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Effect of Levels of Phosphorus and Zinc-EDTA on Growth and Yield of Blackgram (*Vigna mungo* L.) in Zinc-Deficient *Vertisol*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: In pursuit of optimizing crop productivity and nutritional quality, this study aimed to investigate the influence and interaction of phosphorus (P) and zinc (Zn) on the growth, yield, and quality parameters of Blackgram (*Vigna mungo* L.), variety VBN 8.
Study Design: The experiment was designed using Factorial Randomized Block Design (FRBD), incorporating 12 treatment combinations and three replications.
Place and duration of Study: The experiment was conducted in the field no. A 4 of Wetland farm, Tamil Nadu Agricultural University, Coimbatore; from May 2023 to August 2023.

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Methodology: The experiment consisted of 12 treatments, each replicated three times, resulting in a total of 36 experimental plots. The treatments included different combinations of P levels (0, 25, 50, and 75 kg ha^{-1}) and concentrations of foliar-applied Zn-EDTA (0%, 0.5%, and 1.0%) applied twice at 30 and 45 days after sowing. The recommended dose of nitrogen (N) and potassium (K_2O) at 25 kg ha^{-1} each, along with a recommended dose of zinc sulfate ($ZnSO_4$) at 25 kg ha^{-1}, was applied as a blanket recommendation to ensure consistent nutrient supply across treatments.
Results: It was found that the treatment combination of 50 kg ha^{-1} P_2O_5 and 0.5% Zn-EDTA increased morphological characters and yield compared to other treatments followed by treatment combination of 50 kg ha^{-1} P_2O_5 and 1% Zn-EDTA. The minimum yield and morphological characters were recorded in the control plot where neither P_2O_5 nor Zn-EDTA was applied.
Conclusion: This research depicted that the combined application of 50 kg ha^{-1} P_2O_5 and 0.5% Zn-EDTA spray has a positive impact on the growth, yield and quality of blackgram in zinc deficient soil under field conditions resulting in improved morphological characters and crop yield. Hence, it may be concluded that an optimum dose of 50 kg ha^{-1} P_2O_5 and 0.5% Zn-EDTA spray can be recommended for blackgram to enhance crop productivity.

Keywords: Blackgram; phosphorus; Zn-EDTA; yield attributes; seed and haulm yield.

1. INTRODUCTION

Sustainable agricultural methods play a crucial role in ensuring worldwide food security and addressing challenges arising from population growth. Effective nutrient management is a key factor in achieving optimal crop growth and yield. Essential elements like phosphorus (P) and zinc (Zn) are pivotal in shaping plant development, productivity, and growth [1], (Gupta et al., 2015). Black gram (*Vigna mungo* L.), an important leguminous crop, holds promise for enhancing nutrition security and soil health [2]. However, comprehending the intricate connections between different levels of phosphorus and zinc and their impacts on black gram's growth and yield attributes remains a critical area of research. Phosphorus, a fundamental macronutrient, acts as a primary energy carrier in cellular processes and is indispensable for various growth-related activities such as photosynthesis, respiration, and nutrient transport [3]. Similarly, zinc, a micronutrient, plays a pivotal role in enzyme activities, hormone synthesis, and overall plant metabolism [4]. The availability and absorption of these nutrients significantly influence plant physiological functions, thereby affecting growth traits and yield potential. While many studies have examined the separate effects of phosphorus and zinc on plant growth, there's a lack of comprehensive research into their combined influence on black gram. This study aims to bridge this knowledge gap by assessing how varying levels of phosphorus and zinc affect the growth and yield attributes of black gram. By systematically adjusting nutrient concentrations, we aim to uncover their complex interactions and their effects on parameters like plant height, leaf area index, biomass accumulation, pod development, and ultimately, crop yield. The results of this study have significant implications for sustainable agriculture, especially in regions where black gram is a staple crop. By identifying the optimal phosphorus and zinc levels that promote growth and yield attributes, this research contributes to well-informed nutrient management strategies. These strategies are vital not only for boosting agricultural productivity but also for reducing nutrient wastage and environmental impact.

This research endeavors to shed light on the intricate interplay between phosphorus, zinc, and black gram performance.

2. MATERIALS AND METHODS

2.1 Experimental Location and Initial Soil Description

A field study was conducted during *kharif* 2023 in a *Vertisol*, field no. A 4 of Wetland farm, Tamil Nadu Agricultural University, Coimbatore. The experimental field's soil belongs to the Noyyal soil series (*Typic haplustalf*). The initial soil samples before commencing the experiment were collected and analyzed for their physical, physiological and chemical parameters. The result of the initial soil analysis showed the soil is black, calcareous, clay loam, alkaline (pH 8.2), non-saline (EC 0.50 dS m^{-1}), medium soil organic carbon (6.0 g kg^{-1}), low available N (252 kg ha^{-1}), medium available P (22 kg ha^{-1}) and high available K (600 kg ha^{-1}) status. The DTPA-Zn (0.63 mg kg^{-1}) and DTPA-Cu (0.33 mg kg^{-1}) were

in the deficient status while DTPA-Mn (5.52 mg kg^{-1}) and DTPA-Fe (11.27 mg kg^{-1}) were in the sufficient status.

2.2 Experimental Details

An experiment was conducted to investigate the influence of phosphorus (P) and zinc (Zn) on growth, yield, and quality parameters of Blackgram (*Vigna mungo* L.) variety VBN 8. Using a Factorial Randomized Block Design (FRBD) with 12 treatments and three replications, the experiment encompassed varying P_2O_5 levels (0, 25, 50, 75 kg ha^{-1}) and foliar applications of Zn-EDTA (0%, 0.5%, 1.0%) twice on 30 and 45 days after sowing. The recommended dose of nitrogen (N) and potassium (K_2O) at 25 kg ha^{-1} each, along with a recommended dose of zinc sulfate ($ZnSO_4$) at 25 kg ha^{-1}, was applied as a blanket recommendation to ensure consistent nutrient supply across treatments.

Table 1. Treatment details

T_1	:	0 kg P_2O_5 + 0% Zn-EDTA
T_2	:	0 kg P_2O_5 + 0.5% Zn-EDTA
T_3	:	0 kg P_2O_5 + 1.0% Zn-EDTA
T_4	:	25 kg P_2O_5 + 0% Zn-EDTA
T_5	:	25 kg P_2O_5 + 0.5% Zn-EDTA
T_6	:	25 kg P_2O_5 + 1.0% Zn-EDTA
T_7	:	50 kg P_2O_5 + 0% Zn-EDTA
T_8	:	50 kg P_2O_5 + 0.5% Zn-EDTA
T_9	:	50 kg P_2O_5 + 1.0% Zn-EDTA
T_{10}	:	75 kg P_2O_5 + 0% Zn-EDTA
T_{11}	:	75 kg P_2O_5 + 0.5% Zn-EDTA
T_{12}	:	75 kg P_2O_5 + 1.0% Zn-EDTA

Number of factors = 2 (P and Zn)

4 levels of factor P

- P_0 = 0 kg P_2O_5
- P_1 = 25 kg P_2O_5
- P_2 = 50 kg P_2O_5
- P_3 = 75 kg P_2O_5

3 levels of factor Zn

- Zn_0 = 0% Zn-EDTA
- Zn_1 = 0.5% Zn-EDTA
- Zn_2 = 1.0% Zn-EDTA

3. RESULTS AND DISCUSSION

3.1 Plant Height

Throughout the course of the experiment, the age of the crops led to a gradual rise in plant height. The assessment of plant height exhibited a noteworthy elevation across various growth stages, with both phosphorus and zinc levels playing a significant role. The plant height was significantly influenced by the different treatments. Fig. 1 clearly show that with the addition of phosphorus, there was considerable increase in the plant height at all the stages of crop growth. The maximum plant height was seen at harvest stage with application of 50 kg P2O5 ha^{-1} + 0.5% Zn-EDTA (T_8), (42.3 cm) which is 31.4 % higher over control. It was statistically on par with the treatment 50 kg P2O5 ha^{-1} + 1% Zn-EDTA (T_9) (41.8). The minimum height was seen in control $(T_1)(33.2\text{cm})$ which was statistically on par with the treatment $(T_2)(33.4\text{cm})$. This in line with the findings of Singh et al. [5] who observed and indicated plant height of blackgram recorded at three levels of phosphorus *viz.,* 0, 30 & 60 kg ha^{-1}, wherein level 60 kg P ha^{-1} gave the best result.

3.2 Yield Attributes

The data revealed that the effect of the applied nutrients (P and Zn) greatly influenced the yield attributes of blackgram *viz.,* the highest number of pods $plant^{-1}$and 100 seed weight are graphically represented in Figs. 2 and 3. The treatment combination of 50 kg P_2O_5 ha^{-1} + 0.5% Zn-EDTA registered significantly the highest number of pod $plant^{-1}$(35.2) and 100 seed weight (4.82 g) which was statistically on par with the treatment combination P_2Zn_1. The lowest number of pod $plant^{-1}$ (16.2) and 100 seed weight (1.52 g) was registered in the absolute control. The increased effect on yield attributes and yield maybe due to the combined effect of both P and Zn at optimal dose which might have triggered the overall growth of the crop since the soil was deficient in Zn. It is also supported by Debata et al. (2022) who observed that additional foliar application of zinc resulted in increased pod $plant^{-1}$. The result was supported by Singh et al. [6] and Hussain et al. [7]. The findings showed that the application of 40 kg/ha P_2O_5 along with molybdenum (foliar spray 0.8% at 25 DAS) resulted in higher yield attributes such as the number of pods produced per plant, seeds per pod, and test weight [8].

3.3 Seed and Haulm Yield

Regarding yield, the seed and haulm yield ranged from 5.47 to 9.48 q ha^{-1} and 19.81 to 32.18 q ha^{-1} respectively. The significant increase in dry seed (9.48 q ha^{-1}) and haulm

yield (32.18 q ha^{-1}) were recorded with the application of 50 kg P_2O_5 ha^{-1} + 0.5% Zn-EDTA which is statistically on par with the treatment combination P_2Zn_1. The seed and haulm yield increase being 58% and 62% over control (Table 1). This might be due to the function of zinc as catalyst or stimulant in most of the physiological and metabolic processes. The lowest seed and haulm yield was registered in the absolute control (5.47 q ha^{-1} and 19.81 q ha^{-1}) than the treatments enhanced with combination of levels of P and Zn. The increase in yield of blackgram seed and haulm with P application may be due to fact that soil under study was moderate in available P and deficient in available Zn. Singh et al. [5] also observed an increase in yield of blackgram with increasing levels of P. Increase in yield due to application of Zn is quite obvious, as the soil under study was deficient in available zinc (0.63 mg kg^{-1}). Saran et al. [9] and Singh et al. [10] also noted a significant response of legumes to Zn applied to deficient soils. Meena et al. [11] also observed the similar trend in increase in seed and haulm yield of blackgram

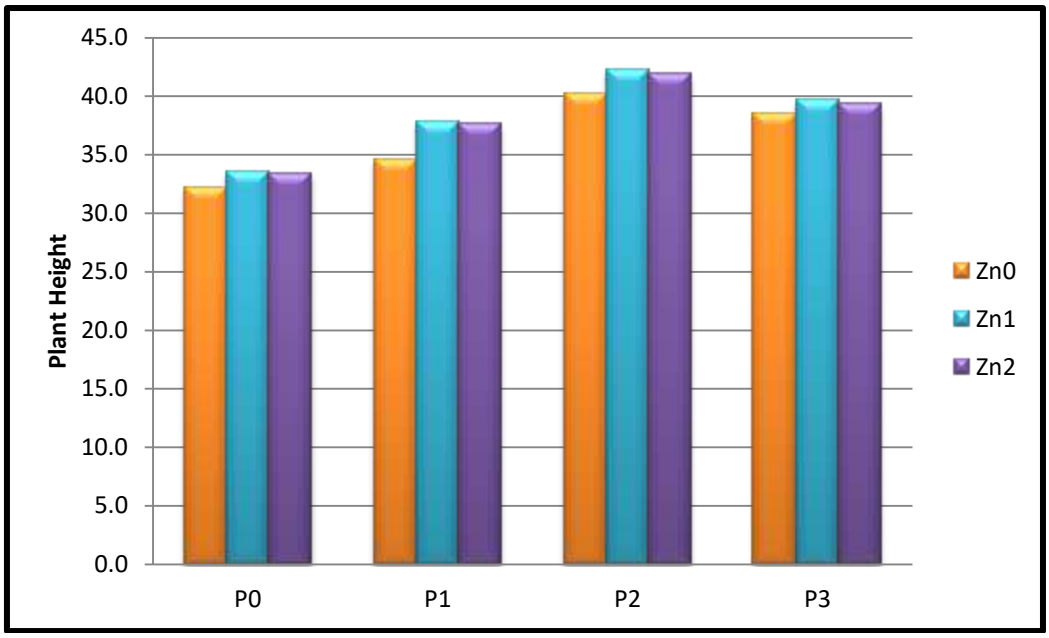

Fig. 1. Effect of applied P and Zn on plant height (cm) of blackgram

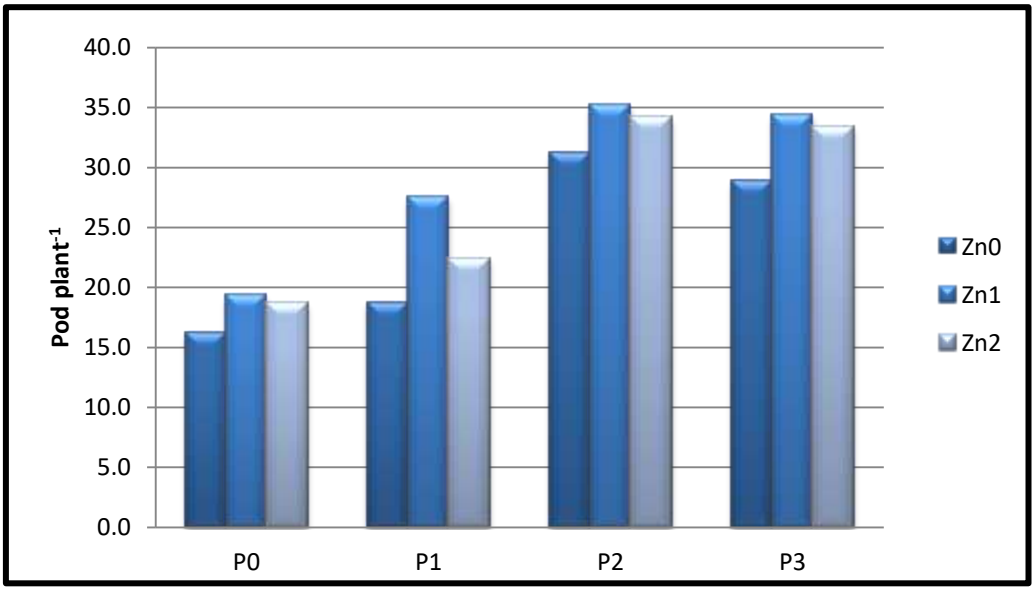

Fig. 2. Effect of applied P and Zn on number of pods $plant^{-1}$ of blackgram

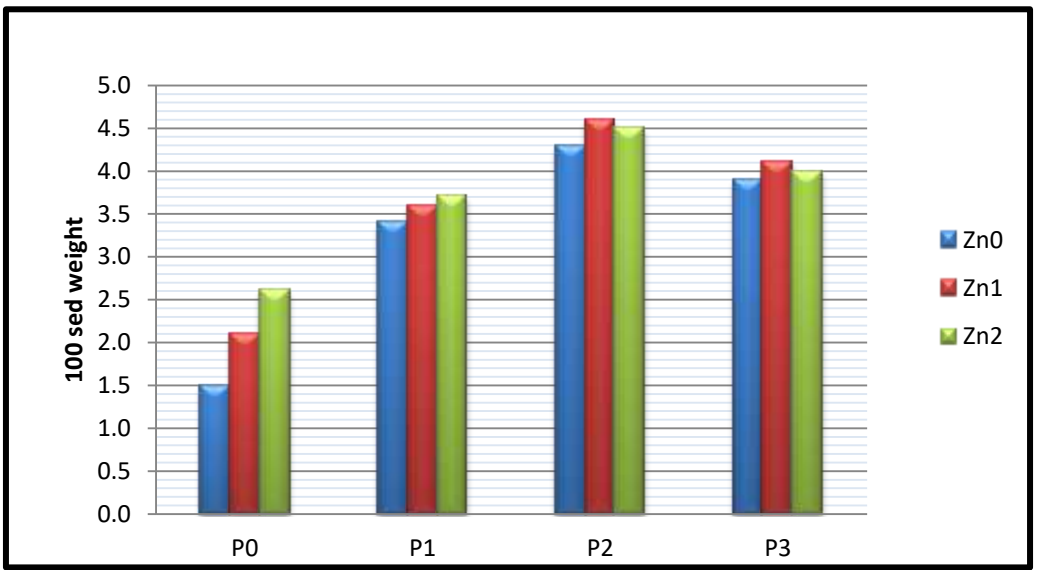

Fig. 3. Effect of applied P and Zn on 100 seed weight (g) of blackgram

Table 2. Effect of applied phosphorus and zinc on seed and haulm yield (q ha^{-1}) of blackgram

Treatments	Seed Yield				Haulm Yield			
	Zn_0	Zn_1	Zn_2	Mean	Zn_0	Zn_1	Zn_2	Mean
P_0	5.47	6.23	6.52	6.07	19.81	21.45	22.12	21.13
P_1	6.88	7.27	7.09	7.08	25.97	26.98	26.33	26.43
P_2	8.32	9.48	9.27	9.02	30.83	32.18	31.62	31.54
P_3	7.99	8.54	8.37	8.30	29.74	30.46	30.17	30.12
Mean	7.17	7.88	7.81		26.59	27.77	27.56	

Treatments	P	Zn	P x Zn	P	Zn	P x Zn
S.E.d	0.10	0.08	0.17	0.23	0.20	0.39
CD (0.05)	0.20	0.17	0.35	0.47	0.41	0.81

using optimal dose of phosphor enriched compost and zinc. Kachave et al. [12] reported that the application of different levels of P alone significantly increased the straw and grain yield of black gram, with the treatment of 100% N + 60 kg P2O5 ha-1 showing the highest increase [13-15].

4. CONCLUSION

This study demonstrated that when phosphorus is applied at a rate of 50 kg P_2O_5 ha^{-1}in combination with foliar spraying of 0.5% Zn-EDTA, done twice at 30 and 45 days after sowing in zinc-deficient soil under field conditions, it has a positive influence on the growth, yield, and quality of blackgram. This leads to improvements in the plant's physical characteristics and overall crop yield. Consequently, it can be inferred that for blackgram grown in zinc-deficient soils, an optimal treatment involving 50 kg P_2O_5 ha^{-1}along with 0.5% Zn-EDTA foliar application is recommended to enhance the productivity of the crop.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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