of Khanna et al., l.c.)
13	**Courtoisina cyperoides** (Roxb.) Soják	Sept.– Mar.	Bastar, Bilaspur, Dhamtari, Korba, Raigarh, Raipur, Rajnandagaon	Bastar, 23.09.2005 S.L. Bondya & A.N. Shukla, 63115 (BSA); Raigarh, 02.10.1974, N.C. Rathkrishnan, 21262 (BSA); Raipur, 05.10.1976, D.M. Verma, 24970 (BSA); Rajnandangaon, 26.09.1976, P.C. Pant, 25451 (BSA)

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Table 1 Cont...

S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
14	**Cyperus alopecuroides** Rottb.	Jul.– Dec.	Dhamtari, Raipur, Rajnandgaon	Dhamtari (Flora of M.P Vol-3, pg. 255); Raipur, 10.01.1976, D.M. Verma 23526 (BSA); Rajnandangaon, 13.09.1976, P.C. Pant, 25375 (BSA)
15	**Cyperus alulatus** J. Kern	Jul.– Dec.	Bilaspur, Dantewada, Dhamtari, Durg, Raipur, Surguja	Bilaspur, 14.07.1973, S. K. Murti, 19111(BSA); Durg, 25.08.1978, P.C. Pant, 29180 (BSA); Raipur, 04.06.1976, D.M. Verma, 17527 (BSA); Rajnandangaon, 09.09.1976, P.C. Pant, 25241 (BSA); Surguja, 25.08.1974; G. Sengupta, 20619 (BSA)
16	**Cyperus brevifolius** (Rottb.) Hassk.	Throughout the year	Batsar, Bilaspur, Dantewada, Durg, Korba, Raigarh, Raipur, Rajnandgaon, Surguja	Bastar, 24.08.2005,B.K. Shukla, 63367 (BSA); Bilashpur, 28.04.1964, G.P. Arora, 3751 (BSA), Durg, 04.04.1974, P.C. Pant, 20104 (BSA); Dantewada, Korba (Mudgal et al., 1997); Raigarh, 31.03.1976,N.C. Rathkrishnan, 24444(BSA); Raipur, 10.01.1976, D.M. Verma, 23525 (BSA); Rajnandagaon, 23.08.1979, P.C.Pant, 37881 (BSA); Surguja, 23.03.1974, G. Sengupta,19973 (BSA).
17	**Cyperus castaneus**	Aug.	Raipur	Raipur, 16.10.1976, D.M. Verma (BSA)
18	**Cyperus cephalotes** Vhal (Cyperaceae)	Mar.– Apr.	Batsar, Bilaspur	Bastar, 24.11.1984, S.K. Dixit, 42154 (BSA); Bilaspur, 19.02.1972, G. Panigrahi, 1676 (BSA)
19	**Cyperus compactus** Retz. (Cyperaceae)	Sept.– Jan.	Bilaspur, Raipur, Raigarh Dantewada, Surguja	Bilaspur, 23.10.1970, G. Panigrahi, 12748 (BSA); Dantewada, (recorded on the basis of Khanna et al., 2005); Raigarh, Surguja (recorded on the basis of N.P. Singh et al., 2001); Raipur, 06.10.1976, D.M.Verma, 25036 (BSA)
20	**Cyperus compressus** L. (Cyperaceae)	Jul.– Dec.	Bilaspur, Durg, Dantewada, Dhamtari, Korba, Raipur, Rajnandgaon, Surguja	Bilaspur, 03.11.1970, G Panigrahi, 13288 (BSA); Durg, 06.08.1978, PC Pant, 29246 (BSA); Korba, 17.11.2006, BK Shukla, 67378 (BSA); Raipur, 10.01.1976, DM Verma, 23504 (BSA); Rajnandangaon, 10.09.1976, PC Pant, 25308 (BSA), Surguja, 11.10.2016, ML Malik, 250 (BSA)
21	**Cyperus corymbosus** Rottb. (Cyperaceae)	Dec.– Jan.	Raipur	Specimen not available (recorded on the basis of N.P. Singh et al., 1.c.)
22	**Cyperus cuspidatus** Kunth (Cyperaceae)	Aug.– Nov.	Dantewada, Durg, Raigarh, Raipur, Surguja	Dantewada (Mudgal et al., 1997); Durg, 26.08.1978, P.C. Pant, 29244 (BSA); Raigarh, 02.10.1974, N.C. Rathakrishnan, 21258 (BSA); Raipur (Mudgal et al., 1997); Surguja, 22.08.1974, G. Sengupta, 20558 (BSA)
23	**Cyperus cyperoides** (L.) Kuntze, Revis. (Cyperaceae)	Aug.– Mar.	Bastar, Bilaspur, Dantewada, Dhamtari, Raipur, Rajnandangaon	Bastar, 23.08.2005, B.K. Sukla, 63344 (BSA); Bilaspur, 14.07.1973, S.K. Murti, 19130 (BSA); Dantewada, Dhamtari (Mudgal et al., 1997); Raipur, 17.08.1976, D.M. Verma, 24947 (BSA); Rajnandgaon, P.C. Pant, 25477 (BSA)

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Table 1 Cont...

S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
24	**Cyperus difformis** L. (Cyperaceae)	Jul.–Apr.	Bastar, Bilaspur, Durg, Raipur, Raigarh, Rajnandangaon, Surguja, Dantewada, Dhamtari, Kanker	Bastar, 21.12.1971, C.B. Das, 14826 (BSA); Bilaspur, 25.07.1973, S.K.Murti, 27120 (BSA); Durg, 05.04.1974, P.C.Pant,20167 (BSA); Raipur, 26.05.1975, D.M. Verma, 17233 (BSA); Raigarh, 31.03.1976, N.C. Rathkrishnan, 24429 (BSA); Rajnandangaon, 11.04.1974, P.C. Pant, 20307 (BSA), Surguja, 16.03.1974, G. Sengupta, 18920 (BSA); Dantewada, Dhamtari, Kankar (Florist. Diversity Chhattisgarh (Angio.): 507. 2005)
25	**Cyperus digitatus** Roxb. (Cyperaceae)	May– Dec.	Bastar	Specimen not available (recorded on the basis of N.P. Singh et al., 1.c.)
26	**Cyperus distans** L.f. (Cyperaceae)	Sept.–Feb.	Bastar, Bilaspur, Dantewada, Korba, Raipur, Raigarh	Bastar, 14.01.2004, A.K. Jha, 57392 (BSA). Bilaspur, Dantewada, Korba, Raigarh, Raipur (Florist. Diversity Chhattisgarh (Angio.): 507. 2005
27	**Cyperus dubius** Rottb. (Cyperaceae)	Oct.– Nov.	Bilaspur, Koriya	Bilaspur, 19.07.1973, S.K. Murti, 19250 (BSA); Koriya, 25.06.2013, A.P. Tiwari, 73208 (BSA)
28	**Cyperus exaltatus** Retz. (Cyperaceae)	Sept.– Feb.	Bastar, Bilaspur, Dantewada, Jashpur, Kawardha, Raipur, Rajnandagaon	Bastar, 29.09.2005, S.L. Bondya & A.N. Shukla, 63259 (BSA); Bilaspur, 29.07.1973, S.K. Murti, 19395(BSA); Raipur, 06/1976, D.M. Verma, 25038(BSA); Rajnandagaon, 06.09.1976, P.C. Pant, 20456 (BSA)
29	**Cyperus flavidus** Retz. (Cyperaceae)	Sept.–Nov.	Bilaspur, Durg, Korba, Raigarh, Rajnandagaon, Surguja	Rajnandagaon, 16.09.1976, P.C. Pant, 25449 (BSA); Surguja, 19.11.1972, 15527 (BSA)
30	**Cyperus haspan** L. (Cyperaceae)	Aug.– Dec.	Bastar, Bilaspur, Dantewada, Koriya, Korba, Mahasamund, Raigarh, Raipur, Rajnandagaon, Surguja	Bastar,23.09.2005, S.L. Bondya, 63102 (BSA); Bilaspur, 24.04.1964, C.N. Arora, 3748(BSA); Koriya, 23.06.2013, A.P. Tiwari, 73030 (BSA); Korba, 17.11.2006, B.K. Sinha, 67429 (BSA); Mahasamund,18.07.2016, V. Singh, 253 (BSA); Raipur, 17.01.1976, D.M. Verma, 23741(BSA); Rajnandagaon, 16.09.1976, P.C. Pant, 25438 (BSA); Surguja, 22.03.1974, G. Sengupta, 199969 (BSA)
31	**Cyperus iria** L. (Cyperaceae)	Aug.– Feb.	Bastar, Bilaspur, Dantewada, Dhamtari, Raigarh, Raipur, Rajnandagaon, Surguja	Bastar, 16.9.2002, A.K. Jha, 56130 (BSA); Bilaspur, 23.07.1973, S.K. Murti, 19305 (BSA); Dhamtari, 06.08.1976, 23951 (BSA); Raigarh, 04.04.1976, N.C. Rathkrishnan, 24577A (BSA); Raipur, 27.09.1962, G Panigrahi, 5080 (BSA); Rajnandangaon, P.C. Pant, 09.09.1976, 25249 (BSA); Surguja, 28.11.1972, G. S. Gupta, 17802 (BSA)
32	**Cyperus kyllingia** Endl. (Cyperaceae)	Aug.–Oct.	Bilaspur, Jashpur, Korba, Raipur	Bilaspur, 29.07.1973, S.K. Murti, 19394 (BSA); Raipur, 08.08.1976, D.M. Verma, 23974 (BSA)

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Table 1 Cont...

S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
33	Cyperus kyllingiella Larridon (Cyperaceae)	Oct.	Raipur	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
34	**Cyperus laevigatus** L. (Cyperaceae)	Jul.– Sept.	Jashpur	Jashpur (recorded on the basis of N.P. Singh et al., l.c.)
35	**Cyperus latespicatus** Boeck (Cyperaceae)	Aug.– Sept.	Raipur, Surguja	Raipur, 22.01.1976, D.M. Verma, 23866 (BSA); Surguja, 25.08.1974, G. Sengupta, 20617 (BSA)
36	**Cyperus leucocephalus** Retz. (Cyperaceae)	May	Bastar	Bastar, 26.08.2005, B. K, Sukala 63398 (BSA)
37	**Cyperus metzii** (Hochst. ex Steud.) Mattf. & Kuekenth. (Cyperaceae)	Sept.– Oct.	Raipur	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
38	**Cyperus melanospermus** (Nees) Valck.Suring. (Cyperaceae)	Aug.–Oct.	Bastar	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
39	**Cyperus michelianus** (L.) Delile (Cyperaceae)	Aug.– Oct.	Bilaspur, Korba, Raipur	Bilaspur, 15.04.1965, G. Panigrahi & C.M. Arora, 8577 (BSA); Raipur, 13.01.1976, D.M. Verma, 23596 (BSA)
40	**Cyperus niveus** Retz. (Cyperaceae)	Aug.– Dec.	Bastar, Bilaspur, Dantewada, Dhamtari, Jaspur, Koriya, Raigarh, Raipur, Koriya, Surguja	Bilaspur, 12.07.1973, S.K. Murti, 19068 (BSA); Jaspur, 20.06.2013, A.P. Tiwari, 73151 (BSA); Koriya, 23.06.2013, A.P. Tiwari, 73031 (BSA); Raipur, 02.06.1969, D.M. Verma, 17441 (BSA)
41	**Cyperus nutans** Vahl var. **nutans** (Cyperaceae)	May	Bastar	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
42	**Cyperus nutans** Vahl var. **eleusinoides** (Kunth) Haines (Cyperaceae)	Jul.– Dec.	Bastar, Bilaspur, Dantewada, Raigarh, Raipur, Surguja	Bastar, 20.04.2005, S.L. Bondya & S. Mishra, 62402 (BSA); Bilaspur, 02.08.1976, S.K. Murti, 19469 (BSA); Raigarh, 02.04.1976, N.C. Rathkrishnan, 24531 (BSA); Raipur, 17.08.1976, D.M. Verma, 24910 (BSA); Surguja, 26.11.1972, G Sengupta, 15927 (BSA)
43	**Cyperus pangorei** Rottb. (Cyperaceae)	Feb.–Oct.	Bastar, Bilaspur, Dantewada, Raigarh, Raipur, Rajnandgaon, Surguja	Bastar, 20.09.2002, A.K. Jha, 56443 (BSA); Raigarh, 26.02.1976, G Sengupta, 24190 (BSA); Raipur, 04.10.1976, D.M. Verma, 24964 (BSA); Rajnandgaon, 20.09.1976, P.C. Pant, 25523 (BSA); Surguja, 23.02.1976, G Sengupta, 24130 (BSA)

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Table 1 Cont...

S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
44	**Cyperus pilosus** Vhal (Cyperaceae)	Apr.–Oct.	Bilaspur, Raipur, Raigarh, Rajnandangaon, Surguja	Bilaspur, 18.04.1965, G. Panigrahi & C.M. Arora, 8743 (BSA); Raipur, 06.10.1976, D.M. Verma, 25037 (BSA); Raigarh, 02.04.1976, N.C. Rathkrishnan, 24531(BSA). Rajnandangaon ((recorded on the basis of N.P. Singh et al., l.c.); Surguja, 20.08.1976, G. Sengupta, 20516 (BSA)
45	**Cyperus platystylis** R. Br. (Cyperaceae)	Apr.– May	Bilaspur, Dantewada, Korba, Raipur	Bilaspur, 16.04.1965, G. Panigrahi & C.M. Arora, 8581 (BSA)
46	**Cyperus polystachyos** Rottb. (Cyperaceae)	Aug.– Nov.	Bilaspur, Koriya, Surguja	Bilaspur, 13.07.1973, S.K. Murti, 19101 (BSA); Koriya, 24.02.2015, A.P. Tiwari, 73854 (BSA); Surguja, 28.08.1974, G Sengupta, 20520 (BSA)
47	**Cyperus procerus** Rottb. (Cyperaceae)	Sept.	Bastar, Dantewada, Rajnandagaon	Bastar, 17.09.1962, K.K. Khanna & A.K. Jha, 56171 (BSA); Rajnandagaon, 16.09.1976, P.C. Pant, 25452 (BSA)
48	**Cyperus pulchellus** R. Br. (Cyperaceae)	Sept.–Nov.	Bilaspur	Bilaspur (recorded on the basis of N.P. Singh et al., l.c.)
49	**Cyperus pygmaeus** Rottb. (Cyperaceae)	Aug.– Nov.	Bilaspur, Dantewada, Dhamtari, Raigarh, Raipur	Bilaspur, 07.08.1973, S.K. Murti, 19521 (BSA); Raigarh, 25.05.1996, R.C. Srivastava, 44212 (BSA)
50	**Cyperus rotundus** L. (Cyperaceae)	Jul.– Apr.	Bastar, Bilaspur, Dantewada, Dhamtari, Korba, Raigarh, Raipur, Rajnandgaon, Surguja.	Bastar, 25.05.1983, G.P. Roy, 35184 (BSA); Bilaspur, 31.07.1973, S.K. Murti, 19445 (BSA); Korba, 29.03.2006, B.K. Shukla, 65040 (BSA); Raipur, 14.08.1976, D.M. Verma, 24840 (BSA); Surguja, 06.05.1964, C.M. Arora, 3908 (BSA)
51	**Cyperus squarrosus** L. (Cyperaceae)	Sept.–Nov.	Bastar, Bilaspur, Durg, Dhamtari, Raipur, Rajnandgaon, Surguja	Bastar, 24.08.2005, B.K. Shukla 63374 (BSA); Durg, 25.08.1978. P.C. Pant, 29178 (BSA); Raipur, 05.08.1976, P.C. Pant, 23923 (BSA); Rajnandangaon, 10.09.1976, P.C. Pant, 253307 (BSA); Surguja, 28.08.1974, G. Sengupta, 20624 (BSA)
52	**Cyperus tenuispica** Steud. (Cyperaceae)	Nov.–Feb.	Dantewada, Kanker, Korba, Raigarh, Raipur, Rajnandgaon	Bilaspur, 29.07.1973, S.K. Murti, 19416 (BSA); Korba, 17.11.2006, B.K. Shukla, 67423 (BSA); Raipur, 13.01.1976, D.M. Verma, 23601 (BSA); Raipur, 30.09.1974, N.C. Rathkrishnan, 21230 (BSA); Rajnandgaon, 16.09.1976, P.C. Pant, 25438 A (BSA)
53	**Eleocharis acutangula** (Roxb.) Schult. (Cyperaceae)	Sept.–Oct.	Durg, Mahasamund, Surguja	Durg, 08.04.1974, P.C. Pant, 20256 (BSA); Raipur, 15.10.1976, D.M. Verma, 25809 (BSA)

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S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
54	**Eleocharis atropurpurea** (Retz.) J. Presl & K. Presl (Cyperaceae)	Aug–Dec.	Bilaspur, Dantewada, Dhamtari, Korba, Raigarh, Raipur, Rajnandgaon	Bastar, 06.03.1984, G.P. Roy, 35574(BSA); Dhamtari, 13.01.1976, 23612 (BSA); Raipur, 26.05.1972, D.M. Verma, 17262 (BSA); Raipur, 26.05.1972, D.M. Verma, 17262 (BSA)
55	**Eleocharis congesta** D. Don (Cyperaceae)	Aug.– Nov.	Bilaspur, Jashpur, Raigarh, Rajnandgaon, Surguja	Jasjpur, 20.02.2013, A.P. Tiwari, 73738 (BSA); Raigarh, 17.09.1976, P.C. Pant, 25476 (BSA); Surguja, 21.02.1976, G. Sengupta, 24079 (BSA)
56	**Eleocharis dulcis** (Burm.f.) Hensch. (Cyperaceae)	Sept.– Dec.	Bilaspur, Raipur	Bilaspur, 29.07.1976, S.K. Murti, 19390 (BSA); Raipur, 15.10.1976, D.M. Verma, 25808 (BSA)
57	**Eleocharis geniculata** (L.) Roem. & Schult. (Cyperaceae)	Jan.	Raipur	Raipur, 12.01.1976, D.M. Verma, 23576 (BSA)
58	**Eleocharis palustris** (L.) R. Br. (Cyperaceae)	Apr.	Bilaspur, Durg, Raipur	Durg, 08.04.1974, P.C. Pant, 20256 (BSA); Raipur, 23.09.1962, G. Panigrahi, 5074 (BSA)
59	**Eleocharis retroflexa** (Poir.) Urb. (Cyperaceae)	Sept.–Oct.	Dantewada, Korba, Raigarh Raipur	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
60	**Eleocharis spiralis** (Rottb.) Roem. & Schult. (Cyperaceae)	Sept.	Raipur, Rajnandangaon	Rajnandangaon,10.09.1976, P.C. Pant, 25284 (BSA)
61	**Fimbristylis acuminata** Vahl (Cyperaceae)	Sept.– Feb.	Bilashpur, Korba, Raigarh	Bilaspur, 16.04.1965, G. Panigrahi & C.M. Arora, 8601 (BSA); Raigarh, 05.04.1976, N.C. Rathkrishnan, 24600 (BSA)
62	**Fimbristylis aestivalis** (Retz.) Vahl (Cyperaceae)	Sept.–Jan.	Bastar, Bilashpur, Dantewada, Dhamtari, Jashpur, Korba, Raigarh, Raipur	Bastar, 24.05.1983, G.P. Roy, 34010 (BSA); Bilaspur, 24.07.1973, S.K. Murti, 19341 (BSA); Jashpur, 20.06.2018, A.P. Tiwari, 73156 (BSA); Raigarh, 03.02.1974, N.C. Rathkrishnan, 19677 (BSA); Raipur, 27.05.1972, D.M. Verma, 17306 (BSA)
63	**Fimbristylis alboviridis** C.B. Clarke (Cyperaceae)	Oct.	Bastar, Raipur, Mahasamund	Mahasamund, 18.07.2016, A.P. Tiwari, 275 (BSA)

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S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
64	**Fimbristylis argentea** (Rottb.) Vahl (Cyperaceae)	Dec.– Jan.	Bastar, Dantewada	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
65	**Fimbristylis bisumbellata** (Forssk.) Bubani (Cyperaceae)	Oct.	Bastar, Bilaspur, Raipur, Raigarh	Bastar, 15.04.2005, S.L. Bondya & S. Mishra, 62292 (BSA); Bilaspur, 12.02.1972, G. Panigrahi, 15398 (BSA); Raipur, 26.05.1972, D.M. Verma, 17243 (BSA); Raigarh, 31.03.1976, N.C. Rathkrishnan, 24407 (BSA)
66	**Fimbristylis cinnamometorum** (Vahl) Kunth (Cyperaceae)	Aug.–Oct.	Bastar	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.).
67	**Fimbristylis complanata** (Retz.) Link (Cyperaceae)	Sept.– Oct.	Bilaspur	Bilaspur, 29.07.1973, S.K. Murti, 19393 (BSA)
68	**Fimbristylis dichotoma** (L.) Vahl subsp. **Dichotoma** (Cyperaceae)	Throughout year	Bastar, Bilaspur, Dantewada, Dhamtari, Durg, Jaspur, Kawardha, Korba, Raipur, Raigarh, Rajnandgaon, Surguja	Bastar, 19.02.1963, G. Panigrahi, 6977 (BSA); Bilaspur, 15.07.1973, S.K. Murti, 19144 (BSA); Durg, 04.04.1974, P.C. Pant, 20131 (BSA); Raipur, 17.08.1976, D.M. Verma, 24834 (BSA); Raigarh, 04.04.1976, N.C. Rathkrishnan, 24587 (BSA); Rajnnandgaon, 16.09.1976, P.C. Pant, 25442 (BSA); Surguja, 12.02.2014, A.P. Tiwari, 73625 (BSA)
69	**Fimbristylis dichotoma** (L.) Vahl subsp. **podocarpa** (Nees) T. Koyama (Cyperaceae)	Aug.–Nov.	Bastar, Bilaspur, Dantewada, Dhamtari, Korba, Raigarh, Raipur, Rajnandgaon, Surguja	Bastar, 28.11.1972, G. Sengupta, 16000 (BSA)
70	**Fimbristylis dipsacea** (Rottb.) C.B. Clarke (Cyperaceae)	Oct.–Dec.	Bilaspur, Korba	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
71	**Fimbristylis eragrostis** (Nees) Hance (Cyperaceae)	Apr.– Sept.	Bastar	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
72	**Fimbristylis falcata** (Vahl) Kunth (Cyperaceae)	Aug.–Jan.	Bastar, Bilaspur, Koriya, Dhamtari, Raipur	Bastar, 25.05.1983, G.P. Roy, 34034 (BSA); Koriya, 23.06.2013, A.P. Tiwari, 73023 (BSA); Raipur, 02.06.1972, A.P. Tiwari, 17470 (BSA)
73	**Fimbristylis ferruginea** (L.) Vahl (Cyperaceae)	Oct.	Dantewada, Jashpur	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)

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S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
74	**Fimbristylis fusca** (Nees) Benth ex C. B. Clarke (Cyperaceae)	May	Bilaspur, Dhamtari, Raipur	Bilaspur, 23.07.1973, S.K. Murti, 19278 (BSA); Raipur, 03.07.1972, D.M. Verma, 17522 (BSA)
75	**Fimbristylis hookeriana** Boeckeler (Cyperaceae)	Aug.– Feb.	Bastar	Bastar, 18.11.1984, G.P. Roy & S.K. Dixit, 36254 (BSA)
76	**Fimbristylis intonsa** S.T. Blake (Cyperaceae)	Nov.	Surguja	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
77	**Fimbristylis littoralis** Gaudich. (Cyperaceae)	Sept.–Apr.	Bastar, Bilaspur, Dantewada, Dhamtari, Durg, Raigarh, Raipur, Rajnandgaon, Surguja	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
78	**Fimbristylis ovata** (Burm.f.) J. Kern (Cyperaceae)	Aug.–May	Bastar, Bilaspur, Dantewada, Korba, Raipur	Bastar, 21.08.1974, G. Sengupta, 20541 (BSA); Bilaspur, 06.08.1973, S.K. Murti, 19494 (BSA); Raipur, 13.08.1976, D.M. Verma, 24816 (BSA)
79	**Fimbristylis quinqueangularis** Kunth (Cyperaceae)	Sept.– Dec.	Bastar, Bilaspur, Dantewada, Korba, Raipur, Raigarh, Surguja, Rajnandgaon.	Bastar, 22.09.2002, A.K. Jha, 56487 (BSA); Bilaspur, 20.04.1965, G. Panigrahi, 8795 (BSA); Dantewada, 29.09.1962, S.K. Jain, 5207 (BSA); Raipur, 23.09.1961, G. Panigrahi, 5061 (BSA); Raigarh 04.04.1976, N.C. Rathkrishnan, 245854 (BSA); Rajnandgaon, 05.11.1993, Rajnandgaon, S.K. Srivastava & B.K. Shukla, 47869 (BSA)
80	**Fimbristylis schoenoides** (Retz.) Vahl (Cyperaceae)	Aug.–Dec.	Bilaspur, Dantewada, Dhamtari, Raipur, Rajnandgaon, Surguja. Koriya	Koriya, 08.10.2012, R.K. Singh, 69336 (BSA)
81	**Fimbristylis squarrosa** Vahl (Cyperaceae)	May–Jun.	Bastar	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
82	**Fimbristylis tetragona** R. Br. (Cyperaceae)	Aug.– Nov.	Bastar, Bilaspur, Dantewada, Dhamtari, Korba, Koriya, Raigarh, Raipur, Rajnandgaon, Surguja.	Bastar, 23.09.2002, K.K. Khanna & A.K. Jha, 56625 (BSA); Bilaspur, 12.09.2015, A.P. Tiwari, 75431 (BSA); Raipur, 04.10.1976, D.M. Verma, 24251 (BSA); Raigarh, 14.11.1971, G. Sengupta, 16289 (BSA); Koriya, 28.02.2014, R.K. Singh, 72853 (BSA); Rajnandgaon, P.C. Pant, 19.09.1976, 25502 (BSA)

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S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
83	**Fuirena ciliaris** (L.) Roxb. (Cyperaceae)	Oct.–May	Bastar, Bilaspur, Dantewada, Durg, Jaspur, Kanker, Koriya, Korba, Raigarh, Raipur, Surguja	Bastar, 06.12.1972, G. Sen Gupta, 17910 (BSA); Bilaspur 14.09.2015, A.P. Tiwari, 75542 (BSA); Durg, 08.04.1974, P.C. Pant, 20247 (BSA); Jaspur, 13.05.2017, A.P. Tiwari, 282 (BSA); Koriya, 23.02.2013, A.P. Tiwari, 73811 (BSA); Korba, 17.11.2006, B.K. Shukla, 67424 (BSA); Raigarh, 02.02.1974, N.C. Rathkrishnan, 19636 (BSA); Raipur, 27.05.1972, D.M. Verma, 17305 (BSA)
84	**Lipocarpha chinensis** (Osbeck) Kern (Cyperaceae)	Aug.–Dec.	Bastar, Bilaspur, Dantewada, Koriya, Raigarh, Raipur, Rajnandgaon, Surguja	Bilaspur, 08.09.2015, A.P. Tiwari, 75303 (BSA); Raigarh, 20.05.1996, R.C. Srivastava, 43430 (BSA); Rajnandgaon, 11.09.1976, P.C. Pant, 25348 (BSA); Koriya, 25.06.2013, A.P. Tiwari, 73216 (BSA)
85	**Lipocarpha gracilis** (Rich.) Nees (Cyperaceae)	Sept.– Nov.	Raigarh, Surguja, Koriya	Bastar, 25.08.1974, G. Sengupta, 20621 (BSA); Raigarh, 10.11.1971, G. Sengupta, 16087 (BSA); Koriya, 10.10.2012, R.K. Singh, 69400 (BSA)
86	**Pycreus pumilus** (L.) Nees (Cyperaceae)	Aug.– Nov.	Bastar**,** Bilaspur, Dantewada, Dhamtari, Durg, Korba, Raipur, Rajnandgaon	Bastar, 26.12.1971, C.R. Das, 14941 (BSA); Bilaspur, 02.08.1973, S.K. Murti, 19466 (BSA); Durg, 08.04.1974, P.C. Pant, 20248 (BSA); Raipur, 17.10.1976, D.M. Verma, 25764 (BSA); Rajnandgaon, 16.09.1976, P.C. Pant, 25401 (BSA)
87	**Pycreus sanguinolentus** Nees (Cyperaceae)	Sept.– Dec.	Dantewada, Raipur, Raigarh, Surguja	Raigarh, 26.12.1964, C.M. Arora, 7245 (BSA); Surguja, 04.10.1976, D.M. Verma, 24950 (BSA), Dantewada (recorded on the basis of N.P. Singh, l.c.)
88	**Rhynchospora longisetis** R. Br. (Cyperaceae)	Oct.– Jan.	Bastar, Bilaspur, Dantewada, Raigarh, Surguja	Bastar, 22.11.1972, G. Sengupta, 15829 (BSA); Bilaspur, 22.11.1972, G. Sengupta, 15829 (BSA); Raigarh, 28.09.1974, N.C. Rathkrishnan, 21167 (BSA)
89	**Rhynchospora rubra** (Lour.) Makino (Cyperaceae)	Oct.	Bastar	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
90	**Scleria annularis** Nees ex Steud. (Cyperaceae)	Oct.– Nov.	Bastar, Bilaspur, Dantewada	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
91	**Scleria biflora** Roxb. (Cyperaceae)	Sept.–Nov.	Dantewada, Rajnandgaon	Koriya, 07.10.2012, R.K. Singh 69286 (BSA); Rajnandgaon, 16.09.1976, P.C. Pant, 25445 (BSA)

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S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
92	**Scleria levis** Retz. (Cyperaceae)	Oct.–Feb.	Bastar, Bilaspur, Korba, Koriya, Raipur, Surguja	Bastar, 06.10.2005, S.L. Bondya, 63566 (BSA); Bilaspur, 25.10.1970, G. Panigrahi, 12930 (BSA); Koriya, 23.06.2013, A.P. Tiwari, 73028 (BSA); Raipur, 16.10.1976, D.M. Verma, 25045 (BSA)
93	**Scleria lithosperma** (L.) Sw. (Cyperaceae)	Throughout the year	Raipur	Raipur, 06.10.1976, D.M. Verma, 25044 (BSA)
94	**Scleria pergracilis** (Nees) Kunth (Cyperaceae)	Oct.–Mar.	Bastar, Bilaspur, Raipur	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
95	**Scleria terrestris** (L.) Fassett (Cyperaceae)	Aug.– Oct.	Bastar, Bilaspur, Raigarh	Bastar, 13.02.1963, G. Panigrahi, 6886 (BSA); Bilaspur, 01.08.1973, S.K. Murti, 19452 (BSA); Koriya, 23.02.2013, A.P. Tiwari, 73835(BSA)
96	**Schoenoplectiella articulata** (L.) Lye (Cyperaceae)	Sept.	Bastar, Bilaspur, Dantewada, Durg, Raigarh, Raipur, Rajnandgaon	Bastar, 06.03.1984, G.P. Roy & S.K. Dixit, 35563 (BSA); Bilaspur, 12.02.1972, G. Panigrahi, 15375 (BSA); Raipur, 12.01.1973, D.M. Verma, 17691 (BSA); Raigarh, 02.02.1974; N.C. Rathkrishnan, 34633 (BSA); Rajnandgaon, 16.09.1976, P.C. Pant, 25457 (BSA)
97	**Schoenoplectiella juncoides** (Roxb.) Lye	Aug.– Nov.	Bastar, Bilaspur, Durg, Korba, Raigarh, Surguja	Bastar, 24.05.1983, G.P. Roy, 35197 (BSA); Bilaspur, 10.02.1972, G. Panigrahi, 15288 (BSA); Durg, 05.04.1974, P.C. Pant, 20166 (BSA); Raigarh, 15.11.1971, G. Sengupta, 16323 (BSA)
98	**Schoenoplectiella lateriflora** (J.F.Gmel.) Lye	Throughout the year	Bastar, Bilaspur, Dantewada, Dhamtari, Durg, Korba, Raigarh, Raipur, Rajnandgaon, Surguja	Bastar, 25.05.1983, G.P. Roy, 35196 (BSA); Durg, 08.04.1974, P.C. Pant, 20258 (BSA); Raipur, 02.09.1960, G. Panigrahi, 5075 (BSA); Rajnandgaon, 16.09.1976, P.C. Pant, 25453 (BSA)
99	**Schoenoplectiella mucronata** (L.) J.Jung & H.K.Choi (Cyperaceae)	Aug.– Dec.	Bastar, Bilashpur, Raigarh	Bastar, 15.03.1974, G. Sengupta, 18883 (BSA); Bilaspur, 05.05.1969, C.M. Arora, 3889 (BSA); Raigarh, 24.11.1971, G. Sengupta, 16600 (BSA)
100	**Scirpus squarrosus** L. (Cyperaceae)	Oct.–May	Bastar, Bilaspur, Durg, Dantewada, Dhamtari, Korba, Raigarh, Raipur, Rajnandgaon	Bastar, 23.08.2005, B.K. Shukla, 63322 A (BSA); Bilaspur, 29.07.1973, S.K. Murti, 19417 (BSA); Durg, 26.08.1978, P.C. Pant, 29236 (BSA); Raigarh, 02.10.1974, N.C. Rathkrishnan, 21260 (BSA); Raipur, 24.01.1976, D.M. Verma, 23893 (BSA); Rajnandgaon, 17.09.1976, 25473 (BSA)
101	**Scirpus tuberosus** Desf. (Cyperaceae)	Feb.–Jun.	Raipur	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)

Cont...

Table 1 Cont...

S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
			Eriocaulaceae	
102	**Eriocaulon achiton** Koern.	Sept.– Oct.	Raipur	Raipur, 07.11.1976, DM Verma 25102 (BSA)
103	**Eriocaulon breviscapum** Koern.	Nov. – Mar.	Bastar, Raigarh, Surguja, Bilaspur	Bastar, 13.02.1963, G. Panigrahi & C.M. Arora 6864 (BSA); Raigarh, 10.02.1976, N.C. Rathkrishnan, 19817 (BSA); Surguja, 06.03.1990, G. Sengupta, 35124 (BSA); Bilaspur, Apr 1965, G. Panigrahi 9013 (BSA)
104	**Eriocaulon cinereum** R. Br.	Aug. – Nov.	Bastar, Bilashpur, Dantewada, Mahasamund, Raigarh, Raipur, Rajnandgaon	Bastar, 21.09.2002, K.K. Khanna & A.K. Jha, 67871 (BSA); Rajnandgaon 16.09.1976, P.C. Pant, 25443 (BSA); Raipur, 06.10.1976, D.M. Verma, 25006 (BSA)
105	**Eriocaulon cuspidatum** Dalzell (Eriocaulaceae)	Aug.– Oct..	Bastar, Bilaspur	Bilaspur, 08.02.1972, G. Panigrahi, 15267 (BSA)
106	**Eriocaulon hamiltonianum** Mart. (Eriocaulaceae)	Sept.–Oct.	Raipur	Raipur, 09.11.1971, G. Sengupta, 16061 (BSA)
107	**Eriocaulon longicuspe** Hook. f. (Eriocaulaceae)	Feb.	Ambikapur, Bastar, Bilashpur, Korba	Ambikapur, 8.12.1972, G.S. Gupta, 17942 (BSA); Bastar, 13.2.1963, G. Panigrahi & C.M. Arora 6864 (BSA); Bilashpur, 18.04.1965, C.M. Arora 8699 (BSA)
108	**Eriocaulon nepalense** Prescott ex Bong. (Eriocaulaceae)	Nov.– Dec.	Surguja	Surguja, (recorded on the basis of N.P. Singh et al., l.c.)
109	**Eriocaulon parviflorum** (Fyson) Ansari & Balakr. (Eriocaulaceae)	Oct.– Feb.	Bastar, Raigarh, Raipur	Bastar,19.02.1963, G Panigrahi & Arora, 4036 (BSA); Raigarh, 02.02.1974; N.C. Rathakrishnan, 19642 (BSA)
110	**Eriocaulon quinquangulare** L. (Eriocaulaceae)	Sept.–Apr.	Bastar, Bilashpur, Dantewada, Durg, Kanker, Korba, Raigarh, Raipur, Rajnandgaon, Surguja	Bastar,12.03.1984, G.P. Roy & R.D. Dixit, 35302 (BSA); Bilashpur 21.02.1972, G. Panigrahi, 16826 (BSA); Dantewada, 12.02.1963, G. Panigrahi, 6778 (BSA); Durg, 08.04.1984, P.C. Pant, 20244(BSA); Korba, 10.02.1972, G. Panigrahi, 15328 (BSA); Raigarh, 07.02.1974, N.C. Rathkrishnan, 19738 (BSA); Raipur, 15.01.1976, P.C. Pant, 23653 (BSA); Rajnandgaon,06.11.1974, P.C. Pant, 21599 (BSA), Surguja, 25.02.1976, G. Sengupta, 15597 (BSA)

Cont...

Table 1 Cont...

S. No.	Taxon (Family)	Phenology	Distribution	Specimen consulted
111	**Eriocaulon raipurense** K. K. Khanna & Mudgal & An. Kumar (Eriocaulaceae)	Oct.–Nov.	Raipur, Surguja	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
112	**Eriocaulon rajendrababui** Ansari & Balakr.	Nov.	Rajnandgaon	Rainandgaon (recorded on the basis of N.P. Singh et al., l.c.)
113	**Eriocaulon sollyanum** Royle (Eriocaulaceae)	Oct.–Feb.	Bastar, Raipur, Surguja	Raipur, 14.10.1976, D.M. Verma, 25782 (BSA)
114	**Eriocaulon truncatum** Buch.- Ham. ex Mart. (Eriocaulaceae)	Apr.– Dec.	Bilashpur, Raigarh, Surguja	Bilaspur, 10.12.1969, C.M. Arora, 9534 (BSA); Raigarh, 04.04.1976, K.K. Khanna, 30430 (BSA), Surguja, 04.02.2006, B.K. Shukla, 64093 (BSA)
			Potamogetonaceae	
115	**Potamogeton crispus** L.	Nov.–Jun.	Bilaspur, Raipur, Surguja, Batsar	Bilsapur, 16.02.1972, G. Panigrahi 16486 (BSA); Bastar, 01.03.1985, G.P. Roy & S.K. Dixit 42329 (BSA); Korba, 28.03.2006, B.K. Shukla, 64996 (BSA)
116	**Potamogeton nodosus** Poir.	Oct.–Jun.	Bilaspur, Raipur, Raigarh	Raipur (Deodhara), 12.10.1976, D.M. Verma 25734 (BSA); Raigarh (Saranggarh), 19.03.1976, N.C. Rathkrishnana 24351 (BSA); Bilashpur (Kudia), 16.02.72, G. Panigrahi 15487 (BSA)
117	**Potamogeton perfoliatus** L.	Nov.–Mar.	Bijapur, Bilashpur	Bijapur, 14.11.1962, G. Panigrahi 5857 (BSA); Bilashpur (Behari), 24.02.1972, G. Panigrahi 16858 (BSA)
118	**Potamogeton octandrous** Poir.	Feb.	Surguja	Specimen not available (recorded on the basis of N.P. Singh et al., l.c.)
119	**Stuckenia pectinata** (L.) Börner	Nov.–Apr.	Bilaspur, Raipur	Raipur, Raipur, 17.06.1972, D.M. Verma 17734 (BSA); 12.10.1976, D.M. Verma 25734 (BSA); Raigarh (Saranggarh), 19.03.1976, N.C. Rathkrishnana 24351 (BSA); Bilashpur (Kudia), 16.02.72, G. Panigrahi 15487 (BSA)

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Montane subtropical forests are confined to Bastar and Bilaspur area on hilly tracts. These are dense forests and composed of evergreen elements. Top canopy consists of *Canthium dicoccum, Celtis cinnamomea, Chionanthus ramiflorus, Syzygium cumini, S. nervosum, Wendlandis heynei, etc.* Second storey components are *Symplocos lauria, S. racemosa, Glochidion multiloculare, grewia tiliifolia, mallotus philippensis, Memecylon umbellatum, etc*. In third storey *Melastoma malabathricum, Rhinacanthus nasuta, Pogostemon benghalense*, etc. are mainly found. Noticeable climbers in this type of vegetation are *Cansjera rheedii, Calycopteris floribunda, Symphorema polyandrum, Smilax zeylanica, Clematis smilacifolia, etc*.

After review of the past publications on the diversity of angiosperm of Chhattisgarh *viz.* by Wood (1902), Hains (1916), Narayanaswami and Mooney (1941), Mooney (1942), Raizada (1947), Tiwari (1957, 1963), Tiwari and Maheshwari (1963, 1965), Unni (1967b), Subramanyam and Henry (1967), Arora (1968), Champion and Seth (1968), Saxena (1973), Saxena and Khotele (1976), Verma and Chandra (1981), Verma et al. (1985), Roy and Chaturvedi (1987), Panigrahi and Murthi (1989), Dixit and Roy (1992a), Dixit and Roy (1992b), Verma, *et al*. (1993), Kumar (1993, 1995, 1998), Mudgal et al. (1997), Murthi and Panigrahi (1999), Khanna et al. (2001), Singh *et al*. (2001), Jha and Khanna (2002a), Jha and Khanna (2003). it was concluded that the updated checklist of the Cyperaceae, Eriocaulaceae and Potamogetonaceae is not available; therefore, present work has been taken up with the objective of studying the diversity in family Cyperaceae, Eriocaulaceae and Potamogetonaceae in Chhattisgarh .

MATERIAL AND METHODS

The data has been collected from the herbarium specimens preserved at herbarium of Central Regional Circle, Botanical Survey of India, Allahabad (BSA) and relevant literatures published on Chhattisgarh (Miudgal et al., 1997; Singh *et al*., 2001; Khanna *et al.*, 2005). In present treatment, list of herbarium under above mention family have been shorted and list of taxon with collection data have been noted down. After verification of the species with relevant literatures, left-out species were added to the list. Information given on annotation slips was considered and details of the consulted specimens have been compiled with the associated taxa. Further, phenological information and distribution at district level have been compiled from herbarium (BSA) and literatures. Nomenclatures of the taxa has been updated with help of International Plant Names Index (IPNI) https://www.ipni.org/ and Plants of the World Online (POWO) https://powo.science.kew.org/.

RESULTS AND DISCUSSION

A total of 118 taxa have been enumerated in present communication (Table 1). In family Cyperaceae, a total of 102 species, one subspecies (*Fimbristylis dicotoma* subsp. *podocarpa*) and one variety (*Cyperus. nutans* var. *elensinoides*) have been documented. Family Cyperaceae is represented by 12 genera and the maximum representation is by genera *Cyperus* (37 species and one variety), followed by *Fimbristylis* (21 species and one subspecies), *Scirpus* (9 species), *Carex* and *Eleocharis* (8 species), *Scleria* (6 species), etc. (Fig. 1). Family Potamogetonaceae has two genera *Potamogeton* (4 species) and *Stuckenia* (1 species). Family Eriocaulaceae is represented by one genus *Eriocaulon* having 13 species.

Out of 33 districts, distribution of taxa in 17 districts have been recorded maximum number of taxa has been documented Raipur (75 taxa), Bilaspur (70 taxa), Bastar (64 taxa), Surguja (48 taxa), Raigarh (47 taxa), Dantewada (44 taxa), Korba (32 taxa), Dhamtari and Rajnandgaon (25 taxa each), Durg (20 taxa), Koriya (12 taxa), Jashpur (8 taxa), Kanker and Mahasamund (4 taxa each), Jaspur (3 taxa), Kawardha (2 taxa) and Bijapur (1 taxa) (Fig. 2). The distribution in the old districts is recorded because herbarium specimens are collected before creation of new districts. Observation of phenology shows that flowering and fruiting time of four species (*Cyperus brevifolious, Fimbristylis dicotoma, Scleria lithosperma* and *Scirpus lateriflorus*) are throughout the year, three species have 10 months of flowering and fruiting time (*Cyperus difformis, Cyperus rotundus, Fimbristylis ovata*) and 19 species has only one month of flowering and fruiting time. Fig. 3 shows that out of 118 taxa, 72 taxa have reproductive phase in month of October, 70 taxa have reproductive phase in month of September, 59 taxa have reproductive phase in month of November, 44 taxa have reproductive phase in month of December, 42 taxa have reproductive phase in month of August, etc.

Distributions of taxa were documented on the basis of herbarium collection data and authentic literatures. The herbarium collection data of 78 taxa were available and distribution records of rest of the 24 taxa were taken from authentic literatures (Khanna *et al.*, 2005).

LITERATURE CITED

Arora, C.M. 1968. The Botany of Bailadilla, Bastar State, M.P. Bull. Bot. Surv. India 10: 61-66.

Champion, H.G and Seth, S.K. 1968. A revised survey of the forest types of india. Manager of Publications, Delhi.

Dixit, S.K and Roy, G.P. 1992a. Recollection of some little known taxa from Bastar district, Madhya Pradesh. *Journal of Economic and Taxonomic Botany*. 16(1): 185-192.

Dixit, S.K and Roy, G.P. 1992b. Additions to the flora of Bastar District, Madhya Pradesh. *Journal of Economic and Taxonomic Botany*. 16(2): 351-365.

Jha, Ajay Kumar and Khanna, K.K. 2002a. Preliminary studies on the floristic diversity (Angiosperms) of Bastar, Chhattisgarh. Proc. 89th Indian Sci. Congress, Part III. 26-27.

Jha, Ajay Kumar and Khanna, K.K. 2003. Status of floristic studies in Bastar district, Chhattisgarh. Proc. 90th Indian Sci. Congress, Part III. 1-2.

Khanna, K.K. 2005. Floristic Diversity of Chattisgarh. Bishen Singh Mahendra Pal Singh, Dehra Dun-248001.

Khanna, K.K., Kumar Anand, Dixit, R.D and Singh, N.P. 2001. Supplement to the flora of Madhya Pradesh. Botanical Survey of India, Calcutta.

Kumar Anand. 1993. New distributional records of some angiosperms from Madhya Pradesh. *Journal of Economic and Taxonomic Botany*. 17: 143-145.

Kumar Anand. 1998. Contribution to the flora of the Indravati Tiger Reserve, Bastar (Madhya Pradesh). *Journal of Economic and Taxonomic Botany*. 22: 287-320.

Kumar Anand. 1995. Contribution to the rare flowering plants of the Indravati Tiger Reserve, Bastar (Madhya Pradesh). *Journal of Economic and Taxonomic Botany*. 19: 411-418.

Kumar Anand. Family Opiliaceae in Madhya Pradesh. *Journal of Economic and Taxonomic Botany*. 12: 430-432. 1988.

Mooney, H.F. 1942. A sketch of the flora of Bailadilla Range in Bastar State. Indian For. Rec. (n.s.) 3(7): 197-253.

Mudgal, V., Khanna, K.K and Hajra, P.K. 1997. Flora of Madhya Pradesh Vol. II. Botanical Survey of India, Calcutta.

Murthi, S.K. and Panigrahi, G. 1999. Flora of Bilaspur District (Madhya Pradesh) – Vol. 2. Flora of India-Series 3. Botanical Survey of India, Calcutta.

Panigrahi, G. and Murthi, S.K. 1989. Flora of Bilaspur District (Madhya Pradesh) – Vol. 1. Flora of India-Series 3. Botanical Survey of India, Calcutta.

Roy, G.P. and Chaturvedi, K.K. 1987. Less known medicinal uses of rare and endangered plants of Abujhmarh reserve area, Bastar (M.P.). J. Econ. Tax. Bot. 9: 325-328.

Saxena, H.O. and Khotele, S.N. 1976. A contribution to the flora of Bastar (M.P.). J. Bombay Nat. Hist. Soc. 73: 21-34.

Saxena, H.O. 1973. Further contribution to the flora of Bailadilla (M.P.). J. Bombay Nat. Hist. Soc. 70: 586-590.

Singh, N.P., Khanna, K.K., Mudgal, V. and Dixit, R.D. 2001. Flora of Madhya Pradesh Vol. III. Botanical Survey of India, Calcutta.

Subramanyam, K. and Henry, A.N. 1967. Vascular plants of Bastar, M.P. Bull. Bot. Surv. India 8: 207-215.

Tiwari, S.D.N. 1963. Supplement to the grasses of Madhya Pradesh. Indian For. 89: 593-612.

Tiwari, S.D.N. and Maheshwari, J.K. 1963. Orchids of Madhya Pradesh. Indian For. 89: 426-444.

Tiwari, S.D.N and Maheshwari, J.K. 1965. Commelinaceae of Madhya Pradesh. Indian For. 91: 580-590.

Tiwari, S.D.N. 1957. Grasses of Madhya Pradesh. Indian For. 80: 601-611, 681-689. 1954; 81: 107-115. 1955; 83: 191-200.

Unni, K.S. 1967b. Compositae of Raipur and its surroundings. J. Bombay Nat. Hist. Soc. 64: 333-338.

Verma, D.M. and Chandra, V. 1981. Cyperaceae of Madhya Pradesh. Rec. Bot. Surv. India 21: 221-275.

Verma, D.M., Balakrishnan, N.P. and Dixit, R.D. 1993. Flora of Madhya Pradesh Vol. I. Botanical Survey of India, Calcutta.

Verma, D.M., Pant, P.C. and Hanfi, M.I. 1985. Flora of Raipur, Durg and Rajnandgaon. Flora of India-Series 3. Botanical Survey of India, Howrah.

Wood, J.J. 1902. Plants of Chhota Nagpur, including Jashpur and Surguja. Rec. Bot. Surv. India 2(1): 1-170.

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GENETIC DIVERGENCE STUDIES FOR YIELD, YIELD COMPONENTS AND RESISTANCE TO LATE LEAF SPOT IN GROUNDNUT (*Arachis hypogaea* L.)

PRACHI JAIN*, M. SREVALLI DEVI, K. JOHN AND P. ARUNASRI

Department of Genetics & Plant Breeding, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

A set of thirty one groundnut genotypes were assessed for genetic divergence during kharif season of 2023 using Mahalanobis D^2 statistics with regards to pod yield, yield components and resistance to late leaf spot. Among the characters studied, the plant height contributed maximum towards the total divergence. The groundnut genotypes were grouped into 12 clusters using Tocher's method of clustering. Among these 12 clusters, cluster I had maximum number of 13 genotypes followed by cluster II with 7 genotypes, cluster XI with 2 genotypes and the remaining clusters were solitary having only one genotype. Cluster XI had the maximum intra cluster distance followed by cluster I. The maximum inter- cluster distance was observed between cluster XI and XII followed by cluster IX and cluster XI. In order to get better segregants for yield and yield components and resistance to late leaf spot, taking into consideration the cluster distances and cluster means in the current experiment, the crossing between the genotypes from clusters IX and XI is rewarding.

KEYWORDS: Cluster means, genetic divergence, groundnut, late leaf spot (LLS), Mahalanobis D^2 statistics.

INTRODUCTION

Groundnut is one of the most important oil seed crops of India which is native to Brazil. It is an annual legume, self-pollinated, allotetraploid (2n = 4x = 40) belongs to family Fabaceae (earlier Leguminosae). Groundnut is known as a "wonder legume" for its flowering, pegging and pod formation pattern (Boraiah *et al*., 2012). It contains oil (48-50%), protein (26-28%), carbohydrates (8-14%). It provides 564 kcal of energy from 100 g of kernels. Peanuts are a valuable source of essential minerals including calcium, phosphorus, and iron, as well as important vitamins like vitamin E, niacin, folic acid, riboflavin, and thiamine. Beyond their dietary and industrial uses, peanuts are gaining attention for their content of "resveratrol" a naturally occurring phenolic compound produced by plants under stress. Resveratrol has a variety of health benefits, including the effects against aging, cardiovascular diseases, cancers and atherosclerosis (Baur and Sinclair, 2006).

India ranks first in groundnut area under cultivation and is the second largest producer in the world and is grown in an area of 5.7 million ha with a production and productivity of 10.1 million tonnes and 1777 kg ha^{-1}, respectively (FAOSTAT, 2024). Knowing the value of groundnut as a significant oilseed crop, in addition to ensuring food security, assessment of genetic divergence is essential for planning an effective breeding programme. The divergence analysis plays an effective role in choosing divergent parents for hybridization. Keeping the above in view, the present investigation was undertaken to identify the best performing genotypes.

MATERIAL AND METHODS

The experimental material for the present investigation comprised of 31 groundnut genotypes obtained from Regional Agricultural Research Station (RARS), Tirupati,

ANGRAU which is located at an altitude of 182.9 m above the mean sea level and are sown in dry-land farm during *Kharif* 2023 using a randomized block design (RBD) with three replications. Each entry was sown in 2 rows of 3 m row length at a spacing of 30 cm between rows and 10 cm within the row, in each replication.

For each genotype of groundnut, observations were recorded on five competitive plants at random except for days to 50% flowering and days to maturity, which were recorded on plot basis. Data was recorded for yield, yield components and resistance to late leaf spot *viz.,* plant height at harvest, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, number of mature pods $plant^{-1}$, number of immature pods $plant^{-1}$, pod yield $plant^{-1}$, dry haulms yield $plant^{-1}$, harvest index, shelling percent, kernel yield $plant^{-1}$, sound mature kernel, hundred kernel weight, disease scoring of LLS at 75 DAS and 90 DAS. The data collected was subjected to Mahalanobis D^2 statistics (Mahalanobis, 1936) and first suggested by Rao (1952) for the assessment of genetic divergence in plant breeding. Grouping of 31 genotypes of groundnut into different clusters were performed by

*Corresponding author, E-mail: prachijain221298@gmail.com

Tocher's method. The methods of Singh and Chaudhary (1977) were used for calculating the intra and inter cluster distances.

RESULTS AND DISCUSSION

The thirty one genotypes studied in the present investigation were grouped into twelve clusters based on D^2 values (Table 1). Cluster I is the largest with thirteen genotypes followed by Cluster II and Cluster XI with seven and two genotypes, respectively. Remaining clusters *viz*., Cluster III, IV, V, VI, VII, VIII, IX, X and XII consists of single genotype.

Inter- cluster distances (Table 2) were higher than intra- cluster distances indicating the availability of wider genetic divergence between the clusters rather than with in the clusters. Maximum intra- cluster distance was observed in cluster XI (54.06) followed by cluster I (45.34) and cluster II (41.32). This indicates the genotypes present in these clusters had wide variation among themselves. These results were confirmed with the findings of Suneetha *et al*. (2013), Shruti *et al*. (2019) and Dudhatra *et al*. (2022). Highest inter- cluster distance was observed between cluster XI and cluster XII (629.85) followed by cluster IX and cluster XI (403.73), cluster II and cluster XI (386.68), cluster VIII and cluster XII (337.66) and cluster IV and cluster XII (311.49). Hence, the hybridization between genotypes of these clusters may create more variability in segregating population. Whereas, minimum inter- cluster distance was identified between cluster IV and V (25.27) followed by cluster V and VI (30.25), cluster III and cluster VIII (36.54). This states that clusters showing low inter- cluster distances are genetically nearer than clusters showing high inter-cluster distances.

Based on mean performance of different characters for various clusters (Table 3) revealed that genotypes present in the cluster VIII (25.33 days) was early for days to 50% flowering, high number of primary branches plant^{-1} (5.60), maximum mean value for number of mature pod plant^{-1} (19.43), low number of immature pod plant^{-1} (2.43), high dry haulms yield plant^{-1} (46.49 g), high harvest index (78.27%), maximum mean value for shelling percent (14.27%), maximum mean value for kernel yield plant^{-1} (92.00 g), lowest mean value for LLS score (75 DAS) (1.33) and low mean for LLS score (90 DAS) (18.23). Cluster XII was early maturing

Table 1. Clustering of groundnut genotypes based on Tocher's method

Clusters	Number of genotypes	Genotypes
I	13	TCGS-2488, TCGS-2529, TCGS-2517, TCGS-2530, TCGS-2526, TCGS-2528, TCGS-2503, TCGS-2502, TCGS-2495, TCGS-2531, TCGS-2520, TCGS-2490, TCGS-2532
II	7	TCGS-2496, TCGS-2497, TCGS-2485, TCGS-2491, TCGS-2499, TCGS-2486, TCGS-2493
III	1	TCGS-2500
IV	1	TCGS-2501
V	1	TCGS-2494
VI	1	TCGS-2489
VII	1	TCGS-2492
VIII	1	Visista (TCGS-1694) (C)
IX	1	TCGS-2498
X	1	TCGS-2519
XI	2	K-6 (C), K-1812 (C)
XII	1	TAG-24 (C)

Table 2. Inter and Intra cluster (diagonal) D^2 and D values (in parentheses) of groundnut genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
I	45.34 **(6.73)**	72.05 **(8.49)**	59.48 **(7.71)**	56.59 **(7.52)**	57.38 **(7.57)**	81.83 **(9.05)**	74.03 **(8.60)**	89.56 **(9.46)**	65.21 **(8.08)**	81.60 **(9.03)**	255.02 **(15.97)**	204.05 **(14.28)**
II		41.32 **(6.43)**	66.30 **(8.14)**	97.62 **(9.88)**	106.39 **(10.31)**	143.01 **(11.96)**	144.16 **(12.01)**	119.96 **(10.95)**	81.73 **(9.04)**	137.52 **(11.73)**	386.68 **(19.66)**	167.10 **(12.93)**
III			0.00 **(0.00)**	45.48 **(6.74)**	78.85 **(8.88)**	153.99 **(12.41)**	107.20 **(10.35)**	36.54 **(6.04)**	102.07 **(10.10)**	168.70 **(12.99)**	255.07 **(15.97)**	263.35 **(16.23)**
IV				0.00 **(0.00)**	25.27 **(5.03)**	73.97 **(8.60)**	89.70 **(9.47)**	83.09 **(9.12)**	103.67 **(10.18)**	127.39 **(11.29)**	223.12 **(14.94)**	311.49 **(17.65)**
V					0.00 **(0.00)**	30.25 **(5.50)**	72.74 **(8.53)**	116.12 **(10.78)**	95.07 **(9.75)**	86.62 **(9.31)**	216.14 **(14.70)**	278.82 **(16.70)**
VI						0.00 **(0.00)**	94.72 **(9.73)**	192.94 **(13.89)**	124.12 **(11.14)**	45.32 **(6.73)**	243.48 **(15.60)**	248.02 **(15.75)**
VII							0.00 **(0.00)**	153.77 **(12.40)**	99.47 **(9.97)**	105.32 **(10.26)**	168.12 **(12.97)**	252.37 **(15.89)**
VIII								0.00 **(0.00)**	133.93 **(11.57)**	176.86 **(13.30)**	231.44 **(15.21)**	337.66 **(18.38)**
IX									0.00 **(0.00)**	84.40 **(9.19)**	403.73 **(20.09)**	162.71 **(12.76)**
X										0.00 **(0.00)**	282.80 **(16.82)**	202.59 **(14.23)**
XI											54.06 **(7.35)**	629.85 **(25.10)**
XII												0.00 **(0.00)**

Table 3. Cluster means for yield, yield components and late leaf spot resistance in groundnut

Clusters	Characters															Productivity traits	
	DFF	DM	PH	NPB	NSB	NMP	NIP	PYP	DHY	HI	SP	KYP	SMK	HKW	LLS Score (75 DAS)	LLS Score (90 DAS)	Total score	Final rank
Cluster 1	27.31 (5)	99.08 (5)	35.12 (5)	4.85 (8)	2.34 (6)	11.27 (6)	2.86 (5)	24.62 (5)	44.10 (7)	64.82 (6)	12.21 (8)	70.56 (11)	54.44 (4)	3.32 (6)	4.58 (3)	19.05 (6)	96	4
Cluster 2	27.33 (6)	102.00 (9)	29.80 (2)	4.28 (10)	1.82 (8)	11.70 (5)	3.30 (7)	19.81 (9)	51.27 (2)	64.02 (7)	13.07 (4)	74.81 (8)	57.14 (3)	4.02 (5)	5.36 (5)	20.70 (9)	99	5
Cluster 3	26.67 (4)	101.00 (8)	33.67 (4)	5.37 (5)	1.53 (11)	15.30 (2)	3.17 (6)	18.10 (10)	**54.19 (1)**	60.73 (10)	12.87 (6)	67.00 (12)	34.00 (11)	2.67 (7)	3.67 (2)	21.50 (10)	109	8
Cluster 4	26.67 (4)	102.33 (10)	35.83 (6)	**6.20 (1)**	3.33 (4)	9.47 (9)	4.27 (11)	27.30 (2)	45.38 (6)	59.07 (11)	13.40 (3)	72.33 (10)	34.00 (11)	2.33 (8)	3.67 (2)	22.67 (11)	109	8
Cluster 5	27.33 (6)	101.00 (8)	36.80 (9)	5.23 (6)	4.23 (3)	13.67 (3)	4.10 (9)	25.53 (3)	43.36 (8)	63.84 (8)	12.47 (7)	75.00 (6)	41.67 (10)	4.50 (3)	6.17 (7)	19.57 (7)	103	6
Cluster 6	28.33 (9)	98.67 (4)	37.27 (10)	4.03 (11)	**5.50 (1)**	8.40 (12)	4.23 (10)	24.67 (4)	42.72 (10)	59.03 (12)	10.87 (9)	75.00 (7)	51.33 (5)	4.17 (4)	4.67 (4)	18.40 (5)	117	9
Cluster 7	27.33 (6)	94.33 (2)	40.13 (11)	5.77 (2)	1.67 (10)	8.80 (11)	2.47 (4)	20.20 (8)	49.49 (3)	67.03 (5)	13.07 (4)	74.00 (9)	51.00 (6)	**6.00 (1)**	7.17 (9)	19.73 (8)	99	5
Cluster 8	**25.33 (1)**	100.67 (6)	36.20 (7)	5.60 (3)	1.50 (12)	**19.43 (1)**	2.43 (3)	21.00 (7)	46.49 (5)	78.27 (2)	**14.27 (1)**	**92.00 (1)**	48.33 (8)	1.00 (9)	**1.33** (1)	18.23 (4)	71	1
Cluster 9	28.00 (8)	94.33 (2)	32.10 (3)	5.57 (4)	2.00 (7)	13.50 (4)	4.27 (11)	**30.07 (1)**	42.89 (9)	61.18 (9)	13.80 (2)	85.00 (4)	70.00 (2)	4.17 (4)	6.00 (6)	22.67 (11)	87	3
Cluster 10	27.67 (7)	97.33 (3)	36.73 (8)	4.43 (9)	4.47 (2)	10.40 (8)	4.07 (8)	23.13 (6)	41.79 (12)	**78.37 (1)**	13.00 (5)	75.67 (5)	**86.67 (1)**	2.67 (7)	3.67 (2)	16.60 (3)	87	3
Cluster 11	25.67 (2)	100.83 (7)	50.27 (12)	5.02 (7)	1.75 (9)	11.10 (7)	2.25 (2)	16.27 (11)	42.54 (11)	75.73 (3)	9.28 (10)	88.83 (3)	46.50 (9)	2.67 (7)	3.67 (2)	12.82 (2)	104	7
Cluster 12	26.33 (3)	**90.00 (1)**	**24.50 (1)**	3.23 (12)	2.50 (5)	9.30 (10)	**1.70 (1)**	9.03 (12)	49.25 (4)	75.16 (4)	6.50 (11)	89.33 (2)	49.33 (7)	5.33 (2)	7.00 (8)	**10.47** (1)	84	2
Mean	27.00	98.46	35.70	4.97	2.72	11.86	3.26	21.64	46.12	67.27	12.07	78.29	52.03	3.57	4.75	18.53	-	-

Note: Values in parenthesis () indicates order of preference

DFF: Days to 50% flowering; **DM**: Days to maturity; **PH**: Plant height at harvest (cm); **NPB**: Number of primary branches plant^{-1}; **NSB**: Number of secondary branches plant^{-1}; **NMP**: Number of mature pods plant^{-1}; **NIP**: Number of immature pods plant^{-1}; **PYP**: Pod yield plant^{-1} (g); **DHY**: Dry haulm yield plant^{-1} (g); **HI**: Harvest index (%); **SP**: Shelling per cent

Table 4. Relative contribution of yield, yield components and late leaf spot resistance towards genetic divergence in groundnut genotypes

S. No.	Character	No of times ranked first	Per cent contribution
1.	Days to 50% flowering	7	1.51
2.	Days to maturity	16	3.44
3.	Plant height at harvest (cm)	191	41.08
4.	Number of primary branches plant^{-1}	22	4.73
5.	Number of secondary branches plant^{-1}	81	17.42
6.	Number of mature pods plant^{-1}	11	2.37
7.	Number of immature pods plant^{-1}	9	1.94
8.	Pod yield plant^{-1} (g)	0	0
9.	Dry haulm yield plant^{-1} (g)	36	7.74
10.	Harvest index (%)	0	0
11.	Shelling percent	0	0
12.	Kernel yield plant^{-1} (g)	0	0
13.	Sound mature kernel (%)	1	0.22
14.	Hundred kernel weight (g)	67	14.41
15.	LLS score (75 DAS) 1-9 scale	22	4.73
16.	LLS score (90 DAS) 1-9 scale	2	0.43

as it recorded lowest mean values for days to maturity (90.00 days) and possessed lowest mean value for plant height (24.50 cm), lowest mean value for number of immature pods plant^{-1} (1.70) along with lowest mean value for LLS score (90 DAS) (10.47). Genotypes in cluster IV showed maximum mean value for number of primary branches plant^{-1} (6.20), low values for days to 50% flowering (26.67 days), higher values for number of secondary branches plant^{-1} (3.33), higher values for pod yield plant^{-1} (27.30 g) higher values for shelling percent (13.4%). Cluster III recorded low values for days to maturity (101.00 days) and possessed maximum mean value for dry haulm yield plant^{-1} (54.19 g). The cluster VI showed maximum mean value for number of secondary branches plant^{-1} (5.50). The maximum mean value for hundred kernel weight (6.00 g) was recorded in cluster VII. The maximum mean value for pod yield plant^{-1} (30.07 g) was recorded in cluster IX. The cluster X showed maximum mean value for harvest index (78.37%) along with maximum mean value for sound mature kernel (86.67%). Therefore, crosses between members of clusters having high inter cluster distance along with high mean value for important characters are likely to be highly rewarding (Rajalakshmi *et al.,* 2020).

Information on the relative contribution of various plant characters towards divergence has also been reported to aid the breeder in choice of parents for hybridization and effective selections in the advance generations (Suneetha *et al.,* 2013). In the present study, plant height contributed maximum towards total divergence (41.08%) followed by number of secondary branches plant^{-1} (17.42%), hundred kernel weight (14.41%), dry haulms yield plant^{-1} (7.74%), number of primary branches plant^{-1} (4.73%), LLS score (75 DAS) (4.73%), days to maturity (3.44%) and number of mature pod plant^{-1} (2.37%) (Table 4). The results obtained are in agreement with the findings of Mahalakshmi *et al*. (2005) for shelling percent, Raghuwanshi *et al*. (2016) for hundred pod weight, Vivekananda *et al*. (2015) and Yadav *et al*. (2022) for hundred kernel weight. Contribution of the remaining characters to total divergence was, however, relatively low. Therefore, the characters days to 50% flowering, days to maturity, plant height, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of mature pods plant^{-1}, number of immature pods plant^{-1}, dry haulms yield plant^{-1}, hundred kernel weight, disease scoring of LLS at 75 DAS contributing to 99.37 per cent of the total

divergence need to be emphasised in selection of parents for hybridization.

From the present study it was concluded that, based on the divergence analysis the crosses *viz.,* K-1812 x TAG-24, K-1812 x TCGS 2498, K-1812 x TCGS 2493, K-1812 x TCGS 2485, K-6 x TCGS 2486, Visista x TAG-24, TAG-24 x TCGS 2501 and K-1812 x TCGS 2519 were identified as the best cross combinations to get transgressive segregants for yield, yield components and resistance to late leaf spot in groundnut.

LITERATURE CITED

Baur J and Sinclair D.A. 2006. Therapeutic potential of resveratrol, the in vivo evidence. *Nature reviews Drug Discovery*. 5(6): 493–506.

Boraiah, K.M., Goud, S., Gejli, K., Konda, C.R., Babu and H.P. 2012. Heterosis for yield and yield attributing traits in groundnut (*Arachis hypogaea* L.). *Legume Research*. 35(2): 119-125.

Dudhatra, R.S., Viradiya, Y.A., Joshi, K.B., Desai, T.A and Vaghela, G.K. 2022. Genetic divergence analysis in groundnut (*Arachis hypogaea* L.) genotypes. *Emer Life Science Research*. 8(1): 114-118.

FAOSTAT, 2024. Food and Agriculture Organization of the United Nations. World Agricultural Production, Rome, Italy. http: // faostat.fao.org/.

Mahalakshmi, P., Manivannan, N and Muralidharan, V. 2005. Variability and correlation studies in groundnut (*Arachis hypogaea* L.). *Legume Research.* 28(3): 194-197.

Mahalonobis, P.C. 1936. On the generalized distance in statistics. *Proceedings of the National Institute of Science of India*. 2(1): 49-55.

Raghuwanshi, S.S., Kachhadia, V.H., Vachhani, J.H., Jivani, L.L and Patel, M.B. 2016. Genetic divergence in groundnut (*Arachis hypogaea* L.). *Electronic Journal of Plant Breeding*. 7(1): 145-151.

Rajalakshmi, K., Manivannan, N., Anand, G., Vanniarajan, C and Harish, S. 2020. Genetic divergence among black gram [*Vigna mungo* (L.) Hepper] genotypes using Mahalanobis D^2 statistics. *Electronic Journal of Plant Breeding*. 11(1): 116-119.

Rao, C.R. 1952. *Advanced Statistical Methods in Biometrical Research.* John Wiley and sons. New York. 236-272.

Shruti, K, Rao, V.S., Rani, M.G., Sreekanth, B., Kumar, V.M and Umar, N. 2019. Genetic diversity studies in yield and its contributing traits in groundnut (*Arachis hypogaea* L.) genotypes using D^2 statistics. *International Journal Current Microbiology and Applied Sciences*. 8(6): 32-38.

Singh, R.K and Chaudhary, B.D. 1977. *Biometrical methods in quantitative genetic analysis*. Kalyani Publishers, New Delhi. 215-218.

Suneetha, N., Vasanthi, R.P., Sudhakar, P and Reddy, K.R. 2013. Genetic diversity analysis among released and pre-release cultures in groundnut. *Legume Research-An International Journal*. 36(3): 208-213.

Vivekananda, Y., Khoyumthem, P and Singh, N.B. 2015. Genetic divergence analysis in groundnut (*Arachis hypogaea* L.). *Electronic Journal of Plant Breeding*. 6(1): 315-317.

Yadav, G.L., Rajput, S.S., Gupta, D., Kunwar, R., Yadav, O.P and Meena, A.K. 2022. Assessment of genetic diversity in groundnut (*Arachis hypogaea* L.) genotypes under semi-arid condition of Rajasthan. *The Pharma Innovation Journal.* 11(4): 538-541.

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EFFECT OF ORGANIC NUTRIENT MANAGEMENT PRACTICES ON GROWTH AND YIELD OF FOXTAIL MILLET

P. ADITYA KAMAL*, Y. REDDI RAMU, N. SUNITHA, B. SANTHOSH AND V. CHANDRIKA

Department of Agronomy, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

A field experiment was conducted during *kharif,* 2023 on sandy loam soils of S.V. Agricultural College Farm, Tirupati to know that the effect of organic nutrition in foxtail millet. The experiment was laid out in a randomized block design and replicated thrice. The results of the experiment indicated that plant height, leaf area index, grain and straw yield were recorded with 100 per cent RDF (40-20-0 kg N, P_2O_5 and K_2O ha^{-1}), was significantly higher compared to rest of the treatments. Among organic nutrient management practices, 50 per cent N through FYM + two sprays of panchagavya @3 per cent at panicle initiation and flowering stage recorded significantly higher plant height, leaf area index, grain and straw yield compared to rest of organic nutrient management practices tired. Significantly lower plant height, leaf area index, grain and straw yield were recorded with control..

KEYWORDS: Foxtail millet, Recommended dose of fertilizer, Panchagavya, Seaweed extract.

INTRODUCTION

The use of chemical fertilizers has increased food grain production but introduced problems such as diminishing crop output and sustainability concerns. Rising fertilizer costs have led India to promote organic farming, which maximizes crop productivity by enhancing ecological processes with fewer external inputs (Shukla *et al*., 2011). Organic farming emphasizes locally accessible agro-inputs and minimizes synthetic agrochemicals.

In India, small millets are grown on 4.23 lakh ha, producing 3.75 lakh tonnes with a productivity of 885 kg ha^{-1}. In Andhra Pradesh, small millets occupy 0.14 lakh ha, producing 0.11 lakh tonnes with a productivity of 786 kg ha^{-1} (APEDA, 2021-22). Foxtail millet, one of the oldest millets, is a nutritional powerhouse with a low glycemic index of 50.8, making it suitable for diabetics. Per 100 g, it contains 12.3 g protein, 4.3 g fat, 60.9 g carbohydrates, and 8.0 g fiber (Vanithasri *et al*., 2012).

Organic manures provide more nutrients and beneficial microbes but can be less efficient due to nutrient loss. Foliar feeding of nutrients, such as FYM combined with organic liquids like panchgavya, cow urine, vermi wash, fish amino acid, and seaweed extract, can offer cost-effective, eco-friendly nutrient management.

In India's climate-changing environment, organic millet-based farming can ensure nutrient-dense food security. Research is needed on using local manure to grow foxtail millet without chemical fertilizers, aiming to reduce pollution and sustain long-term soil productivity. Current agricultural research focuses on developing ecologically sound, biologically sustainable, and socioeconomically viable technologies. Millets can address micronutrient deficiencies, and efficient crop nutrition can enhance productivity. However, scientific information on organic nutrient management in foxtail millet is lacking. Thus, the present investigation aims to identify suitable organic nutrient management practices for foxtail millet.

MATERIAL AND METHODS

The present investigation was carried out at S.V. Agricultural College Farm, Tirupati campus of Acharya N.G. Ranga Agricultural university which is in the Southern Agro-climatic Zone of Andhra Pradesh. The experiment was laid out in a randomized block design and replicated thrice. There are nine treatments *viz.,* Control (T_1), 100 per cent RDF (40- 20- 0 kg N, P_2O_5 and K_2O ha^{-1}) (T_2), 100 per cent N through FYM (T_3), 50 per cent N through FYM + water spray (T_4), 50 per cent N through FYM + cow urine @ 5 per cent (T_5), 50 per cent N through FYM vermiwash @ 5 per cent (T_6), 50 per cent N through FYM + sea weed extract @ 1per cent (T_7), 50 per cent N through FYM + fish amino acid @ 3 per cent (T_8) and 50 per cent N through FYM + panchagavya @ 3%(T_9). FYM was applied based on per cent of nitrogen content. Foliar spraying was done twice at panicle initiation and flowering stage of the crop.

Plant height was recorded from five randomly tagged plants at different intervals *viz*., 20, 40, 60 DAS and at harvest. It was measured from the base of the plant

*Corresponding author, E-mail: adhip2851@gmail.com

to the tip of the longest leaf up to panicle initiation stage and later on it was measured from the base of the plant to the tip of the panicle and mean was expressed in cm. Five plants were selected outside the net plot area, leaving the extreme border row, for destructive sampling to generate data on leaf area at different stages of crop growth. Leaf area of five destructively sampled plants from border rows was measured at 20, 40, 60 DAS and at harvest by using LI-COR model, LT-300 leaf area meter with transparent conveyor belt and electronic digital display. After computing the leaf area (cm^2), leaf area index was calculated by using the following formula as suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area } (cm^2)}{\text{Unit land area } (cm^2)}$$

Crop was harvested at physiological maturity. The grain and straw yield obtained from the net plot area including the grain of the sampled plants was thoroughly sundried, weighed and expressed in kg ha^{-1}. The data collected on plant height, leaf area index, grain and straw yield, were analyzed statistically following the procedure given by Panse and Sukhatme (1978) wherever the treatment differences were significant, critical differences were worked out at 5 per cent probability level. Treatment differences that were not significant are denoted as NS.

RESULTS AND DISCUSSION

Data pertaining to the plant height, leaf area index and yield as influenced varied by organic foliar nutrition.

Plant height

At all the stages of observation *viz.,* 20, 40, 60 DAS and at harvest. the highest plant height was recorded with soil application of 100 per cent RDF (T_2), which was significantly superior over the rest of the treatments tried.

Among the organic nutrient management practices tried application of 50 per cent N through FYM + panchagavya @ 3 per cent (T_9) recorded higher plant height, followed by 50 per cent N through FYM + seaweed extract @ 1 per cent (T_7), 50 per cent N through FYM + vermiwash @ 5 per cent (T_6), 50 per cent N through FYM + fish amino acid @ 3 per cent (T_8), 50 per cent N through FYM + cow urine @ 5 per cent (T_5) and 100 per cent N through FYM (T_3), which were comparable among themselves. Except at 20 DAS where it was comparable with rest of treatments tried except control (T_1). Significantly the lowest plant height was recorded with control (T_1).

Plant height of foxtail millet showed a progressive increase as the crop advanced towards maturity. At all the stages of plant growth, the tallest plants were observed with the application of 100 per cent recommended dose of fertilizers (RDF) compared to organic nutrient management practices. This increase in height might be due to the rapid release and availability of nutrients, especially nitrogen, which is a critical component of protoplasm and plays a significant role in cell division and elongation. The enhanced plant height with 100 per cent RDF (T_2) can also be attributed to improved sugar translocation and increased turgor pressure within the plant cells, leading to cell enlargement and multiplication leading to higher plant height (Thesiya *et al*., 2019).

Among organic nutrient management practices tried, higher plant height recorded with 50 per cent N through FYM + panchagavya (T_9), might be due to better translocation of nutrients, which enhanced cell division and cell elongation. Panchagavya helps in the production of growth promoting substances like auxins and gibberellins, which might have helped in the accerlation of plant height. The results are in conformity with Priya and Sathyamoorthi (2019) and Aravind *et al.* (2020). The lowest plant height with control (T_1) might be due to the poor nutrient status of the soil. Sreenivasa *et al.* (2010) reported the presence of many beneficial microorganisms *viz.*, nitrogen fixers, phosphorus solubilizers, actinomycetes and fungi in panchagavya.

Leaf Area Index

The higher leaf area index of foxtail millet was recorded with application of 100 per cent RDF (T_2) which was significantly superior over rest of the treatments tried at all the stages of observations.

Among the organic nutrient management practices tried, application of 50 per cent N through FYM + panchagavya @ 3 per cent (T_9) recorded higher leaf area index over rest of the organic nutrient management practices. LAI recorded with application of 50 per cent N through FYM + seaweed extract @ 1 per cent (T_7), 50 per cent N through FYM + vermiwash @ 5 per cent (T_6), 50 per cent N through FYM + fish amino acid @ 3 per cent (T_8), 50 per cent N through FYM + cow urine @ 5 per cent (T_5) and 100 per cent N through FYM (T_3), was comparable among them, except at 20 DAS where it was comparable with rest of the treatments tried except control (T_1). Significantly the lowest LAI was recorded with control (T_1).

Leaf area index is a measure of leaf area produced per unit land area. The increase in leaf area index with application of 100 per cent RDF (T_2) might be due to the

Table 1. Plant height (cm) of foxtail millet at different growth stages as influenced by organic nutrient management practices

Treatments	20 DAS	40 DAS	60 DAS	At harvest
T_1 : Control	27.5	36.0	68	78
T_2 : 100% RDF (40-20-0 kg N, P_2O_5 and K_2O ha^{-1})	42.5	74.0	105	118
T_3 : 100% N through FYM	32.1	56.7	84	95
T_4 : 50% N through FYM + Water spray	31.6	47.2	76	86
T_5 : 50% N through FYM + Cow urine @ 5%	31.4	57.0	85	97
T_6 : 50% N through FYM + Vermi wash @ 5%	31.0	59.5	87	98
T_7 : 50% N through FYM + Sea weed extract @ 1%	31.8	62.0	89	100
T_8 : 50% N through FYM + Fish amino acid @ 3%	31.0	58.4	86	98
T_9 : 50% N through FYM + Panchagavya @ 3%	33.5	67.9	96	109
SEm±	1.12	1.94	2.1	2.4
CD (P= 0.05)	3.3	5.1	6	7

readily availability of nutrients there by higher uptake by crop, which have favorable effect on cell division and elongation, which might have resulted in production of more number of large sized leaves, which in turn responsible for higher leaf area index. Similar findings were also reported by Ullasa *et al*. (2017) and Thesiya *et al*. (2019).

In the context of organic nutrient management practices, the increase in Leaf Area Index (LAI) may be attributed to improved assimilate transport, leading to healthier growth characterized by bright green with larger leaves. The higher LAI values observed with Panchagavya spray can be explained by the presence of microbial metabolites, which facilitate stomatal opening for extended periods, both under optimal and sub optimal conditions during the crop growth period. This enhanced stomatal activity resulted in an increased Co_2 intake, thereby larger source (leaves). These results are in consistent with findings of Panchal *et al*. (2017) and Priya and Sathyamoorthi (2019).

Further, significant increase in LAI with application of panchagavya might be due to availability of growth promoting substance in addition to huge microbial population in panchagavya, thus when applied to the crop as foliar spray trigger the plant growth (Patel *et al*., 2021).

Grain and straw yield

Different organic nutrient management practices exerted significant influence on grain straw yield of foxtail millet. Significantly the highest grain and straw yield of foxtail millet was noticed with 100 per cent RDF (T_2). Among the organic nutrient management practices tried 50 per cent N through FYM + panchagavya @ 3 per cent (T_9) noticed with higher grain and straw yield, followed by 50 per cent N through FYM + seaweed extract @ 1 per cent (T_7), 50 per cent N through FYM + vermiwash @ 5 per cent (T_6), 50 per cent N through FYM + fish amino acid @ 3 per cent (T_8), 50 per cent N through FYM + cow urine @ 5 per cent (T_5) and 100 per cent N through FYM (T_3), which were statistically comparable among themselves. Significantly the lowest grain straw yield was noticed with control (T_1).

The higher concentration of nutrient ions in the soil with applying 100 per cent recommended dose of fertilizer (T_2), have resulted in higher grain and straw yield. Further it might have contributed to improved root activity, high physiological efficiency, better vegetative growth, higher dry matter, better yield attributes which in turn resulted higher grain and straw yield. These results are in conformity with those of Mubeena *et al*. (2019) and Vineetha *et al*. (2024).

Table 2. Leaf area index of foxtail millet at different growth stages as influenced by organic nutrient management practices

Treatments	20 DAS	40 DAS	60 DAS	At harvest
T_1 : Control	0.18	0.92	1.30	1.17
T_2 : 100% RDF (40-20-0 kg N, P_2O_5 and K_2O ha^{-1})	0.26	1.44	1.90	1.75
T_3 : 100% N through FYM	0.23	1.12	1.55	1.37
T_4 : 50% N through FYM + Water spray	0.22	1.03	1.42	1.29
T_5 : 50% N through FYM + Cow urine @ 5%	0.21	1.13	1.57	1.45
T_6 : 50% N through FYM + Vermi wash @ 5%	0.23	1.18	1.62	1.49
T_7 : 50% N through FYM + Sea weed extract @ 1%	0.22	1.21	1.64	1.51
T_8 : 50% N through FYM + Fish amino acid @ 3%	0.22	1.15	1.61	1.47
T_9 : 50% N through FYM + Panchagavya @ 3%	0.23	1.31	1.77	1.64
SEm±	0.007	0.031	0.038	0.034
CD (P= 0.05)	0.02	0.10	0.12	0.11

Table 3. Grain and straw yield of foxtail millet at different growth stages as influenced by organic nutrient management practices

Treatments	Grain yield	Straw yield
T_1 : Control	350	896
T_2 : 100% RDF (40-20-0 kg N, P_2O_5 and K_2O ha^{-1})	1052	1795
T_3 : 100% N through FYM	586	1060
T_4 : 50% N through FYM + Water spray	487	979
T_5 : 50% N through FYM + Cow urine @ 5%	587	1075
T_6 : 50% N through FYM + Vermi wash @ 5%	621	1090
T_7 : 50% N through FYM + Sea weed extract @ 1%	658	1154
T_8 : 50% N through FYM + Fish amino acid @ 3%	594	1080
T_9 : 50% N through FYM + Panchagavya @ 3%	740	1295
SEm±	24.9	26.3
CD (P= 0.05)	75	79

The enhanced release of growth-promoting substances by microbes in panchagavya may have contributed to increased leaf area and promoting higher net photosynthesis. This facilitated greater soluble protein production and enhanced RUBP carboxylase activity in the carbon cycle, resulting higher biological yield. Additionally, Farm Yard Manure (FYM) might have improved soil biochemical properties and boosted beneficial microorganism activity, prolonging nutrient availability. These factors collectively benefited growth,

dry matter and economic yield. Similar results were reported by Priya and Satyamoorthi. (2019) and Javiya *et al*. (2019). However, the deflated stature of growth parameters with control (T_1) resulted in the lowest grain and straw yield.

From the results of the present study, it is concluded that highest plant height, leaf area index and economic yield realized could be with application of 40-20-0 kg N, P_2O_5 and K_2O ha^{-1} (RDF) through fertilizers. Among organic nutrient management practices tried, 50 per cent N through FYM + foliar spray of panchagavya @ 3 per cent at panicle initiation & flowering stage (T_9) proved to be the best with higher plant height, Leaf area index and economic yield of foxtail millet in Southern Agro-climatic Zone of Andhra Pradesh. At present in the context of climate change and decline in soil health application of 50 per cent N through FYM @ 3.3 t ha^{-1} along with foliar spray of panchagavya is found to be the sustainable nutrient management strategies for organic foxtail millet production.

LITERATURE CITED

APEDA (Agriculture and Processed food products Export Development Authority) state wise millet production report, 2021-22.

Aravind, A.S., Kumar, S.N., Hemalatha, M and Paramasivan, M. 2020. Influence of organic supplements on growth and yield of finger millet (*Eleusine coracana* L.). *Journal of Pharmacognosy and Phytochemistry*. 9(3): 1564-1567.

Javiya, P.P., Mathukia, R.K., Kaneria, S.C and Rupareliya, V.V. 2019. Effect of various cow-based bio-enhancers and botanicals on growth, yield and quality of organic wheat. *International Journal of Chemical studies.* 7(3): 3193-3196.

Mubeena, P., Halepyati, A.S and Chittapur, B.M. 2019. Effect of date of sowing and nutrient management on nutrient uptake and yield of foxtail millet (*Setaria italica* L.). *International Journal of Bio-resource and Stress Management*. 10(1):092-095.

Panchal, P., Patel, H.P., Patel, A.G and Desai, A. 2017. Effect of panchagavya on growth, yield and economics of chick pea (*Cicer arietinum*). *International Journal of Chemical Studies*. 5(2): 265-267.

Panse, V.G and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers.* ICAR, New Delhi. 100-174.

Patel, S.P., Malve, S.H., Chavda, M.H and Vala, Y.B. 2021. Effect of panchagavya and jeevamrut on growth, yield attributes and yield of summer pearl millet. *The Pharma Innovation Journal*. 10(12): 105-109.

Priya, G and Sathyamoorthi, K. 2019. Influence of organic manures on the growth and yield of foxtail millet (*Setaria italica* (L.) Beavu). Chemical Science Review and Letters. 8(29): 114- 117.

Shukla, A., Patel B.R., Patel A.N and Patel, A.R. 2011. Organic farming for sustainable agriculture. *Kisan world*. 38(3): 39-42.

Sreenivasa, M.N., Nagaraj, M., Naik and Bhat, S.N. 2010. Beejamrutha: A source for beneficial bacteria. *Karnataka Journal of Agricultural Sciences*.17 (3): 72-77.

Thesiya, N.M., Dobariya, J.B. and Patel, J.G., 2019. Effect of integrated nutrient management on growth and yield parameters of kharif little millet under little millet-green gram cropping sequence. *Internationa Journal of Pure and Applied Biosciences*. *7*(3): 294-298.

Vanithasri, J., Kanchana, S., Hemalatha, G., Vanniarajan, C and Sahulhameed, M. 2012. Role of millets and its importance in new mellinium. *International Journal of Food Science & Technology*. 2(1): 35-47.

Vineetha, S.B., Singh, S., Hepsibha, M and Christina, B.B., 2024. Effect of nutrient management on growth and yield of foxtail millet. *Journal of Experimental Agriculture International*. 46(6): 398-403.

Watson, D.J. 1952. The physiological basis of variation in yield. *Advances in Agronomy*. 6: 103-109.

Andhra Pradesh J Agril. Sci : 10(4): 274-279, 2024

STUDY ON FOLIAR APPLICATION OF PLANT GROWTH REGULATORS FOR IMPROVING REPRODUCTIVE EFFICIENCY AND YIELD OF GROUNDNUT (*Arachis hypogaea* L.) GENOTYPES

O. VENKATANARAYANA*, B. SANTOSH, T. RAGHAVENDRA, M. RAGHAVENDRA AND V. UMA MAHESH

Department of Crop Agronomy, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

A field experiment entitled "Study on foliar application of plant growth regulators for improving reproductive efficiency and yield of groundnut (*Arachis hypogaea* L.) genotypes" was carried out during *Rabi*, 2023-24 at wetland farm of S. V. Agricultural College, Tirupati campus of Acharya N. G. Ranga Agricultural University, Andhra Pradesh. The present experiment was laid out in randomized block design with factorial concept and replicated thrice, with four genotypes as factor-I (G_1-Nithyaharitha, G_2-Dharani, G_3-K-6, G_4-Vishista) and plant growth regulators as Factor-2 (T_1- Control + RDF of NPK, T_2-Prohexadione calcium@105 g a.i/ha at before and after peak flowering, T_3- Putrescine@100 ppm at before and after peak flowering, T_4-Paclobutrazol@ 100ppm at before and after peak flowering. With the objectives to study the effect of growth retardants on plant Phenological and Morpho-Physiological parameterss of Groundnut, to study the effect of growth retardants on reproductive efficiency of Groundnut and to study the effect of plant growth regulators on yield and yield components. Among the plant growth regulators studied, the maximum yield per plant was observed with T2 (Prohexadione Calcium@105 a.i/ha) (36.9g) and maximum harvest index was observed with T2 (Prohexadione Calcium@ 105 a.i/ha) (36.4%).

KEYWORDS: Reproductive efficiency, Paclobutrazol, Prohexadione calcium, Putrescine.

INTRODUCTION

Groundnut (*Arachis hypogaea L.*) is an important leguminous oilseed crop. Groundnut is valued for its high oil content and edible seeds and is mostly grown under rainfed situation in scarce Rainfall zone of AndhraPradesh. Groundnut belongs to the division *Papiolionaceae* of the family *leguminosae*.

Globally, Groundnut is cultivated under 327 lakh hectares, producing 539 lakh tonnes with the productivity of 1648 kg per hectare (FAOSTAT, 2021). India ranks first in Groundnut area under cultivation (54.2 Lakh Ha) and is the second largest producer in the world (101 Lakh Tonnes) and has productivity of 1863 kg per hectare. In Andhra Pradesh, groundnut is cultivated in an area of 8.23 lakh hectares with a production of 5.19 lakh tonnes, contributing 6.20 per cent to India's groundnut production. Groundnut seed contains 44 to 56 per cent oil and 22 to 30 per cent protein. Kernels are rich sources of riboflavin, thiamine, nicotinic acid and vitamin E and is rich in minerals like P, Ca, Mg and K and vitamins. (Crop outlook reports of Andhra Pradesh, Annual report, January to December 2022).Flowering and reproductive efficiency plays an important role in determining yield of Groundnut. Reproductive efficiency of groundnut depends primarily on light absorption, assimilates production, production of viable flowers, pegs, flower to peg ratio, conversion of flowers and pegs to filled pods (Swethasree *et al.,* 2021).

Flowering in Groundnut commences at 25 days and plant reaches 50 per cent of flowering by 30-35 days after sowing. The prolonged vegetative phase and excessive vegetative growth reduces the yield and dry matter partitioning also hampers the Harvest Index. Pod yield can be considered as the result of sequential processes of flower production, peg initiation, conversion of peg to pods and pod filling. The objective of this study is to evaluate the responses of peanut genotypes and plant growth regulators on reproductive efficiency.

Putrescine is a naturally occurring organic compound that belongs to the class of polyamines. In plants, Putrescine is involved in various physiological processes, including growth, development and stress responses. It promotes root development, leading to increased nutrient uptake and overall plant biomass. It is also known to enhance the tolerance of crops to various abiotic stresses such as drought, salinity, and extreme temperatures. Putrescine helps in maintaining cellular integrity, regulating osmotic balance and scavenging reactive oxygen species, thereby reducing stress-induced damage and also play a role in the defense response of

*Corresponding author, E-mail: omkaramv891@gmail.com

plants against pathogens and pests. Due to its positive effects on growth promotion, stress tolerance and disease resistance, Putrescine application results in increased crop yields (Deotale *et.al.,*2018).

Paclobutrazole (PBZ) is a plant growth retardant that belongs to the class of triazole compounds, commonly used in agriculture to regulate plant growth, enhance crop quality and improve productivity. Paclobutrazole is primarily known for its ability to inhibit the biosynthesis of gibberellins, which promote stem elongation, thereby it slows down stem growth, resulting in compact plants with shorter internodes with stouter stem, increasing root growth and causing better fruit set (Berova and Zlatev, 2000). This can be particularly beneficial in crops where reduced height and compactness are desirable.This results in development of more secondary shoots, which can increase the overall plant density, foliage volume and flower or fruit production. It is also reported to improve drought resistance by reducing water loss through stomatal closure and improving water use efficiency and also enhances tolerance to low temperatures and salinity in some plant species (Goswami *et al.,* 2022).

Prohexadione calcium inhibits the synthesis of gibberellins, a group of plant hormones that promote stem elongation. By reducing gibberellin production, it can control excessive vegetative growth, resulting in shorter internodes and a more compact plant structure. This causes strength in stems, which leads to lodging resistance and improved plant stability. It is also reported to have indirect effects on disease resistance. By reducing plant height and canopy density, it can improve air circulation and sunlight penetration within the crop, which can help reduce the incidence and severity of certain fungal diseases that thrive in humid and shaded conditions. Prohexadione calcium can suppress apical dominance, leading to increased branching and lateral bud development. This can result in a bushier plant with more side shoots and increased overall plant density. Prohexadione Calcium increased yield and decreased pod loss percentage in peanut (Beam *et al.,* 2002).

MATERIAL AND METHODS

The experiment entitled "Study on foliar application of plant growth regulators for improving reproductive efficiency and yield of Groundnut (*Arachis hypogaea* L.) genotypes" was conducted during *Rabi*, 2023-24 in field number. 43 of wetland 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 longitude at an altitude of 182.9 m above mean sea level in the Southern Agro-climatic Zone of Andhra Pradesh.

The field experiment soil was sandy loam in texture, neutral in reaction (pH - 6.8), low in organic carbon (0.38%)and available nitrogen (120.3 kg ha^{-1}), high in available phosphorus (27.2 kg ha^{-1}) and medium in potassium (214 kg ha^{-1}). The plots of 3 m × 2 m size were used for each treatment. The experiment was laid out in random block design with factorial concept replicated thrice. with four Genotypes as factor-1 and plant growth regulators as factor-2 .The foliar sprays were applied at before (30 DAS) and after flowering stage(60 DAS). All the weeds were removed by hand weeding twice at 20 and 40 days after sowing and crop irrigated at regular intervals up to one week before harvesting. The plants in net plot were harvested, dried for 2 days and then threshed. Pod yield from five plants per plot recorded and expressed as yield per plant(g). The protein content of the kernels was determined by Lowry method and expressed in (per cent). The data were recorded during the investigation was statistically analyzed following the analysis of variance for Factorial randomized block design as suggested by Panse and Sukhatme (1985). Statistically significance was tested with "F" value at five percent level of probability.

Application of chemicals

Preharvest chemical treatment Sprays were prepared and applied at before and after peak flowering.

In order to prepare 105 g a.i./ha Prohexadione calcium, 105 g of chemical active ingredient is dissolved in 500 lit of water and applied per hectare.

In order to prepare 100 ppm of Putrescine, 100 mg of chemical was dissolved in 1 litre of water. And in order to prepare 100ppm of Paclobutrazol, 100 mg of chemical is dissolved in 1 litre of water.

RESULTS AND DISCUSSION

Yield per plant (g)

Influence of genotypes and plant growth regulators on yield per plant of groundnut was recorded and depicted in table 2. and in fig.2.

The genotypes of study and plant growth regulator treatments were found to be differed significantly with respect to per plant yield. However, the interaction effects (G × T) did not vary significantly with respect to per plant yield.

The highest yield per plant of groundnut was recorded with the G1(Nithyaharitha)(38.8 g) which is significantly superior to the rest of the genotypes of study. Minimum yield per plant recorded in genotype G4(Vishista)(29.1 g). The higher yield of Nithyaharitha

Table 1. Shelling percentage (%) and harvest index (%) of groundnut genotypes at different growth stages as influenced by plant growth regulators

Treatments	Shelling (%)					Harvest index (%)				
	T_1	T_2	T_3	T_4	Mean value of genotypes	T_1	T_2	T_3	T_4	Mean value of genotypes
G_1	68.8	75.9	72.5	73.9	72.8	34.2	37.8	35.4	36.7	36.0
G_2	64.4	72.4	68.4	69.8	69.3	34.8	38.4	36.2	37.3	36.7
G_3	63.7	72.8	66.5	69.1	68.0	25.6	29.7	27.2	28.5	27.7
G_4	66.8	73.8	70.3	71.7	70.6	36.3	39.9	37.5	38.7	38.1
Mean value of treatments	66.5	73.7	69.4	71.1		32.7	36.4	34.1	35.3	
	G	T	G × T			G	T	G × T		
SEm	0.37	0.37	0.73			0.40	0.40	0.81		
CD(P=0.05)	1.06	1.06	NS			1.17	1.17	NS		

G1 : Nithyaharitha; G2: Dharani; G3: K-6; G4: Vishista
T1 : Control + (RDF of NPK); T2 : Prohexadione Calcium 105 a.i /ha; T3 : Putrescine @ 100 ppm, T4 : Paclobutrazol @ 100 ppm

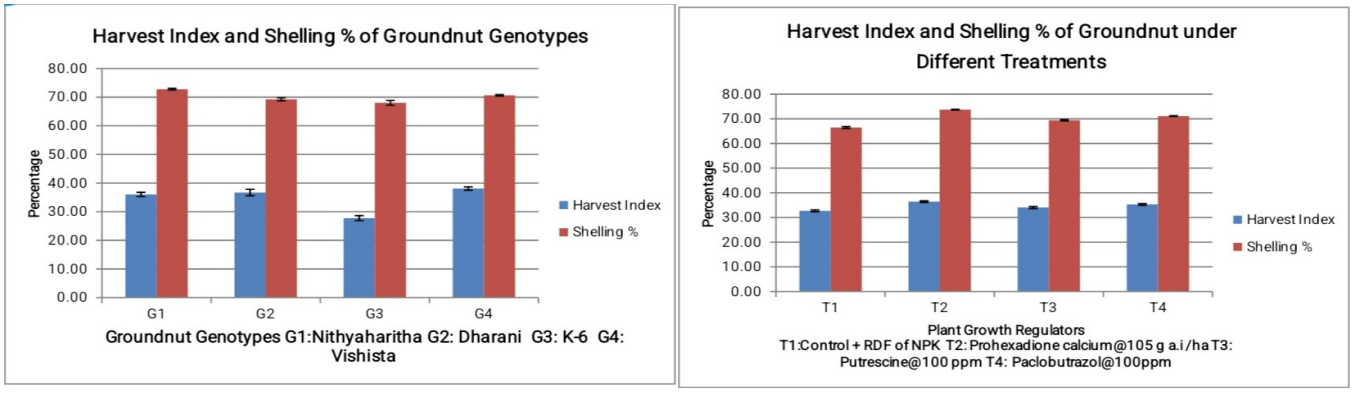


Fig. 1. Shelling percentage (%) and harvest index (%) of groundnut genotypes at different growth stages as influenced by Plant growth regulators

genotype might be attributed to higher number of pegs, higher mature pods per plant of the genotype.

Similar observations were also made by Attarde *et al*. (2001). Pod yield is highly related to the number of mature pods per plant, 100 seed weight, height and number of primary branches per plant (Labana *et al.,* 1980).

Among the plant growth regulators studied, the maximum yield per plant was observed with T2 (Prohexadione Calcium@105 a.i/ha) (36.9g) followed by T4 (Paclobutrazol@100ppm) (35.6g) which were significantly superior over the rest of treatments tested. Minimum yield per plant recorded with T1 (control + RDF of NPK) (29.7g).

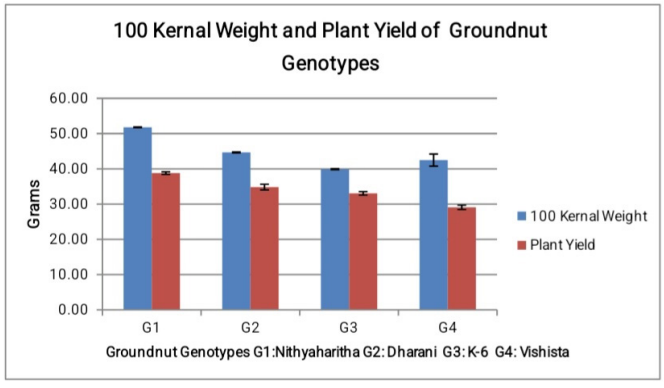
The table -provides data on the interaction effects between genotypes and treatments (G×T). Genotype G1 (Nithyaharitha) treated with T2(Prohexadione Calcium@ 105 a.i/ha) recorded maximum yield per plant (46.3 g). This increment in pod yield might be due to acceleration of dry matter distribution to the early-bearing pods, which resulted from the inhibition of stem growth, increased chlorophyll content resulting in enhanced CO_2 assimilation rates by PGRs application. And minimum yield recorded in genotype G4(Vishista) (26.6 g) treated with T1 (control + RDF of NPK).

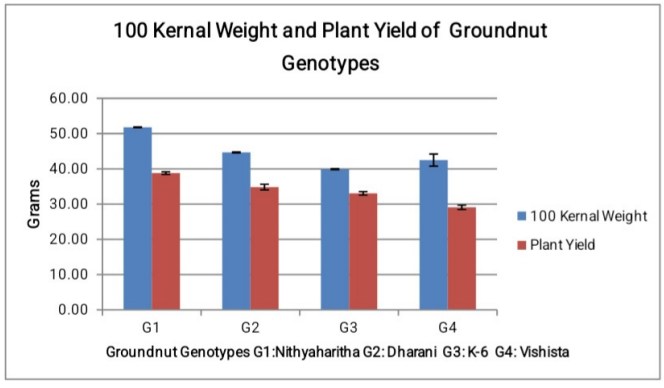
A similar finding was also reported by Win *et al*. (2017). Higher pod yield (4480 kg/ha) recorded in groundnut, when treated with Prohexadione calcium,

Table 2. 100 kernel weight (g) and yield per plant (g) of groundnut genotypes at different growth stages as influenced by Plant growth regulators

Treatments	100 kernel weight(g)					Yield per Plant (g)				
	T_1	T_2	T_3	T_4	Mean value of genotypes	T_1	T_2	T_3	T_4	Mean value of genotypes
G_1	47.9	54.6	51.9	52.9	51.8	34.5	46.3	37.9	40.6	38.8
G_2	41.6	46.4	44.9	45.9	44.7	30.1	38.0	34.7	36.4	34.8
G_3	36.6	42.6	39.9	40.6	39.9	27.5	36.6	32.5	35.6	33.0
G_4	38.7	44.5	43.0	43.8	42.5	26.6	31.0	28.8	29.9	29.1
Mean value of treatments	41.2	47.0	44.9	45.8		29.7	36.9	33.5	35.6	
	G	**T**	**G × T**			**G**	**T**	**G × T**		
SEm	0.403	0.403	0.806			0.040	0.040	0.080		
CD(P=0.05)	1.164	1.164	NS			1.16	1.16	NS		

G1 : Nithyaharitha; G2: Dharani; G3: K-6; G4: Vishista
T1 : Control + (RDF of NPK); T2 : Prohexadione Calcium 105 a.i /ha; T3 : Putrescine @ 100 ppm, T4 : Paclobutrazol @ 100 ppm





less pod yield (4210 kg/ha) recorded when treated with Cyclanilide over. Increased pod yield of peanut by prohexadione calcium was attributed to increased pod retention (Jordan *et al.*, 2004).

Paclobutrazol of 250 ppm, applied at 45 DAS of groundnut resulted in maximum pod yield (3719 kg/ha) when compared to control. This is due to an acceleration of dry matter distribution to the early-bearing pods, which resulted from the inhibition of stem growth by paclobutrazol application which increased chlorophyll content resulting in enhanced CO2 assimilation rates (Srikanth *et al.,* 2024).

100 Kernel Weight (g)

Influence of genotypes and plant growth regulators on 100 kernel weight of groundnut was recorded and depicted in table 2. and in fig.2. The genotypes of study and plant growth regulator treatments were found to be differed significantly with respect to 100 kernel weight. However, the interaction effects (G × T) did not vary significantly with respect to per plant yield.

Maximum 100 kernel weight of groundnut was recorded with the G1(Nithyaharitha) (51.8 g) which was significantly superior to the rest of the genotypes of study. Minimum 100 kernel weight (g) recorded in genotype G3-K-6(39.9 g). Higher 100 kernel weight

of Nithyaharitha might be attributed to it having sound mature kernels which is a genotypic trait.

Among the plant growth regulators studied, the maximum 100 kernel weight was observed with T2 (Prohexadione Calcium@ 105 a.i/ha) (47.0 g) followed by T4(Paclobutrazol@100ppm) (45.8g) which was significantly superior over the rest of treatments tested. Minimum 100 kernel weight recorded with T1 (control + RDF of NPK) (41.2 g).

Data on the interactions between genotypes and treatments (G × T) are included in the table 2. and in fig.2. Genotype G1(Nithyaharitha) treated with T2 (Prohexadione calcium@ 105 a.i/ha) recorded maximum 100 kernel weight (54.6 g) due to effective distribution of dry matter source to sink (pods). Minimum of 100 kernel weight recorded in genotype G3(K-6)(36.6 g) in T1(control + RDF of NPK) among in all interactions.

These results are close vicinity to the Isoda *et al*.(1999), who reported the increase in seed output by PBZ treatment. The timing of paclobutrazol administration is important for changing the distribution of dry matter and increasing seed yield. Higher 100 kernel weight recorded by paclobutrazol might be due to the acceleration of dry matter distribution to the early-bearing pod by PBZ (Goswami *et al.*,2022). Pod yield plot is highly related to the number of mature pods per plant, 100 seed weight, height and number of primary branches per plant (Labana *et al.,* 1980).

Shelling Percentage (%)

Influence of genotypes and plant growth regulators on shelling percentage of groundnut was recorded and depicted in Table 1 and in Fig. 1.

Maximum shelling percentage of groundnut was recorded with the G1-Nithyaharitha (72.8%) followed by G4(Vishista)(70.6%),G2-Dharani(69.3%). Minimum shelling percentage recorded in genotype G3-K-6 (68.0%). Higher shelling percentage of G1 genotype might be attributed to it having sound mature kernels which was a inherent character of genotype. The higher photosynthates production because of higher chlorophyll content and better dry matter partitioning of genotype and also may be due to more assimilate translocation efficiently to reproductive parts during pod development stages of G1 (Nithyaharitha) could be the reason behind this greater shelling Percentage.

Among the plant growth regulators studied, the maximum shelling percentage was observed with T2 (Prohexadione Calcium@ 105 g a.i/ha) (73.7%) followed by T4 (Paclobutrazol@100ppm) (71.1%) T3 (Putrescine@100ppm) (69.4%) which was significantly superior over the rest of treatments tested. Minimum shelling percentage recorded with T1 (control + RDF of NPK) (66.5%).

Data on the interactions between genotypes and treatments (G × T) are depicted in the Table 1. This shows that there were not significant differences in the effects of treatments on shelling percentage or in how various genotypes responded to treatments in this study.

Genotype G1(Nithyaharitha) sprayed with T2 (Prohexadione Calcium@ 105 a.i/ha) recorded maximum shelling percentage (75.9%) and minimum recorded in genotype G3(K-6)(63.7 %) in T1(control + RDF of NPK) among in all interactions.

Maximum shelling percent recorded by application of Putrescine@100 ppm (76.79 %) over control (74.63 %) due to larger sized kernel was obtained by effective partitioning of accumulates from source and sink (Deotale *et al*., 2018).

Harvest Index (%)

Influence of genotypes and plant growth regulators on harvest Index of groundnut was recorded and depicted in table 1. and in fig.1.

Maximum harvest index of groundnut was recorded with the G4- Vishista (38.1%) which was significantly superior to the rest of the genotypes of study. The next best genotypes Dharani (36.7%), Nithyaharitha (36.0%), Minimum harvest index recorded in genotype G3-K-6 (27.7%). Higher harvest index of G4 genotype might be attributed to it having more number of mature pods along with sound mature kernels and less vegetative growth compared to other genotypes, which was a inherent character of this genotype.

Among the plant growth regulators studied, the maximum harvest index was observed with T2 (Prohexadione Calcium@ 105 a.i/ha) (36.4%) followed by T4(Paclobutrazol@100ppm)(35.3%) T3(Putrescine@100ppm) (34.1%) which was significantly superior over the rest of treatments tested. Minimum harvest index recorded with T1 (control + RDF of NPK) (32.7%).

The data in the table 1.0 show how genotypes and treatments (G × T) interact. The harvest index was not significantly affected by the interaction effects (G × T).

Genotype G4 (Vishista) treated with T2 (Prohexadione Calcium @ 105 a.i/ha) recorded maximum harvest index (39.9 %) and minimum recorded in genotype G3(K-6) in T1(control + RDF of NPK)(25.6

%) among in all interactions. Maximum harvest index recorded by application of PBZ@250 ppm (42.6 %) over control (37.8 %) due to the observed reduction in plant height and vegetative growth which possibly enhanced partitioning of assimilate to pods (Barman *et al.,* 2017).

Present study concludes that, the effective control of height and higher Phenological, morpho-physiological, reproductive efficiency, yield, quality parameters and biochemical parameters were obtained with Prohexadione Calcium@ 105 g a.i/ha in groundnut during *Rabi*,2023-24 season on sandy clay loam soils of Southern Agro-climatic Zone of Andhra Pradesh.

LITERATURE CITED

Attarde, D.R., Suryawanshi, R.T and Wadile, S.C. 2001. Performance of groundnut varieties to different dates of sowing in summer season. *Journal of Maharashtra Agricultural Universities.* 26(3):329-330.

Barman, M., Gunri, S.K., Puste, A.M and Paul, S. 2017. Effect of paclobutrazol on growth and yield of *Kharif* groundnut (*Arachis hypogaea* L.). *International Journal of Agriculture, Environment and Biotechnology.* 10(4):513-518.

Beam, J.B., Jordan, D.L., York, A.C., Isleib, T.G., Bailey, J.E., McKemie, T.E., Spears, J.F and Johnson, P.D. 2002. Influence of prohexadione calcium on pod yield and pod loss of peanut. *Agronomy Journal*. 94(2): 331-336.

Berova, M and Zlatev, Z. 2000. Physiological response and yield of paclobutrazol treated tomato plants (*Lycopersicon esculentum* Mill.). *Plant Growth Regulation*. 30(2):117-123.

Crop outlook reports of Andhra Pradesh, Annual report, January to December, 2022.

Deotale, R.D., Shinde, R.D and Meshram, S.D. 2018. Impact of Putrescine and indole-3-butyric acid in enhancing chemical-biochemical parameters and yield of groundnut. *Journal of Soils and Crops.* 28(2): 359-365.

Goswami, P., Gunri, S.K., Sengupta, A and Barman, M. 2022. Effect of paclobutrazol on succeeding crop summer groundnut (*Arachis hypogaea* L.) after potato. *International Journal of Bio-resource and Stress Management.* 13(10): 1124-1129.

https://www.fao.org/faostat/en/#home.

Isoda, A and Senoo, S. 2003. Effects of paclobutrazol on dry matter distribution and yield in peanut. *Plant Production Science.* 6(1): 90-94.

Jordan, D.L., Beam, J.B., Lanier, J.E., Lancaster, S.H and Johnson, P.D. 2004. Peanut (*Arachis hypogaea* L.) response to cyclanilide and prohexadione calcium. *Peanut Science.* 31(1): 33-36.

Labana, K.S., Chaurasia, B.D and Singh, B. 1980. Genetic variability and inter-character associations in the mutants of Indian mustard. *Indian Journal of Agricultural Science.* 50: 803-806.

Lowry, O.H. 1952. Biochemical evidence of nutritional status. *Physiological Reviews*. 32(4):431-448.

Panse, V.G and Sukhatme, P.V. 1985. Statistical Methods for Agricultural Workers. *Indian Council of Agricultural Research Publication.* 87-89.

Srikanth, B., Santhosh, B., Rani, P.S and John, K. 2024. Effect of growth retardants on plant yield and seed quality of groundnut (*Arachis hypogaea* L.). *Advances in Research*. 25(4): 57-63.

Swethasree, M., Sudhakar, P., Mahesh, V.U., Prathima, T and Krishna, G.T. 2021. Variation in reproductive Efficiency of groundnut (*Arachis hypogea* L.) Genotypes at Different Planting Densities. *Indian Journal of Pure and Applied Biosciences.* 9(3): 91-96.

Win, A.W., Nyo Mar Htwe, N.M.H., Nang Ohn Myint, N.O.M., Kyi Toe, K.T and Nang Hseng Hom, N.H.H. 2017. Effects of paclobutrazol on growth of groundnut (*Arachis hypogaea* L.). *Journal of Agricultural Research*. 4(1); 15-22.

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EFFECT OF BORDER CROPS ON ACTIVITY OF PREDATORY FAUNA IN BLACKGRAM (*Vigna mungo* L.)

N. SREESANDHYA*, S. DHRUVA, M.S.V. CHALAM, P. KISHORE VARMA, G. MOHAN NAIDU AND M. RAJASRI

Department of Entomology, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

The aim of this study was to investigate the impact of various border crops *viz*., maize, pearl millet, fodder sorghum, foxtail millet, sunhemp, dhaincha, sunflower and marigold on predator populations, specifically coccinellids and spiders in blackgram as major crop. The research was conducted at the Agricultural College Farm, Naira, ANGRAU, during the *rabi* seasons of 2021-22 and 2022-23.The findings revealed that the populations of coccinellids in blackgram crop with marigold and maize as border crops were 24.63 and 24.30 numbers per 10 plants, respectively. Similarly, the spider populations were recorded at 16.73 and 16.50 numbers per 10 plants for marigold and maize, respectively. These populations were significantly higher compared to the sole blackgram crop, which had an average of 13.5 coccinellids and 10.55 spiders per 10 plants across both vegetative and reproductive stages. Notably, all other border crops were statistically comparable to marigold and maize in terms of spider population, with the exception of the blackgram sole crop. It is concluded that, marigold and maize crops were found to be effective border crops for enhancing predator population in blackgram.

KEYWORDS: Blackgram, biodiversity, border crops, coccinellids and spiders.

INTRODUCTION

Blackgram (*Vigna mungo*) contain 22-24 per cent protein, which is almost twice the protein in wheat and thrice that of rice. Pulses provide significant nutritional and health benefits, and are known to reduce several non communicable diseases such as colon cancer and cardiovascular diseases (Jukanti *et al.,* 2012). Protein, energy, malnutrition as well as micronutrient deficiencies can be addressed by increasing the consumption of pulses which are a rich source of proteins, minerals, iron and fibre.

The urdbean production of India was 2.78 million tonnes from an acreage of 4.63 million hectares with a productivity of 600 Kg/ha. (http://des.ap.gov.in/). India is the largest producer and consumer of urdbean and its production contributes to 11 per cent of India's total pulses production (25.46 million tonnes in 2020-21) (Agricultural Statistics Division, DES, MoAF & W, 2022). According to 1st Advance Estimates of Production of Food grains for 2022-23, all India blackgram production estimate was 1.84 million tonnes.

Andhra Pradesh produced 4.29 lakh tonnes of blackgram in an area of 4.01 lakh ha during 2021-22. According to 1st advance estimates during *kharif* 2022-23, blackgram was grown in 0.38 lakh hectares with a production of 0.35 lakh tonnes and productivity was 927 kg ha^{-1}. Among the major producing states, productivity was highest in Andhra Pradesh (915 kg ha^{-1}), followed by Jharkhand (879 kg/ha) during 2020-21 (https://iipr.icar.gov.in).

The black gram ecosystem supports a diverse range of beneficial arthropods and insect pests. Recently, Agro cropping systems has emerged as a strategic approach that leverages habitat manipulation to boost the effectiveness of natural enemies and aims to significantly reduce or even eliminate insecticide use (Gurr *et al*., 2004).

This approach seeks to protect crops from insect damage by enhancing biocontrol services (Cullen *et al*., 2008). One method includes planting flowering crops along field borders, providing non-prey food sources and essential resources for natural enemies of crop pests when the main crop is not flowering (Wanner *et al*., 2006).

Despite these promising strategies, there is limited research on border cropping in black gram with pulse or non-pulse crops and its impact on the abundance of

*Corresponding author, E-mail: sandhyanagiri@gmail.com

natural predators. This study, therefore, investigates the importance of integrating black gram and other pulse and non-pulse crop varieties to support conservation biological control, focusing on the role of crop diversity in sustaining entomophages and enhancing pest suppression naturally.

MATERIAL AND METHODS

Field experiments were conducted during *rabi* 2021-22 and 2022-23 at Agricultural College, Naira (18.3828° N, 83.9460° E), Andhra Pradesh, India. Experiment was laid out in Randomized Block Design (RBD) consisting nine treatments and three replications with a field plot size of 5 X 6 m^2. Blackgram variety LBG 752 was sown as main crop with a spacing of 30 X 10 cm. Maize (DHM 104), Pearl millet (ABV-4), Foxtail millet (Surya Nandi SIA 3088), Fodder Sorghum (SSG 59-3), Sunhemp (JRJ 610), Dhaincha (ACN-1), Sunflower (DRSH-1) and Marigold (Bengal Yellow) were taken up as border crops in four rows with a spacing of 30 X 30 cm.

All border crops were sown at 30 days in advance to blackgram sowing to facilitate for the synchronized flowering of both blackgram and border crops. Normal agronomic practices like fertilizer application and manual weeding were carried out as per the recommended crop production practices of ANGRAU. No chemical pesticides were applied throughout the season.

In situ observations on the population of grubs and adults of various species of coccinellids (numbers/10 plants) on blackgram and intercrops from 10 randomly selected plants from each replication were made. Standard taxonomic keys as prescribed by (Poorani, 2002) were used for the identification of coccinellid species observed during the study. Observations were taken during early morning hours at seven days interval from 40 days after sowing (DAS) to 64 DAS.

STATISTICAL ANALYSIS

The data on predators *viz.,* coccinellids and spiders (no's per 10 plants) was subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) ($P \leq 0.05$).

RESULTS AND DISCUSSION

Coccinellid species observed

Coccinellid species *viz., Chielomenus sexmaculata, Coccinella transversalis and Micraspis* sp. were observed in the blackgram border cropping systems were depicted in Plate 1.

Impact of border crops on predatory fauna in blackgram during *rabi,* 2021-22

The results pertaining to predatory fauna during *rabi*, 2021-22 were presented in Table 1. ranging between 10.69 to 18.36 coccinellids / 10 plants and 5.50 to 10.81 spiders / 10 plants at 40 DAS.

At 47 DAS, highest coccinellid population was recorded in blackgram crop with marigold as border crop (24.25 no's/ 10 plants) followed by dhaincha (22.91 no's/ 10 plants) and maize (22.68 no's/ 10 plants) respectively, which were observed to be statistically at par with each other. The lowest coccinellid population was recorded in the blackgram crop with foxtail millet as border crop (13.59 no's/ 10 plants) followed by blackgram sole crop (14.11 no's/ 10 plants) were found to be statistically at par with each other. Whereas, the spider population was observed to have equally enhanced by all the border crops ranging between 11.26 to 18.63 spiders/ 10 plants, except in blackgram as sole crop (10.84 spiders/10 plants) which was observed to be significantly different from blackgram crop with marigold as border crop and was at par with all other treatments.

At 54 DAS, highest coccinellid beetle population was recorded in blackgram crop with marigold as border crop (28.56 numbers/ 10 plants) followed by the blackgram crop with maize as border crop (27.16 numbers/ 10 plants) were statistically at par with each other and different from the coccinellid population recorded in blackgram sole crop (15.91 coccinellids/ 10 plants) showing the significance of border crop in attracting the predatory fauna.

Pertaining to spider population, the highest number of spiders (19.13 per 10 plants) were recorded in blackgram crop with marigold as border crop and lowest in blackgram sole crop (11.64 per plant) representing the influence of border crop in enhancing the predatory spider fauna at 54 DAS.

At 61 DAS, the predatory coccinellid fauna recorded were highest in the blackgram crop with maize as border crop (30.12 no's/ 10 plants) followed by marigold as border crop (29.83 no's/ 10 plants) were observed to be at par with each other. The lowest coccinellid population (16.36 no's/ 10 plants) was recorded in blackgram with

Table 1. Effect of different border crops on natural enemy activity in blackgram during *rabi*, 2021-22

Treatment No.	Name of the Treatment	Vegetative stage				Reproductive stage					
		40 DAS		47 DAS		54 DAS		61 DAS		68 DAS	
		No's/ 10 plants		No's/ 10 plants		No's/ 10 plants		No's/ 10 plants		No's/ 10 plants	
		Coccinellids	Spiders	Coccinellids	Spiders	Coccinellids	Spiders	Coccinellids	Spiders	Coccinellids	Spiders
T1	Maize	16.83 (4.10)^{a}	10.25 (3.20)^{a}	22.68 (4.76)^{a}	17.36 (4.17)^{ab}	27.16 (5.21)^{ab}	18.25 (4.27)^{ab}	30.12 (5.49)^{a}	18.86 (4.34)^{ab}	28.56 (5.34)^{ab}	20.52 (4.53)^{ab}
T2	Pearl Millet	14.15 (3.76)^{ab}	7.31 (2.70)^{ab}	16.98 (4.12)^{ab}	14.76 (3.84)^{ab}	18.39 (4.29)^{abc}	14.98 (3.87)^{ab}	17.41 (4.17)^{b}	15.88 (3.98)^{ab}	15.98 (4.00)^{bc}	16.39 (4.05)^{ab}
T3	Foxtail Millet	10.69 (3.27)^{b}	8.48 (2.91)^{ab}	13.59 (3.69)^{b}	11.26 (3.36)^{ab}	17.85 (4.22)^{abc}	12.38 (3.52)^{ab}	16.36 (4.04)^{b}	14.71 (3.84)^{ab}	14.81 (3.85)^{bc}	13.97 (3.74)^{ab}
T4	Fodder Sorghum	11.21 (3.35)^{ab}	6.89 (2.62)^{ab}	14.36 (3.79)^{b}	11.58 (3.40)^{ab}	16.98 (4.12)^{bc}	12.12 (3.48)^{ab}	17.01 (4.12)^{b}	13.64 (3.69)^{b}	13.33 (3.65)^{c}	13.91 (3.73)^{ab}
T5	Sunhemp	18.36 (4.28)^{a}	10.81 (3.29)^{a}	19.53 (4.42)^{ab}	15.47 (3.93)^{ab}	24.66 (4.97)^{abc}	16.77 (4.10)^{ab}	22.46 (4.74)^{ab}	17.01 (4.12)^{ab}	20.71 (4.55)^{abc}	17.92 (4.23)^{ab}
T6	Dhaincha	14.82 (3.85)^{ab}	7.37 (2.71)^{ab}	22.91 (4.79)^{a}	15.10 (3.89)^{ab}	23.18 (4.81)^{abc}	15.86 (3.98)^{ab}	18.68 (4.32)^{ab}	16.39 (4.05)^{ab}	15.92 (3.99)^{bc}	17.35 (4.17)^{ab}
T7	Sunflower	13.67 (3.70)^{ab}	9.11 (3.02)^{ab}	15.72 (3.96)^{ab}	12.98 (3.60)^{ab}	20.43 (4.52)^{abc}	13.12 (3.62)^{ab}	17.12 (4.14)^{b}	15.11 (3.89)^{ab}	16.24 (4.03)^{abc}	15.86 (3.98)^{ab}
T8	Marigold	15.50 (3.94)^{ab}	5.50 (2.35)^{b}	24.25 (4.92)^{a}	18.63 (4.32)^{a}	28.56 (5.34)^{a}	19.13 (4.37)^{a}	29.83 (5.46)^{a}	20.44 (4.52)^{a}	30.68 (5.54)^{a}	23.68 (4.87)^{a}
T9	Blackgram sole crop	13.58 (3.69)^{ab}	8.32 (2.88)^{ab}	14.11 (3.76)^{b}	10.84 (3.29)^{b}	15.91 (3.99)^{c}	11.64 (3.41)^{b}	16.86 (4.11)^{b}	13.13 (3.62)^{b}	11.85 (3.44)^{c}	12.44 (3.53)^{b}
	S.Em.±	0.33	0.23	0.32	0.30	0.38	0.30	0.39	0.27	0.51	0.38
	CD	0.98	0.69	0.96	0.93	1.13	0.90	1.17	0.82	1.53	1.15
	CV%	7.76	6.77	7.04	7.21	9.26	7.85	9.99	6.72	9.83	9.19

Figures in parentheses are $\sqrt{X} + 0.5$ transformed values

Means within a column followed by the same letter do not differ significantly CD at P=0.05 as per DMRT

DAS- Days After Sowing

Table 2. Effect of different border crops on natural enemy activity in blackgram during *rabi* , 2022-23

Treatment No.	Name of the Treatment	Vegetative stage				Reproductive stage					
		40 DAS		47 DAS		54 DAS		61 DAS		68 DAS	
		No's/ 10 plants		No's/ 10 plants		No's/ 10 plants		No's/ 10 plants		No's/ 10 plants	
		Coccinellids	Spiders	Coccinellids	Spiders	Coccinellids	Spiders	Coccinellids	Spiders	Coccinellids	Spiders
T1	Maize	13.38 (3.66)^{ab}	8.52 (2.92)^{a}	20.86 (4.57)^{ab}	16.56 (4.07)^{a}	24.32 (5.13)^{a}	17.25 (4.15)^{a}	29.66 (5.45)^{a}	18.13 (4.26)^{ab}	27.37 (5.23)^{ab}	19.25 (4.39)^{ab}
T2	Pearl Millet	11.51 (3.39)^{ab}	5.81 (2.41)^{abc}	14.54 (3.81)^{ab}	13.79 (3.71)^{ab}	17.41 (4.17)^{ab}	13.72 (3.70)^{a}	15.98 (4.00)^{b}	14.74 (3.84)^{ab}	14.84 (3.85)^{abc}	15.66 (3.96)^{abc}
T3	Foxtail Millet	9.61 (3.10)^{ab}	6.86 (2.62)^{abc}	11.95 (3.46)^{b}	9.66 (3.11)^{ab}	16.93 (4.11)^{ab}	11.83 (3.44)^{a}	15.32 (3.91)^{b}	14.07 (3.75)^{ab}	13.71 (3.70)^{bc}	12.78 (3.57)^{abc}
T4	Fodder Sorghum	8.94 (2.99)^{b}	4.99 (2.23)^{bc}	12.48 (3.53)^{ab}	9.43 (3.07)^{ab}	15.99 (4.00)^{ab}	11.42 (3.38)^{a}	16.61 (4.08)^{ab}	13.11 (3.62)^{b}	12.14 (3.48)^{c}	11.98 (3.46)^{bc}
T5	Sunhemp	15.63 (3.95)^{a}	8.62 (2.94)^{a}	17.35 (4.17)^{ab}	13.74 (3.71)^{ab}	22.91 (4.79)^{ab}	15.37 (3.92)^{a}	20.82 (4.56)^{ab}	16.48 (4.06)^{ab}	19.62 (4.43)^{abc}	16.29 (4.04)^{abc}
T6	Dhaincha	11.79 (3.43)^{ab}	5.74 (2.40)^{abc}	20.79 (4.56)^{ab}	13.23 (3.64)^{ab}	21.34 (4.62)^{ab}	14.86 (3.85)^{a}	16.73 (4.09)^{ab}	15.44 (3.93)^{ab}	14.81 (3.85)^{abc}	15.53 (3.94)^{abc}
T7	Sunflower	10.58 (3.25)^{ab}	7.55 (2.75)^{ab}	13.87 (3.72)^{ab}	10.86 (3.30)^{ab}	18.83 (4.34)^{ab}	12.48 (3.53)^{a}	15.24 (3.90)^{b}	14.63 (3.82)^{ab}	14.92 (3.86)^{abc}	13.88 (3.73)^{abc}
T8	Marigold	12.32 (3.51)^{ab}	3.99 (2.00)^{c}	22.58 (4.75)^{a}	16.54 (4.07)^{a}	26.31 (5.13)^{a}	18.39 (4.29)^{a}	27.43 (5.24)^{ab}	19.71 (4.44)^{a}	28.79 (5.37)^{a}	21.22 (4.61)^{a}
T9	Blackgram sole crop	10.63 (3.26)^{ab}	6.86 (2.62)^{abc}	12.14 (3.48)^{b}	8.59 (2.93)^{b}	14.75 (3.84)^{b}	10.92 (3.30)^{a}	16.01 (4.00)^{b}	12.64 (3.56)^{b}	9.65 (3.11)^{c}	10.11 (3.18)^{c}
	S.Em.±	0.30	0.21	0.41	0.32	0.38	0.33	0.47	0.26	0.50	0.35
	CD	0.93	0.66	1.24	1.00	1.18	1.01	1.42	0.81	1.53	1.06
	CV%	7.11	8.23	10.26	9.39	9.78	9.45	9.19	7.67	10.27	9.11

Figures in parentheses are $\sqrt{X} + 0.5$ transformed values

Means within a column followed by the same letter do not differ significantly CD at P=0.05 as per DMRT

DAS- Days After Sowing

to enhance the predatory spider fauna on blackgram crop by recording 9.66 to 6.56 spiders/ 10 plants were statistically at par except blackgram sole crop (2.59 spiders/ 10 plants) which recorded the minimum.

Even at 54 DAS all the border crops were observed to exhibit their capacity in enhancing the predatory fauna of coccinellid ranging from 26.31 to 15.99 no's/ 10 plants were at par statistically. But the coccinellid count recorded in the blackgram crop with marigold (26.31) and maize (24.32) as border crops were statistically at par with each other and all other treatments except blackgram sole crop (14.75 no's/ 10 plants) which recorded the minimum.

No statistical difference was observed in the spiders' count (10.92 to 18.39 no's/ 10 plants) recorded in blackgram crop with or without border crops at 54 DAS.

At 61 DAS, highest coccinellid count was recorded in blackgram crop bordered with maize (29.66 no's/ 10 plants) followed by marigold (27.43 no's/ 10 plants), blackgram bordered with sunhemp (20.82 no's/ 10 plants), dhaincha (16.73 no's/ 10 plants) and fodder sorghum (16.61 no's/ 10 plants) were observed to be statistically at par with each other. Lower counts of coccinellid beetles were recorded in blackgram bordered with sunflower, foxtail millet, pearl millet and blackgram sole crop with 15.24, 15.32, 15.98 and 16.01 no's/ 10 plants, respectively were at with each other and also with all other treatments.

Pertaining to Spiders, blackgram with marigold as border crop (19.71 no's/ 10 plants) recorded the highest. Lowest population was recorded in blackgram sole crop 12.64 spiders/ 10 plants at 61 DAS.

At 68 DAS, all the blackgram plots with border crops *viz*., marigold, maize, sunhemp, pearl millet, dhaincha and foxtail millet were observed to record significantly higher counts ranging between 13.71 to 28.79 coccinellids/ 10 plants being statistically at par with each other Whereas the minimum coccinellid counts/ 10 plants were recorded in blackgram sole crop (9.65) followed by blackgram bordered with fodder sorghum (12.14) were on par statistically.

The spider population recorded in blackgram crop with marigold (21.22 no's/ 10 plants), maize (19.25 no's/ 10 plants), sunhemp (16.29 no's/ 10 plants), pearl millet (15.66 no's/ 10 plants), dhaincha (15.53 no's/ 10 plants), sunflower (13.88 no's/ 10 plants) and blackgram bordered with foxtail millet (12.78 no's/ 10 plants) as border crops were observed to be statistically at par. But the predatory spider count recorded on blackgram sole crop (10.11 no's/ 10 plants) was statistically minimum.

Impact of border crops on predatory fauna in blackgram during *rabi* 2021-22 and 2022-23:

The pooled mean of predatory fauna in the blackgram crop with maize, pearl millet, foxtail millet, fodder sorghum, sunhemp, dhiancha, sunflower and marigold as border crops was calculated from the mean coccinellid beetles and spiders in vegetative stages (40 DAS and 47 DAS) and reproductive stages (54 DAS, 61 DAS and 68 DAS) during *rabi* 2021-22 and 2022-23. The pooled mean population of coccinellid beetles per 10 plants during vegetative stage *i.e.,* 40 DAS and 47 DAS was observed to range between 10.08 to 23.42, where the highest population of 23.42 no's/ 10 plants and 21.77 no's/ 10 plants were recorded in blackgram crop with marigold and maize as border crops, respectively, displaying their efficacy in enhancing the beetle population. Similarly, pooled mean spider population per 10 plants during vegetative stage *i.e.,* 40 DAS and 47 DAS ranged between 4.75 to 17.59, where the highest population of 17.59 no's/ 10 plants and 16.96 no's/ 10 plants were recorded in blackgram crop with marigold and maize as border crops, respectively, exhibiting statistical significance in attracting the spiders (Fig. 1).

Later, during reproductive stage (54 DAS, 61 DAS and 68 DAS) the coccinellid beetle population was observed to range between 10.75 to 29.89 no's/ 10 plants, where the highest beetle population of 29.89 and 29.74 no's/ 10 plants was observed to have recorded in blackgram crop with maize and marigold as border crops, respectively, displaying statistical significance over foxtail millet and fodder sorghum along with sole blackgram crop during entire reproductive stage. The highest spider population of 22.45 and 20.08 no's/ 10 plants was recorded in blackgram crop with marigold as border crop exhibiting its significance over foxtail millet and fodder sorghum as border crops along with blackgram as sole crop which were inferior in enhancing the predatory fauna during reproductive stage.

The grand pooled mean population of coccinellids and spiders in blackgram crop revealed that blackgram with marigold and maize as border crops were

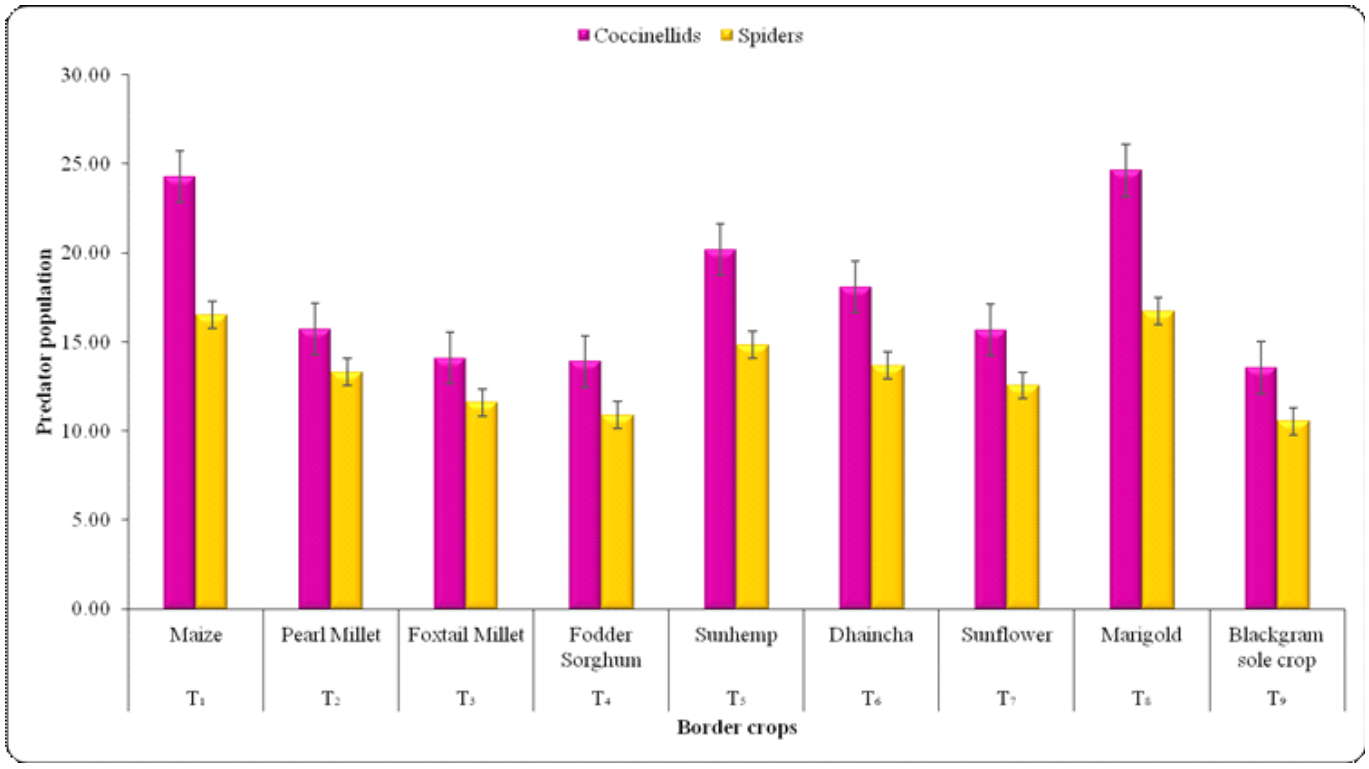

Fig. 1. Pooled mean of predator population on blackgram with border crops during *rabi* 2021-22 and 2022-23.

foxtail millet as border crop followed by blackgram sole crop (16.86 no's/ 10 plants), and found to be statistically at par with each other.

The highest spider population per 10 plants was recorded in blackgram crop with marigold as border crop (20.44) followed by blackgram crop with maize (18.86), sunhemp (17.01), dhaincha (16.39), pearl millet (15.88), sunflower (15.11) and foxtail millet (14.71) as border crops were observed to be on a par each other. The lowest spider count was recorded in blackgram sole crop (13.13 no's/ 10 plants)

At 68 DAS, highest coccinellid counts were recorded in blackgram with marigold and maize as border crops with 30.68 and 28.56 no's/ 10 plants, respectively were found to be at par. The lowest coccinellid population was recorded in blackgram sole crop (11.85 no's/ 10 plants).

A highest spider count of 23.68 no's/ 10 plants was recorded in blackgram bordered with marigold showing the enhancing capacity of predatory population in the main crop statistically different from the lowest population (12.44 no's/ 10 plants) noticed in blackgram without any border crop.

Impact of border crops on predatory fauna in blackgram during *rabi,* 2022-23

During *rabi* 2022-23, the maximum coccinellid population per ten plants was recorded in blackgram crop with sunhemp as border crop (15.63) followed by maize (13.38) and marigold (12.32) were statistically at par with each other at 40 DAS. The minimum coccinellid population per ten plants was recorded in blackgram crop with fodder sorghum as border crop (8.94). Whereas, the predatory spider fauna was recorded highest with 8.62 (blackgram with sunhemp as border crop) followed by 8.52 (maize), 7.55 (sunflower), 6.86 (foxtail millet and blackgram sole crop), 5.81 (pearl millet) and 5.74 (blackgram with dhaincha as border crop) spiders/ 10 plants were statistically at a par with each other (Table. 2)

At 47 DAS, all the border crops exhibited effectiveness in upgrading the predatory Coccinellid population on blackgram ranging between 22.58 no's/ 10 plants (with marigold as a border crop) to 12.48 no's/ 10 plants (with fodder sorghum as border crop) except in the blackgram sole crop (12.14 no's/ 10 plants) and blackgram bordered with foxtail millet (11.95 no's/ 10 plants). Similarly, all the border crops were observed

Coccinella transversalis- Grub (left), Adult (right)

Cheilomenus sexmaculatus – Grub (left), Adult (right)

Micraspis sp. Spider, *Oxyopes* sp.

Plate 1. Predatory fauna observed in blackgram border cropping systems

outperformed in enhancing the coccinellid population (24.63 and 24.30 no's/ 10 plants, respectively) and spider population (16.73 and 16.50 no's/ 10 plants, respectively) exhibiting significance over blackgram as sole crop with 13.5 no's coccinellids / 10 plants and 10.55 no's spiders/ 10 plants collectively during both vegetative and reproductive stages. However, all other border crops were statistically on par with marigold and maize pertaining to spider population except blackgram sole crop.

The present studies were observed to be in accordance with the results fetched from the field experiments conducted on blackgram intercropped with maize, sunflower and marigold recorded 4.92, 4.58 and 4.46 coccinellids/ plant, respectively, followed by sorghum (3.65 no's coccinellids /plant) compared to black gram (2.08 coccinellids / plant) when cultivated alone (Lokesh *et al*. 2017). As well, the studies made by Selvam and Rajvel (2018) found that black gram intercropped with maize recorded the maximum number of coccinellids and spiders population (2.68 coccinellids/ plant and 1.73 spiders/ plant) followed by marigold (2.52 coccinellids/ plant and 1.70 spiders/ plant) and a minimum of 1.78 coccinellids and 0.96 spiders per plant were recorded in sole blackgram crop was similar to the present studies where maximum population of coccinellids and spiders were observed in black gram crop with marigold and maize as border crops . Analogous studies made by Parthiban *et al*. (2018) in groundnut based intercropping also revealed that highest coccinellid population of 8.11 and 5.94 no's/ 10 plants was recorded with maize and pearl millet as inter crop while it was only 1.73 no's/ 10 plants in sole groundnut crop.

The work done by Sheeba *et al*. (2020) was also in concurrence with the present studies in enhancing the predatory coccinellid population (1.10 no's/plant) through cultivation of sorghum and that of the spider population by cultivating pearl millet (0.73 no's / plant) and sorghum (0.67 no's/ plant) as intercrops in sesame towards management of capsule borer .

Singh *et al.* (2013) showed that pigeon pea intercrops had significant influence to enhance the population of spiders (0.75 no's/plant) in pigeon pea bordered with rice and pigeon pea + pearl millet (0.67 no's/plant) where the sole pigeon pea recorded 0.42 spiders / plant. Similarly, Sujayanand *et al.* (2021) recorded a mean of 0.77, 0.85 and 0.76 no's per plant of *Coccinella septumpunctata*, *Cheilomenes sexmaculata* and spiders on pigeon pea bordered with sorghum displaying the prominence of border crops in escalating the count of predatory fauna on the host crop was in concurrence with present studies.

Escalated appearance of mean number of coccinellids (3.80 /plant) and spiders (4.20 / plant) were observed in groundnut (Indiragandhi *et al.*, 2018) when farmscaped with border crops like sorghum, sunflower, pearl millet and maize where Sujayanand *et al.* (2016) noticed that the treatments having maize, marigold and coriander as intercrops in okra recorded highest population of predatory fauna.

Studies by Ogenga-Latigo *et al*., 1992 shown that in crop mixtures, variations were observed herbivore load which in turn increased the abundance of natural enemies. Flowering can be used as attractant plants to encourage coccinellids in and around pulses (NIPHM, 2014).

The effectiveness of intercropping in pest management is supported by studies made by Lokesh *et al.* (2017), which demonstrate that interplanting maize with cowpea enhances biodiversity within crop systems, resulting in increased populations of natural enemies. The diversity of microhabitats within this intercropping system provides multiple resources, such as prey, nectar, and pollen, creating a favorable environment for predator colonization and population growth. In contrast, monocultures tend to lack such diversity, often leading to higher pest pressures due to the absence of natural biological control mechanisms.

Moreover, intercropping and border cropping influence pest dynamics through various ecological mechanisms. Soundarajan and Chitra (2012) identified several factors by which diversified cropping systems can suppress pest populations. These factors include attracting natural enemies, disrupting pest dispersal patterns through physical and environmental changes, and creating microclimatic conditions such as altered temperature and moisture that may hinder pest reproduction or survival. Furthermore, the physical arrangement of different crops can serve as a barrier, restricting pest movement and limiting their ability to reach susceptible plants.

Border cropping of blackgram with maize and marigold could be a better choice for conserving the coccinellids species and spiders which would in turn facilitate for the natural suppression of insect pests.

LITERATURE CITED

Cullen, R., Warner, K. D., Jonsson, M and Wratten, S. D. 2008. Economics and adoption of conservation biological control. *Biological Control.* 45: 272–280.

Gurr, G. M., Wratten, S. D. and Altieri, M.A. 2004. Ecological engineering: advances in habitat manipulation for arthropods. Collingwood (Australia): CSIRO Publishing. 232

Indiragandhi, P., Meena, B and Ushakumari, R. 2018. Eco-feast crop plants for insect pest management in groundnut. *Journal of Pharmacognosy and Phytochemistry*. SP 1: 1469-1474.

Jukanti, A. K., Gaur, P. M., Gowda, C. L. L., and Chibbar, R. N. 2012. Nutritional quality and health benefits of chickpea (Cicer arietinum L.): a review. *British Journal of Nutrition*. 108(S1), S11-S26. Cambridge University Press.

Poorani, J., 2002. An annotated checklist of the coccinellidae (Coleoptera) (excluding Epilachinae) of the Indian Sub region. *Journal Oriental Insects*. 36: 307-383.

Lokesh, S., N. Muthukrishnan, N. Ganapathy, J.R. Kannan Bapu and Somasundaram, E. 2017. Ecological Engineering of Intercropping in Blackgram Promotes Services of Coccinellids and Suppress *Aphis gossypii* (Glover). *International Journal of Current Microbiology and Applied Sciences.* 6(11): 1963-1972.

NIPHM (National Institute of Plant Health Management). 2014. The AESA based IPM. *Brinjal.* 23.

Ogenga-Latigo, M.W., Ampofo, J.K.O., Baliddawa, C.W., 1992. Influence of maize row spacing on infestation and damage of intercropped beans by the bean aphid (*Aphis fabae* Scop.). 1.Incidence of aphids. *Field Crops Research*. 30: 111–112.

Parthiban, P., Chinniah, C., Baskaran, R. M., Suresh, K. and Ravikumar, A. 2018. Positive Influence of Intercrops on Natural Enemies in Groundnut Eco-System. *International Journal of Research Studies in Zoology.* 14:1-6.

Selvam, K and Rajavel, D. S. 2018. Influence of various intercrops on podborers of Blackgram. *International Journal of Trend in Scientific Research and Development.* 2(5):1029-1043.

Sheeba, R., Indiragandhi, P., and Motilal, A. (2020). Diversified cropping system for managing major insect pests in sesame. *Journal of Pharmacognosy and Phytochemistry*. 9 (2S), 227-231.

Singh, R. S., Nath, P and Kumar, A. 2013. Effect of biorational approaches for the management of blue butterfly (*Lampides boeticus* L.) in pigeonpea. *Agricultural Science Digest*. 33: 299-303.

Soundararajan, R. P. and Chitra, N. 2012. Impact of intercrops on insect pests of black gram, *Vigna mungo* L. *Journal of Entomology*. 9: 208-219.

Sujayanand, G.K., Chandra, A., Pandey, S., Bhatt, S. 2021. Seasonal Abundance of Spotted Pod Borer, *Maruca vitrata* Fabricius in Early Pigeonpea [*Cajanus cajan* (L.) Millsp.] and its Management through Farmscaping in Uttar Pradesh. *Legume Research.* 44(2): 233-239.

Sujayanand, G.K., Sharma, R.K. and Shankarganesh, K. 2016. Impact of intercrops and border crops on pest incidence in okra. *Indian Journal of Horticulture*. 73(2): 219-223.

Wanner, H., Gu, H., Gunther, D., Hein, S and Dorn, S. 2006. Tracing spatial distribution of parasitism in fields with flowering plant strips using stable isotope marking. *Biological Control*. 2: 39.

https://iipr.icar.gov.in/urdbean/

http://des.ap.gov.in/

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STATUS OF HANDLOOM ARTISANS & MARKETING CONSTRAINTS: A STUDY IN THE WEST TRIPURA, INDIA

SUJOY HAZARI*, MAMONI KALITA, BHARGABI CHAKRABORTY AND ANAMIKA DEBNATH

The ICFAI University Tripura, Kamalghat-799210.

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ABSTRACT

The handloom industry is both a traditional and a cottage industry in India, employing a large number of indigenous rural people. Tripura's people consider weaving to be an integral part of their lives and they produce a variety of crafts. Out of the different crafts, handloom is one of the primary crafts in Tripura. Handloom provides livelihood opportunities for rural people, including a large number of indigenous women and people from disadvantaged social groups. Despite all these opportunities, the handloom sector still faces lots of constraints and challenges. Thus, the current research is about the socio-economic condition of handloom artisans in Tripura and also identifies the artisans' consultants and challenges. The study was conducted in the region of sixteen villages in the Hezamara, Belbari, Mandai, and Lefunga rural development blocks of West Tripura. The information was gathered by utilizing a semi-structured interview schedule. A sample of 200 women entrepreneurs was selected based on the availability of handloom artisans. Data were gathered for the current investigation using convenience sampling. According to the study, it was observed that 91 percent of respondents are females engaged in handloom weaving activity out of that 38 percent of women artisans are illiterate, and the majority (51.50 percent of them) are in the age range of 18 ≤ 35 years. The study also revealed various challenges faced by handicrafts artisans, which include price fluctuation, a lack of marketing linkage, high marketing costs, a lack of infrastructural facilities, and many more.

KEYWORDS: Handloom, Artisans, Tripura, Crafts and Women.

INTRODUCTION

Handloom and handicrafts industry is a traditional and also cottage industry in India. It employs a large section of poor people (Tanusree, 2015). However, the role and significance of the industry in national development is declining. The industry is facing a lot of problems such as men, materials, methods, machines, money, marketing, and management (Narzary, 2013).

In common parlance, handicraft is a traditional work where useful and decorative items are made completely by hand or using only simple tools. The handicraft sector plays a major role in rural economic development. The definition of handicrafts given by the task force is, handicrafts are items made by hand, often with the use of simple tools, and are generally artistic and/or traditional.

The Handloom sector plays a very important role in the country's economy. It is one of the largest economic activities providing direct employment to over 65 lakh people engaged in weaving and allied activities. Handlooms have been known in India right from the historic ages (Patil, 2012). Handloom weaving occupies a key place in debates about Indian industrialization which tends to be identified with the rise of mechanized factories. Artisans have a marginal role in this narrative. In overview, artisans, particularly handloom weavers, even represent ade-industrialization. Decline and transformation were a worldwide phenomenon in the nineteenth and early twentieth century in the artisan group. According to Roy (2002), 1.7 million power loom units employed 8 million workers in the year 1997. This ratio shows that this employment is more than 20 percent of all industrial wage labor in India. Thus, the modern power loom industry is the most significant form of industrialization in India and unquestionably one of the world's largest industries (Roy, 2002).

According to Debbarma and Murugesan, 2022, people in Tripura consider weaving to be an integral element of life. Generating from generation to generation, the industry has survived. Tribal women in Tripura dedicated their lives to weaving. Each tribe the family has a history of starting the ritual by offering flowers and a lovely piece of Rignai and Risa that is provided by the women ancestors. Infect knowledge of weaving was a requirement for all indigenous girls. Popular handloom products being produced include scarves, bed sheets, shoulder bags, and table cloth, cushion covers, etc.

*Corresponding author, E-mail: sujoyhazari@iutripura.edu.in

The Office of Development Commissioner (Handicrafts) is the nodal agency in the Government of India for craft and artisan-based activities. It assists in the development, marketing, and export of handicrafts, and the promotion of craft forms and skills. The assistance is in the form of technical and financial support, including schematic interventions implemented through its field offices. The operations of the Development Commissioner (Handicrafts) are closely linked to other organizations under the Ministry of Textiles beyond, i.e. Metal Handicrafts Service Centre, Moradabad; (statutory/autonomous body);

Handicrafts and Handlooms Export Corporation, New Delhi (public sector undertaking); Export Promotion Council for Handicrafts (EPCH), New Delhi; Indian Institute of Carper Technology, Bhadohi (U.P.); and National Center for Design and Product Development (NCDPD), New Delhi and Moradabad (Ministry of Tribal Affairs). From the early 19th century, the handloom industry has been started to decline and lost its market due to industrialization. Industrialization took place in the traditional handloom industry of India when trade liberalization and market liberalization came into existence (Ganguly *et al*, 2003).

But the scenario does not seem to be very attractive. Still, handicraft artisans are not able to overcome their weaknesses and hence struggle hard for their existence. Some art has slowly lost relevance with the advent of industrialization and the sector carries the stigma of inferiority and backwardness (Shah and Patel, 2017). Hence, here an attempt has been done to study the weaknesses and challenges faced by such artisans engaged in the most popular craft of Tripura, i.e. hand embroidery & beadwork. In this study, the problems faced by the industry and the solutions to solve the problems are discussed.

REVIEW OF LITERATURE

The purpose of the study is to analyze the socioeconomic status and challenges faced by handloom and handicraft artisans in selected districts in Tripura. Accordingly, this section reviewed related literature.

Narzary (2013) conducted a study to find out the marketing problems and prospects of the handlooms and handicrafts industry in the B.T.A.D area. The sample size of the study comprised 200 respondents who are the producers and retailers of the handloom and handicraft products. The findings of the study show the different marketing problems faced by the producers and retailers in the area. In these efforts, we have been supported by weavers, traders, retailers, customers of handlooms, Experts and cooperative society elected personnel as well as officials of the government in getting the required information.

Shah and Patel (2017) studied "Problems and challenges faced by handicraft artisans in Gujarat" and found that the Women of Gujarat are very prosperous in the art of 'Needle and Thread'. Generally, they are used to do such work for their domestic use. But nowadays, such products are demanded everywhere. They require professional touch as per the requirement of demand of the market. The government tries to uplift the art and artisans through various programs and policies. Despite of various government and non-government efforts, the reality is not satisfactory. The handicraft artisans suffer a lot due to being unorganized, lack of education, low capital, poor exposure to new technologies, absence of market intelligence, and a poor institutional framework. Shah & Patel (2016) also found in 'E-commerce and Rural Handicraft Artisans', have focused on various opportunities of e-marketing available to handicraft artisans, as today is the age of mobile and technology. Evaluating the data of internet users in the country as well as in the world; and the mobile internet users in urban and rural India, the authors have tried to show ample opportunities open to these artists, if proper awareness and efficient system is developed in this sector. Besides, researchers suggested that E-commerce is one of the most promising channels in the marketing scenario today for selling handicrafts.

Roy *et al*. 2018, Livelihood of Traditional Handloom Weavers of Darlong Community in Unakoti District of Tripura, India the research tries to find out the status of socio-cultural-economic life of the Darlongs in the rural sites of Unakoti District, Tripura through an extensive field survey. Modernization plays a crucial role in the developmental process of social traits of the Darlong Community. The research additionally explores the challenges being faced by the community weaving mores. Acculturation of Darlong culture and that of modern Western culture is transforming their own culture giving a new shape. It has been observed that large segments of the Darlong society who reside in the interior part of the hilly state have little scope of getting involved in

Fig. 1. Activity of Handloom Artisans in the rural areas

handloom activities. The socio-economic status of the surveyed rural villages of Darlong has been changing rapidly because of educational improvement and cultural assimilation as a result which time-honoured cultural elements especially traditional dresses particularly of men gradually being replaced by modern Western dress.

Avirami *et al.* 2017 has tried to understand the current scenario of the handicraft industry and the challenges faced by the artisans in India. The study is also for the technological gradation to capture more market values, to emphasis interest among the youth and to adopt internet technology to sell products through E-Commerce sites. Jain 2016, has studied the impact of government policies on the marketing strategy of handicrafts with special reference to 220 artisans who had participated in 12 trade fares held in Madhya Pradesh during the span of the study at different point of time. The study was concentrated on the role and performance of the Government concerning the upliftment of handicrafts and their respective policies and regulations. It was observed that design scheme, marketing support scheme, export scheme, publicity scheme, planning & research scheme, and marketing scheme were hardly recognized by the artisans.

Before taking a sincere attempt in that line, the situation arises a pertinent research question to answer:

Whether the existing economics of livelihood generations from the handloom by the rural people have the potential for socio-economic development through supplementary livelihood generation activity by taking any commercial venture?

Thus, against the present backdrop, we attempt to status of handloom artisans & marketing constraints in the Tripura, with specific objectives 1) to analyse the socioeconomic status of handloom and handicraft artisans; 2) to analyse the profitability of Handloom product; 3) to identify the challenges faced by handicraft artisans.

MATERIAL AND METHODS

The current study is descriptive and tries to understand the "socioeconomic status and issues faced by handloom and handicraft workers in West Tripura District, Tripura." Both primary and secondary sources have been used to collect the data for this research work. The study was conducted in the region of sixteen villages in the Hezamara, Belbari, Mandai, and Lefunga rural development blocks of West Tripura district. A semi-structured schedule created specifically for the purpose was used to collect primary data from the respondents. The information was specially acquired by the researcher in the West Tripura villages. Semi-structured interviews that took place in the year 2023 were used to collect the information and to check the reliability of *Cronbach's* Alpha was observed at 0.886. To accommodate the responders, who make up a sizable share and do not speak English, this scheduling method was used. A variety of secondary sources, including journals, articles, books, reports, websites, and so forth, were used to collect the data. Convenience sampling has been used by the researcher to gather data for the current study. Among the rural handcraft artisans, samples of 200 respondents are chosen for the study.

Likert Scale

To measure the respondent's opinions on different constraints a *Likert* scale was used for scaling the attitudes of the respondents. In this survey respondents were asked to rate each item in terms of agreement or disagreement of the given statements. Here data collected are in the ordinal (ranking) according to priority by the respondent's responses. Five is the highest possible score on the charts and one is the lowest. The responses elicited may be coded as 1-Strongly disagree, 2-Somewhat disagree, 3-Undecided, 4-Somewhat agree; 5-Strongly agree (Devore and Peak, 1992). The higher scores indicate more important and vice versa. Modal values were used to describe the response. The result gives different percentages across different attributes. The percentage towards each attribute indicates their opinion shares towards each problem.

Henry Garrett Ranking Method

The Garrett method is often used to complete the ranking of an alternative based on the ratings of respondents that are converted into certain ranks (Dhanavandan, 2016). This ranking is done by determining the most significant weakness of handloom artisans from their opinion.

The positioning of options utilizing the Garrett method is finished by computing the respondent's information as a variable of the rate position esteem utilizing the following equation;

$$\text{Per cent position} = \frac{100\,(R_{ij} - 0.5)}{N_j}$$

where, R_{ij} is the rank given for the i variable by the j^{th} respondents, while N_j is the number of variables ranked by j^{th} respondents. The results of the percentage position are then converted into Garrett Values using the Garrett ranking conversion table.

RESULT AND DISCUSSION

Age is a determining factor in individual physical growth, mental maturity, decision-making, and physical and confidence level differs based on age. There are 200 respondents, of which 51.50 percent respondents belong to the young age group, 22 percent respondents belong to the Middle age group i.e. 35-45 years, and 26.50 percent respondents to the old age of above 45 years. It is concluded that the young age group of 18-35 years are more engaged to the handicrafts work than of other groups. Middle age group of respondents are significantly influenced the artisan activity (Debbarma and Geetha, 2017).

In this context to the gender distribution in the artisan, it was observed that only 9 percent of respondents are male and 91 percent of respondents are female are engaged in handloom weaving, so it is referred from the above analysis that more females are involved in handicraft activities. The research area's weavers' participation in the activity is significantly influenced by gender.

The study revealed that out of 200 respondents, 75 percent of the respondents are married and 25 percent of the respondents are unmarried in the case of the living standard of the respondents in the study areas, it was found that 67.50 percent of the respondents belong to below poverty level (BPL) category, 25 percent of the respondents belong to above poverty level (APL) category and 7.50 percent belongs to Antyodaya category.

The educational status of the respondents in the rural areas is also shown. It explains that out of 200 respondents, 38 percent are illiterate, 20.50 percent are up to the primary level, 17.50percent are up to high school and 13 percent are up to the higher secondary level of education, 7.50 percent have the educational level up to graduation and only 3.50 percent had post-graduation. So it can be referred that only 11 percent of respondents in the study area have an education level up to the college/universities. Education plays a significant role as the majority of the respondents are literate (Debbarma, 2020).

There are 85 percent of the family belongs to the nuclear family and 15 percent of respondents belong to joint family only. On average 1.73 person is directly or indirectly involved in the handloom activity. They may have found it advantageous to have small families to lead a more comfortable and fulfilling life due to the small family standards they follow, their understanding of the costs of living, and the challenges associated with caring for large size families. (Debbarma, 2020).

The study also explains the awareness of the fair and exhibition of selected respondents. Out of that, only 37 percent are aware of the fair and exhibition and the rest of the 63 percent is not aware of the fair. The awareness about the fair and exhibition to the artisan

Table 1. Socioeconomic status of handloom weavers in West Tripura

(n = 200)

S. No.	Particulars	Respondents	Percentage	Std. Deviation	Chi-Square
1	**Age**				
a	Young (18 ≤ 35 years)	103	51.5	0.82	30.31***
b	Middle (>35-45 years)	44	22		
c	Old (> 45 years)	53	26.5		
2	**Gender**				
a	Male	18	9	0.28	134.48***
b	Female	182	91		
3	**Marital status**				
a	Married	150	75	0.43	50.00***
b	Unmarried	50	25		
4	**Living standards**				
a	BPL	135	67.5	0.54	114.25***
b	APL	50	25		
c	Antyodaya	15	7.5		
5	**Formal education**				
a	Yes	123	61.5	0.48	10.58***
b	No	77	38.5		
6	**Level of education**				
a	Illiterate	76	38	1.53	88.96***
b	Primary education	41	20.5		
c	Secondary education	35	17.5		
d	Higher secondary	26	13		
e	Graduation	15	7.5		
f	Post-Graduation	7	3.5		
7	**Family Size**				
a	Joint family	170	85	1.07	98.00***
b	Nuclear family	30	15		
8	Average members involved in the handloom activity	1.73		0.82	
9	Awareness about fair and exhibitions				
a	Yes	74	37	0.48	13.52***
b	No	126	63		

Note: significance at the level ***p<0.001

Table 2. Source of income of handloom weavers in West Tripura

(n = 200)

S. No	Activity	Primary		Secondary	
		Respondents	Percentage	Respondents	Percentage
1	Agriculture	65.00	32.50	53.00	26.50
2	Livestock	15.00	7.50	38.00	19.00
3	Fishery	9.00	4.50	6.00	3.00
4	handloom	38.00	19.00	82.00	41.00
5	Wage employment	15.00	7.50	0.00	0.00
6	Services	35.00	17.50	0.00	0.00
7	Business	23.00	11.50	21.00	10.50
	Total	**200**	**100**	**200**	**100**

Note: Significance at the level ***p<0.001

plays a significant role in the socioeconomic status of the respondents.

The above-mentioned table shows the primary and secondary sources of income of handloom weavers. Out of the total respondents, 32.50 percent state agriculture as their primary source of income whereas 26.50 percent consider agriculture as percent secondary source of income. 19.00 percent state handloom as their primary source of income whereas 41.00% consider handloom as a secondary source of income. 7.50 percent and 19.00 percent of respondents say livestock as a primary and secondary source of income respectively.

The above table 3 shows the experience in handloom activity of the respondents of the study area. Out of 200 respondents, 44 percent are having experience of 1-5 years. 4.50 percent of the respondents had less than 1 year of handloom experience, 19.00 percent had 5-10years of experience, 12 percent had 10-15 years of experience, 7.50 percent had 15-20 years, and 13.00 percent had More than 20 years of experience in handloom activity. Experience plays a significant role as the majority of the respondents are having experience of 1-5 years.

The above table 4 shows the income of the respondents in the study area. It states that 37 percent, of respondents have a monthly income below 10,000. Of the respondents 25 percent have a monthly income of between 10,001-20,000, 19.00 percent have a monthly income of 20,001-30,000, and 9 percent of the respondents are having a monthly income of 30,001 – 40,000. 6 percent have a monthly income of 40,001-

Table 3. Experience (years) in handloom activity

S. No	Particulars	Respondents	Percentage	Chi-Square
1	Less than 1 years	9.00	4.50	
2	1-5 years	88.00	44.00	
3	5-10 years	38.00	19.00	
4	10-15 years	24.00	12.00	122.38***
5	15-20 years	15.00	7.50	
6	More than 20 years	26.00	13.00	
	Total	**200**	**100.00**	

Note: Significance at the level ***p<0.001

Table 4. Distribution of Respondents average monthly income

S. No	Particulars	Respondents	Percentage	Chi-Square
1	Below 10000	74.00	37.00	
2	10001-20000	50.00	25.00	
3	20001-30000	38.00	19.00	
4	30001-40000	18.00	9.00	98.56***
5	40001-50000	12.00	6.00	
6	Above 50000	8.00	4.00	
	Total	**200**	**100.00**	

Note: Significance at the level ***p<0.001

50,000 and 4 percent have a monthly income above 50,000 in the area. The monthly income of the artisan plays a significant role in their socioeconomic status.

All the respondents have been categorized into three categories:1) Running their own business 2) Doing service in some handicraft unit with a fixed salary and 3) Potential artisans doing handicrafts in their leisure time only.

It is noticeable that 132 artisans (66 percent) are in their own handicraft business either established by themselves or by family. 56 artisans (28 percent) are part-time artisans who are not currently employed regularly in the field of handicrafts. They are skilled people but not getting regular work in handicrafts. So, such artisans work in their leisure time to earn supplementary income. Some are employed in other occupations. And only 12 artisans i.e. 6 percent are engaged in service with fixed salary in some other handicraft business.

Table 5. Form of handloom activity by handloom weavers

S. No.	Particulars	Respondents	Percentage	Chi-Square
1	Own Business	132.00	66.00	
2	Service with Fixed Salary	12.00	6.00	110.56***
3	Part-Time Artisans	56.00	28.00	
	Total	**200**	**100.00**	

It is clear from the above table that most of the respondents 85.50 percent do not have any membership but operate at the individual level. 10 percent of the artisans are a member of some Self-help-groups, while 1.50 percent is members of NGOs. And 3 percent of respondents registered in some other organization.

From the above-mentioned Table 7, it has been found that the majority of the artisans, i.e., 85 (42.50 percent) have joined this handicraft activity to utilize free time. Thus, such activity can be helpful to women artisans to utilize their leisure time in some creative and productive work which can add supplemental income to their family income. 27 numbers of respondents (13.50 percent) said that being easy to learn and to do; they have accepted such handicrafts, while 53 numbers of respondents (26.50 percent) had no other option than handicrafts. Only 3 respondents, 1.50 percent respondents have been inspired to come into this field by the government's efforts and help. Thus, the reach of government initiatives seems weak and must be focused more. Being a less investment demanding activity, 16.00 percent of people have been motivated to start it.

The economic feasibility indicators of handloom artisans are presented in Table 8. The average B-C ratio

Table 6. Membership category of handloom weavers

S. No.	Particulars	Respondents	Percentage	Chi-Square
1	SHG	20.00	10.00	
2	NGO	3.00	1.50	
3	Any Other	6.00	3.00	393.72***
4	No Membership	171.00	85.50	
	Total	**200**	**100.00**	

Note: Significance at the level ***p<0.001

was estimated at 2.14:1. The B-C ratio analysis indicates that the investment in handloom is economically viable and on average Rs 1 investment brings Rs 2.14 returns. Handloom activity is capital intensive. It was found to be economically feasible in the state.

Garrett ranking technique has been used to analyze the factors influencing the handloom by the respondents. The respondents were asked to rank the eight factors identified for this study from 1 to 8 to know their preference in the selection of constraint. The calculated percentage position for the rank 1 to 8and their correspondent Garrett's table as shown in Table 9, For factors, the total score is calculated by multiplying the number of respondents ranking that factor as 1 to 8.

Based on the ranks assigned by the sample respondents, the various challenges/constraint experienced by the handloom weavers in the study area are analyzed through Garret Ranking Techniques,

Table 7. Reasons to join the handloom

S. No.	Particulars	Respondents	Percentage	Chi-Square
1	Easy	27.00	13.50	
2	Less Investment	32.00	16.00	
3	Utilization of Free Time	85.00	42.50	94.90***
4	Govt. Help	3.00	1.50	
5	No Option	53.00	26.50	
	Total	**200**	**100.00**	

Note: Significance at the level ***p<0.001

It is evident from the above table reveals that the less information about Market and Marketing (71.46), was the main constraint experienced by the handloom weavers followed by the Scarcity of Working capital / Financial problems (70.92), Lack of information about government aid/credit facilities (69.88), Lack of modern managerial skills (66.55), Problems due to less education (56.72), Lack of knowledge about latest designs/current market demands (54.77), No information about exports (46.58), Lack of organized identity (42.96).

Table 8. Economics of Handloom Activity (Rs/year)

S. No.	Particulars	Amount (Rs.)
1	Expenditure	18011.80
2	Income	38552.90
3	Profit	20541.20
4	BCR	2.14

Table 9. Percentage positions and their corresponding Garetts table values

S. No.	100 (Rij – 0.5)/Nj	Per cent position	Garrett score
1	100(1-0.5)/8	6.25	80
2	100(2-0.5)/8	18.75	67
3	100(3-0.5)/8	31.25	60
4	100(4-0.5)/8	43.75	53
5	100(5-0.5)/8	56.25	47
6	100(6-0.5)/8	68.75	40
7	100(7-0.5)/8	81.25	32
8	100(8-0.5)/8	93.75	20

The artisans shared their own experiences when asked or the challenges faced by them in this field. The above-mentioned table shows the mean and standard deviation of constraints faced by the selected handloom Weavers. As can be seen from the table that the mean of almost all the constraints is more than point 3, hence all the constraints are crucial for the respondents. The challenges of 'Competition with latest machine-made products of large industries' and 'Lack of infrastructural facilities' and 'High marketing cost' are also important constraints. They told that they have to face competition from the latest machine-made products produced on a large scale in big industries, as they are cheap, identical, and fast to be produced; besides such artisans feel that there is the improper implementation of government schemes and programs though such programs seem attractive at planning and policy level. Most of the respondents told that there is less gain as compared to hard work. They feel that it is laborious work not having social status, as gain is very less as compared to time spent and energy invested in it.

Table 12 indicates the Component wise distribution of different constraints faced but handloom artisans in the study area. It shows that there are 8 particulars under Production techniques and interest component viz. decreasing demand due to change in the taste & interest of people, handicraft is losing its original form due to changes in lifestyle and culture, competition with latest machine made products of large industries, problems of quality and durability due to handmade, gain is less as compared to hard work, new generation is not interested in handicrafts, lack of infrastructural facilities, lack of raw materials. Under Government regulation & intervention component there are 2 factors viz. improper implementation of government schemes/ programmes, irregularity in employment. And under Lack of marketing functions & infrastructure component there are 4 factors *viz.,* middlemen earn huge profit, high marketing cost, lack of marketing linkage, price fluctuation (Abebe, 2016).

According to the study, all of Tripura's handloom weavers come from the state's indigenous communities, which are entirely controlled by women. The majority of women working in the handloom industry are members of Tripura's tribal community who live in rural regions. The handloom industries have primarily or secondarily given the rural women's population work options. Production techniques and interest, government regulation & intervention, and lack of marketing functions & infrastructure are being severely challenged to the rural handloom weavers. Artisans mostly work in traditional and unorganized sector in which they are vulnerable to exploitation and low wages. It finds that the artisans are unaware about the schemes and also due to lack of training facilities quality of the products could not meet the tasteof theconsumer in the towns and cities. To address the issues facing the weavers, it is vital to move forward.

RECOMMENDATION

The need of the hour is urgent reforms and upgrades to ensure sustainability andlongevity for artisans at the grassroots level. This is a generational skill but we can findthat there is lack of income as most of the respondent

Table 10. Ranking constraint associated to handloom weavers

S. No.	Particulars	Rank								Total No. of respondents	Total score	Total mean	Rank
		I	II	III	IV	V	VI	VII	VIII				
1	Lack of modern managerial skills	73	53	35	15	9	15	0	0	200	13309	66.55	**IV**
2	Problems due to less education	62	32	26	15	3	6	32	24	200	11344	56.72	**V**
3	Scarcity of Working capital /Financial problems	106	50	15	21	3	5	0	0	200	14184	70.92	**II**
4	Less information about Market and Marketing	112	41	24	14	6	3	0	0	200	14291	71.46	**I**
5	Lack of information about government aid/credit facilities	88	62	29	9	12	0	0	0	200	13975	69.88	**III**
6	Lack of knowledge about latest designs/current market demands	64	24	9	15	21	9	32	26	200	10954	54.77	**VI**
7	Lack of organized identity	18	12	18	24	17	26	38	47	200	8591	42.96	**VIII**
8	No information about exports	30	11	15	26	20	32	30	36	200	9315	46.58	**VII**

Table 11. Constraints faced by the selectedhandloom weavers

S. No.	Particulars	Mean	Std. deviation
1.	Decreasing demand due to change in the taste & interest of people.	3.691	1.175
2.	Handicraft is losing its original form due to changes in lifestyle and culture.	3.529	1.397
3.	Competition with latest machine made products of large industries	4.191	0.885
4.	Problems of quality and durability due to handmade.	3.544	1.418
5.	Gain is less as compared to hard work	3.970	0.772
6.	Middlemen earn huge profit	3.882	1.203
7.	New generation is not interested in handicrafts	3.588	1.488
8.	Lack of infrastructural facilities	4.014	0.872
9.	Improper implementation of government schemes/programmes	3.691	1.224
10.	Irregularity in employment	3.544	1.013
11.	Lack of raw materials	3.676	0.953
12.	High marketing cost	4.044	0.678
13.	Lack of marketing linkage	3.838	0.745
14.	Price fluctuation	4.029	0.897

belongs to BPL category. Theawareness regarding various government schemes are to be created among the artisanso that that find better sources of financial help. The academic researchwill not be enough to create confidence among the handloom workers. Though oursample size reveals that young generation are involved in the handloom industry it hasalso highlighted that most of them are carrying it as their part time activity since they donot have others engagement. Most of the respondent feels that the work is laboriouswithout any social status. Thus we can realize that absences of dignity of labour aredeterring the current generation from entering the industry in a full-fledged manner andthus they are not taking this business seriously. Government and local bodies shouldtake a serious note of it. Lack of marketing facilities is also becoming a constraint forthese artisan. The problems are multi layered. Despite multiple bodies, governmentschemes and funds geared at holistic change, long-term benefits don't trickle down tothe artisans. For the women workforce and the immediate concern is hygienic workingconditions with washrooms, natural light and airflow for them. We need to improve theinfrastructure and make it aspirational. Further, both at the governmental and privatelevel, regular gathering of statistical information is required to understand the realsituation on ground with regards to production, markets and quality. This can be furtherleveraged for the creation of policies as well as local and national organisations whichcan stand for the handloom sector.

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Table 12. Component wise distribution of different constraints

S. No.	Particulars	Component		
		Production techniques and interest	Government regulation & intervention	Lack of marketing functions & infrastructure
1	Decreasing demand due to change in the taste & interest of people.	0.806		
2	Handicraft is losing its original form due to changes in lifestyle and culture.	0.805		
3	Competition with latest machine made products of large industries	0.540		
4	Problems of quality and durability due to handmade.	0.840		
5	Gain is less as compared to hard work	0.615		
6	Middlemen earn huge profit			0.875
7	New generation is not interested in handicrafts	0.918		
8	Lack of infrastructural facilities	0.807		
9	Improper implementation of government schemes/programmes		0.827	
10	Irregularity in employment		0.672	
11	Lack of raw materials	0.703		
12	High marketing cost			0.536
13	Lack of marketing linkage			0.732
14	Price fluctuation			0.654
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.			0.828	
Bartlett's Test of Sphericity		Approx. Chi-Square		595.723
		df		91
		Sig.		0.000***
Inference		H(0):	Not accepted/Rejected	
Conclusion	Problems encountered by collectors found to mutually correlated at 99 per cent level of confidence			

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization

LITERATURE CITED

Abebe, G.K., Bijman, J and Royer, A. 2016. Are middlemen facilitators or barriers to improve smallholders' welfare in rural economies? Empirical evidence from Ethiopia. *Journal of Rural Studies*. 43: 203-213.

Avirami, P. 2017. Indian Handicrafts and its Challenges faced by Artisans Community. *International Journal of Economic Research*. 14(7): 431-438.

Debbarma, A and Geetha, V.J. 2017. Problems of Women Handloom Entrepreneurs in West Tripura District, Tripura. *International Journal of Law, Humanities and Social Science*, 1(6) 68-80.

Debbarma, S. 2020. A Study on the socio economic status of rural handicraft artisans in Hezamara RD block west Tripura District, Tripura. *M.Phil*. Dissertation Submitted to the Annamalai University, Tamil Nadu, India.

Debbarma, S and Murugesan, P. 2022. A Study on the status of rural handicraft artisans in Mandwi RD Block, West Tripura District, Tripura. *Journal of Pharmaceutical Negative Results.* 13(2): 1292-1297.

Devore, J.L and Peck, R. 1993. Statistics: The exploration and analysis of data 2nd edition Duxbury Press (Belmont, Califonia).

Dhanavandan, S. 2016. Application of garret ranking technique: practical approach. *International Journal of Library and Information Studies*. 6(3): 135-140.

Ganguly, A. Gokhale, Y and Gadgil, M. 2003. Developing responsive indicators for the Indian biosphere reserve programme. *Journal of the Bombay Natural History Society*. 100 (2-3): 214-225.

Jain, R. 2016. A study of the impact of government policies on marketing strategy of handicrafts. *Ph.D. Thesis* Submitted to the Devi Ahilya Vishwavidyalaya, Indore, India.

Narzary, J. 2013. Marketing problems and prospects of handloom and handicrafts industry in BTAD. *Global Research Methodology Journal*. 2(7).

Patil, N.U. 2012. Role of handloom industry in India. *International Indexed & Referred Research Journal*. 4: 1-2.

Roy T. 2002. Acceptance of innovations in early twentieth century Indian weaving. *The Economic History Review New Series*. 55(3): 507-532.

Roy, S., Debbarma, D., Darlong, S and Mitra, S. 2018. Livelihood of traditional handloom weavers of darlong community in Unakoti District of Tripura, India. *Geographic*, 13(1): 35-47.

Shah, A and Patel, R. 2016. E-commerce and Rural Handicraft Artisans. *Voice of Research*. 5: 24-29.

Shah, A and Patel, R. 2017. Problems and challenges faced by handicraft artisans. *Voice of Research*. 6(1): 57-61.

Tanusree, S. 2015. A study of the present situation of the traditional handloom weavers of Varanasi, Uttar Pradesh, India. *International Research Journal of Social Sciences*. 4(3): 48-53.

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MORPHOLOGICAL CHARACTERIZATION OF NATIVE ISOLATES OF *Beauveria bassiana* (Balsamo) Vuillemin AND *Metarhizium anisoplieae* (Metchnikoff) Sorokin FROM RAYALASEEMA REGION OF ANDHRA PRADESH

S. ABDUL MUJEEB*, K. MANJULA, P.N. HARATHI, A. KANDAN AND P. LAVANYA KUMARI

Department of Entomology, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

This study characterizes the morphological traits of native isolates of *Beauveria bassiana* and *Metarhizium anisopliae*, two key entomopathogenic fungi (EPF) used in biocontrol of agricultural pests. In the present study conducted at S.V. Agricultural College,Tirupati, native isolates of *B. bassiana* and *M. anisopliae* were collected from major field crops like groundnut and maize from major groundnut growing districts of Rayalaseema region. These isolates were cultured on SMAY media and morphological characters were studied. Morphological characters *viz.,* width of mycelium, width of conidiophore and length and width of conidia were measured. Observations revealed that *B. bassiana* isolates exhibited cottony white mycelium with globose conidia, while *M. anisopliae* isolates developed greenish colonies with elongated, cylindrical conidia. Conidia structure varied between the isolates, highlighting intraspecific diversity. In *B. bassiana* conidia were measured from 1.9 – 3.1 µm in length and 1.6 – 2.8 µm in width whereas in case of *M. anisopliae*, conidia were measured from 6.7 to 7.2 µm in length and 3.2 to 3.5 µm in width..

KEYWORDS: *Beauveria bassiana*, *Metarhizium anisopliae*, native isolates, conidiophore, conidia.

INTRODUCTION

The use of Entomopathogenic fungi (EPF) like *Beauveria bassiana* and *Metarhizium anisopliae* is upsurging in recent years for the management of crop insect pests. EPF are considered better than synthetic insecticides as they are safe for humans, sustainable to the environment, target-specific in nature and more commonly in natural occurrence.

B. bassiana, a filamentous fungus, belongs to a class of insect pathogenic deuteromycete and strains of *B. bassiana* are highly adapted to particular host insects. A broad range of *B. bassiana* has been isolated from a variety of insects worldwide which are of agricultural importance. *B. bassiana* is a fungus that grows naturally in soils throughout the world and it has a wide host range that causes white muscardine disease among the insects of orders Lepidoptera, Coleoptera, Orthoptera, Diptera, Dermaptera, hymenoptera and Hemiptera (Toledo *et al*., 2008).

M. anisopliae is a mitosporic fungus with asexual reproduction, which belongs to Deuteromycetes. Many attempts have been made to use these naturally occurring fungi against insect pests including soil-inhabiting pests like scarab larvae. However use of entomopathogenic fungi for controlling insect pests did not resurface until the 1970s as public awareness of pesticide hazards increased. During 2018-20, it is observed to cause epizootics in *Spodoptera litura* and *Aproaerema modicella* in *rabi* and *kharif* groundnut respectively in Tirupati region (Manjula *et al*., 2019).

Morphological and molecular identification of fungi is considered as essential step in the selection of biocontrol agents (Boucias *et al*., 2000). Diversity within entomopathogenic fungal species has been traditionally analysed using morphological features by assessing the phenotypic characteristics. However, assessing the species diversity by analysing morphological features alone could lead to ambiguity with regard to identification at species level, due to the observed divergence of morphological characters produced by genetic variability. Therefore applications of molecular methods have been quite useful to detect the level of variation among species (Fernandes *et al*., 2009; Nishi *et al*., 2011).

In recent years, these two prominent fungi have been infecting various lepidopteran insect pests in the

*Corresponding author, E-mail: mujeebsam001@gmail.com

Rayalaseema region and other parts of Andhra Pradesh. Keeping the importance of these two fungal pathogens in view, native isolates collected from different areas within the Rayalaseema region were morphologically characterized.

MATERIAL AND METHODS

Purification of fungal isolates

Roving survey was conducted for collection of lepidopteran caterpillars infected with two entomopathogenic fungi showing *Beauveria* and *Metarhizium* growth from field crops like Groundnut and maize during *kharif,* 2022 and *rabi,* 2022-23. Soil samples were also collected from the surveyed locations. The infected cadavers were inoculated onto SMAY (Saboraud's maltose Agar Yeast) medium and the soil samples were serially diluted upto 10^{-4} and transferred 1ml of suspension onto the medium containing petriplates (Meyling and Nicolai, 2007). The inoculated plates were maintained in BOD at 22°C. Growth of fungi was monitored for 10 days and obtained pure cultures were maintained in the laboratory.

Morphological Characterization of Isolates of *B. bassiana* and *M. anisopliae*

Morphology characters were studied at Insect pathology laboratory, Department of Entomology and Central instrumentation laboratory at S. V. Agricultural College, Tirupati.

The characters of mycelium, conidiophores and conidia of fungal isolates were studied. In the laminar airflow chamber, with the help of a sterilized inoculating needle, took a minute portion of *B. bassiana* culture from the Petri plate and placed it on the sterilized glass slide. Then a drop of lactophenol cotton blue was placed. The fungus was spread with help of a needle, placed a cover slip and removed excess lacto-phenol cotton blue with blotting paper. The measurements *viz.,*width of mycelium, width of conidiophore as well as length and width of conidia were studied with the help of Research microscope. In the same way, morphological identification was carried out for *M. anisopliae* isolates also.

RESULTS AND DISCUSSION

A total of six isolates of *B. bassiana* and six isolates of *M. anisopliae* were obtained from the survey. The isolates were named by taking into consideration of the village and district name. They were named as followed.

1. *B. bassiana* isolate Bb. Dpl. Ctr (Dandapalle, Chittoor)
2. *B. bassiana* isolate Bb. Pmr. Ctr (Palamaner, Chittoor)
3. *B. bassiana* isolate Bb. Pkd. knl (Pattikonda, Kurnool)
4. *B. bassiana* isolate Bb. Dvk. Knl (Devanakonda, Kurnool)
5. *B. bassiana* isolate Bb. Gty. Atp (Gooty, Anantapuramu)
6. *B. bassiana* isolate Bb. Utr. Kdp (Utukur, Kadapa)
7. *M. anisopliae* isolate Ma. Dpl. Ctr (Dandapalle, Chittoor)
8. *M. anisopliae* isolate Ma. Pmr. Ctr (Palamaner, Chittoor)
9. *M. anisopliae* isolate Ma. Pkd. Knl (Pattikonda, Kurnool)
10. *M. anisopliae* isolate Ma. Dvk. Knl (Devanakonda, Kurnool)
11. *M. anisopliae* isolate Ma. Gty. Atp (Gooty, Anantapuramu)
12. *M. Anisopliae* isolate Ma. Rkl. Atp (Rekulakunta, Anantapuramu)

Morphological characters of *B. bassiana* isolates

The beginning of mycelial development in case of *B. bassiana* isolates was noticed as white tiny spots two days after inoculation of the isolates on SDAY medium. Then, day by day, there was a noticeable increase in the formation of mycelia, starting as a white cottony colony and gradually turning from white to light yellow, becoming powdery during sporulation. Reverse, pale yellow with white margin. It took about 7-8 days to cover whole petriplates with mycelia development. After 10 days, white powdery spores were observed on the mycelium. Microscopic examination of mycelia threads of fungi indicated that they are hyaline and Mycelium (hypha) is septate, branched, hyaline, smooth walled, 1.2–2.3 µm wide.

Isolate 1. *Beauverai bassiana,* Palamaner, Chittoor (Bb. Pmr. Ctr)

The fungal development begins with the growth of white, cottony mycelium on the SDAY medium, with

hyphae measuring 1.3-2.2 µm in width. Simultaneously, sporulation occurs as conidiophores develop, typically solitary but often clustering in groups of two or more. These conidiophores have a sub-spherical to ampulliform base, 3.5–5.2 µm wide, and extend into an indeterminate denticulate rachis at the apex. Conidia are produced in clusters, globose or subglobose in shape, and eventually mature to a size of 2.5–3.1 µm in length and 2.1–2.8 µm in width (Plate 1a).

Isolate 2. *Beauveria bassiana,* Dandapalle, Chittoor (Bb. Dpl. Ctr)

On the SDAY medium white mycelial growth was observed after two days of inoculation. As the growth progressed, puffy white mycelium developed, accompanied by simultaneous sporulation. The mycelium was branched, hyaline, and septate, with a width ranging from 1.2 - 2.1 µm. In the next stage, conidiophores began to form in clusters of three or more, each with a spherical base measuring 3.2–4.9 µm in width. As the fungus matured, conidia were produced in clusters, ranging from oval to globose in shape (Plate 1b). These conidia measured 2.3 - 3.0 µm in length and 2.0-2.7 µm in width.

Isolate 3. *B. bassiana.* Pattikonda, Kurnool (Bb. Pkd. Knl)

During the initial stages of fungal development on SDAY medium, a white puffy growth was observed, accompanied by simultaneous sporulation of the fungal hyphae. The developing mycelium was septate, hyaline, and branched, with a width ranging from 1.0-2.1 µm. As the fungus advanced, conidiophores began to form, typically appearing in clusters of two or more. These conidiophores had a sub-spherical to ampulliform base, measuring 3.1-5.1 µm in width, and featured an apex with an indeterminate denticulate rachis. In the later stages, conidia were produced in clusters, displaying a round to oval shape (Plate 1c). The conidia measured between 2.1-2.9 µm in length and 1.9-2.5 µm in width.

Isolate 4. *B. bassiana.* Devanakonda, Kurnool (Bb. Dvk. Knl)

On SDAY medium, white mycelial growth was observed within two days of inoculation, characterized by a cottony white appearance and simultaneous sporulation. As development progressed, the mycelium, which was branched, hyaline, and septate, was measured to be between 1.2- 2.0 µm in width. Conidiophores formed in clusters of two or more, featuring a sub-spherical base with a width of 2.9 - 5.0 µm. As the fungus matured, conidia were produced in clusters, ranging in shape from oval to globose (Plate 1d). These conidia were measured at 2.2-2.8 µm in length and 2.0-2.6 µm in width.

Isolate 5. *B. bassiana.* Gooty, Anantapuramu (Bb. Gty. Atp)

In the initial stages of fungal development on SDAY medium, the puffy growth of mycelia with abundant sporulation of *B. bassiana* was observed in the petri plate. The mycelia, ranged from 1.0-2.0 µm in width. As development continued, straight conidiophores emerged in clusters, each bearing a denticulate rachis at the apex. These conidiophores measured between 2.7-4.8 µm in width. As the fungus advanced to the sporulation stage, the majority of conidia were produced in clusters, taking on a globose to sub-globose shape (Plate 1e). Conidia measured between 1.9-2.6 µm in length and 1.8-2.5 µm in width.

Table 1. Measurements of morphological structures of different *B. bassiana* isolates identified from survey

S. No.	Isolate	Mycelium	Conidiophore	Conidia	
		Width (µm)	Width (µm)	Length (µm)	Width (µm)
1.	**Bb. Pmr. Ctr**	1.3-2.2	3.5-5.2	2.5-3.1	2.1-2.8
2.	**Bb. Dpl. Ctr**	1.2-2.1	3.2-4.9	2.3-3.0	2.0-2.7
3.	**Bb. Pkd. Knl**	1.0-2.1	3.1-5.1	2.1-2.9	1.9-2.5
4.	**Bb. Dvk. Knl**	1.2-2.0	2.9-5.0	2.2-2.8	2.0-2.6
5.	**Bb. Gty. Atp**	1.0-2.0	2.7-4.8	1.9-2.6	1.8-2.5
6.	**Bb. Utr. Kdp**	1.1-2.1	3.0-4.9	1.9-2.7	1.6-2.4

Table 2. Measurements of morphological structures of different *M. anisopliae* isolates identified from survey

S. No.	Isolate	Mycelium	Conidiophore	Conidia	
		Width(µm)	Width(µm)	Length(µm)	Width(µm)
1.	**Ma. Dpl. Ctr**	3.3-4.1	4.0-6.3	6.5-7.8	3.5-4.0
2.	**Ma. Pmr. Ctr**	3.0-3.6	4.3-6.0	6.7-7.5	3.2-3.5
3.	**Ma. Pkd. Knl**	3.2-3.7	4.0-5.9	6.0-7.1	3.1-3.3
4.	**Ma. Dvk. Knl**	3.2-4.1	4.2-6.0	6.3-7.2	3.2-4.0
5.	**Ma. Gty. Atp**	3.0-3.6	4.3-6.1	6.4-7.5	3.4-3.6
6.	**Ma. Rkl. Atp**	3.2-3.7	4.0-6.2	6.7-7.2	3.2-3.5

Isolate 6. *B. bassiana.* Utukur, Kadapa (Bb. Utrr. Kdp)

The white cottony growth was observed on SDAY medium with simultaneous sporulation of mycelium. Mycelia measured to be between 1.1-2.1 µm in width. Conidiophores are solitary but usually in clusters of four or more, base sub-spherical to ampulliform and 3.0-4.9 µm wide, apex with denticulate rachis. Conidia are produced in clusters globose or subglobose in shape (Plate 1). Conidia were measured from 1.9-2.7 µm in length and 1.6-2.4 µm in width.

In the present study of *B. bassiana* isolates, the growth of mycelia was puffy with abundant sporulation on SDAY medium. The white powdery sporulation was observed in the centre part, surrounded by whitish mycelium. Conidia were raised from conidiophores. Conidiophores are solitary but usually in clusters of two or more. The majority of the conidia was oval to globose and sub globose in shape (Plate 1). Mycelia width was measured and ranged between 1.0- 2.2 µm in width. Conidiophores ranged in width from 2.7 – 5.2 µm. Conidia were measured from 1.9 – 3.1 µm in length and 1.6 – 2.8 µm in width (Table 1f).

The isolates of *B. bassiana* Bb. Dpl. Ctr, Bb. Pmr. Ctr, Bb. Pkd. Knl, Bb. Dvk. Knl, Bb. Gty. Atp, and Bb. Utr. Kdp were found to be more or less identical in their morphological characteristics.

Morphological structures of *M. anisopliae* isolates

After purifying the cultures, the morphology of six *M. anisopliae* isolates was studied. Two days after inoculation of *M. anisopliae* isolates on SMAY medium, the beginning of mycelial development was seen as white to yellowish small portion. The mycelium was creamy white or yellowish in colour. During sporulation, the colonies became greenish in colour. After 10- 15 days, it was changed to dark green in colour

Microscopic examination of mycelia threads in isolates indicated that they were septate mycelia and interwoven. Mycelium (hypha) width ranged from 3.0 to 4.5 µm.

Isolate 7. *Metarhizium anisopliae*, Dandapalle, Chittoor (Ma. Dpl. Ctr)

On SMAY media, colonies were somewhat raised in appearance, with smooth mycelia and simultaneous sporulation is observed. The colony of this isolate presented a white edge with sporulation observed mostly in the centre part. Mycelia was measured to be between 3.3 to 4.1 µm in width. Conidiophores were less and not branched. Conidiophores ranged in width from 4.0 to 6.3 µm. Conidia were produced directly from conidiophores and the majority of the conidia were elongated with broader ends (Oblong) and cylindrical in shape (Plate 2a). Conidia were measured from 6.5 to 7.8 µm in length and 3.5 to 4.0 µm in width.

Isolate 8. *Metarhizium anisopliae*, Palamaner, Chittoor (Ma. Pmr. Ctr)

The growth of mycelia on SMAY media was observed as a fine, white to pale yellowish mycelial mat. This early stage typically forms a cottony or velvety texture, with the fungus spreading radially across the medium with simultaneous abundant sporulation. The dark green sporulation was seen in the centre part, surrounded by pale yellowish mycelium. Mycelia width

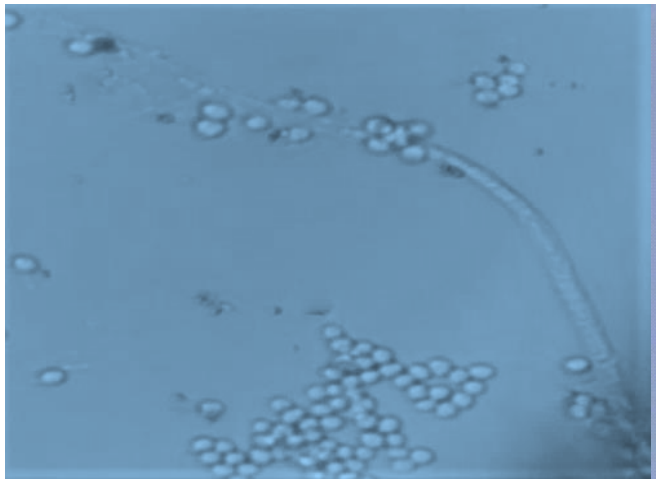

Plate 1 (a) Bb. Pmr. Ctr

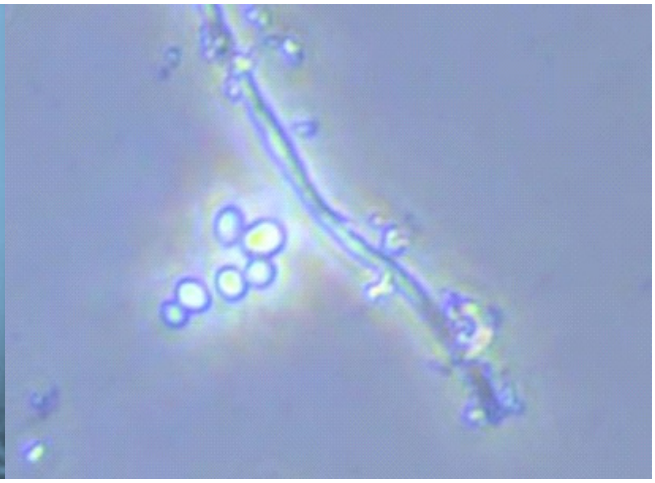

Plate 1 (b) Bb.Dpl. Ctr

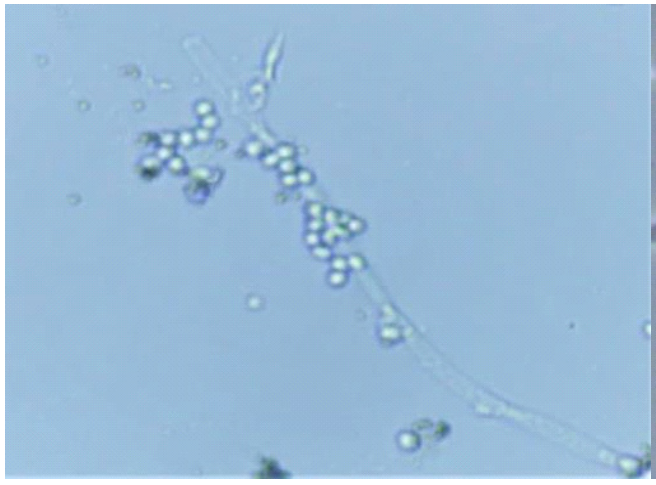

Plate 1 (c) Bb.Pkd. Knl

Plate 1 (d) Bb.Dvk Knl

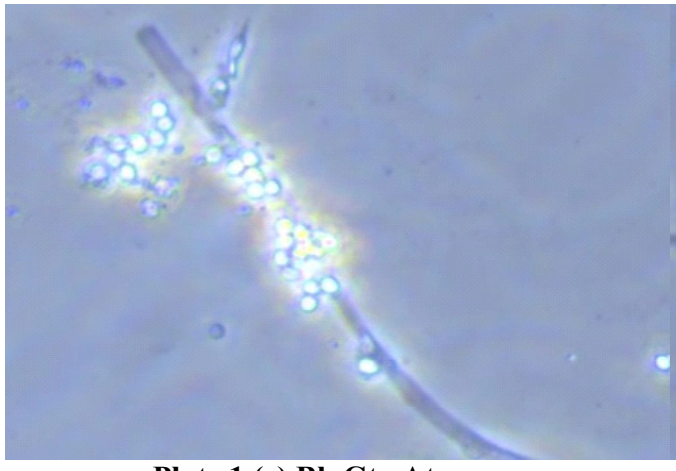

Plate 1 (e) Bb.Gty Atp

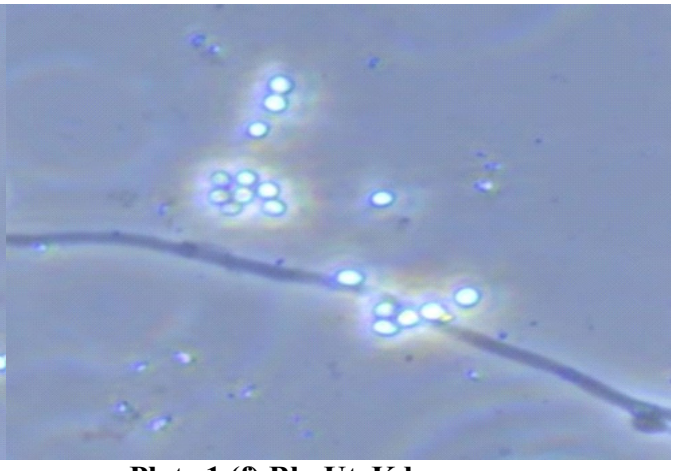

Plate 1 (f) Bb. UtrKdp

Plates 1. Morphological structures of native isolates of *B. bassiana* observed at 400x magnification.

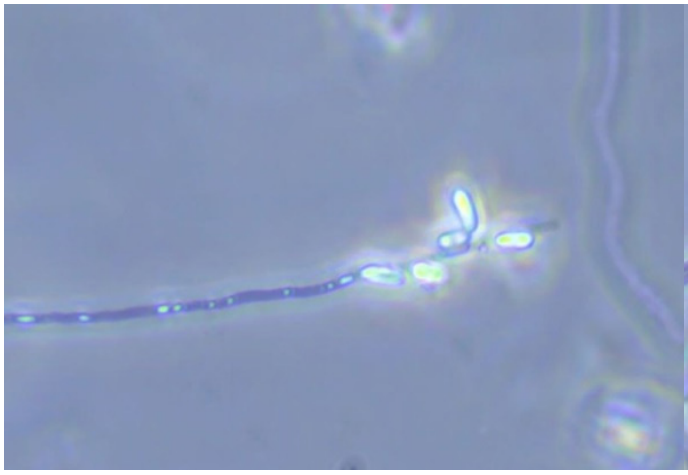

Plate 2 (a) Ma.Dpl.

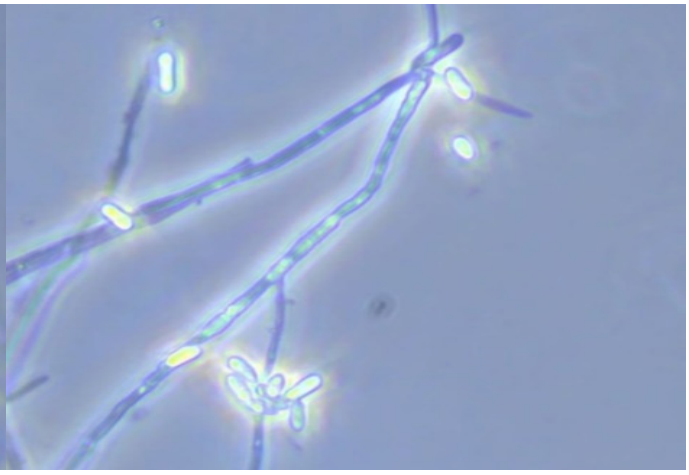

Plate 2 (b) Ma. Pmr. Ctr

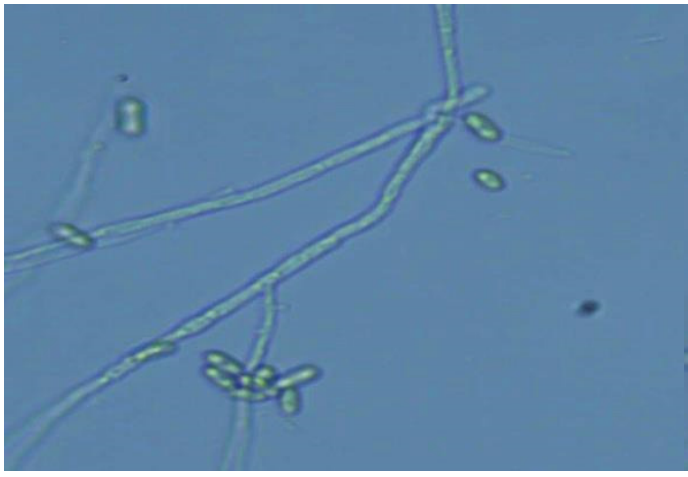

Plate 2 (c) Ma.Gty. Atp

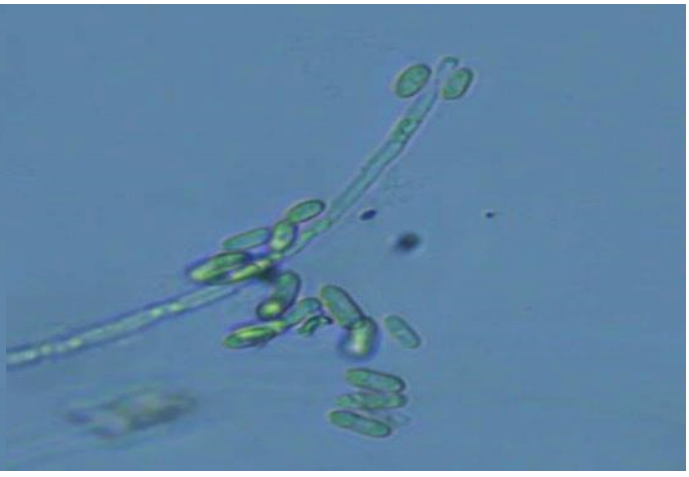

Plate 2 (d) Ma.Pkd. Knl

Plate 2 (e) Ma.Dvk. Knl

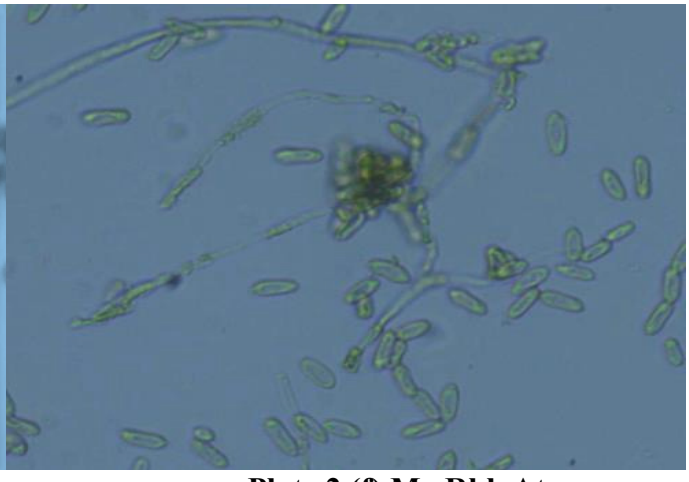

Plate 2 (f) Ma.Rkl. Atp

Plates 2. Morphological structures of native isolates of *M. anisopliae* observed at 400x magnification.

was measured to be between 3.0 and 3.6 µm in width. No branched conidiophores. Conidiophores ranged in width from 4.3 to 6.0 µm. Conidia were raised from the conidiophores. The majority of the conidia were elliptical and elongated in shape (Plate 2b). Conidia were measured from 6.7 to 7.5 µm in length and 3.2 to 3.5 µm in width.

Isolate 9. *Metarhizium anisopliae*, Pattikonda, Kurnool (Ma. Pkd. Knl)

The growth of this isolate on SMAY medium began with the development of white to yellowish mycelia, followed by the simultaneous sporulation after 7 days. Mycelial strands measured between 3.2 to 3.7 µm in width, while conidiophores ranged from 4.0 to 5.9 µm in width. Conidia were produced directly from the conidiophores, which were observed to be unbranched in this instance. The conidia displayed an elongated ellipsoidal to cylindrical shape (Plate 2c). The conidia were measured to be 6.0 to 7.1 µm in length and 3.1 to 3.3 µm in width.

Isolate 10. *Metarhizium anisopliae*, Devanakonda, Kurnool (Ma. Dvk. Knl)

On SMAY medium, the growth of fungi began with the appearance of white to yellowish hyphae, spreading radially across the plate. The colony exhibited a distinct white edge, while sporulation was primarily concentrated in the central region. The conidiophores were sparse and unbranched, producing conidia directly. The width of the mycelia was measured between 3.2 and 4.1 µm, while the conidiophores ranged from 4.2 to 6.0 µm in width. The majority of the conidia displayed an elongated shape, with broader elliptical ends or cylindrical forms (Plate 2d). The conidia measured between 6.3 and 7.2 µm in length and 3.2 to 4.0 µm in width. This sequential growth pattern reflects typical morphological development, with a clear differentiation between hyphal growth and sporulation stages.

Isolate 11. *Metarhizium anisopliae*, Gooty, Anantapuramu (Ma. Gty. Atp)

The growth of mycelia was raised form with simultaneous abundant sporulation of *M. anisopliae* on SMAY medium in the petriplate was observed. The dark green sporulation was seen in the centre part, surrounded by pale yellowish mycelium. Mycelia width was measured to be between 3.0 and 3.6 µm in width. Conidia were raised from the conidiophores. No branched conidiophores. Conidiophores ranged in width from 4.3 to 6.1 µm. The majority of the conidia were elliptical and elongated in shape (Plate 2e). Conidia were measured from 6.4 to 7.5 µm in length and 3.4 to 3.6 µm in width.

Isolate 12. *Metarhizium anisopliae*, Rekulakunta, Anantapuramu (Ma. Rkl. Atp)

The growth of mycelia was observed as white to yellowish mycelia with simultaneous abundant sporulation of *M. anisopliae* on SMAY medium in the petriplate was observed. Conidia were raised from the conidiophores. No branched conidiophores. The majority of the conidia were elongated ellipsoidal to cylindrical in shape (Plate 2f). Mycelia width was measured to be between 3.2 to 3.7 µm. Width of the conidiophores ranged from 4.0 to 6.2 µm. Conidia were measured from 6.7 to 7.2 µm in length and 3.2 to 3.5 µm in width.

In the present study of *M. anisopliae* isolates, the growth of mycelia was raised form with concurrent abundant sporulation of *M. anisopliae* on SMAY medium was seen. The dark green sporulation was observed in the centre part, surrounded by yellowish to white mycelium. Conidia were raised from conidiophores. Conidiophores were less branched or had no branches. The majority of the conidia were elongated with broader ends (Oblong) and round in shape. The mycelial width of *M. anisopliae* isolates ranged between 3.0 to 4.1 µm, conidiophore width ranged between 4.0 to 6.3 µm. Conidia were measured from 6.0 to 7.8 µm in length and 3.1 to 4.0 µm in width. (Table 2)

The results of Ma. Dpl. Ctr, Ma. Pmr. Ctr, Ma. Pkd. Knl, Ma. Dvk. Knl, Ma. Gty. Atp, Ma. Rkl. Atp isolates measurements revealed that different structures of *M. anisopliae* had more or less identical measures. The mycelial width of *M. anisopliae* isolates ranged between 3.0 to 4.5 µm, conidiophore width ranged between 4.0 to 7.4 µm. Conidia were measured from 6.0 to 7.9 µm in length and 3.1 to 4.0 µm in width.

The results are in conformity with Neto *et al.* (2024) whoreported that *B. bassiana* presents white to yellowish white colonies with a woolly to cottony appearance on media. Colonies are composed of aerial hyphae and aggregates of conidiogenic hyphae and conidia, which form spherical clusters (conidiophores). Microscopically, the fungus has hyaline, septate and branched hyphae with smooth walls, measuring up to

2.5 µm thick. Conidiogenic hyphae are either in groups or single and have an ampulliform basis. Conidia (1.9–2.7×1.4–1.8 µm) are hyaline, globose to subglobose, and not septate and have thin, smooth walls.

The presesnt findings are also in agreement with the findings of Cokola *et al.* (2023) who reported that conidia from *B. bassiana* isolate P5E were slightly larger than those from KA14 in size, on average. Conidial measurements were variable and ranged from 2.4-3.6 µm in length and from 1.8 to 3.0 µm in width. The mean conidial length was 3.2±0.32 µm for isolate P5E versus 2.7±0.21 µm for isolate KA14. The largest value of conidial width was recorded in isolate P5E (2.45±0.27 µm) compared to isolate KA14 (2.34±0.17 µm).

The results are in line with Gowri (2022) who stated in the morphological study of four isolates of *M. anisopliae*, conidiophores were found to be few branched to no branches, Aseptate, and wider than mycelium in the majority of isolates. The shape of the conidia was elongated with broader ends, round and elliptical conidia. Mostly, similar measurements were found in all the isolates. The mycelial width of *M. anisopliae* isolates ranged between 3.3 to 4.5 µm, conidiophore width ranged between 4.3 to 7.7 µm. Conidia were measured from 6.0 to 8.0 µm in length and 3.2 to 4.0 µm in width. The colonies grow from white to dark green to brownish green in colour. Similarly, Thaochan and Sausaard (2017) categorized *M. anisopliae* conidial morphologies according to length to width (L/W) ratio into four groups: 1.69-1.96, 2.01-2.47, 2.55-2.94 and 3.14-3.16.

Bai *et al.* (2015) observed that colony borders of all the isolates of *M. anisopliae* were regular. During sporulation, the colour of colonies became yellow green or olivaceous green to dark green. The average spore width was 2.10- 4.10 µm, while the average spore length was 3.20- 7.69 µm. The spores were categorized as oval, round, or elongated based on their length and width. Sepulveda *et al*. (2016) studied the six promising strains of *Metarhizium* spp. The average conidia length and width for the six strains were 5.09 µm and 1.92 µm, respectively.

The morphological characterization of native *Beauveria bassiana* and *Metarhizium anisopliae* isolates shows distinct growth and sporulation patterns, providing essential markers for initial identification in biocontrol efforts. *B. bassiana* isolates consistently displayed white to powdery mycelia with globose conidia, while *M. anisopliae* developed dark green colonies with cylindrical conidia. In *B. bassiana* Conidia were measured from 1.9 – 3.1 µm in length and 1.6 – 2.8 µm in width whereas in case of *M. anisopliae*, Conidia were measured from 6.7 to 7.2 µm in length and 3.2 to 3.5 µm in width. Future studies should integrate molecular techniques to complement morphological data, enhancing species identification and insights into genetic diversity. This approach is vital for optimizing entomopathogenic fungi use in pest management, supporting precision and sustainability in agriculture.

LITERATURE CITED

Bai, N.S., Sasidharan, T.O., Remadevi, O.K., Dharmarajan, P., Pandian, S.K and Balaji, K. 2015. Morphology and RAPD analysis of certain potentially entomopathogenic isolates of *Metarhizium anisopliae* Metsch. (Deuteromycotina: Hypocreales). *Journal of Microbiology and Biotechnology Research.* 5(1): 34- 40.

Boucias, D., Stokes, C., Suazo, A and Funderburk, J. 2000. AFLP analysis of the entomopathogen *Nomuraea rileyi. Mycologia*. 92: 638-648.

Cokola, M.C.,Fekih, B.I., Bisimwa, E.B., Megido,C. R., Delvigne, F and Francis, F. 2023. Natural occurrence of *Beauveria bassiana* (Ascomycota: Hypocreales) infecting *Spodoptera frugiperda* (JE Smith)(Lepidoptera: Noctuidae) and earwig in eastern DR Congo. *Egyptian Journal of Biological Pest Control*. 33(1): 54.

Fernandes, E.K.K., Keyser, C.A., Chong, J.P., Rangel, D.E.N., Miller, M.P and Roberts, D.W. 2009. Characterization of *Metarhizium* species and varieties based on molecular analysis, heat tolerance and cold activity. *Journal of Applied Microbiology.* 108: 115-128.

Gowri, V. 2022. Morphological and molecular characterization of *Metarhizium rileyi* and *Metarhizium anisopliae*. *M.Sc. (Ag.) Thesis*. Acharya N.G. Ranga Agricultural University Lam, Guntur.

Manjula, K., Saheb, P.Y., Sudheer, J.M and Rao, R.A. 2019. First Record on Occurrence of Epizootics of *Metarhizium anisopliae* (Metchnikoff) Sorokin on Groundnut Leaf Miner, *Aproaremamodicella* (Deventer). *International Journal of Current Research.* 11(4): 2715-2717.

Neto, S.C.D.M., Calaça, F.J.S., de Souza, W.G., Santos, L.A.C., de Pina, I.J., Xavier-Santos, S. and Calil, F.N., 2024. First natural occurrence of the entomopathogenic fungus *Beauveria bassiana* (Bals. Criv.) Vuill. on Cosmopolites sordidus (Germar, 1824)(Curculionidae, Coleoptera) in an agroforestry system in the Brazilian Cerrado. *Check List*. 20(1): 47.

Nishi, O., Iiyama, K., Yasunaga-Aoki, C and Shimizu, S. 2011. Incongruence between EF1α Phylogeny and Morphology of *Metarhizium majus* and *Metarhizium guizhouense* in Japan. *Entomotech*. 34:19-23.

Sepulveda, M., Vargas, M., Gerding, M., Ceballos, R and Oyarzua, P. 2016. Molecular, morphological and pathogenic characterization of six strains of *Metarhizium spp*. (Deuteromycotina: Hyphomycetes) for the control of Aegorhinussuperciliosus (Coleoptera: Curculionidae). Chelian. *Journal of Agricultural Research.* 76(1): 77- 83.

Thaochan, N and Sausard, W. 2017. Occurrence and effectiveness of indigenous *Metarhizium anisopliae* against adults *Zeugodacuscucurbitae* (Coquillett) (Diptera: Tephritidae) in Southern Thailand. Songklanakarin. *Journal of Science and Technology.* 39(3): 325-334.

Toledo, A.V., De Remes Lenicov, A.M.M and Lastra, L.Y.C.C. 2008. Host range findings on *Beauveria bassiana* and *Metarrhizium anisopliae* (Ascomycota: Hypocreales) in Argentina. *Bulletin of the Botanical Society Argentina*. 43(3-4): 211-220.

Andhra Pradesh J Agril. Sci : 10(4): 311-317, 2024

GENETIC DIVERSITY ANALYSIS OF 64 MAIZE INBRED LINES FOR YIELD TRAITS USING D² STATISTICS AND PRINCIPAL COMPONENT ANALYSIS

N. SUDHARSHAN, I. SUDHIR KUMAR*, M. SHANTHI PRIYA, P. MUNIRATHNAM AND M. REDDY SEKHAR

Department of Genetics and Plant Breeding, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

To discriminate maize inbred lines based on yield traits using D^2 statistics and principal component analysis (PCA), sixty four genotypes available at Department of Genetics and Plant breeding, Agriculture Research Station, Peddapuram, Andhra Pradesh were tested during *Rabi*, 2023-24 under irrigation condition in Alpha lattice design with two replications. Analysis of variance revealed significant differences for 14 characters studied among the genotypes. The D^2 statistics displayed that cluster II, being largest group, comprises 37 maize genotypes followed by cluster I (15), III (10), IV (1) and V (1). The maximum intra-cluster distance was obtained for cluster I (99.05) while cluster IV and V showed null values as they were monogenetic clusters. Furthermore, maximum inter-cluster distance was recorded between cluster V and IV (2342.19) followed by clusters I and IV (2038.71) and clusters V and III (1391.95). D^2 statistics and principal component analysis (PCA) emphasized that days to 50 per cent anthesis, plant height, ear height, 100- kernel weight, shelling percentage, number of kernels row^{-1}, and number of kernel rows ear^{-1} and kernel yield $plant^{-1}$ were major contributing traits for total genetic diversity. Research results indicated that the inbreds under study are highly diversified and hence, high heterotic hybrids would be resulted through the crossing of diverse lines clubbed under different clusters as parent in any breeding programme aimed to enhance grain yield.

KEYWORDS: Genetic diversity, Inbred lines, D^2 stastic, Yield traits, Principal component analysis.

INTRODUCTION

Maize (*Zea mays* L.) is a diploid plant species with a chromosome number of 20 (2n=20), ranking as one of the world's most important cereal crops, alongside rice and wheat. It belongs to the family Poaceae, the subfamily Panicoideae, and the tribe Maydeae. Archaeological and molecular evidence indicates that modern maize was domesticated from annual teosinte (*Zea mays* ssp. *Parviglumis*) in southern Mexico between 6,600 and 9,000 years ago (IIMR, 2023). Known as the "Queen of Cereals," maize boasts the highest yield potential among all cereals. It is a versatile crop with wide genetic variability, capable of thriving in tropical, subtropical, and temperate agro-climatic conditions worldwide.

Global maize production reached approximately 1.21 billion tonnes in 2023. The United States led the production with an estimated production of 384 mt, making it the top producer worldwide. Other major maize-producing countries are China, Brazil, and Argentina. India has been among the top 10 maize producers in the world since 1961, and currently ranks 5th (FAO 2023) and 14th largest exporter of Maize in the world (UN-COMTRADE data, 2022), contributing around 38.09 mt in 2023. Andhra Pradesh produced approximately 4.14 mt of maize, with an area under cultivation of around 2.6 lakh hectares. This accounted for about 11.5% of India's total maize production, which was around 33 m t (APSSDC, 2023).

The hybrid seed industry utilizes maize inbred lines selectively, depending on the availability of lines from diverse source populations and gene pools, while evaluating their individual performance and hybrid potential. Comprehensive understanding of genetic diversity among genotypes is critical for selecting parents in hybridization programs, particularly in cross-pollinated crops like maize.

Grain yield, a complex quantitative trait, results from the interplay of key processes such as photosynthesis, transpiration, and food storage (Naushad *et al*., 2007), alongside the coordinated contribution of traits like the number of kernels per plant, number of kernel rows per ear, number of kernels per row, and 100-kernel weight (Viola *et al*., 2003). Significant genetic variability, which reflects heritable differences among cultivars, is essential to ensure the effectiveness and longevity of plant breeding programs. Advanced biometrical

*Corresponding author, E-mail: i.sudhirkuma@angrau.ac.in

techniques, such as multivariate analysis (Rao, 1952) using Mahalanobis' (1936) D^2 statistics and principal component analysis (PCA) (Pearson, 1901), have made it possible to quantify and assess the genetic diversity within germplasm. This study focused on distinguishing maize inbred lines based on yield and yield contributing traits using D^2 statistics and PCA.

MATERIAL AND METHODS

The study was conducted at Agricultural Research Station, Peddapuram, Andhra Pradesh during *Rabi* 2023-24 under irrigated conditions. The experiment was laid out in Alpha Lattice design. The experimental material used in the present study consisted of 64 maize inbred lines developed at ARS, Peddapuram. The entire experimental area was divided into two replications, each comprising (64 of 8) = 8 blocks. Within each block, eight inbred lines were allocated. Each inbred line was planted in two rows, each spanning 4 meters in length, with a spacing of 60cm between rows and 20cm within the rows.

Observations on various parameters were recorded for three plants selected at random from each entry in each replication except for days to 50% anthesis, days to 50% silking, anthesis silking interval were recorded on plot basis.

Statistical analysis

Statistical analysis of genetic divergence was computed by using D^2 statistics of Mahalanobis (1936), and clustering of genotypes was done according to Tocher's optimization method as described by Rao (1952). Relative contribution of characters towards genetic divergence was calculated as per the guideline of Singh and Chaudhary (1985). The principal component analysis was done as described by Pearson (1901).

RESULTS AND DISCUSSION

Cluster composition

The 64 inbred lines were grouped into five clusters by using Tocher's method. The distribution of inbred

Table 1. List of genotypes studied

S. No.	Inbred line	T. No.	Inbred line	S. No.	Inbred line	T. No.	Inbred line
1	PL 23039	**17**	PL 23055	**33**	PL 23071	**49**	PL 23087
2	PL 23040	**18**	PL 23056	**34**	PL 23072	**50**	PL 23088
3	PL 23041	**19**	PL 23057	**35**	PL 23073	**51**	PL 23089
4	PL 23042	**20**	PL 23058	**36**	PL 23074	**52**	PL 23090
5	PL 23043	**21**	PL 23059	**37**	PL 23075	**53**	PL 23091
6	PL 23044	**22**	PL 23060	**38**	PL 23076	**54**	PL 23092
7	PL 23045	**23**	PL 23061	**39**	PL 23077	**55**	PL 23093
8	PL 23046	**24**	PL 23062	**40**	PL 23078	**56**	PL 23094
9	PL 23047	**25**	PL 23063	**41**	PL 23079	**57**	PL 23095
10	PL 23048	**26**	PL 23064	**42**	PL 23080	**58**	PL 23096
11	PL 23049	**27**	PL 23065	**43**	PL 23081	**59**	PL 23097
12	PL 23050	**28**	PL 23066	**44**	PL 23082	**60**	PL 23098
13	PL 23051	**29**	PL 23067	**45**	PL 23083	**61**	PL 23099
14	PL 23052	**30**	PL 23068	**46**	PL 23084	**62**	PL 23100
15	PL 23053	**31**	PL 23069	**47**	PL 23085	**63**	PL 23101
16	PL 23054	**32**	PL 23070	**48**	PL 23086	**64**	PL 23102

lines into five clusters is presented in Table 2. Cluster I had 15 inbred lines while, cluster II had highest number of inbred lines i.e., 37, cluster III had 10 inbred lines. The clusters IV and V had single inbred line i.e., unitary clusters. Jaishreepriyanka *et al.* (2020) reported similar grouping pattern of maize inbred lines in their studies.

Intra and Inter-cluster average distance

The intra- and inter-cluster distances for the five clusters are summarized in Table 3 and visualised in Figure 2. Intra-cluster average D^2 values ranged from 0 to 99.05, with cluster II exhibiting the highest intra-cluster distance (99.05) and cluster I showing the lowest (51.91). Clusters IV and V had zero intra-cluster distances, as each contained a single inbred line, indicating their uniqueness and potential utility in breeding programs. Among inter-cluster distances, the lowest D^2 value was observed between clusters I and V (143.11), followed by clusters IV and III (175.83). The highest inter-cluster distance was recorded between clusters V and IV (2342.19), followed by clusters I and IV (2038.71).

Relative contribution of individual characters towards divergence

The characters appeared in the first rank contribute more towards diversity. Among all the characters, kernel yield plant^{-1} contributed the maximum (14.53%) to the diversity by taking the first rank in 291 times, followed by shelling percentage (12.32%) with 246 times ranked first, number of kernels rows^{-1} (9.25%) with 185 times ranked first and number of kernel rows ear^{-1} contributed 8.54% with 170 times ranked first. 100-Kernel weight (8.54%) with 171 times ranked first. Other characters *viz*., anthesis- silking interval, ear height, tassel height, days to maturity, ear girth, ear length, plant height, days to 50% silking, days to 50% anthesis contributed 7.87, 6.58, 5.88, 5.87, 4.87, 4.8, 3.87, 3.76 and 3.32 per cent, respectively to the total genetic diversity (Table 5). Similar kind of results were reported by Amin *et al.* (2013), Maruthi *et al.* (2015) and Lone *et al.* (2017).

In this study, Mahalanobis D^2 statistics and the clustering pattern showed that Cluster II had the highest intra-cluster distance (99.05), indicating significant variability and potential for within-cluster selection. Clusters IV and V, containing only one inbred line each, were unique and may harbor rare alleles beneficial for breeding programs. The highest inter-cluster distance was recorded between Clusters IV and V (2342.19), followed by Clusters I and IV (2038.71), reflecting their extreme genetic divergence. Inbred lines from clusters with high inter-cluster distances are likely to produce

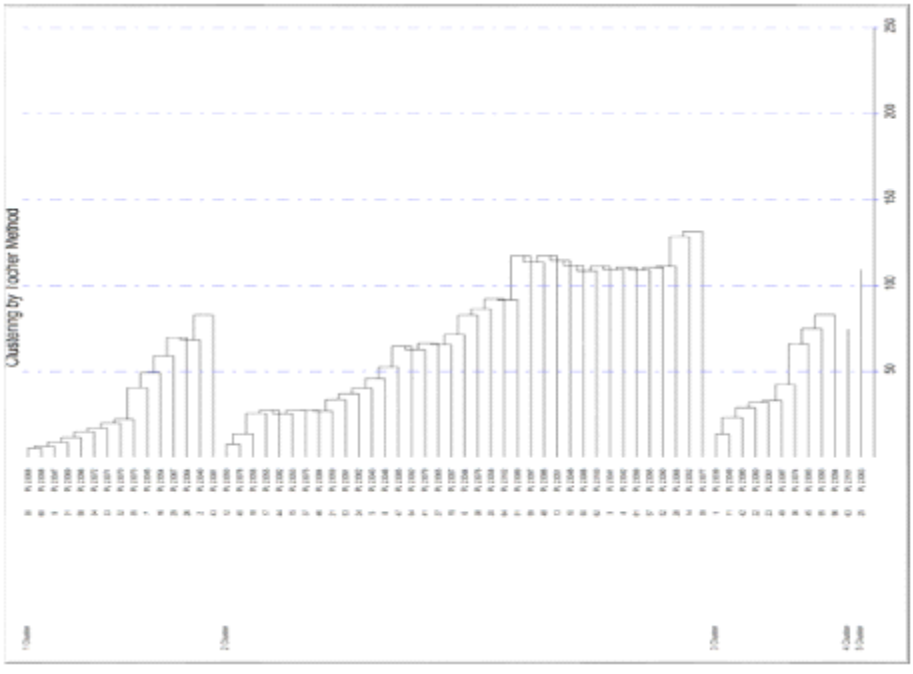

Fig 1. Dendrogram showing relationship based on Mahalanobis D^2 values in 5 clusters among 64 inbred lines of maize (*Zea mays* L.).

Table 2 Clustering pattern by Tocher's method

Cluster Group	No. of Genotypes	List of Genotypes
I Cluster	15	PL23068, PL23098, PL23047, PL23069, PL23096, PL23072, PL23071, PL23070, PL23073, PL23045, PL23054, PL23067, PL23064, PL23040 and PL23081
II Cluster	37	PL23050, PL23078, PL23056, PL23055, PL23082, PL23053, PL23075, PL23084, PL23059, PL23091, PL23062, PL23043, PL23046, PL23085, PL23092, PL23079, PL23065, PL23057, PL23044, PL23076, PL23058, PL23102, PL23089, PL23097, PL23086, PL23051, PL23048, PL23088, PL23100, PL23041, PL23042, PL23099, PL23095, PL23090, PL23066, PL23052 and PL23077
III Cluster	10	PL23039, PL23049, PL23080, PL23060, PL23061, PL23087, PL23074, PL23083, PL23093 and PL23094.
IV Cluster	1	PL23101
V Cluster	1	PL23063

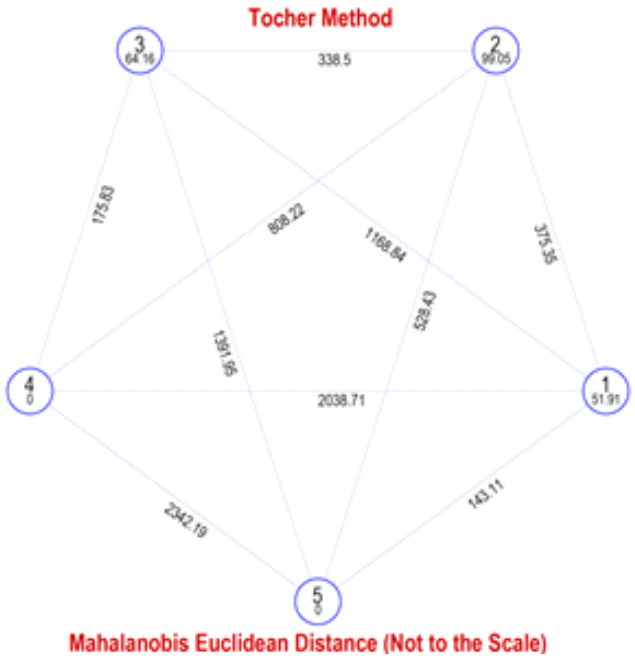

Fig 2. Intra and inter-cluster distances in five clusters based on Tocher's method in maize.

hybrids with maximum heterosis. Key traits contributing to genetic diversity included kernel yield plant^{-1} (14.53%), shelling percentage (12.32%), and number of kernels row^{-1} (9.25%), making lines excelling in these traits ideal for hybridization programs.

PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) simplifies large datasets, like the one with 14 variables in this case, into a smaller set of variables called principal components (in this study, six components). PCA is a straightforward eigenvector-based multivariate analysis, typically performed on a symmetric covariance matrix. The process involves eigenvalue decomposition of the covariance matrix or singular value decomposition of the data matrix to extract the principal components.

The first principal component (PC1) explained 38.35 per cent of the variance, mainly driven by anthesis-silking interval, days to 50 per cent silking, and kernel traits. The second component (PC2) accounted for 12.80 per cent of the variance, with kernel yield plant^{-1} and 100-kernel weight as key factors. PC3 (11.23%) was influenced by tassel height and ear length, while PC4 (10.38%) highlighted 100-kernel weight and days to 50 per cent anthesis. PC5 (8.11%) was shaped by days to 50% anthesis and ear height, and PC6 (6.19%) by the number of kernel rows^{-1} and days to 50% anthesis.

The PCA scores for 64 maize genotypes across the first three principal components were calculated and presented as three axes (X, Y, Z), with squared distances of each genotype from these axes. The scores were plotted in biplot. Figures 3. Genotypes positioned at the extreme

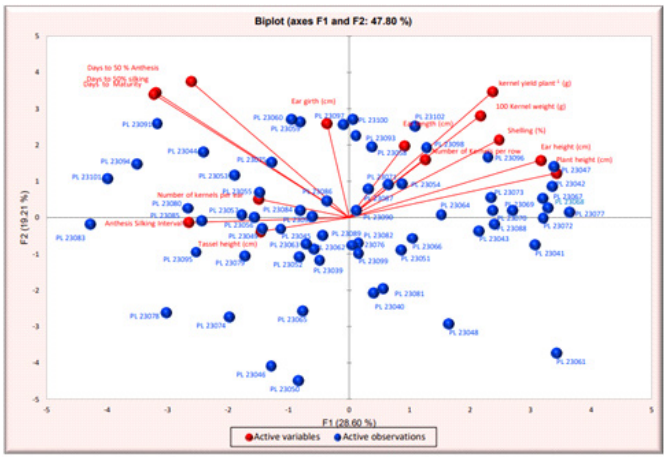

Fig 3. Biplot showing scattering of 64 genotypes of maize (*Zea mays* L.) based on PCA score.

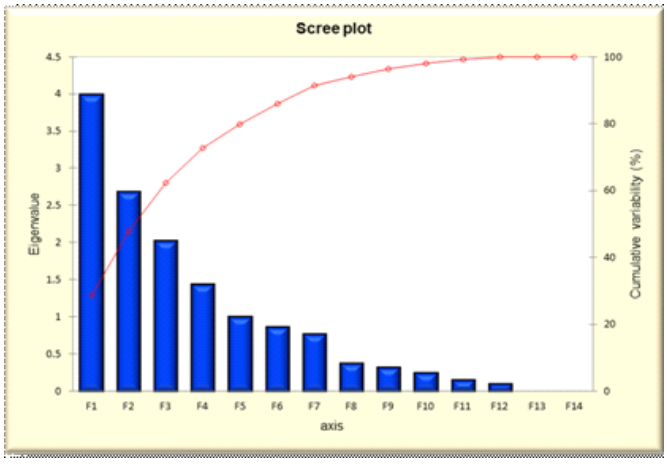

Fig 3. Scree plot showing the eigen values of principal components in PCA of maize (*Zea mays* L.).

Table 5. The relative contribution of 14 characters to genetic diversity in 64 maize inbred lines

S. No.	Source	Contribution %	Times ranked 1st
1	Days to 50% anthesis	3.32	66
2	Days to 50% silking	3.76	75
3	Anthesis-silking Interval	7.87	157
4	Plant height (cm)	3.87	77
5	Tassel height (cm)	5.88	118
6	Ear height (cm)	6.58	132
7	Ear length (cm)	4.8	96
8	Ear girth (cm)	4.87	97
9	Days to maturity	5.87	117
10	Number of kernels rows ear^{-1}	8.54	171
11	Number of kernels row^{-1}	9.25	185
12	100-Kernel weight (gm)	8.54	171
13	Shelling (%)	12.32	246
14	Kernel yield plant^{-1} (g)	14.53	291

positive side on both axes, such as PL23101, PL23094, PL23083, PL23093, PL23049, and PL23060 along PCA I, and PL23093, PL23094, PL23102, PL23089, and PL23101 along PCA II, were identified as superior. In the biplot, genotypes like PL23091, PL23094, PL23101, PL23083 located far from the center which may be useful for hybridization programs.

The scree plot graph, constructed using eigen values and component numbers (Table 6), shows that from the 6th component onward, the line becomes nearly flat, indicating that each successive component contributes less to the total variance. In plant breeding, only those principal components with eigenvalues greater than 1 are typically retained, as they explain a significant amount of

Table 6. Eigen values, proportion of total variance represented by first six principal components

Canonical Roots Analysis (P.C.A.)							
Sl. No.		1 Vector	2 Vector	3 Vector	4 Vector	5 Vector	6 Vector
	Eigen Value (Root)	5.369	1.791	1.572	1.454	1.135	0.867
	% Vac. Exp.	38.353	12.796	11.229	10.384	8.109	6.192
	Cum. Van Exp.	38.353	51.149	62.379	72.763	80.872	87.064
1.	Days to 50% anthesis	0.047	0.305	0.308	0.242	0.520	0.415
2.	Days to 5 0% silking	0.393	0.201	0.150	-0.082	0.142	0.046
3.	Anthesis silking interval	0.406	0.126	0.071	-0.158	0.000	-0.072
4.	Plant height	-0.121	0.255	-0.404	-0.477	0.115	-0.132
5.	Tassel height	-0.200	-0.029	0.576	-0.158	-0.049	0.075
6.	Ear height	-0.045	0.398	0.015	-0.143	0.515	-0.307
7.	Ear length	-0.1S9	0.036	0.535	-0.037	-0.162	-0.535
8.	Ear girth	-0.302	0.200	0.113	-0.200	-0.244	0.364
9	Days to Maturity	-0.388	0.089	-0.191	-0.183	0.080	0.180
10.	Number of kernel rows ear^{-1}	0.331	-0.050	0.125	-0.248	-0.131	0.429
11.	Number of Kernels row^{-1}	0.258	-0.028	0.124	-0.549	-0.003	-0.144
12.	100 Kernel weight	0.152	0.473	-0.096	0.441	-0.227	-0.183
13.	Shelling percentage	-0.381	0.099	0.086	-0.015	0.149	0.051
14.	kernel yield plant^{-1}	-0.017	0.584	0.005	-0.070	-0.496	0.103

variance. In this study, components like days to 50 per cent anthesis (4.004), days to 50 per cent silking (2.689), anthesis-silking interval (2.032), plant height (1.438), and tassel height (1.002) have eigenvalues greater than 1. Components with eigenvalues less than 1, including traits such as ear height, ear length, ear girth, days to maturity, and others, account for less variance and are considered less useful. The scree plot of these values is shown in Figure 4.

The application of Mahalanobis D² statistics and Principal Component Analysis (PCA) in this study effectively identified significant genetic diversity among 64 maize inbred lines. Cluster analysis revealed substantial intra- and inter-cluster variation, with clusters IV and V showing unique potential for breeding due to their genetic divergence. The PCA reduced the complexity of 14 morphological traits into six principal components, explaining over 87% of the total variability, and identified key traits such as kernel yield plant^{-1}, plant height and ear height as primary contributors to genetic diversity. Genotypes like PL23101 and PL23094 on extreme positive axes of PCA were superior, while combining clusters with high D² and PCA identified traits that ensures generation of heterotic hybrids with significant yield improvement. Selecting complementary traits, such as pairing high kernel yield with desirable morphological traits, can enhance hybrid performance and accelerate breeding for improved maize varieties.

LITERATURE CITED

Amin, M.N., Amiruzzaman, M., Ahmed, A., Rohman, M.M and Ali, M.R. 2013. The genetic diversity of white inbred lines of quality protein maize (QPM). *Eco-Friendly Agricultural Journal*. 6(9): 13-17.

Beck, D.L., Vasal, S.K and Crossa, J. 1990.Heterosis and combining ability of CIMMYT's tropical early and intermediate maturity maize (*Zea mays* L.) germplasm. *Maydica.* 35 : 279-285.

DESAP. 2022. Annual report. Directorate of Economics and Statistics Andhra Pradesh. https://des.ap.gov.in.

FAO. 2023. Database. Food and Agriculture Organization, United Nations. www.fao.org/publications.

Jaishreepriyanka, R., Sinha, S., Mandal, S.S., Singh, B and Rashmi, K. (2020). Diversity Analysis of Maize Inbred Lines. *International Journal of Current Microbiology and Applied Sciences*. 9(10), 2765-2773.

Lone, R.A. 2017. Genetic diversity in maize (*Zea mays* L.) inbred lines from Kashmir. *International Journal of Pure Applicational Bioscience*. 5 (1): 229-235.

Mahalanobis, P.C. 1936. On the generalized distance in statistics. *Proceedding of National Institute of Science*. 49-55.

Maruthi, R.T and Rani, K.J. 2015. Genetic variability, heritability, and genetic advance estimates in maize (*Zea mays* L.) inbred lines. *Journal of Applied and Natural Science*. 7 (1): 149-154.

Moll, R.H., Lonquist, J.H., Velez Fortuno, J. and Johnson, E.C. 1965.The relationship of heterosis and genetic divergence in maize. *Genetics*. 52:139-144.

Naushad, A., Turi, S., Shah, S., Ali, S., Rahman, H., Ali, T and Sajjad, M. 2007. Genetic variability for yield parameters in maize (*Zea mays* L.) genotypes. *Journal of Agricultural and Biological Science*. 2(4-5): 1-3.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical methods for agricultural workers. *ICAR Publications*.

Pearson, K. 1901.On lines planes of closest fit to systems of points in space. *Philosophical Magazine*. 2: 559–572.

Rao, C. R. 1952. Advanced statistical method in biometric research. *John Wiley and Sons.*

Singh, R.K. and Chaudhary, B.D. 1985. Biometrical methods in quantitative genetic analysis. *Kalyani Publishers*.

UN-COMTRADE. 2022. Database. The United Nations commodity trade statistics database. https://comtradeplus.un.org/Publication/ITSY

Viola, G., Ganesh, M., Reddy, S.S and Kumar, C.V.S. (2003). Study on heritability and genetic advances in elite baby corn (*Zea mays* L.) lines. *Progressive Agriculture*. 3(2): 127-128.

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SOIL PHYSICAL AND PHYSICO-CHEMICAL PROPERTIES AS INFLUENCED BY CROPPING SYSTEMS IN SPSR NELLORE DISTRICT, ANDHRA PRADESH, INDIA

R. CHANDANA*, B. VAJANTHA, M. SREENIVASA CHARI, U. VINEETHA AND M.V.S. NAIDU

Department of Soil Science And Agricultural Chemistry, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

Soil physical, physico-chemical properties are important for favourable crop growth and maintaining soil health. Cropping systems exert significant influence on soil properties which effects crop yield. Keeping this view, a study was taken up to know the effect of major cropping systems on soil physical and physico-chemical properties in SPSR Nellore district, Andhra Pradesh, India. Totally 100 soil samples were collected from five major cropping systems *viz.,* paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses and groundnut-paddy (20 samples from each cropping systems) in SPSR Nellore district analysed for texture, bulk density, pH, EC and organic carbon. The results revealed that the texture of soils under study in different cropping systems are sandy clay loam, sandy loam, clay loam and clay. The bulk density of soil varied from 1.10 Mg m^{-3} in fallow-paddy, paddy-pulses cropping systems to 1.80 Mg m^{-3} in paddy-paddy cropping systems. The pH of soils varied from 5.7 (slightly acidic) in paddy-cotton cropping system to 8.7 (strongly alkaline) in paddy-pulses cropping system. The EC of soils varied from 0.07 dS m^{-1} in fallow- paddy cropping system to 0.9 dS m^{-1} in paddy-pulses cropping system. The organic carbon varied from 0.29 per cent in paddy-paddy cropping system to 0.62 per cent in paddy-pulses cropping system.

KEYWORDS: Cropping systems, Soil physical and physico-chemical properties, SPSR Nellore district.

INTRODUCTION

Soil serves as a crucial medium for plant growth and its physical and physico-chemical properties significantly influence its fertility, structure and overall health. Different cropping systems have distinct effects and understanding these properties is essential for effective soil management and sustainable agricultural practices. For instance, diverse crop rotations often enhance soil structure, improve nutrient balance and increase organic matter content compared to monoculture systems, which may lead to nutrient depletion and soil degradation. The physical properties, such as soil texture, bulk density influence the soil's ability to support plant growth, manage water and ensure proper aeration. Meanwhile, the physico-chemical properties, including soil pH, EC, organic carbon determine the soil's fertility and its capacity to sustain crop yields. In this connection, the effect of cropping systems on soil physical and physico chemical properties in SPSR Nellore district was studied.

MATERIAL AND METHODS

The study area SPSR Nellore district lies in between 14° 4′ 12.9″ and 14^0 57′ 56.8″ latitude and $79^0$30′29.6″and $80^0$4′24.7″ longitude and the investigation was carried in the year 2024. One hundred soil samples were collected from five cropping systems *viz*., paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses and groundnut-paddy. From each cropping system 20 samples were collected. All the samples were analyzed for pH, EC, organic carbon following the standard procedures (Jackson, 1973). Particle size distribution of the soils was determined by Bouyoucous hydrometer method as described by Baruah and Barthakur (1997). Based on particle size distribution, textural classification was given using the *nomograph* (textural diagram) of USDA. Bulk density of soil samples were determined by following Keen Raczkowski's method as described by Sankaram (1966). Soil samples were rated as low, medium and high categories as per the limits suggested by Ahmed *et al*. (2007) for pH, EC and organic carbon.

RESULTS AND DISCUSSION

The data pertaining to soil physical and physico-chemical properties under different cropping systems in SPSR Nellore district was presented in Table 1.

Particle size distribution

Influence of cropping systems on soil physical and physio chemical properties

The texture of soils under different cropping systems were sandy clay loam, sandy loam, clay loam and clay in type. In the cropping system study percent of sand varied from 31.22 to 82.04, silt 2.80 to 26.95 and clay ranged

*Corresponding author, E-mail: rangechandana7@gmail.com

from 10.84 to 45.60. In paddy-paddy, fallow-paddy and groundnut-paddy cropping systems observed texture is sandy clay loam to sandy loam in texture while in paddy-cotton cropping system observed texture is sandy clay loam to clay loam. Fine textured clay loam to clay texture was noticed in cropping systems of paddy-pulses.

Variations in topographic situation, type of parent material, in situ weathering, clay translocation and soil age were considered as major factors to cause variations in soil texture. According to Charan *et al*. (2021), the soils in different cropping systems of Nellore district showed sandy clay loam to clay in soil texture.

Bulk density

The BD data presented in Table 1and is deduced that the bulk density of soils varied from 1.10 Mg m^{-3} in fallow-paddy, paddy-pulses and paddy-groundnut cropping systems to1.80 Mg m^{-3} in paddy-paddy cropping systems. The bulk density of soils in paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses and groundnut-paddy cropping systems was ranged from 1.45-1.8, 1.1-1.38, 1.35-1.66, 1.1-1.39 and 1.13-1.32 Mg m^{-3}, respectively with a mean value of 1.56, 1.23, 1.54, 1.20 and 1.20 Mg m^{-3}, respectively. The lowest mean bulk density was observed in paddy-pulses as 1.20 Mg m^{-3}, paddy-groundnut 1.20 Mg m^{-3}, fallow-paddy (1.23 Mg m^{-3}, paddy-cotton 1.54 Mg m^{-3} and paddy-paddy cropping system 1.56 Mg m^{-3}.

The highest bulk density was observed in paddy-paddy cropping system due to compaction of the top soil by repeated ploughing and puddling. Similar results were reported by Selassie and Ayanna (2013). The lowest bulk density was found under paddy-pulses and fallow- paddy cropping system due to higher amount of added biomass from leguminous crops made soil loose, porous and less squeezed (Kumar *et al*., 2020).

Physico - Chemical Properties Of Soils In Different Cropping Systems

The physico-chemical properties of soil samples under different cropping systems of SPSR Nellore district are presented in Table 1.

The pH of soils varied from 5.7 (slightly acidic) in paddy-cotton cropping system to 8.7 and (strongly alkaline) in fallow-paddy. The pH of soils in paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses and paddy-groundnut cropping systems were ranged from 7.2-8.3, 6.8-8.7, 5.7-8.1, 6.9-7.9 and 5.9-8.2, respectively.

The highest pH was recorded in soils of paddy-pulses cropping system and lowest in groundnut-paddy. This variations in soil reaction of different cropping systems is due to parent material from which soils were developed and due to the fact that continuous submerged conditions in paddy which might be resulted in lowering the pH of soils. Similar findings were also made by Bhatt *et al*. (2018) under the soils of rice-wheat cropping system.

Electrical Conductivity (EC)

The data pertaining to soil EC was presented in Table 1 and reveals that, the soils of major cropping systems in SPSR Nellore district were non-saline and are showing less than 4 dS m^{-1}.

The EC of soils varied from 0.07 dS m^{-1} in fallow-paddy cropping system to 0.97 dS m^{-1} in paddy-pulses cropping system. The EC of soils in paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses and paddy-groundnut cropping systems are ranged from 0.10-0.26, 0.07-0.38, 0.08-0.30, 0.40-0.97 and 0.07-0.43 dS m^{-1} respectively with a mean value of 0.20, 0.21, 0.17 ,0.66 and 0.19 respectively. The mean EC in different cropping systems were in the order of paddy-cotton (0.17 dS m^{-1}) followed by paddy-groundnut (0.19 dS m^{-1}), paddy-paddy (0.20 dS m^{-1}), fallow-paddy (0.21 dS m^{-1}) and paddy-pulses (0.66 dS m^{-1}).

The maximum EC of 0.97 dS m^{-1} was observed in soils of paddy-pulses cropping system in soils and minimum value of EC (0.07 dS m^{-1}) was observed in paddy-cotton cropping system soils. The soils in all cropping systems are non-saline with respect to soluble salt concentration. The data further revealed that because of good drainage condition, soil EC is within the normal range and soils are highly favorable to crop growth as they are free from salinity problem. The normal EC may be ascribed to leaching of salts to lower horizons. (Sharma*et al*., 2008).

Organic Carbon (OC)

The organic carbon of major cropping systems in SPSR Nellore district are low (0.29%) to medium (0.62%).

The organic carbon varied from 0.29 per cent in paddy-paddy cropping system to 0.62 per cent in paddy-pulses cropping system. The organic carbon of soils in paddy-paddy, fallow-paddy, paddy-cotton, paddy-pulses

Table 1. Physical and Physico-chemical properties of soils in different cropping systems of SPSR Nellore district

Paddy-Paddy Cropping System								
Sample No	Particle size distribution				BD ($Mg\ m^{-3}$)	pH	EC (dSm^{-1})	OC (%)
	Textural Class	Sand (%)	Silt (%)	Clay (%)				
1	Sandy clay loam	70.13	7.47	22.40	1.67	7.9	0.23	0.42
2	Sandy clay loam	63.18	8.45	28.37	1.80	7.9	0.22	0.32
3	Sandy clay loam	70.37	16.79	12.84	1.55	7.7	0.13	0.36
4	Sandy clay loam	62.87	9.59	27.54	1.61	7.8	0.25	0.42
5	Sandy clay loam	57.70	13.43	28.87	1.60	7.7	0.23	0.34
6	Sandy clay loam	69.24	9.68	21.08	1.55	7.6	0.23	0.44
7	Sandy clay loam	70.13	6.97	22.90	1.52	7.8	0.23	0.29
8	Sandy clay loam	69.04	6.36	24.60	1.53	7.9	0.25	0.32
9	Sandy clay loam	59.65	14.24	26.11	1.50	7.6	0.26	0.42
10	Sandy loam	72.68	16.04	11.28	1.56	7.5	0.24	0.36
11	Sandy loam	72.00	16.29	11.71	1.45	7.4	0.23	0.38
12	Sandy clay loam	64.06	14.06	21.88	1.48	7.3	0.25	0.36
13	Sandy clay loam	63.15	11.61	25.24	1.54	7.4	0.26	0.42
14	Sandy clay loam	63.26	11.73	25.01	1.51	7.9	0.13	0.34
15	Sandy clay loam	61.18	13.45	25.37	1.61	8.3	0.10	0.38
16	Sandy loam	70.34	14.64	15.02	1.52	7.2	0.11	0.37
17	Sandy loam	72.37	13.79	13.84	1.50	7.6	0.23	0.44
18	Sandy clay loam	72.65	5.61	21.74	1.60	7.7	0.10	0.36
19	Sandy clay loam	69.12	8.45	22.43	1.52	7.7	0.11	0.29
20	Sandy clay loam	53.70	16.43	29.87	1.64	7.8	0.12	0.32
Range	**SCl&Sl**	**53.70-72.68**	**5.61-16.79**	**11.28-29.87**	**1.45-1.80**	**7.2-8.3**	**0.10-0.26**	**0.29-0.44**
Mean	**SCl&Sl**	**66.34**	**11.75**	**21.91**	**1.56**		**0.20**	**0.37**

Cont...

Table 1. Physical and Physico-chemical properties of soils in different cropping systems of SPSR Nellore district

Fallow – Paddy Cropping System								
Sample No		**Particle size distribution**			**BD**	**pH**	**EC**	**OC**
	Textural Class	**Sand (%)**	**Silt (%)**	**Clay (%)**	**(Mg m^{-3})**		**(dS m^{-1})**	**(%)**
21	Sandy clay loam	74.26	6.76	22.98	1.38	7.2	0.23	0.39
22	Sandy clay loam	68.26	5.60	26.14	1.27	7.8	0.23	0.34
23	Sandy clay loam	73.17	4.28	22.55	1.13	7.7	0.25	0.37
24	Sandy loam	69.37	12.68	17.95	1.35	7.6	0.24	0.38
25	Sandy clay loam	71.65	6.21	22.14	1.32	8.7	0.22	0.41
26	Sandy clay loam	64.32	11.25	24.43	1.13	7.2	0.23	0.32
27	Sandy clay loam	55.56	12.43	32.01	1.36	7.7	0.25	0.38
28	Sandy clay loam	67.24	6.48	26.28	1.33	7.3	0.23	0.41
29	Sandy loam	79.70	4.26	16.04	1.23	7.9	0.23	0.34
30	Sandy loam	77.35	11.81	10.84	1.18	6.8	0.22	0.31
31	Sandy clay loam	58.34	9.26	32.40	1.16	7.6	0.38	0.34
32	Sandy loam	82.04	2.80	15.16	1.13	7.5	0.32	0.44
33	Sandy clay loam	65.48	6.34	28.18	1.26	7.7	0.24	0.42
34	Sandy clay loam	63.54	10.43	26.03	1.15	7.9	0.20	0.49
35	Sandy clay loam	63.89	14.04	22.27	1.14	7.8	0.12	0.48
36	Sandy loam	75.58	10.17	14.25	1.33	7.3	0.14	0.32
37	Sandy loam	72.23	11.74	16.03	1.23	7.6	0.14	0.38
38	Sandy loam	74.27	10.79	14.94	1.29	7.3	0.13	0.54
39	Sandy clay loam	72.27	6.51	21.22	1.20	7.7	0.11	0.42
40	Sandy clay loam	74.24	4.98	20.78	1.12	7.8	0.07	0.46
Range	**SCl&Sl**	**55.56-82.04**	**2.80-14.04**	**10.84-32.40**	**1.10-1.38**	**6.8-8.7**	**0.07-0.38**	**0.31-0.54**
Mean	**SCl&Sl**	**70.14**	**8.44**	**21.63**	**1.23**		**0.21**	**0.40**

Cont...

Table 1. Physical and Physico-chemical properties of soils in different cropping systems of SPSR Nellore district

Paddy – Cotton Cropping System								
Sample No	Particle size distribution				BD (Mg m^{-3})	pH	EC (dS m^{-1})	OC (%)
	Textural Class	Sand (%)	Silt (%)	Clay (%)				
41	Sandy clay loam	68.06	7.68	24.26	1.53	7.5	0.11	0.48
42	Sandy clay loam	57.26	12.50	30.24	1.56	7.4	0.13	0.54
43	Sandy clay loam	64.78	5.16	30.06	1.66	7.7	0.10	0.42
44	Sandy clay loam	56.28	15.36	28.36	1.60	7.8	0.08	0.36
45	Sandy clay loam	69.34	10.30	20.36	1.56	7.6	0.22	0.48
46	Sandy clay loam	72.82	3.88	23.30	1.40	7.7	0.14	0.36
47	Sandy clay loam	60.06	14.10	25.84	1.50	7.8	0.26	0.34
48	Sandy clay loam	59.60	15.31	25.09	1.52	7.9	0.25	0.44
49	Clay loam	44.65	17.90	37.45	1.64	7.6	0.30	0.52
50	Clay loam	42.95	24.45	32.60	1.66	8.1	0.24	0.55
51	Sandy clay loam	50.85	20.85	28.30	1.58	6.2	0.22	0.34
52	Sandy clay loam	58.30	16.10	25.60	1.47	5.7	0.23	0.38
53	Sandy clay loam	58.16	12.39	29.45	1.54	6.5	0.10	0.36
54	Sandy clay loam	51.85	17.35	30.80	1.35	6.4	0.10	0.37
55	Clay loam	45.50	20.64	33.86	1.63	7.9	0.13	0.49
56	Clay loam	43.86	25.58	30.56	1.43	7.9	0.12	0.46
57	Clay loam	43.30	26.24	30.46	1.42	7.6	0.08	0.55
58	Clay loam	43.70	26.95	29.35	1.52	7.8	0.20	0.48
59	Sandy clay loam	54.86	18.24	26.90	1.63	7.7	0.22	0.35
60	Sandy clay loam	62.06	11.42	26.52	1.56	7.8	0.24	0.49
Range	**SCl& Cl**	**42.95-72.82**	**3.88-26.95**	**20.36-37.45**	**1.35-1.66**	**5.7-8.1**	**0.08-0.30**	**0.34-0.55**
Mean	**SCl& Cl**	**55.41**	**16.12**	**28.47**	**1.54**		**0.17**	**0.44**

Cont...

Table 1. Physical and Physico-chemical properties of soils in different cropping systems of SPSR Nellore district

Sample No	Paddy – Pulses Cropping System							
	Particle size distribution				BD ($Mg\ m^{-3}$)	pH	EC ($dS\ m^{-1}$)	OC (%)
	Textural Class	Sand (%)	Silt (%)	Clay (%)				
61	Clay loam	42.24	21.47	36.29	1.18	7.6	0.40	0.48
62	Clay loam	44.06	17.27	38.67	1.21	7.2	0.65	0.62
63	Clay loam	40.85	25.78	33.37	1.19	7.7	0.92	0.54
64	Clay loam	44.02	22.53	33.45	1.26	7.9	0.77	0.62
65	Clay loam	43.16	24.46	32.38	1.32	6.9	0.60	0.56
66	Clay loam	43.14	23.39	33.47	1.12	7.6	0.67	0.44
67	Clay loam	43.36	19.18	37.46	1.11	7.4	0.76	0.59
68	Clay loam	44.34	16.36	39.30	1.15	7.3	0.76	0.54
69	Clay loam	41.14	20.26	38.60	1.21	7.4	0.57	0.52
70	Clay	31.22	23.18	45.60	1.14	7.4	0.61	0.58
71	Clay loam	35.90	22.57	41.53	1.28	7.4	0.59	0.53
72	Clay	33.28	25.32	41.40	1.39	7.1	0.46	0.56
73	Clay	32.96	21.56	45.48	1.27	7.2	0.83	0.48
74	Clay loam	43.12	20.63	36.15	1.33	7.1	0.97	0.42
75	Clay loam	42.55	20.58	36.87	1.22	7.3	0.44	0.58
76	Clay loam	45.04	25.69	29.27	1.10	7.2	0.63	0.52
77	Clay loam	45.26	18.18	36.56	1.18	7.4	0.43	0.49
78	Clay loam	44.14	17.56	38.30	1.13	7.6	0.83	0.55
79	Clay loam	43.24	20.26	36.50	1.15	7.7	0.79	0.48
80	Clay	33.32	22.66	44.02	1.10	7.5	0.57	0.43
Range	**Cl & C**	**31.22-45.26**	**16.36-25.78**	**29.27-45.60**	**1.10-1.39**	**6.9-7.9**	**0.40-0.97**	**0.42-0.62**
Mean	**Cl & C**	**40.82**	**21.44**	**37.73**	**1.2**		**0.66**	**0.53**

Cont...

Table 1. Physical and Physico-chemical properties of soils in different cropping systems of SPSR Nellore district

Groundnut – Paddy Cropping System

Sample No	Particle size distribution				BD (Mg m^{-3})	pH	EC (dS m^{-1})	OC (%)
	Textural Class	Sand (%)	Silt (%)	Clay (%)				
81	Sandy loam	66.56	15.28	18.16	1.27	6.4	0.30	0.41
82	Sandy clay loam	64.84	6.80	28.36	1.20	6.4	0.26	0.38
83	Sandy clay loam	62.18	9.45	28.37	1.16	6.1	0.25	0.42
84	Sandy clay loam	63.48	8.34	28.18	1.24	5.9	0.23	0.32
85	Sandy clay loam	64.54	10.43	25.03	1.23	6.3	0.25	0.46
86	Sandy clay loam	62.89	14.04	19.27	1.14	7.7	0.09	0.48
87	Sandy loam	73.58	11.17	18.25	1.16	7.4	0.10	0.41
88	Sandy loam	73.23	12.74	14.03	1.22	7.7	0.21	0.46
89	Sandy clay loam	57.28	14.56	28.16	1.32	7.7	0.23	0.38
90	Sandy clay loam	63.06	15.06	21.88	1.22	7.7	0.09	0.37
91	Sandy clay loam	62.21	12.67	25.12	1.19	8.1	0.10	0.41
92	Sandy clay loam	57.70	14.43	27.87	1.17	7.7	0.13	0.42
93	Sandy clay loam	73.24	5.68	21.08	1.20	7.2	0.16	0.44
94	Sandy clay loam	71.13	5.97	22.90	1.23	7.1	0.09	0.48
95	Sandy clay loam	69.04	6.60	24.60	1.18	7.5	0.08	0.44
96	Sandy clay loam	57.65	13.24	29.11	1.21	6.9	0.13	0.48
97	Sandy clay loam	65.37	8.29	26.34	1.14	7.4	0.16	0.42
98	Sandy clay loam	71.65	5.25	23.10	1.18	8.2	0.43	0.41
99	Sandy loam	73.96	11.02	15.02	1.24	7.4	0.38	0.38
100	Sandy loam	72.56	12.34	15.10	1.13	7.2	0.07	0.41
Range	**SCl&Sl**	**57.28-73.96**	**5.25-15.28**	**14.03-29.11**	**1.13-1.32**	**5.9-8.2**	**0.07-0.43**	**0.32-0.48**
Mean	**SCl&Sl**	**66.31**	**10.67**	**23.00**	**1.22**	**7.22**	**0.19**	**0.42**
Overall range		**31.22-82.04**	**2.8-26.95**	**10.84-45.6**	**1.1-1.8**	**5.7-8.7**	**0.07-0.97**	**0.29-0.62**

Cont...

and groundnut-paddy cropping systems are ranged from 0.29-0.44, 0.31-0.54, 0.34-0.55, 0.42-0.62 and 0.32-0.48 per cent, respectively with a mean value of 0.37, 0.40, 0.44, 0.53 and 0.42 per cent, respectively. The mean organic carbon of studied cropping systems are in the order of 0.37%, 0.40%, 0.42%, 0.44 % and 0.53% in paddy-paddy followed by fallow-paddy, groundnut-paddy, paddy-cotton and paddy-pulses cropping system respectively. The studied cropping systems falls in low to medium in organic carbon status.

The paddy-pulses cropping system showed higher OC than that of other cropping systems due to legume crop in the sequence might be having high root biomass, higher carbon sequestration and less carbon release than that of soils under other cropping systems. Similar findings were also made by Rajpoot *et al*. (2021) in rice-based cropping systems. The higher OC in paddy-pulses cropping system is also due to decomposition of fallen leaves and root biomass leads to improve the OC in soils. (Kumar *et al*.,2019).

In conclusions, the soils of SPSR Nellore district are sandy clay loam, sandy loam, clay loam and clay in type. The bulk density of soil varied from 1.10 Mg m^{-3} to1.80 Mg m^{-3}. The pH was slightly acidic to strongly alkaline in reaction and non-saline in nature. The organic carbon content was low to medium in range. The results underscore the importance of adopting diversified cropping systems to maintain and enhance soil health. Further pulse crops in cropping system are helping in improving organic carbon. Sustainable agricultural practices that can improve further the soil physical and physico-chemical properties in the cropping sequences of SPSR district.

LITERATURE CITED

Ahmed, S.R., Reddy, D.V.R., Muralidharudu, Y and Rao, A.S. 2007. Soil test based fertilizer application. ICAR, ANGRAU and dept. of Agriculture, Andhra Pradesh. ANGRAU press, Hyderabad.34-35.

Baruah, T.C and Barthakur, H.P. 1997. *A text book of soil analysis*. Vikas Publishing House Pvt. Ltd., New Delhi.

Bhatt, M.K., Raverkar, K.P., Labanya, R and Bhatt, C.K. 2018. Effects oflong-termbalancedandimbal anceduseofinorganicfertilizersandorganic manure (FYM) on soil chemical properties and yield of rice under rice-wheat cropping system. *Journal of Pharmacognosy and Phytochemistry*.7(3): 703-708.

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analysis of soil. *Agronomy Journal*. 54 (5): 464-465.

Charan, G.R., Munaswamy, V., Krishna, T. G and Subramanyam, D. 2021. Dynamics of soil potassium under different cropping systems in YSR Kadapa District of Andhra Pradesh, India. *Soil Science Research Network.*

Devi, P.A.V and Naidu M.V.S. 2015. Nutrient status of sugarcane growing soils of chittoor district in Andhrapradesh. *BIOINFOLET* 12 (4A): 864- 872.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Oxford IBH Publishing House, Bombay.38.

Kumar, U., Mishra, V.N., Kumar, N., Dotaniya, C.K and Mohbe, S.2019. Effects of long term rice-based cropping systems on soil quality indicators in central plain of Chhattisgarh. *International Journal of Current Microbiology and Applied Sciences*. 8(4): 1544-1552.

Kumar, V., Singh, S.K., Singh, P., Tiwari, S., N and, M.M., Chiranjeeb, Kand Majhi, M. 2020. Effects of Cropping Systems on Soil Properties and Enzymatic Activities in Calcareous Soil.*International Journal of Current Microbiology and Applied Sciences*. 9(4): 1255-1262.

Rajpoot, R.S., Bajpai, R.K., Shrivastava, L.K., Kumar, U., Tedia, K and Mishra, V.N. 2021. Evaluation of soil physical and chemical properties under rice-based cropping system in Alfisols of Northern Hill Region of Chhattisgarh. *International Journal of Current Microbiology and Applied Sciences.*10(1): 2748-2761.

Sankaram, A.1966. *A laboratory Manual for Agricultural Chemistry*. Published by Jaya Singer Asia Publishing House, Bombay.56-57.

Selassie, Y.G and Ayanna, G. 2013. Effects of different land use systems on selected physico-chemical properties of soils in Northwestern Ethiopia. *Journal of agricultural science*. 5(4): 112.

Sharma, P.K., AnilSood, R.K., Setia, N.S., Tur Deepak and Harpinder Singh. 2008. Mapping of micronutrients in soils of Amritsar district, Punjab-A GIS Approach. *Journal of the Indian Society of Soil Science*. 56: 34-41.

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EXTENT OF AWARENESS AND ADOPTION OF CLIMATE RESILIENT TECHNOLOGIES (CRA) BY FARMERS IN SCARE RAINFALL CLIMATIC ZONE IN ANDHRA PRADESH

SHAIK SUMIYA BANU*, SEEDAI UJWALA RANI, S.RAJESWARI and P. LAVANYA KUMARI

Department of Agricultural Economics, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

The present study was frame to analyse the farmers awareness and adoption of CRA technologies. The data was collected through primary survey from sample farmers with sample size of 120 from Ananthapuramu and Kurnool districts of Scarce rainfall zone in Andhra Pradesh. The awareness level of National Innovations in Climate Resilient Agriculture (NICRA) and NICRA Non beneficiary farmers were compared using Mann-Whitney U test. It was inferred that, NICRA farmers were more aware (79.18%) on NICRA technologies than NICRA Non beneficiary farmers famers (23.12%) in Ananthapuramu while in case of Kurnool the NICRA farmers awareness level was 77.57 per cent which is larger than that in non-NICRA (20.50%). The ranking of CRA technologies under each module based on the mean scores of extents of adoption were analysed through Garatte ranking. In-situ moisture conservation technologies in cotton and redgram through dead furrows (I Rank) followed by Farm Ponds (II Rank) having realized the importance of saving the crop from drought. In crop production module, crop diversification practices from paddy to Jowar and vegetable as contingent crop (I Rank) followed by drought tolerant variety of red gram (II Rank). In the livestock module revealed that the majority of the farmers adopted conservation of green fodder (I Rank) followed by preventive vaccination (II Rank). Institutional interventions are Custom Hiring Centre for timely field operations (I Rank) was highly adopted as it saved up to 80 per cent of field costs and enabled timely field operations followed by agro-met services (II Rank). Understanding CRA technologies will help non beneficiary farmers to adopt and increase their crop yield..

KEYWORDS: Climate resilient technologies, National Innovations in Climate Resilient Agriculture Scarce rainfall Zone, Awareness, Adoption.

INTRODUCTION

Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of the huge population dependent on agriculture. Climate change has also become a global issue requiring attention and action because of increasing temperatures, extensive glacier melt, variations in the increased frequency of catastrophic events, and more (Pabba *et al*., 2022). Resilience is the ability change and their adoption and their economic returns through adoption and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event by ensuring the preservation, restoration or improvement of its essential basic structures and functions (IPCC, 2012).National Innovations on Climate Resilient Agriculture (NICRA), is a project launched by the Indian Council of Agricultural Research (ICAR) with the aim to enhance the resilience of Indian agriculture to climate change and climate variability through strategic research and technology demonstrations. The project is being implemented at large number of research institutes of ICAR, State Agricultural Universities and KVKs. NICRA, the four intervention modules are Natural resource management, Crop production, Livestock and fisheries and Institutional interventions. These interventions include climate resilient practices like micro irrigation systems, crop diversification, introduction of improved varieties, provision of farm machineries through custom hiring centres and increasing climate literacy of farmers. Scare rainfall climatic zone has two districts Ananthapuramu & Kurnool district which are drought prone & farmers are practicing many adaptation strategies to combat climate change and its impact on agriculture.

The study will reveal the level of knowledge and extent of adoption of climate resilient technologies by the beneficiary and non- beneficiary farmers of the NICRA project. The understanding of the adaptation measures used by the farmers to cope with climate extremes and identifying socio-economic factors governing adaptation to climate change is also vital in framing policies and programmes that enhance resilience to climate change. Keeping this in view, an effort has been made farmers awareness and adoption of CRA technologies by scarce rainfall climatic zone of Andhra Pradesh.

*Corresponding author, E-mail: shaiksumiyabanu729@gmail.com

MATERIALS AND METHODOLOGY

This study was purposively conducted in Anantapuramu and Kurnool district of Andhra Pradesh which represent dry land and rain-fed agro-ecosystem which mostly affected by drought and poor soil health. The two villages were chosen from each district. First village belongs to NICRA beneficiary (N=40) & second village belongs to NICRA Non –Beneficiary (N=20) from one district. Therefore, two villages from NICRA & two villages from NICRA Non beneficiaries. Thus, it constitutes four villages. The beneficiary sample size is 80 & non beneficiary sample is 40 which constitutes 120 sample farmers. The NICRA implemented village are Yagantipalli (Ananthapuramu) and Chakaraipeta (Kurnool) to identify beneficiary farmers. The NICRA Beneficiary villages are Sodanapalli (Ananthapuramu) and Yerragudi (Kurnool) as non-NICRA villages to enable comparative study.

i) Level of awareness: Level of awareness can be operationalized as degree to which the farmers had information related to climate resilient technologies. Awareness level of farmers was measured with a set of statement reflecting various activities on climate resilient technologies. The responses of the respondents were assigned score on a two-point scale. Score of one is given for 'yes' and response 'no' is scored as zero. Adoption has been operationalized as willingness of individuals to take up the recommended climate resilient technologies on their field. Extent of adoption is per cent of adoption of practices recommended under climate resilience.

ii) Extent of adoption of climate resilient technologies:

Extent of Adoption=Technologies being practiced/ Technologies demonstrated X 100

iii) Mann Whitney U test :

Mann-Whitney U test is the non-parametric alternative test to the independent sample t-test. It is a non-parametric test that is used to compare two sample means that come from the same population, and used to test whether two sample means are equal or not. Mann Whitney u test formula was given by

$$U_1 = R_1 - \frac{n1(n1+1)}{2}$$

Where n_1 is the sample size for sample 1 (smaller group)

R_1 is the sum of the ranks in sample 1

iv) Garrett's Ranking Technique

The adaptation strategies practiced by farmers were analysed using Garrett ranking technique which identifies and ranks various strategies based on the calculated mean score. Garrett's formula for converting ranks in to per cent was given by:

$$\text{Per cent position} = 100\ (R_{ij}-0.5)/N_j$$

Where,

R_{ij}: Rank given for the i^{th}factor by the j^{th} individual

N_j: Number of factors ranked by the j^{th} individual

The per cent position of each rank is converted into scores referring to the table given by Garrett and Woodworth (1969). For each strategy, the scores of individuals respondents are added together and divided by the total number of the respondents for whom scores are added. These mean scores for all the factors are arranged in descending order, ranks are given and most important factors are identified.

RESULTS AND DISCUSSION

Socio Economic characters of Sample Farmers in Anamthpuamu and Kurnool district

The socio-economic characters of sample farmers (N=120) such as age, are shown in Table 1, 2 and 3.Through primary survey for the agricultural year 2023-24. It is found that ,majority the NICRA farmers of Ananthapuramu district were belonged to 36 -55 years (60percent) and in Kurnool district was 55 percent. The results on distribution of age were on par with the findings of Sharma *et al*. (2012).

Educational status of the farmers influences their decision behaviour to a greater extent, therefore the details of educational status of the head of family of sample households are presented. In Ananthapuramu about 45 per cent of the NICRA farmers were primary school followed by illiterate (27.5percent) followed by secondary high school (17.5percent) & even in Kurnool district 40 per cent of the NICRA farmers completed primary schooling followed by illiterate(35percent), secondary high school (17.5percent), Higher education (5percent) and graduate(2.55percent). which the results on distribution of education status were on par with the findings of Lokhande (2013).

Table 1: Age , Educational statusand Size of the family of NICRA Beneficairy (N=80)and Non Beneficairy Farmers (N=40)

	Particulars	Ananthapuramu				Kurnool				Overall NICRA farmers (n=80)		Overall non-NICRA farmer(n=40)	
	Age (in Years)	NICRA farmers(n=40)		NON-NICRA farmers(n=20)		NICRA farmers(n=40)		NON-NICRA farmers(n=20)					
		F	%	F	%	F	%	F	%	F	%	F	%
1	18-35	9	22.5	5	25	14	35	7	37	23	28.75	12	30
2	36-55	24	60	12	60	22	55	11	48	46	57.50	23	58
3	>55	7	17.5	3	15	4	10	2	15	11	13.75	5	12
	Total	**40**	**100**	**20**	**100**	**40**	**100**	**20**	**100**	**80**	**100**	**40**	**100**
	Educational Status												
1	Illiterate	11	27.5	7	35	14	35	5	45	25	31	12	30
2	Primary	18	45	8	40	16	40	9	25	34	43	17	43
3	Secondary	7	17.5	3	15	7	17.5	3	15	14	18	6	15
4	Higher education	3	7.5	2	10	2	5	2	10	5	6	4	10
5	Graduate	1	2.5	0	0	1	2.5	1	5	2	3	1	3
	Total	**40**	**100**	**20**	**100**	**40**	**100**	**20**	**100**	**80**	**100**	**40**	**100**
	Size of the family												
1	1 to 3	15	37.5	6	30	13	32.5	5	25	28	35	11	27.5
2	4 to 5	21	52.5	11	55	22	55	13	65	43	53.75	24	60
3	>5	4	10	3	15	5	12.5	2	10	9	11.25	5	12.5
	Total	**40**	**100**	**20**	**100**	**40**	**100**	**20**	**100**	**80**	**100**	**40**	**100**

Table 2.Occupational status Land holding size of NICRA Beneficairy (N=80)and Non Beneficairy Farmers

(N=40)

S. No.	Particulars	Ananthapuramu				Kurnool				Overall NICRA farmers(n=80)		Overall non-NICRA farmers(n=40)	
		NICRA farmers(n=40)		NON-NICRA farmers(n=20)		NICRA farmers(n=40)		NON-NICRA farmers(n=20)					
	Occupational status	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
1	Farming	23	57.5	12	60	21	52.5	11	55	44	55	23	58
2	Agricultural labour	9	22.5	5	25	14	35	5	25	23	29	10	25
3	Farming and business	8	20	3	15	5	12.5	4	20	13	16	7	18
	Total	**40**	**100**	**20**	**100**	**40**	**100**	**20**	**100**	**80**	**100**	**40**	**100**
	Land holding size												
1	Marginal<1 acre	6	15	2	10	4	10	2	10	10	12.5	4	10
2	Small(1-2)	10	25	6	30	8	20	5	25	18	22.5	11	27.5
3	semi-Medium (2-4)	22	55	10	50	25	62.5	12	60	47	58.8	22	55
4	Medium (4-10)	1	2.5	1	5	2	5	1	5	3	3.75	2	5
5	Large >10 acres	1	2.5	1	5	1	2.5	0	0	2	2.5	1	2.5
	Total	**40**	**100**	**20**	**100**	**40**	**100**	**20**	**100**	**80**	**100**	**40**	**100**

Further, it was observed that 52.5 per cent of the NICRA farmers of Ananthapur district had medium family size followed by small (37.5percent) and large(10percent). On the contrary. In Kurnool district majority (55percent) of farmers of NICRA had medium followed by small (32.50percent) and large family size (12.5percent). Overall, 55 per cent of the NICRA farmers engaged in farming activities followed by agricultural labour (29percent) and business(18percent), whereas in non-NICRA majority (58percent) of farmers were farming followed by agricultural labour(25percent) and farming and business(18percent) occupation. The results on distribution of occupation were on par with the findings of Kiran and Kanani.

It is observed that, the 52.5 per cent of NICRA farmers had medium annual income followed by low (30percent) and medium (17.5percent). Whereas in non- NICRA (45percent) of farmers were belonged to medium followed by low (42.50percent) and high (12.50percent) annual income. About 35 percent of farmers gives irrigation to their fields in critical stages of crop. It could be seen from results that in both groups NICRA and non-NICRA farmers were belonged rain-fed but comparatively in NICRA group most of the farmers were giving irrigation with bores in critical stages of the crop than non-NICRA. The results on distribution of annual income were on par with the findings of Chinnam Naidu (2012).

Level of awareness of NICRA about climate resilient technologies in Scare Rainfall Climatic Zone

NICRA beneficiary farmers were highly aware about climate resilience and its impact. The responses of the respondents were assigned score on a two-point scale. Score of one is given for 'yes' and response 'no' is scored as zero. The awareness level about climate change and its impact was more among CRA technologies.They gained 100 per cent score on statements revealing their awareness on the existence of different technologies involve in climate resilience. Some of the farmers couldn't able to recognize the Automatic weather stations, which are issuing customized agro- advisory service and improving weather literacy. The results were similar to Jasna *et al*., (2016).

NICRA farmers were more aware about the climate resilient technologies and its adaptation strategy as compared to non-NICRA farmers. Among the climate resilience indicators, non-NICRA farmers were most aware (100%) about the potential of drought tolerant varieties in climate change. They were least aware of Awareness about informed that direct seeded rice can reduce emission of harmful greenhouse gas (20.00%).

The Table 4 presents the information about the awareness level of NICRA and non-NICRA farmers based on comparison using Mann-Whitney U test. It was inferred that NICRA farmers were more aware (mean=79 .18) on NICRA technologies than non-NICRA famers (mean=23.12) in Ananthapuramu while in case of Kurnool the NICRA farmers awareness level was 77.57 which is larger than that in non-NICRA (20.50) The findings can be attributed to their association with exposure to climate resilient practices, trainings they have undergone, field demonstration, group discussions and meetings undertaken through project intervention. The results were found significant at 1 per cent level of significance in both states indicating that there is significant difference between the level of awareness between NICRA and non- NICRA villages.

Extent of adoption of climate resilient technologies by farmers in Scare Rainfall Climatic Zone

The ranking of CRA technologies under each module based on the mean scores of Extent of adoption were presented in Table 5.

Natural Resource Management (NRM)

Under Natural Resource Management (NRM) module as shown in Table 5, the ranks assigned to each technology revealed that In-situ moisture conservation technologies in cotton and redgram through dead furrows(I Rank). The majority of the farmers were found to have adopted Farm Ponds (II Rank) having realized the importance of saving the crop from drought, to excavate the ponds on farmers' fields. Further, farmers follow Trench cum bunding (III Rank)&water management through drip irrigation in chillies (IV Rank). The groundwater recharge structures ranked (V Rank), Ridge and furrow system (VI Rank). deep ploughing (VII Rank). The probable reason for such high adoption was because the farmers felt that this practice controlled many perennial weeds and increased soil water retention characteristics over the long term. Further, Recharge pits (VIII Rank) and Percolation tanks (IX Rank). The findings were similar to Brar *et al*., (2020).

Table 3. Farming experience & Annual Income of NICRA Beneficairy (N=80) and Non Beneficairy Farmers (N=40)

Farming experience	Ananthapuramu				Kurnool				Overall NICRA farmers (n=80)		Overall non-NICRA farmers(n=40)	
	NICRA farmers(n=40)		NON-NICRA farmers(n=20)		NICRA farmers(n=40)		NON-NICRA farmers(n=20)					
	F	%	F	%	F	%	F	%	F	%	F	%
Low (2-18)	9	22.5	6	30	11	27.5	3	15	21	26	7	17
Medium (19-35)	21	52.5	10	50	22	55	12	60	43	53	22	55
High (36-52)	10	25	4	20	7	17.5	5	25	16	20	11	27
Total	**40**	**100**	**20**	**100**	**40**	**100**	**20**	**100**	**80**	**100**	**40**	**100**
Annual Income												
Low (<60000)	13	32.5	10	45	11	28	7	35	24	30	17	42
Medium (60000-120000)	21	52.5	7	35	21	53	11	55	42	52	18	45
High (>120000)	6	15	3	5	8	20	2	10	14	17	5	12

Table 4. Mann-Whitney U test for awareness level of two farmers groups and its level of significance

Particulars	N	Mean	Sum of ranks
Ananthapuramu			
NICRA farmers	80	79.18	6335
non-NICRA farmers	40	23.12	925
Z- value			-8.558***
Kurnool			
NICRA farmers	80	77.57	6206
non-NICRA farmers	40	20.5	820
Z- value			-8.127***

Crop production interventions

Under crop production module, it was observed that the majority of the farmers are fully adopted crop diversificationpractices from paddy to jowar and vegetable as contingent crop (I Rank). Majority of farmers follows drought tolerant variety of red gram (II Rank) Results of red gram demonstrations indicated that the variety PRG-158 performed well in medium to light soils and recorded 23.1 per cent increased yield over long duration variety followed by contingent pest and disease incident level. While CRA of crop rotation (III Rank) and short duration varieties (IV Rank). The intercropping system with high sustainability yield index(V Rank). Intercropping of cotton and pulses as the farmers felt these practices helped in reduction of soil-borne diseases and pests and also farmers felt they can sustain from the second crop in uncertain weather conditions.

Livestock interventions

Under the livestock module revealed that the majority of the farmers adopted conservation of green fodder (I Rank) followed by preventive vaccination(II Rank). The adoption of recommended enrichment of dry fodder (III Rank), de-worming program for sheep and goat animals (IV Rank), improved housing conditions of the livestock (V Rank) and scientific rearing of calves (VI Rank). The farmers were found to have low adoption of rearing of calves due to the presence of high summer temperatures. The results were similar to the findings of Chouksey *et al.,* (2021).

Institutional interventions

Under institutional interventions, it was observed that utilization of a Custom Hiring Centre (CHC) for timely field operations (I Rank) was highly adopted as it saved up to 80 per cent of field costs and enabled timely field operations. The agro-met services (II Rank) and controlling endemic and epidemic diseases (III Rank). As most of the farmers were not much interested in creation of community level seed banks and fodder banks. The farmers were not found capacity building activities.

The results as shown in Table 6, revealed that the natural resource agricultural NICRA farmers (43.25%) were practiced. Another technology was crop production interventions NICRA farmers (41.72%). Livestock interventions were practiced by (39.82%) NICRA farmers and institutional interventions were practiced by 40.65% NICRA farmers in adoption of CRA technology.

NICRA farmers were more aware (79.18%) on NICRA technologies were NICRA. In case Kurnool district (77.57%) which resulted that the more CRA adaptation activities are implemented by Anathapuramu Farmers. The results revealed that majority of the NICRA farmers had the probable reason for this is both the NICRA and non- NICRA villages have red soils which are suitable to vegetable cultivation and orchard crops like mango, sapota, pomegranate, sweet orange. Farmers continuously cultivate contingency crop like sorghum for grain and fodder purpose to feed the cattle and utilizing the bio manure to field which was obtained from the animal husbandry along with rearing poultry

Table 5. Adoption of climate resilient technologies by farmers in scare rainfall zone

S. No	Demonstration adoption	NICRA Beneficiaries (80)		
		Total no of farmers	Mean scale value	Rank
1	Farm Ponds	31	2.41	II
2	Percolation tanks	4	0.08	IX
3	Deep ploughing	11	1.05	VII
4	Recharge pits	8	0.68	VIII
5	In-situ moisture conservation measures	39	2.75	I
6	Introduction of drip irrigation	22	1.90	IV
7	Trench cum budding	25	2.15	III
8	Ridge and furrow system	15	1.05	VI
9	Groundwater recharge structures	19	1.75	V
	Crop Production			
10	Drought/temperature tolerant varieties	32	2.51	II
11	Intercropping systems with high sustainability yield index	14	2.01	V
12	Use of short duration varieties	20	2.05	IV
13	Drought mitigation practices	8	1.90	VI
14	Contingent pest and diseases management	25	2.12	III
15	Crop diversification practices	40	2.75	I
	Livestock Interventions			
16	Conservation of green fodder	35	2.50	I
17	Deworming of animals	12	1.95	IV
18	Scientific rearing of calves	9	1.62	VI
19	Enrichment of dry fodder	20	2.05	III
20	Preventive vaccination	26	2.25	II
21	Improved housing conditions of the livestock	15	1.81	V
	Institutional interventions			
22	Custom Hiring Centers (CHCs)	37	2.32	I
23	Seed bank and Fodder bank	25	1.80	IV
24	Controlling endemic disease or epidemics	15	2.05	III
25	Capacity building activities	12	1.50	V
26	Agro-met advisories	30	2.25	II

Table 6. Adoption pattern by Extent of adoption of CRA technology

S. No.	Demonstration Technology	NICRA (%)
1.	Natural resource management	43.25
2.	Crop production interventions	41.72
3.	Livestock Interventions	39.82
4.	Institutional Interventions	40.65

and goats for generating secondary income during lean period to sustain economically.

LITERATURE CITED

Archana, T. 2017. A Study on adaptive capacity and technologies adopted by farmers for climate resilient agriculture in drought prone areas. *Ph.D Thesis*. Professor Jayashankar Telangana State Agricultural University, Hyderabad, India.

Babu, K.K., Ramachandrappa, B. K., M. N. Thimmegowda, M and Anitha, P. 2019. Impact of NICRA project in Anantapuram district of Andhra Pradesh. *M. Sc.(Ag.) Thesis,* Acharya NG Ranga Agricultural University.

Brar, H.S., Sharma, A and Gill, J.S. 2020. Adaptation strategies being followed by paddy growers towards climate change in Punjab state. *Indian Journal of Extension Education*. 56(3): 107-110.

Chinnam Naidu. 2012. A Study on Farming performance and Entrepreneurial behaviour of sugarcane farmers in north coastal zone of Andhra Pradesh. *Ph.D. Thesis*, Acharya N.G. Ranga Agricultural University.

Chouksey, R., Singh, K.C., Singh, C and Birle, Y. 2021. Adaptation of farmers regarding climate resilient technologies in Rewa block of Rewa District in Madhya Pradesh. *Indian Journal of Extension Education*. 57(1): 26-31.

Harikrishna, Y. V., Naberia, S., Pradhan, S and Hansdah P. 2019. Agro-economic impact of climate resilient practices on farmers in Anantapur district of Andhra Pradesh. *Indian Journal of Extension Education*. 55(4): 91-95.

Harikrishna, Y.V and Naberia, S. 2019. Farmers attitude towards the climate resilient technologies of NICRA project in Anantapur district of Andhra Pradesh. *Indian Journal of Extension Education*. 11: 274-278.

Intergovernmental Panel on Climate Change (IPCC). 2007. Change on climate. *Meteorological Organization.* 52: 1- 43.

Intergovernmental Panel on Climate Change (IPCC). 2012. Managing the risks of extreme events and disasters to advance climate change adaptation summary for policymakers, special report of governmental panel on climatechange.

Jasna, V.K., Burman, R., Padaria, R., Sharma, J., Chakrabarti, B and Dixit, S. 2016. Impact of climate resilient technologies in rainfed agro-ecosystem. *Indian Journal of Agricultural Sciences*. 87(6): 816-824.

Kalyan Babu, K. 2019. Impact of national initiative on climate resilient agriculture project in Ananthapuram District of Andhra Pradesh. *Ph. D Thesis*. Acharya NG Ranga Agricultural University, Guntur.

Lokhande, M.A. 2013. Problems of Socio-economically backward class entrepreneurs: An analysis by responses. *Quest Journals*. 4(8): 53-60.

Mackay, A. 2008. Climate change impacts, adaptation and vulnerability. Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. *Journal of Environmental Quality*. 37(6): 2407.

Pabba, A. S., Naik, R and Sudharani, V. 2022. Adoption of climate resilient agricultural technologies by farmers in Nalgonda district, Telangana State. *Indian Journal of Extension Education.* 58(2): 30-34.

Sharma, N Brar, S.K., Mahal, S.S., Brar, A.S., Vashist, K.K and Buttar, G.S. 2012. Transplanting time and seedling age affect water productivity, rice yield and quality in north-west India. *Agricultural water management*. 115: 217-222.

Waris, A., Kumar, R.M., Surekha, K., Meera, S.N., Nirmala, B and Kumar, S.A. 2019. Climate resilient production practices, Extent of adoption and barriers faced by rice farmers in Telangana state of India. *Journal of Cereal Research*. 11(3): 293-299.

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SPECIES DIVERSITY OF SUGARCANE SHOOTBORERS IN MAJOR SUGARCANE GROWING DISTRICTS OF ANDHRA PRADESH

P. DIVYA*, RAJASRI MANDALI, T.M .HEMALATHA, K.R TAGORE, K. DEVAKI AND Y. AMARAVATHI

Department of Entomology, S.V. Agricultural College, ANGRAU, Tirupati-517 502.

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ABSTRACT

An extensive roving survey was conducted in different sugarcane growing districts of Andhra Pradesh at different cane developmental stages at bimonthly intervals during 2023-2024. Three shoot borers *viz.,* Early shoot borer, *Chilo infuscatellus*, Inter nodal borer *Chilo sacchariphagus indicus* and Top shoot borer, *Scirpophaga excerptalis* were recorded from 60 farmer fields in four districts *viz.,* Vizianagaram, Anakapalle, Krishna and Tirupati districts of Andhra Pradesh. Relative abundance and Diversity indices were calculated for each district based on population of shoot borers to understand the species composition of shoot borers in Andhra Pradesh. Vizianagaram recorded highest mean relative abundance of ESB (60.50%). While, Anakapalle recorded highest mean relative abundance of INB and TSB (40.20, 50.20). Anakapalle district recorded highest Shannon-Wiener index (1.01), Simpson index of Diversity (00.56) and Pielou's evenness index (00.91) indicating the species richness and evenness as more number of three shoot borer species were collected here. Based on the diversity indices it could be concluded that the sugarcane shoot borers exhibited uniform distribution and higher diversity in Anakapalle district and aggregate distribution type and lowest diversity in case of Krishna, Vizianagaram and Tirupati districts of Andhra Pradesh.

KEYWORDS: Diversity indices, Distribution, Simpson index, Shannon-Wiener index Species richness and Evenness.

INTRODUCTION

Sugarcane (*Saccharum officinarum* L. : Poaceae) is an important commercial crop used for producing sugar, jaggery, ethanol, and various by-products. It is a source of income for millions of farmers and supports numerous ancillary industries such as sugar mills, ethanol production and biomass based power generation. It contributes significantly to the agricultural economy, especially in tropical and subtropical regions. Sugarcane is one of the important cash crops in India, contributing significantly to the agricultural economy and rural livelihoods. Worldwide sugarcane production has a vast and varied market and pivotal for industrial usage of sugar, biofuels, and spirits Brazil is the leading producer with a immerse production of 752.9 million tonnes, followed by India with 446.43 million tonnes. In India, 21% (56.48 lakh ha^{-1}) of the agricultural land is used for sugarcane production and yields 22% the total sugarcane in the world with average productivity of 79.03 tonnes ha^{-1} (desagri.gov.in, 2023-24). In Andhra Pradesh, sugarcane was cultivated in an area of 0.66 lakh hectares with an annual production of about 2.10 million tonnes with an average productivity of 76.34 tonnes ha^{-1}. The long duration with diverse environmental conditions under which sugarcane is grown in the world encounters broad spectrum of pests and diseases which have come to acquire a place of priority thereby causing economic loss to growers in terms of quality and quantity. Among them, borers are the major destructive pests which cause 8 to 10 per cent cane yield losses at farmer's level and 10 to 15 per cent sugar recovery losses in sugar industries (Ahad *et al.,* 2015). About 45 per cent of yield losses in sugarcane are due to infestation by borer pests alone. The different stages in sugarcane cultivation includes germination, tillering, early growth, grand growth and elongation (Rao *et al.,* 2009). During these stages they are attacked by many pests and most importantly,ESB, *Chilo infuscatellus*, INB, *Chilo sacchariphagus indicus* and TSB, *Scirpophaga excerptalis*, Gurdaspur borer, *Bissetia steniellus* and Root borer*, Polyocha depressella* are the major shoot borer pests distributed in all the sugarcane growing areas of India (Gupta *et al.,* 1993). Knowledge of the relative abundance of distinct shoot borer species infesting sugarcane is very crucial in estimating the targeted control which reduces indiscriminate pesticide use and safer for environmental and economic reasons. The diversity of shoot borers, their species richness and relative abundance in the different sugarcane districts of the Andhra Pradesh has not been fully assessed. In this connection a roving survey was conducted in different sugarcane growing districts of Andhra Pradesh at different growth stages of sugarcane during 2023–2024 to know the sugarcane shoot borer species species diversity and their relative abundance.

*Corresponding author, E-mail: divyaponnangi531@gmail.com

MATERIAL AND METHODS

A random roving survey was conducted in different 60 farmers fields located in 12 villages of four sugarcane growing districts of Andhra Pradesh *viz.,* Vizianagaram (18.34° N & 83.21° E), Anakapalle (17.80° N & 82.96° E), Krishna (16.11° N & 80.93° E) and Tirupati (13.37° N & 79.32° E) during April 2023 to May 2024 (Figure 1). Destructive Sampling was done at different growth stages of sugarcane *viz.,* tillering, grand growth and harvesting. From each district, three villages and from each village, five farmers were selected for the survey. The survey techniques were followed as suggested by Rao *et al.,* 2009. Shoot borer larvae were collected by destructive sampling method from ten randomly selected spots and from each spot 10 plants were selected for larval collection. The Shannon–Wiener's, Simpson's and Pielou's evenness indices were used to determine the species diversity, richness and evenness. The Shannon–Wiener index was calculated to find out alpha of major species compared to the rare species. In taxonomic or ecological research, similarity indices provide quantitative bases of assessment in comparing species composition or biodiversity. The relative abundance and diversity indices were calculated using following formulae

$$\text{Relative abundance (\%)} = \frac{\text{Total number of individuals for each species}}{\text{Total number of individuals of all species}} \times 100$$

Shannon-Wiener index (H') (Shannon and Weaver, 1949)

$$H' = -\sum\left(\frac{n1}{n2} \text{ X } ln\ \frac{n1}{N}\right)$$

where ni is the number of individuals of amount (biomass) of each of the species and N is the total number of individuals for the site.

Simpson index of Diversity (D) (Simpson, 1949)

$$D = 1 - \sum_{i=1}^{S} (p_i)^2$$

pi=Proportion of total sample belonging to the i^{th} species; S=Numbers of species

Pielou's evenness index (E) (Pielou, 1966)

$$J' = \frac{H'}{H_{max}}$$

where, H′=Shannon diversity index

∑=Sum from species 1 to species

J′=Evenness of allotment of individuals among the species

H_{max}=Maximum species diversity

(H')=log2S

Species richness : The number of different species found in particular environment or site.

RESULT AND DISCUSSION

The survey conducted in 60 farmers fields in 12 villages in four coastal districts of Andhra Pradesh. This study clearly indicated the presence of three major shoot borer species among the surveyed districts of Andhra Pradesh *viz.,* ESB, *C. infuscatellus*, INB, *C. sacchariphagus indicus* and TSB, *S. excerptalis* by considering the morphological characters of larvae, adults and damage symptoms.

The nature and symptoms of damage were very distinct in sugarcane as per the damage caused by different shoot borers. Early shoot borer, (*C. infuscatellus*) is severe at germination to tillering. The larvae is creamish with five violet stripes located dorsally and dorso laterally on its body with dark brown head. Adult Moth is small, slender, greyish brown or straw coloured with labial palpi projected upwards. Larva makes entrance hole at the ground level of sugarcane causes dead hearts which can be easily pulled out. The dead heart emits offensive smell, and it will be identified upto 45-50 days after sowing and in the set plantings rather than ratoon (Fig. 1).

Inter nodal borer (*C. sacchariphagus indicus*) affected the crop from cane formation to harvest. Moth is small, straw coloured. Forewings have a marginal dark line and the hind wings are whitish caterpillar has a white body with dark spots and a brown head. The larva bores at the nodal region and enters the stem. The tissues turn red and the hole is usually plugged with excreta. A larva may attack a number of nodes. Moth is medium sized, creamy white, slightly bigger than early shoot borer moth (Fig. 1).

Top shoot borer *S. excerptalis* female has tuft of orange red coloured hairs at the tip of the abdomen. In case of certain males, each of the forewings has a black spot. caterpillar is creamy white in colour with yellow head. Some of the caterpillar are white in colour and have black colour dorsal line with red colour head. A number of shot holes on affected leaves due to biting across the spindle, reddish brown charred dead heart that cannot be

Table 1. Collection locations of sugarcane shoot borers from different districts of Andhra Pradesh during 2023-24

S. No	District	Village	Geographic coordinates	
			Latitude (°N)	Longitude (°E)
1.		Perumallapalle	13.37	79.32
2.	Tirupati	Sanambatla	13.58	79.35
3.		Mittapalem	13.60	79.32
4.		Kottapenta	18.57	83.35
5.	Vizianagaram	Gollapalli	18.63	83.34
6.		Bobbili	18.34	83.21
7.		Govada	17.80	82.96
8.	Anakapalle	Bangarammapalem	17.68	83.00
9.		Venkupalem	17.69	83.00
10.		Challapalle	16.11	80.93
11.	Krishna	Lakshmipuram	16.39	81.44
12.		Lankapalle	16.22	80.84

Table 2. Per cent incidence and Relative abundance (Mean ± SE) of Sugar cane shoot borers in surveyed districts of Andhra Pradesh during 2023-2024

Districts	ESB (*C. infuscatellus)*	INB (*C. sacchariphagus indicus*)	TSB (*S. excerptalis*)	Cumulative incidence of shoot borers for districts
Vizianagaram	60.50 ± 0.05	12.80 ± 0.01	6.50 ± 0.06	30.82
Anakapalle	30.20 ± 0.05	40.20 ± 0.05	50.20 ± 0.05	41.58
Krishna	6.30 ± 0.03	25.50 ± 0.03	25.30 ± 0.02	33.07
Tirupati	3.00 ± 0.02	21.50 ± 0.05	18.00 ± 0.04	25.93

easily pulled out at later stages of the crop are damage symptoms. Interference with apical growth gives rise to side shoots and critical bunchy top symptom (Fig.1).

From Table 2 it was clearly indicated that the Among the four surveyed districts of Andhra Pradesh Anakapalle district recorded the highest overall cumulative incidence of three shoot borers of 41.58% followed by Krishna (33.07%), Vizianagaram (30.82%). Least cumulative incidence was recorded in Tirupati district of 25.93%. Survey in different growth stages of sugarcane in Andhra Pradesh revealed that 100% damage was due to INB during grand growth stage and vegetative stage was attacked by both ESB (35.50%) and INB (64.50%), whereas INB (57.50%) and TSB (42.50%) was recorded at harvesting (Fig.2).

A cursory examination from the 60 farmer fields from 12 villages of 4 districts indicated Vizianagaram recorded highest mean relative abundance of ESB

Table 3. Diversity indices of Sugar cane shoot borers in surveyed districts of Andhra Pradesh during 2023-2024

Districts	Richness (S)	Shannon-Wiener index (H')	Simpson index of Diversity (D)	Pielou's evenness index (E)
Vizianagaram	3.00	00.81	00.50	00.74
Anakapalle	3.00	1.01	00.56	00.91
Krishna	3.00	00.82	00.51	00.75
Tirupati	3.00	00.74	00.39	00.67

(60.50%) followed by Anakapalle (30.20%), Krishna (6.30%) and Tirupati (3.00%) respectively. Similar trend of relative abundance in case of INB, TSB was also observed in which Anakapalle recorded highest mean relative abundance (40.20, 50.20) followed by Krishna (25.50%, 25.30%), Tirupati (21.50%, 18.00%) and lowest abundance was recorded in Vizianagaram (12.80%,6.50%) (Table 2).

Diversity indices were worked out for the four surveyed districts based on the population of sugarcane shoot borers collected in each district. From Table 3 it was evident that the species richness is same for all areas as all three species of shoot borers *viz.*, ESB, INB and TSB present in all surveyed districts in A.P. Shannon-Wiener index was high for Anakapalle district (1.01) as the three species of shoot borers collected were high in number compared to other districts which indicated the species richness in that particular area. Followed by Krishna (00.82), Vizianagaram (00.81) and lowest was recorded in Tirupati (00.74). Simpson index of Diversity was also followed the same trend as Anakapalle district recorded the high D value of 00.56 followed by Krishna (00.51), Vizianagaram (00.50) and least was recorded in Tirupati (00.39). Pielou's evenness index was also high in Anakapalle (00.91) as it comprised all the species of shoot borers with high number of larvae indicated the populations were evenly distributed. Followed by Krishna (00.75), Vizianagaram (00.74) and least diversity was recorded in Tirupati (00.67). All the values of diversity indices values were mostly on par for Both Krishna and Vizianagaram districts as it was mostly dominated by one species compare to other. From these findings it is clearly noticed that sugarcane shoot borers exhibited uniform distribution in case of Anakapalle district and aggregate distribution in case of Krishna, Vizianagaram and Tirupati districts of Andhra Pradesh.

The range of Shannon-Wiener index is 0 to 1 sometimes 1.5 to 3.5 (for high number of population) Shannon-Wiener index increases when both speciesrichness and the evenness of the community increase. The range of Simpson index of Diversity and Pielou's evenness index ranges from 0 to 1. 0 and near values represents lower diversity and evenness whereas values near to 1 and 1 indicated the higher diversity and evenness.

The results are in line with the findings of Lenonard and Gration (2015) who admitted that rice stem borer exhibited both uniform and aggregate type of distributions. Bonaventure *et al*. (2018) also conducted similar kind of investigation in irrigated lowland rice ecosystem in Kilombero, Tanzania and confirmed an aggregated dispersion pattern for stem borers. The current findings are in accordance with Rani *et al.* (2023) who reported the diversity of rice stem borers in AP, they also confirmed the aggregated dispersion patterns for rice stem borers in Andhra Pradesh. Ndemah *et al.* (2001) and Gounou and Schulthess (2004) also reported the aggregate spatial distribution behavior of lepidopteran rice stem borers. Arbab (2014) who reported random distribution of *C. supressalis* in rice fields in Iran. Widyaningrum (2015) also studied the arthropods biodiversity by employing diversity indices in Indonesia. Moolman *et al.* (2013) reported a high diversity of stemborer parasitoids in South Africa. Otieno *et al.* (2006) also reported the higher Shannon-Wiener index (1.67) in cropping systems for lepidopteran stem borers in Kenya. Which supports the current findings of diversity of sugarcane shoot borers in Andhra Pradesh.

From this present study on the survey of shoot borers depicted the uniform and aggregated distribution patterns of shoot borers in surveyed districts of Andhra Pradesh. High species diversity and evenness reported from Anakapalle district followed by Krishna, Vizianagaram and Tirupati. Diversity indices were useful in predicting the species composition and their diversity in particular locality which in turn used for to predict their abundance which is useful to manage insect pests efficiently.

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LITERATURE CITED

Ahad, M.A., Ferdaus. R.R., Ahsan. M.R., Hoque. M.M and Islam. A.N.M.S. 2015. Survey of major insect pests, uses of management practices and other related information of sugarcane (*Saccharum officinarum* L.) growers of the Northern Region of Bangladesh. *American Journal of Life Sciences*. 3(6): 408-411.

Arbab, A. 2014. Spatial distribution and minimum sample size for overwintering larvae of the rice stem borer in paddy fields of Alamut, Iran. *Neotropical Entomology* 43: 415–420

Bonaventure, J., Gration Rwegasira, M and Tadele, T. 2018. Distribution of rice stem borers and their parasitoid in irrigated low land rice ecosystem in Kilombero valley, Morogoro, Tanzania. *Journal of Entomology*. 6(2): 237-242.

Gounou, S., and Schulthess, F. 2004. Spatial distribution of lepidopterous stem borers on indigenous host plants in West Africa and its implications for sampling schemes. J. Afr. Entomol. 12: 171–178.

Gupta, S.C., Yazdani, S.S., Hameed, S.F and Agarwal, M.L. 1993. Losses in sugarcane by different broods of top borer, *Scirpophaga excerptalis* Walker in northern Bihar. *Journal of Insect Science*. 6(1): 125-127.

Leonard, A and Gration, M. R. 2015. Abundance and spatial dispersion of rice stem borer species in Kahama, Tanzania. *Journal of Insect Science*. 15(1): 132.

Moolman, J., Van Den Berg, J., Conlong, D., Cugala, D., Siebert, S and Le Ru, B. 2014. Species diversity and distribution of lepidopteran stem borers in South Africa and Mozambique. *Journal of Applied Entomology*.138: 52–66

Ndemah, R., F. Schulthess, M. Poehling, and C. Borgemeister. 2001. Spatial dynamics of lepidopterous pests on *Zea mays* (Linnaeus) and *Pennisetum purpureum* (Moench) in the forest zone of Cameroon and their implications for sampling schemes. *Journal of Applied Entomology*. 125: 1–8.

Otieno, N. A., Le Rü, B. P., Ong'amo, G. O., Dupas, S., Calatayud, P. A., Makobe, M and Silvain, J. F. 2006. Diversity and abundance of wild host plants of lepidopteran stem borers in two different agroecological zones of Kenya. In *Annales de la Société Entomologique de France* . 42 :371-380.

Pielou, E.C. 1966. The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology*. 13: 131-144.

Rani, D. S., Chiranjeevi, C. H., Madhumathi, T., Raju, S. K and Umar, S. N. 2023. Abundance, distribution and divergence of stem borer species and predators in rice ecosystem of Krishna district, Andhra Pradesh. *Applied Ecology & Environmental Research*, *21*(1): 133-156.

Rao, C.V.V., Rao, N.V., Bhavani, B and Naidu, N.V.2009. Survey and surveillance of sugarcane insect pests in Andhra Pradesh. *Indian Journal of Plant Protection*. 37(1/2), 24–28.

Shannon, C. E and Weaver, W. 1949. *The Mathematical Theory of Communication*. Urbana: University of Illinois Press.

Simpson, E. 1949. Measurement of diversity. *Nature*. 688: 163.

Widyaningrum, I. 2015. Pest and weed suppressive mechanisms in complex rice system at Malang, East Java, Indonesia. *M.Sc. thesis*. Organic Agriculture Wageningen University, The Netherlands

Websites:

https://des.ap.gov.in. 2022-23. Accessed on 25.06.2024.

https://eands.dacnet.nic.in/ 2021-2022. Accessed on 25.06.2024

https://www.fao.org/faostat/. Accessed on 25.06.2024.

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