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Effects of Phosphorus and Boron on Growth, Yield and Economics of Green Gram (*Vigna radiata* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out during *kharif*, 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) to determine the "Effects of Phosphorus and Boron on growth, yield and economics of green gram (*Vigna radiata* L.)''. The result showed that treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)] recorded significantly higher plant height (42.57 cm), higher number of branches/plant (6.73), higher number of nodules/plant (24.13), higher dry weight (16.88 g). Significant and maximum numbers of pods/plant (32.47), maximum numbers seeds/pod (8.40), higher test weight (37.0 g), higher seed yield (12.43 q/ha), higher stover yield (22.83 q/ha) and higher harvest index (35.38 %) were recorded in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)]. Maximum gross return (1,16,278 INR/ha), net return (82,434 INR/ha) and highest benefit cost ratio (2.43) were also recorded in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)] as compared to other treatments.

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1. INTRODUCTION

"Green gram is one of the important kharif pulse crops of India which can be grown as a catch crop between rabi and kharif seasons. India is its primary origin and is mainly cultivated in east Asia, southeast Asia and the Indian subcontinent. India is the largest pulses producer globally, accounting for 24% of the world total production. Due to its short duration nature, it is an excellent crop to fit an intercropping system with different major crops. It is well known for its high nutritional content, *viz*, crude protein (24.0%), fat (1.3%), carbohydrate (56.6%), minerals (3.5%), lysine (0.43%), methionine (0.10%) and tryptophan (0.04%). The Indian Council of Medical research (ICMR) has recommended a minimum consumption of 40 gram/day. Green gram is popularly known as mung bean. Mung bean contributes 14% in total pulse area and 7% in total pulse production in India. The low productivity of mung bean may be due to nutritional deficiency in soil and imbalanced external fertilization" [1]. "It was extensively cultivated under varying agro-climatic conditions. India is the world's major producer of green gram, which is grown in almost all the states. In India during 2020-21, green gram is grown in about 30.37 lakh/ ha with the total production of 2.64 million tons with a productivity of 888 kg/ha and contributing 10% to the total pulse production. Some of the states like Rajasthan (19.23 lakh/ ha), Karnataka (4.23 lakh/ ha), Maharashtra (4.03 lakh/ ha) Madhya Pradesh (2.10 lakh/ ha), Odisha (1.69 lakh/ ha), Telangana (0.73 lakh/ ha) and Uttar Pradesh (0.30 lakh/ ha) are the major producers of green gram in India" [2].

"Phosphorus is second most critical plant nutrient, but for pulses, it assumes primary importance, owing to its important role in root proliferation and there by atmospheric nitrogen fixation or phosphorus play a vital role in crop production in pulses" [3]. "Indian soil are poor to medium in available phosphorus. Only about 30 % of the applied phosphorus is available for crops and remaining part converted into insoluble phosphorus. As the concentration of the available phosphorus in the soil solution is normally insufficient to support the plant growth, continual replacement soluble phosphorus from inorganic to organic sources is necessary to meet the phosphorus requirement of crops. Phosphorus is added extra dose in recommended dose of phosphorus which increases nitrogen fixation and improves the productivity of green gram. It plays an important role in virtually all main metabolic process in plants including photosynthesis, energy transfer, biosynthesis and respiration" [4].

"Phosphorus is needed in large quantities during the early stages of cell division, the initial overall symptom is slow, weak and stunted growth. Phosphorus is relatively mobile in plants and can be transferred to site of new growth, causing symptoms of dark to blue green coloration to appear on the older leaves of some plants. Under serve deficiency, purplish of leaves and stems may appear. Phosphorus deficiency causes delayed maturity and poor seed and fruit development. which lead to yield reduction by limiting the plants growth" [5].

"Boron is one of the mineral nutrients required for normal plant growth. The most important functions of boron in plants are thought to be its structural role in cell wall development, cell division, seed development and stimulation or inhibition of specific metabolic pathways for sugar transport and hormone development" [6]. "Boron deficiency causes decreases in pollen grain count, pollen germination etc. It also influences growth parameters and the filling up of seeds. It is usually accepted that boron availability is decrease under dry soil conditions. Thus, boron deficiency is often associated with dry weather and low soil moisture conditions. This behaviour may be related to the restricted release of boron from organic complexes. Which ultimately impaired ability of plants to extract boron from soil due to a lack of moisture in the rhizosphere. Even when boron levels in soil are high, then also low soil moisture are also impairing the transport of boron to absorbing root surfaces" [7]. Keeping the above aspect in mind, the present investigation is entitled "Effects of phosphorus and boron on growth, yield and economics of green gram (*Vigna radiata* L)".

2. MATERIALS AND METHODS

The field experiment was carried out during *kharif* 2022 at crop research Farm, Department of Agronomy, Naini agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences. Prayagraj (U.P). The soil of the experimental field was sandy loam soil in texture, nearly neutral in soil reaction (pH 8), low level organic carbon (0.62%), medium available N (225 kg/ha), high in available P (38.2 kg/ha) and low available K (240.7 kg/ha). The treatment consists of 3 levels of phosphorus *viz*. (30kg/ha), phosphorus (40 kg/ha) and phosphorus (50 kg/ha) with a combination of different levels of boron *viz.* (0.6 kg/ha), boron (0.8 kg/ha), boron (1.0 kg/ha). The experiment was laid out in RBD, with 10 treatments, each replicated three times. The treatment combinations are T_1 Phosphorus (30 kg/ha) + Boron (0.6 kg/ha). T_2 (30 kg/ha) + Boron (0.8 kg/ha), T_3 Phosphorus (30 kg/ha) + Boron (1.0 kg/ha), T_4 (40 kg/ha) + Boron (0.6 kg/ha), T_5 Phosphorus (40 kg/ha) + Boron (0.8 kg/ha), T_6 Phosphorus (40 kg/ha) + Boron (1.0 kg/ha), T_7 Phosphorus (50 kg/ha) + Boron (0.6 kg/ha), T_8 Phosphorus (50 kg/ha) + Boron (0.8 kg/ha). T_9 Phosphorus (50 kg/ha) + Boron (1.0 kg/ha), T_{10} (control) N:P: K 25:50:25 kg/ha. Data recorded on different aspects of the crop, *viz.*, growth, and yield attributes, were subjected to statical analysis by the analysis of variance method (Gomez and Gomez, 1984) [8].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The data (Table 1) revealed that significant and higher plant height (42.57 cm) was recorded in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)]. However, treatment 8 [Phosphorus (50kg/ha) + Boron (0.8kg/ha)] and treatment 7 [Phosphorus (50kg/ha+ Boron (0.6kg/ha)] were found to be statistically at par with treatment 9 [Phosphorus (50kg/ha + Boron (1.0kg/ha)]. “The significant and higher plant height observed with the application of phosphorus (50kg/ha) might be due to the adequate availability of plant nutrient through appropriate nutrient supply and sunlight to each plant. An appropriate phosphorus supply indirectly helps in providing nitrogen supply and its availability helped the plants attain more vigr in terms of plant height” [9].

3.1.2 Number of branches/plants

The data (Table 1) revealed that a significant and maximum number of branches/plant (6.13) was recorded in treatment 9 [Phosphorus (50 kg/ha) + (Boron 1.0 kg/ha)]. however, treatment 8 [Phosphorus (50 kg/ha) + Boron (0.8 kg/ha)], treatment 7 [Phosphorus (50 kg/ha) + Boron 0.6 kg/ha)], treatment 6 [Phosphorus (40 kg/ha) + Boron (1.0 kg/ha)], and treatment 5 [Phosphorus (40 kg/ha) + Boron (0.8 kg/ha)] were found to be statically at par with treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)]. The significant and maximum number of branches/plants was observed with the application of boron (1.0 kg/ha) might be due to quick availability of boron, which play crucial role in tissue differentiation, carbohydrate metabolism, sugar translocation in plants, and the development of news cells in meristematic tissue. Similar results were reported by Janaki et al. [10].

3.1.3 Number of nodules/plants

The data (Table 1) revealed that a significant and higher number of nodules/plant (24.13) was recorded in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)]. However, treatment 8 [Phosphorus (50 kg/ha) + Boron (0.8 kg/ha)], treatment 7 [Phosphorus (50 kg/ha) + Boron (0.6 kg/ha)] and treatment 6 [Phosphorus (40 kg/ha) + Boron (1.0 kg/ha)] were found statistically at par with treatment 9 [Phosphorus (50 kg/ha) + (Boron 1.0 kg/ha)]. The significant and higher number of nodules/plants was observed with the application of phosphorus (50 kg/ha) might be due to better proliferation of roots and increased nodulation due to higher phosphorus availability, which leads to higher plant growth [11]. Further, the application of boron (1kg/ha) promoted the nodule due to direct involvement of boron in nodulation, symbiotic nitrogen fixation, and its help in retaining the cell wall and membrane integrity of nodules. These findings were consistent with those of Sharmila et al. [12].

3.1.4 Plant dry weight (g/plant)

The results (Table 1) revealed that plant dry weight was recorded significantly higher (16.88g) in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)]. However, treatment 8[Phosphorus (50kg/ha) +(Boron 0.8kg/ha)], treatment 7 [Phosphorus (50kg/ha) + (Boron 0.6kg/ha)], treatment 6 [Phosphorus (40kg/ha) +(Boron 1kg/ha)], treatment 5 [Phosphorus(40kg/ha) +(Boron 0.8kg/ha)] was found statistically at par with treatment 9 [Phosphorus (50kg/ha) +(Boron 1kg/ha)]. Higher plant dry weight (g) was significantly influenced by the application of phosphorus (50 kg/ha), might be due to adequate supply and availability of phosphorus increased the dry weight of the plant and improved photosynthetic activity due to greater exposure to light and increased the availability of nutrients to the plants, which resulted in higher plant dry weight. A similar result was reported by Swami et al. [13].

3.2 Yield Parameters

3.2.1 Number of pods/plants

The data (Table 2) revealed that a significant and higher number of pods/plant (32.47) was recorded in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)] which was significantly superior over the rest of the treatments. However, treatment 8 [Phosphorus (50kg/ha) + (Boron 0.8kg/ha)], treatment 7 [Phosphorus (50kg/ha) + (Boron 0.6kg/ha)] were statically at par with the treatment 9 [Phosphorus (50kg/ha) + (Boron 1kg/ha)]. A significant and maximum number of pods/plant with the application of boron (1 kg/ha) might be due to its important role in tissue differentiation, carbohydrate metabolism and sugar translocation [14].

3.2.2 Number of seeds/pods

The data (Table 2) revealed that a significant and higher number of seeds/pod was observed in treatment 9 [Phosphorus (50kg/ha) + Boron (1.0 kg/ha)]. However, treatment 8 [Phosphorus (50kg/ha) + (Boron 0.8 kg/ha)], treatment 7 [Phosphorus (50kg/ha) + (Boron 0.6 kg/ha)] was statically at par with the treatment 9 [Phosphorus (50kg/ha) + (Boron 1kg/ha)]. A significant and maximum number of seeds/pods with the application of phosphorus (50 kg/ha) might be due to the increase in vegetative development and reproductive attributes under proper availability of phosphorus and better physical condition of the soil, resulted in a higher number of seeds/pods. A similar result was reported by [15]. Further, the increase in seeds/pods with the application of boron (1kg/ha) might be due to the translocation of photosynthesis, pollen viability, and pollen tube growth. these results are similar to those of Ram et al. [16].

3.2.3 Test weight (g)

The data (Table 2) recorded that the highest test weight (37.70g) was observed in treatment 8 [Phosphorus (50 kg/ha) + Boron (0.8 kg/ha)], though there was no significant difference among other treatments.

3.2.4 Seed yield (q/ha)

The data (Table 2) revealed that a significant and higher seed yield (12.43 q/ha) was observed in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha), which was significantly superior over the rest of the treatments. "However, treatment 8 [Phosphorus (50 kg/ha) + Boron (0.8kg/ha) were statistically at par with the treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)]. The higher and more significant seed yield obtained with application of phosphorus (50 kg/ha) might be due to well- developed root system, greater translocation of photosynthates from source to sink" [17]. Further, increase in seed yield with the application of boron (1.0 kg/ha) might be due to enhancement of the cell wall, tissue difference, sugar transport, maintenance of conducting tissue with regulatory effect on another elements and metabolism of nucleic acids, carbohydrate, auxins and phenols. Similar results were reported by Praveena et al. [18].

3.2.5 Stover yield (q/ha)

The data (Table 2) revealed that a significant and higher stover yield (22.83 q/ha) was observed in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha) which was significantly superior over the rest of the treatments. However, treatment 8 [Phosphorus (50 kg/ha) + Boron (0.8 kg/ha). was statistically at par with treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)]. The maximum stover yield obtained with the application of phosphorus (50 kg/ha) might be due to an increase in the photosynthetic activities of the plant and a root system that enabled the plant to extract more water and nutrients from the soil [19]. Further, increased in stover yield with the application of boron (1.0 kg/ha) might be due to vegetative development creating too many sites for photosynthetic, translocation. A Similar result was reported by Karthik et al. [20].

3.2.6 Harvest index (%)

The data (Table 2) recorded that the highest harvest index (35.38%) was observed in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)] and there was no significant difference among other treatments.

Table 1. Influence of phosphorus and boron on growth parameter of green gram.

S. No.	Treatment combination	At 60 DAS			
		Plant height (cm)	**No of branches/Plant**	**No of nodules/Plant**	**Plant dry weight (g)**
1.	Phosphorus 30 kg/ha + Boron 0.6 kg/ha	33.30	4.33	11.40	12.19
2.	Phosphorus 30 kg/ha + Boron 0.8 kg/ha	34.40	4.73	12.67	13.04
3.	Phosphorus 30 kg/ha + Boron 1.0 kg/ha	35.37	5.00	13.93	14.01
4.	Phosphorus 40 kg/ha + Boron 0.6 kg/ha	36.17	5.40	15.47	14.60
5.	Phosphorus 40 kg/ha + Boron 0.8 kg/ha	37.17	5.60	17.07	15.01
6.	Phosphorus 40 kg/ha + Boron 1.0 kg/ha	38.60	5.87	19.00	15.58
7.	Phosphorus 50 kg/ha + Boron 0.6 kg/ha	40.17	6.27	21.07	16.12
8.	Phosphorus 50 kg/ha + Boron 0.8 kg/ha	41.77	6.53	22.73	16.45
9.	Phosphorus 50 kg/ha + Boron 1.0 kg/ha	42.57	6.73	24.13	16.88
10	Control + RDF (NPK- 25:50:25 kg/ha)	32.53	3.87	10.73	11.07
F-test		s	S	S	S
SEm (±)		1.42	0.52	0.87	0.86
CD (p=0.05)		4.22	1.56	2.60	2.56

Table 2. Influence of phosphorus and boron on yield attribute of green gram.

S. No.	Treatment combination	Yield attributes					
		No. of pods/plant	No. of seeds/pod	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
1.	Phosphorus 30 kg/ha + Boron 0.6 kg/ha	22.73	5.20	33.76	7.49	14.27	34.45
2.	Phosphorus 30 kg/ha + Boron 0.8 kg/ha	23.73	5.60	33.31	8.77	15.29	36.40
3.	Phosphorus 30 kg/ha + Boron 1.0 kg/ha	24.20	6.00	33.95	8.72	16.56	34.52
4.	Phosphorus 40 kg/ha + Boron 0.6 kg/ha	25.00	6.20	34.75	9.83	18.13	35.15
5.	Phosphorus 40 kg/ha + Boron 0.8 kg/ha	26.93	6.60	34.61	10.54	19.34	35.29
6.	Phosphorus 40 kg/ha + Boron 1.0 kg/ha	27.93	7.00	36.03	10.90	20.27	34.97
7.	Phosphorus 50 kg/ha + Boron 0.6 kg/ha	29.27	7.60	36.11	11.34	20.84	35.23
8.	Phosphorus 50 kg/ha + Boron 0.8 kg/ha	30.80	7.80	37.70	11.83	22.03	34.95
9.	Phosphorus 50 kg/ha + boron 1.0 kg/ha	32.47	8.40	37.00	12.43	22.83	35.38
10.	Control + RDF (NPK- 25:50:25 kg/ha)	21.60	4.60	33.01	6.51	13.58	32.64
	F-test	S	S	NS	S	S	NS
	SEm (±)	1.16	0.37	1.01	0.19	0.58	1.09
	CD (p=0.05)	3.45	1.11	-	0.58	1.74	-

Table 3. Influence of phosphorus and boron on economics of green gram

S. No.	Treatment combination	Economics			
		Cost of cultivation (INR/ha)	Gross return(INR/ha)	Net return(INR/ha)	B:C ratio
1.	Phosphorus 30 kg/ha + Boron 0.6 kg/ha	31794	70839	39045	1.22
2.	Phosphorus 30 kg/ha + Boron 0.8 kg/ha	32194	80817	48623	1.51
3.	Phosphorus 30 kg/ha + Boron 1.0 kg/ha	32594	82392	49798	1.52
4.	Phosphorus 40 kg/ha + Boron 0.6 kg/ha	32419	92073	59654	1.84
5.	Phosphorus 40 kg/ha + Boron 0.8 kg/ha	32819	98547	65755	2.00
6.	Phosphorus 40 kg/ha + Boron 1.0 kg/ha	33219	102354	68026	2.04
7.	Phosphorus 50 kg/ha + Boron 0.6 kg/ha	33044	106104	73060	2.21
8.	Phosphorus 50 kg/ha + Boron 0.8 kg/ha	33444	111123	77679	2.32
9.	Phosphorus 50 kg/ha + Boron 1.0 kg/ha	33844	116278	82434	2.43
10.	Control + RDF (NPK- 25:50:25 kg/ha)	28719	63336	34617	1.20

4. ECONOMICS

The findings revealed (Table 3) that the maximum gross return (1,16,278 INR/ha), net return (82,434 INR/ha) and benefit cost ratio (2.43) was recorded in treatment 9 [Phosphorus (50 kg/ha) + Boron (1.0 kg/ha)] as compared to other treatments. Higher gross return, net return and benefit cost ratio were recorded with the application of phosphorus (50 kg/ha) might be due to higher growth and yield attributes resulting in higher seed and stover yields. These results line up with those that Singh et al. [21] observed.

5. CONCLUSION

It can be concluded that in green gram with the application of Phosphorus 50 kg/ha along with the application of Boron 1.0 kg/ha (Treatment 9) was observed highest grain yield and benefit cost ratio. Since the findings are based on one season, further trails are needed to conform the results.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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