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Effect of Micronutrient Fortification, Plant Protection Practices on Yield of Pigeonpea [*Cajanus cajan*(L.)] in Central Plain Region of Uttar Pradesh, India

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ABSTRACT: A field experiment was conducted during the Kharif season in 2017 to evaluate the effect of the mode of micronutrient application along with insecticides on the growth and yield of pigeonpea (*Cajanus cajan* L.) in sandy loam soil. Eight treatments consisting of micronutrients and insecticides (Urea, B, Zn, Indoxacarb, and one systemic insecticide), namely T_1 [RDF i.e., Control (NPKS)], T_2 (T_1 + 2% urea spray at 50% flowering), T_3 (T_1 + 0.5% B spray at 50% flowering), T_4 (T_1 + 0.5% Zn spray at 50% flowering), T_5 (T_1 + 2% urea + 0.5% B + 0.5% Zn spray at 50% flowering), T_6 (T_1 + multi-micronutrient spray @ 2ml/liter of water), T_7 (T_1 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray), T_8 (T_6 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray), were tested in a Randomized Block Design (RBD) with three replications. NPKS was commonly applied in all the plots. The experimental results revealed that growth attributes (plant height, number of primary branches per plant), yield attributing traits (pods per plant, grains per pod, test weight), and yield in pigeonpea differed significantly among the different treatments and were maximized with T_8. Therefore, the study suggests that considering the combined application of different micronutrients and insecticides can be beneficial for optimizing the growth and yield of pigeonpea.

Keywords: Micronutrients, 50% flowering, borax, Zinc, Insecticide, Indoxacarb, yield.

INTRODUCTION

Protein requisite is inherent for human growth and development and pulses play an energetic role in providing protein fulfillment in the human diet. In pulses, the second most important crop credit goes to Pigeonpea. Pigeonpea [*Cajanus cajan* (L.)], also known as red gram, is a versatile legume crop that is widely grown in tropical and subtropical regions of the world. It is an important source of protein, minerals, and vitamins for millions of people, particularly in India and Africa, where it is a dietary staple (Varshney *et al.*, 2012). Proper seed treatment is vital for seed quality improvement and significant increase in crop yield (Akpor and Obeasor 2019). Pigeonpea is a versatile and important crop that plays a significant role in the livelihood of smallholder farmers in many parts of the world. It is a hardy and drought-tolerant crop that can be grown in marginal lands, serving as a source of food, income, and nutrition. The crop has several nutritional and medicinal properties and can also be used as a soil improver and a source of fodder and fuel wood (Gaur *et al.*, 2021). This crop also helps in filling the protein gap in the diet, especially when consumed along with cereals (Kumar *et al.*, 2018).

According to the Food and Agriculture Organization of the United Nations (FAO) for the year 2020, as well as the Ministry of Agriculture and Farmers Welfare, Government of India, the area, production, and productivity of pigeonpea in the world and India during 2020-21 were depicted in Fig. 1 and 2).

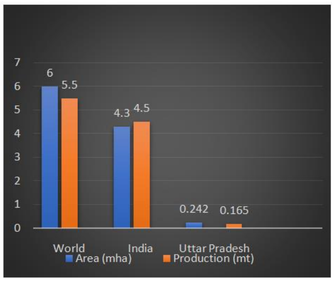

Fig. 1. Area & Production of pigeonpea in World, India & Uttar Pradesh.

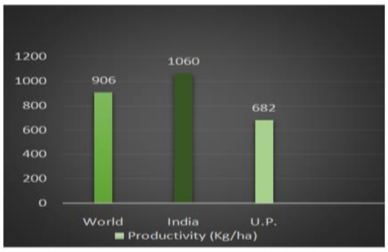

Fig. 2. Productivity of pigeonpea in World, India & Uttar Pradesh.

Despite their importance, pigeonpea faces several challenges, including susceptibility to insect pests, diseases, and abiotic stresses such as drought and salinity, which can reduce yields and compromise food security (Govindaraj *et al.*, 2018**).** These efforts have yielded promising results, suggesting that pigeon pea has great potential to contribute to sustainable agriculture and food systems in the face of climate change and global population growth.

Multi-nutrient fortification involves breeding crops to increase the levels of essential vitamins and minerals, such as iron, zinc, and vitamin A, to address prevalent micronutrient deficiencies in many developing countries. Recent research has shown promising results in developing pigeonpea varieties with enhanced nutrient levels using conventional breeding methods (Govindaraj *et al*., 2019). It was observed that pigeonpea genotypes with increased iron and zinc content exhibited improved agronomic traits, including higher grain yield. This suggests the potential to develop varieties with both enhanced nutritional value and yield (Singh *et al*., 2019). However, similar to many other crops, pigeonpea often lacks essential micronutrients like iron, zinc, and vitamin A, which can lead to serious health issues in human populations, particularly vulnerable groups such as children and pregnant women (Adhikary *et al*., 2020).

Therefore, efforts have been made to develop pigeonpea varieties with enhanced nutritional value, primarily through multi-nutrient fortification, aimed at improving food security and public health.

The impact of nutrient management and insecticide application on the yield and economics of pigeonpea in the southern agro-climatic zone of Tamil Nadu was examined. The authors discovered that the combined application of multi-nutrients and insecticide significantly increased pigeonpea yields and enhanced economic benefits for farmers (Sakthivel and Gurusamy 2017).

In recent years, research has been dedicated to developing pigeonpea varieties with elevated levels of essential micronutrients, such as iron and zinc, through conventional breeding methods. Additionally, studies have explored the potential benefits of combining biofortification with insecticide application to increase crop yields and enhance the nutritional quality of the harvested product.

This research paper aims to provide a comprehensive overview of the current state of research on pigeonpea biofortification and insecticide application. It covers the benefits and challenges of this approach and outlines future directions for research and implementation. The potential of this approach to address both food security and public health issues positions it as a crucial area for research and development in sustainable agriculture for developing countries.

MATERIALS AND METHODS

The study aimed to investigate how different methods of micronutrient fortification along with plant protection application affect the yield of pigeonpea (*Cajanus cajan* L.) in a field with sandy loam soil. The experiment was conducted at Crop Experimental Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kalyanpur, Kanpur in 2017.

Amar variety of pigeonpea was grown in a randomized block design (R.B.D.) in three replications along with 8 treatments. Total of 8 treatments was used *viz*., T_1 [RDF i.e., Control (NPKS)], T_2 (T_1 + 2% urea spray at 50% flowering), T_3 (T_1 + 0.5% B spray at 50% flowering), T_4 (T_1 + 0.5% Zn spray at 50% flowering), T_5 (T_1 + 2% urea + 0.5% B + 0.5% Zn spray at 50% flowering), T_6 (T_1 + multi-micronutrient spray @ 2ml / liter of water), T_7 (T_1 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray), T_8 (T_6 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray). It was raised in 8 lines with a row-to-row distance of 75 cm and a plant-to-plant distance of 25 cm as a gross plot (24 m^2). The seed rate is 18 kg/ha, and the seed material status is good for raising a good crop.

To understand the growth and development mechanism of the pigeonpea plant, it was essential to analyze its behavior under the influence of different treatments. A specific area was selected for observing various growth patterns of the crop, and yield attributes were recorded during harvest. The experimental results revealed growth attributes before harvesting i.e., (plant height, and number of primary branches per plant).

The harvested pigeon pea result was revealed through various yield attributing traits [pods $plant^{-1}$, grains pod^{-1}, test weight (g)], and for yield, the crop was dried under sunlight, and the weight of the harvested net plot area was recorded in kilograms and then expressed as kilograms per hectare respectively.

RESULT AND DISCUSSION

The study demonstrated that applying a combination of multi-micronutrients with insecticides such as (Indoxacarb + One systemic insecticide) to the soil and foliage had a notable effect on the yield of pigeonpea crops (Table 1). The application of these combinations to the soil and foliage had a significant impact on the number of branches $plant^{-1}$, pods $plant^{-1}$, grains pod^{-1}, test weight (g), and yield.

A. Effect of different treatments on plant height

The data shows the plant height of a pigeonpea under different treatments, with the control treatment (T_1) having a plant height of 220.00 (Fig. 3). T_2, T_4, and T_8 treatments resulted in a decrease in plant height, ranging from 7.05% to 8.33%, compared to the control treatment. In contrast, T_3, T_5, T_6, and T_7 treatments led to an increase in plant height, ranging from 0.75% to 8.33%, compared to the control treatment. The highest increase in plant height was observed in the T_3 treatment, which involved applying a 0.5% B spray at 50% flowering (Rupangade *et al.,* 2019). The application of multi-micronutrient spray (T_6) and the combination of Indoxacarb at flowering and one systemic insecticide 15 days after the first spray (T_7 and T_8) also resulted in a noticeable increase in plant height Chaudhary *et al.* (2018); Sharma *et al.* (2018).

B. Effect of different treatments on the number of branches

The number of branches per plant was significantly affected by the different treatments. Among the treatments, the highest number of branches was observed in the T_8 treatment (Fig. 4), which involved the application of multi-micronutrient spray and Indoxacarb insecticide at flowering and 15 days after the first spray Chaudhary *et al.* (2018). The T_8 treatment showed a 26.56% increase in the number of branches compared to the control treatment (T_1). This is also supported by the findings of a study by Gholve *et al.* (2016); Sharma *et al.* (2018). Which reported that the application of micronutrient sprays and insecticides can increase the number of branches and the overall yield of pigeonpea plants.

C. Effect of different treatments on pods per plant

The pods per plant data for different treatments showed significant variations. The highest number of pods per plant was observed in treatment T_8 (Fig. 5), which involved a multi-micronutrient spray at 2ml/liter of water, Indoxacarb at flowering, and one systemic insecticide 15 days after the first spray, with 232.33 pods per plant also reported by Sharma *et al.* (2018); Mishra *et al.* (2020); Singh *et al.* (2022). This was followed by T_4, which involved a 0.5% Zn spray at 50% flowering, with 214.00 pods per plant. On the other hand, the control treatment (T_1) had 196.33 pods per plant. The study suggests that the use of micronutrient spray with insecticide can increase the number of pods per plant in pigeonpea by Chaudhary *et al.* (2018).

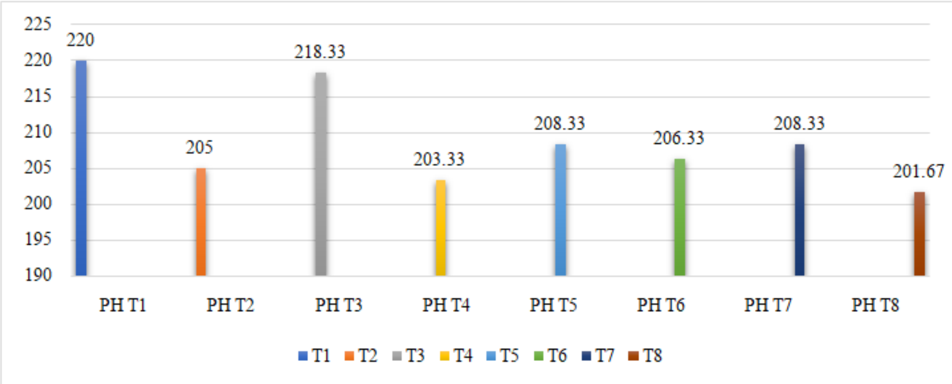

Fig. 3. Plant Height (cm).

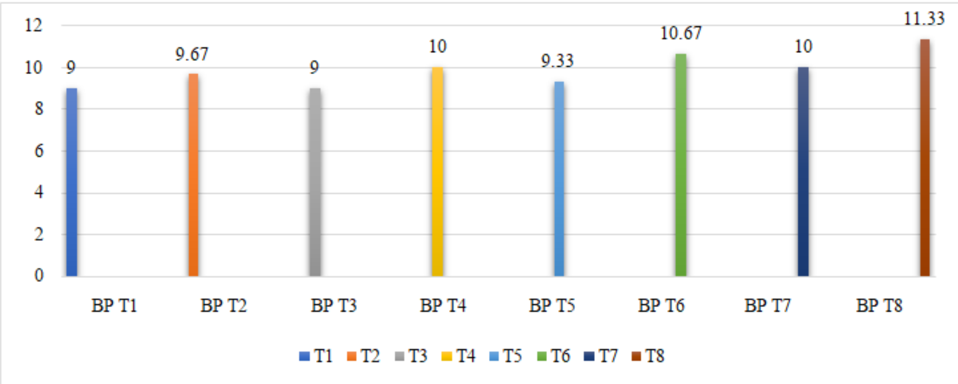

Fig. 4. Branch/Plant.

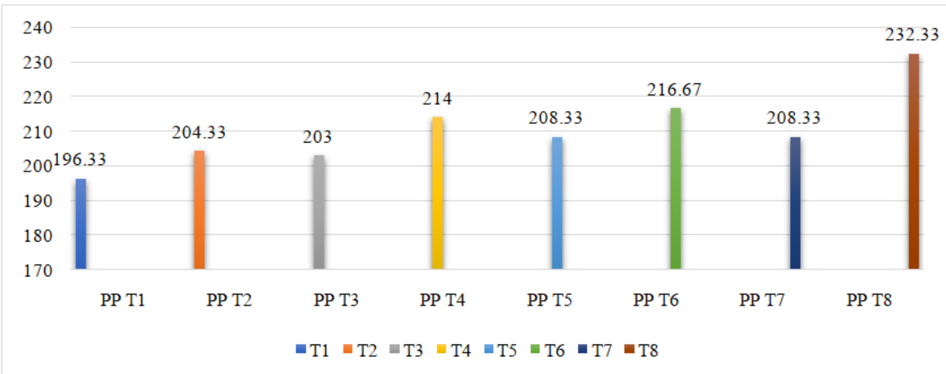

Fig. 5. PODs/Plant.

D. Effect of different treatments on grains per pod

The application of multi-micronutrient spray at 2 ml/liter of water (T_6) and T_8 (T_6 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray) resulted in the highest number of grains per pod in pigeonpea. T_8 produced the highest 4.67 grains per pod, followed by T_7 with 4.00 grains per pod. The control treatment (T_1) had 3.67 grains per pod (Fig. 6). The study recommends the use of micronutrient sprays and insecticides for improved pigeonpea yield as suggested by Singh *et al.* (2022).

E. Effect of different treatments on 100-seed weight

The highest 100-seed weight in pigeonpea was obtained in T_8 (T_6 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray), with 8.67 grams (Fig. 7). T_6 (multi-micronutrient spray at 2 ml/liter of water) also had a high 100-seed weight of 8.60 grams. In contrast, the control treatment (T_1) had a 100-seed weight of 7.90 grams. The study suggests the use of micronutrient sprays and insecticides to increase 100-seed weight in pigeonpea as reported by Singh *et al.* (2019).

F. Effect of different treatments on yield

The application of various treatments resulted in different yields of pigeonpea. The highest yield was obtained in T_8 (T_6 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray), with 3806.66 kg/ha (Fig. 8), while the control treatment (T_1) had a yield of 2936.66 kg/ha similar result is also observed by Chaudhary *et al.* (2018). T_6 (multi-micronutrient spray at 2 ml/liter of water) also showed a significant increase in yield with 3723.33 kg/ha; Singh *et al.* (2019) also reported that micronutrient sprays significantly increased the yield of pigeonpea. The use of micronutrient sprays and insecticides to improve the yield of pigeonpea Singh *et al.* (2022). Additionally, the study by Kukreja *et al.* (2018) found that the application of insecticides, including Indoxacarb, resulted in a decrease in yield in pigeonpea. Irrespective of this Sudhakar *et al.* (2018) found that the application of micronutrients along with bio-regulators significantly increased the yield and economic returns of pigeonpea under rainfed conditions. While Pandey *et al.* (2019); Singh *et al.* (2018), found that the application of micronutrients and plant growth regulators had a significant effect on the yield and nutrient uptake of pigeonpea under rainfed conditions.

Therefore, the use of micronutrient sprays in addition to various treatments such as Insecticides, bioregulators, and plant growth regulators can be a valuable tool in improving the yield of pigeonpea crops.

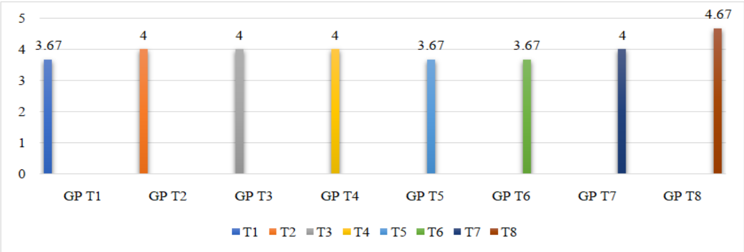

Fig. 6. Grains/Plant.

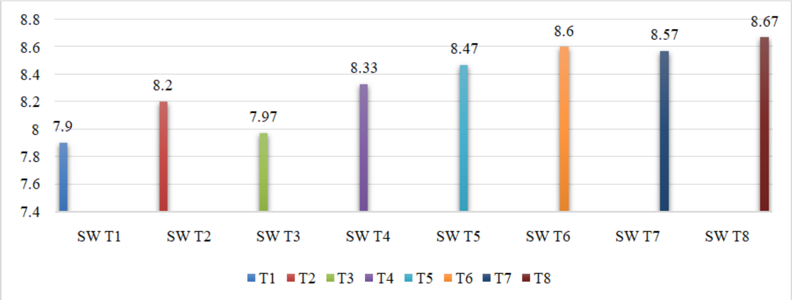

Fig. 7. 100-Seed weight (g).

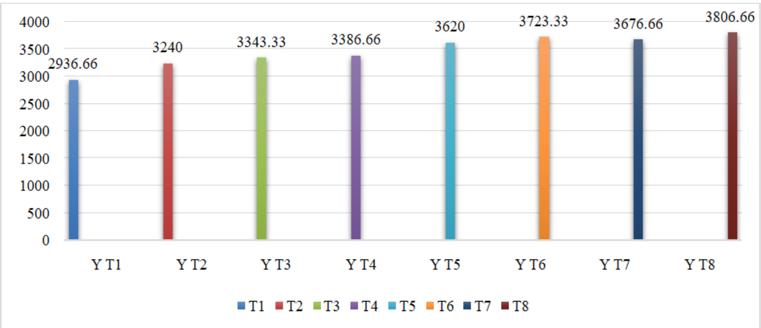

Fig. 8. Yield (kg/ha).

Table 1: Effect of micronutrient fortification and plant protection practices in pigeonpea.

Sr. No.	Treatment	Plant height (cm)	Branch/Plant	Pods/Plant
1.	RDF Control 20:50:20:20 (N:P: K:S) **(T_1)**	**220.00**	9.00	196.33
2.	T_1 + 2% urea spray at 50% flowering **(T_2)**	205.00	9.67	204.33
3.	T_1 + 0.5% B spray at 50% flowering **(T_3)**	218.33	9.00	203.00
4.	T_1 + 0.5% Zn spray at 50% flowering **(T_4)**	203.33	10.00	214.00
5.	T_1 + 2% urea + 0.5% B + 0.5% Zn spray at 50% flowering **(T_5)**	208.33	9.33	208.33
6.	T_1 + multi-micronutrient spray @ 2ml/litre of water **(T_6)**	206.33	10.67	216.67
7.	T_1 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray**(T_7)**	208.33	10.00	208.33
8.	T_6 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray**(T_8)**	201.67	**11.33**	**232.33**
	C.D.	N/A	N/A	**19.18**
	SE(m)	6.29	1.12	6.26
	SE(d)	8.90	1.58	8.85
	C.V.	**5.22**	**19.59**	**5.15**

Sr. No.	Treatment	Grains/pod	100 seed Wt. (g)	Yield (kg/ha)
1.	RDF Control 20:50:20:20 (N:P: K:S)**(T_1)**	3.67	7.90	2936.66
2.	T_1 + 2% urea spray at 50% flowering **(T_2)**	4.00	8.20	3420.00
3.	T_1 + 0.5% B spray at 50% flowering **(T_3)**	4.00	7.97	3343.33
4.	T_1 + 0.5% Zn spray at 50% flowering **(T_4)**	4.00	8.33	3386.66
5.	T_1 + 2% urea + 0.5% B + 0.5% Zn spray at 50% flowering **(T_5)**	3.67	8.47	3620.00
6.	T_1 + multi-micronutrient spray @ 2ml/litre of water **(T_6)**	3.67	8.60	3723.33
7.	T_1 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray**(T_7)**	4.00	8.57	3676.66
8.	T_6 + Indoxacarb at flowering + one systemic insecticide 15 days after the first spray**(T_8)**	**4.67**	**8.67**	**3806.66**
	C.D.	N/A	**0.47**	**257.25**
	SE(m)	0.45	0.15	84.00
	SE(d)	0.63	0.22	118.79
	C.V.	**19.49**	**3.17**	**4.17**

CONCLUSIONS

From the present investigation, it is concluded that the application of micronutrient sprays and insecticides can significantly improve the yield of the crop.

The experiment evaluated the effect of different treatments on the growth and yield of a pigeonpea. The treatments included the use of fertilizers, micronutrient sprays, and insecticides (Table 1). The results show that the application of T_2, T_5, T_6, T_7, and T_8 increased the yield of the crop compared to the control (T_1).

FUTURE SCOPE

The future scope of this study involves finding better ways to help pigeonpea crops grow and produce more food. Researchers can explore different methods for using fertilizers, nutrient sprays, and insecticides. They can experiment with various timings and quantities of these treatments to achieve even better results. It is important to assess whether these methods are environmentally friendly and cost-effective for farmers. Additionally, efforts should be made to encourage more farmers to adopt these methods to enhance crop yield and quality.

Therefore, it is recommended that farmers use appropriate treatments to improve their crop yield and quality.

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Conflict of Interest. None.

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