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Influence of Phosphorus and Boron Application on Yield, Quality, Nutrient Content and Their Uptake by Green Gram (*Vigna radiate* L.)

Nidhi Kamboj* **and R.S. Malik**

Department of Soil Science, CCSHAU, Hisar-125004, Haryana, India

**Corresponding author*

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A B S T R A C T

A screen house experiment was conducted to understand the influence of phosphorus and boron application on yield and enrichment of seed and straw of green gram. Five levels of phosphorus (0, 25, 50, 75 and 100 mg kg^{-1}) and 4 levels of boron (0, 0.25, 0.5 and 1.0 mg kg^{-1}) were applied in pots filled up with 4 kg light texture (sand) soil. Eight seeds of green gram were seeded in each pot and replicated thrice. The soil used in pot had pH 7.90, EC 0.17 dSm^{-1}, organic carbon 0.09%, DTPA Zn 0.36 mg kg^{-1} and hot water soluble B 0.5 mg kg^{-1} soil. The results of the study revealed that application of phosphorus and boron have synergistic effect on yield, P and B content in seed and straw of green gram. Highest seed and straw yield, content of P and B in seed and straw was found when 100 mg kg^{-1} P along with 1.0 mg B kg^{-1} soil. Application of P and B also improve protein content but their interaction was found non-significant. The uptake of P and B increases with their successive P and B application level.

Introduction

In intensive cropping system of the country mungbean (*vigna radiate* L.) has special importance for its short growth period. Mungbean being a leguminous crop, responds well to added phosphorus. An adequate phosphorus supply must be satisfied for the legumes, to fix nitrogen in soil, other factors being adequate. Phosphorus (P) is an essential plant nutrient required for optimum crop production. Plants need phosphorus for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division Atif *et al.,* (2014). Boron's (B) role within the plant includes cell wall synthesis, sugar transport, cell division, differentiation, membrane functioning, root elongation, regulation of plant hormone levels and generative growth of plants Marschner (1995). Phosphorus deficiency causes yield reduction by limiting plant growth Poehlman (1991). It influences nutrient uptake by promoting root growth and nodulation Singh and Singh, (1994). Among the pulses, it is best in nutritional value having about 51% carbohydrates, 26% proteins, 4% minerals and 3% vitamins Kaul (1982). The response to a particular nutrient not only depends on its own level but also on the levels of other nutrients present in soil. Interaction occur when the level of one production factor influence the response to other factor. These Interactions may be Synergetics (positive) leading to the increased availability of other plant nutrient or Antagonistics (negative) in which availability of other plant nutrient adversely affected. If there is neither positive nor negative effect on availability of other nutrient, it is considered as non interaction. Seed yield and its quality in crop plants are greatly influenced by both macro and micronutrients Jasim *et al.,* (2014). Many researchers reported that P and B have significant synergetics effect in improving the growth, yield and quality of plant species Kaya *et al.,* (2009); YuFan *et al.,* (2012). Therefore, the present study was undertaken to see the interaction effect of P and B on the yield and quality of green gram.

Materials and Methods

A screen house experiment was conducted during summer season at CSSHAU, Hisar. Bulk soil samples of (0-15 cm depth) were collected from village Balsamand district Hisar. The soil sample was air dried ground and passed through 2 mm sieve and analysed for physico-chemical properties and initial nutrients status using standard procedure. Four kg thoroughly mixed soil was filled in each pot and placed in completely randomized block design in the screen house. Five levels of phosphorus 0, 25, 50, 75 and 100 mg P_2O_5 kg^{-1} soil through Potassium orthophosphate {KH_2PO_4} and four level of boron 0, 0.25, 0.5 and 1.0 mg B kg^{-1}soil through Borax {$Na_2B_4O_7.10H_2O$} were applied. Recommended doses of nitrogen and phosphorus were uniformly applied as basal in each pot. Eight seeds of green gram (cv: Asha) were seeded in each pot and after thinning four uniform plants per pots were allowed to grow up to maturity. At physiological maturity plants samples were collected, air dried and in oven at 65±2 ^oC till a constant weight was obtained. The dry matter and seed yield was also recorded. For the estimation of P and B content in plants as well as seed, samples were digested with diacid mixture (HNO_3 and $HClO_4$) in 4:1 ratio for analysis of Zn and B content and their uptake was computed accordingly. Seeds were also digested in a diacid mixture of sulphuric and perchloric acid in the ratio of 9:1 for the analysis of total N in colorimetric (Nesslar's reagent) method. Crude protein in green gram seed was computed by multiplying total seed N with 6.25.

Results and Discussion

Seed and straw yield

The seed and straw yield of green gram significantly increases with the increased level of boron up to 0.5 mg B kg^{-1} i.e. 8.18 g pot^{-1} and 58.91 g pot^{-1} over control i.e. 4.56 g pot^{-1} and 39.45 g pot^{-1}, respectively. Subedi and Yadav (2013), also reported higher grain yield of mung-bean (1583 kg ha^{-1}). After the level of boron 0.5 mg B kg^{-1}, a significant decrease was observed in seed as well as in straw yield of green gram due to toxicity of high level of boron i.e. 1.0 mg kg^{-1}. Padbhushan and Kumar (2014), noticed that out of all four levels of soil applied boron viz. 0.5, 0.75, 1.0 and 1.5 mg B kg^{-1} and two levels of foliar viz. 0.1 and 0.2 % borax solution, 0.5 mg kg^{-1} soil applied boron is best treatment while 0.1% is best foliar treatment.

Similarly, in case of P application along with B, the seed and straw yield of green gram increased significantly upto 9.39 g pot^{-1} in seed and 66.83 g pot^{-1} in straw with increasing level of P over control (4.56 g pot^{-1}) (Table 1). The interaction effect of phosphorus and boron on seed yield was significant. The highest seed yield (10.18 g pot^{-1}) was found when 0.5 mg B kg^{-1} applied along with 100 mg P kg^{-1} over control i.e. (4.56 g pot^{-1}). Alam *et al.,* (2010), also conducted an experiment with four levels of P (0, 10, 20 and 30 kg ha^{-1}) and three levels of B (0, 1 and 2 kg ha^{-1}) revealed that yield and yield attributing characters of summer mung-bean influenced significantly by the application of phosphorus (P) and boron (B).

Boron content

The highest concentration of boron in seed and straw of green gram was obtained when P was applied @ 100 mg P kg^{-1} and B @ 1 mg B kg^{-1} of soil. The significant increase in boron content of seed and straw of green gram ranges from 47.43 mg kg^{-1} and 49.75 mg kg^{-1} boron in control to 63.99 mg kg^{-1} and 60.28 mg kg^{-1} boron at 100 mg P kg^{-1} of soil. Singh *et al.,* (2006), found an increase in available P_2O_5 decreased the magnitude of B deficiency by 42% when available P_2O_5 was less than 30 kg ha^{-1}, 38% when P_2O_5 ranging from 30-40 kg ha^{-1} and 29% above 40 kg P_2O_5 ha^{-1}. Similarly, with increasing level of boron application there was significant increase in boron content in seed and straw of green gram from 39.59 mg kg^{-1} and 45.16 mg kg^{-1} boron in control to 66.74 mg kg^{-1} and 62.72 mg kg^{-1} boron at highest level of applied boron i.e. 1.0 mg kg^{-1} of soil, respectively (Table 2) The combined application of phosphorus and boron shows significant higher boron content (77.38 mg B $kg^{-1)}$ in seed and (69.50 mg B kg^{-1}) in straw of green gram when 1 mg B kg^{-1} was applied along with 100 mg P kg^{-1}.

Seed and straw phosphorus concentration

The phosphorus content in seed as well as straw of green gram increases with application of graded level of phosphorus and it ranges from 0.28% and 0.06% under control to 0.51% and 0.25% at higher dose of P applied (100 mg P kg^{-1}), respectively (Table 3). Application of increasing level of boron also increases the phosphorus concentration in seed of green gram significantly from 0.32% in seed and 0.13% in straw under control to 0.48% in seed and 0.17 % in straw when B was applied @ 1.0 mg kg^{-1} of soil. A significant interaction effect of P and B application on seed and straw P content was observed with the combined application of phosphorus and boron. The maximum phosphorus concentration (0.59%) in seed and (0.27 %) in straw of green gram was observed when P and B applied in combination of 100 mg P kg^{-1} and 1 mg B kg^{-1} of soil.

Boron uptake by seed and straw

Similar to yield and concentration of both, phosphorus and boron application also enhance boron uptake in seed of green gram significantly. Boron uptake in seed increased from 269.38 µg pot^{-1} in control to 613.76 µg pot^{-1} when 100 mg P kg^{-1} of soil was applied. Likewise, with the increasing level of boron application from 0 to 1.0 mg kg^{-1}, the uptake of boron also increases significantly from 249.64 µg pot^{-1} to 546.90 µg pot^{-1} when B was applied @ 1.0 mg B kg^{-1} of soil (Figure 1). These results are in close agreement with the findings of Kumar *et al.,* (2009) in which increase in boron uptake up to application of 4 kg B ha^{-1} and 90 kg P_2O_5 ha^{-1} by grain and straw of Lentil was noticed. This increase may be the result of increased grain and straw production with the addition B and P which enhance their availability in soil. The interaction effect of P and B on boron uptake by seed of green gram was found significant and highest B uptake (784.46 µg pot^{-1}) was found when phosphorus and boron were applied in a combination of $P_{100}B_{1.0}$. The uptake of boron in straw of green gram increases at each level of phosphorus and maximum (5073.92 µg pot^{-1}) boron were found at their highest levels over control i.e. 2685.29 µg pot^{-1} where no application of either P or B was done. Graded level of applied boron also enhances the boron uptake significantly in straw of green gram. Highest uptake of B on account of B application was found 3778.71 µg pot^{-1} when B was applied @ 1.0 mg kg^{-1} over control i.e. 2043.72 µg pot^{-1}.

Table.1 Effect of phosphorus and boron application on seed and straw yield (g pot^{-1}) of green gram

Phosphorus level (mg kg^{-1})	Boron Level (mg kg^{-1})				Mean
	0	0.25	0.5	1.0	
Seed yield					
0	4.56	5.50	6.09	5.04	5.29
25	5.22	6.23	7.08	7.02	6.39
50	6.47	7.26	8.24	8.16	7.53
75	7.22	8.20	9.31	9.11	8.46
100	7.92	9.30	10.18	10.14	9.39
Mean	6.28	7.29	8.18	7.89	
CD at 5%	P = 0.18	B = 0.16	P×B = 0.36		
Straw yield					
0	32.81	39.62	43.89	41.48	39.45
25	37.61	44.83	51.00	50.26	45.93
50	46.58	52.29	59.35	58.75	54.24
75	51.96	59.07	67.03	65.62	60.92
100	57.05	66.98	73.27	70.00	66.83
Mean	45.20	52.56	58.91	57.22	
CD at 5%	P = 1.32	B = 1.18	P × B = N.S.		

Table.2 Effect of phosphorus and boron application on green gram seed and straw boron content

Phosphorus level (mg kg^{-1})	Boron Level (mg kg^{-1})				Mean
	0	0.25	0.5	1.0	
Boron content (mg kg^{-1}) in seed					
0	38.73	45.33	55.67	52.00	47.43
25	38.80	51.33	58.80	64.83	53.44
50	39.02	55.83	62.80	68.47	56.53
75	39.83	57.70	70.50	71.02	59.76
100	41.57	61.20	75.83	77.38	63.99
Mean	39.59	54.278	64.72	66.74	
CD at 5%	P = 1.58	B = 1.42	P×B = 3.17		
Boron content (mg kg^{-1}) in straw					
0	44.30	48.50	51.50	54.70	49.75
25	45.10	54.37	56.20	60.20	53.97
50	45.53	57.90	58.60	62.60	56.16
75	45.27	59.70	61.60	66.60	58.29
100	45.60	61.80	64.20	69.50	60.28
Mean	45.16	56.45	58.42	62.72	
CD at 5%	P = 1.34	B = 1.19	P×B = 2.68		

Table.3 Effect of phosphorus and boron application on green gram seed and straw phosphorus content

Phosphorus level (mg kg^{-1})	Boron Level (mg kg^{-1})				Mean
	0	**0.25**	**0.5**	**1.0**	
phosphorus content (%) in seed					
0	0.23	0.25	0.31	0.32	0.28
25	0.26	0.28	0.37	0.37	0.32
50	0.33	0.35	0.46	0.53	0.42
75	0.36	0.45	0.51	0.58	0.48
100	0.42	0.47	0.56	0.59	0.51
Mean	0.32	0.36	0.44	0.48	0.28
CD at 5%	P = 0.02	B = 0.01	P×B = 0.03		
Phosphorus content (%) in straw					
0	0.05	0.06	0.07	0.07	0.06
25	0.09	0.09	0.10	0.10	0.09
50	0.12	0.15	0.16	0.18	0.15
75	0.17	0.20	0.20	0.23	0.20
100	0.21	0.24	0.26	0.27	0.25
Mean	0.13	0.15	0.16	0.17	
CD at 5%	P = 0.01	B = 0.01	P×B = 0.02		

Table.4 Effect of phosphorus and boron application on seed protein content (%) of green gram

Phosphorus level (mg kg^{-1})	Boron Level (mg kg^{-1})				Mean
	0	0.25	0.5	1.0	
0	16.67	19.01	20.83	19.01	18.88
25	18.13	21.88	22.93	20.21	20.79
50	20.46	21.44	23.67	20.21	21.45
75	21.25	23.84	25.83	21.25	23.04
100	22.35	24.08	25.57	22.29	23.57
Mean	19.77	22.05	23.77	20.59	
CD at 5%	P = 1.03	B = 0.92	P×B = N.S.		

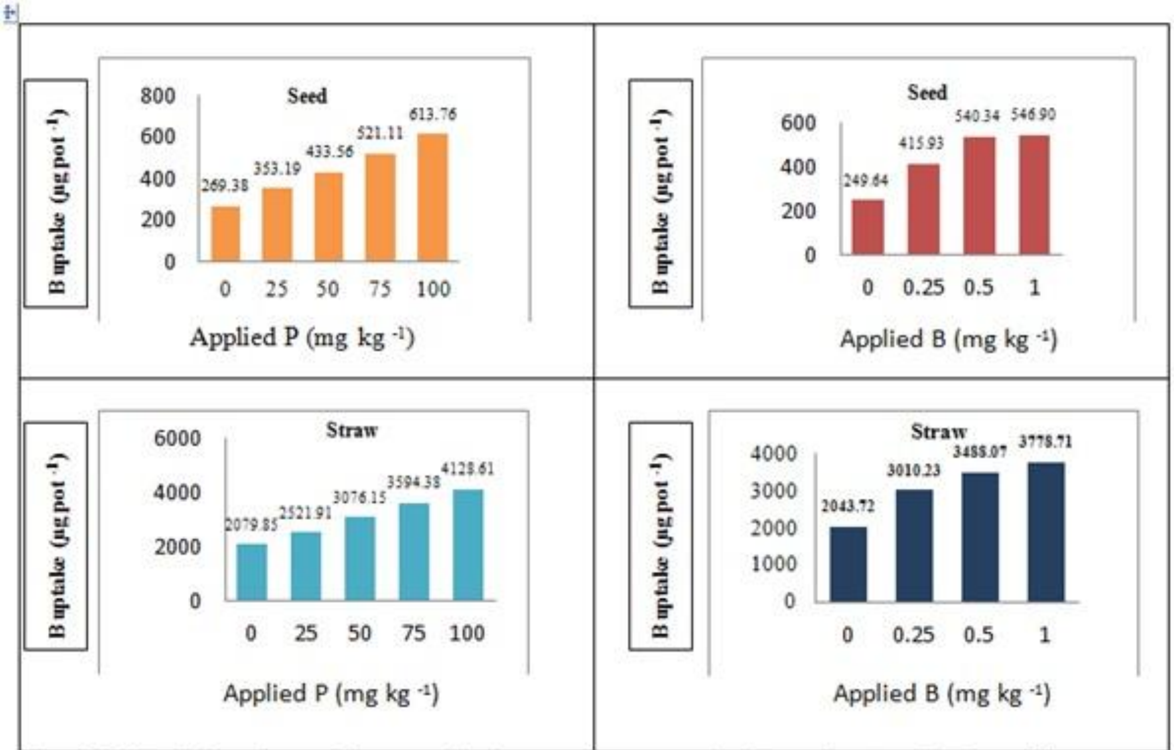

Figure 1: Effect of phosphorus and boron application on green gram seed and straw boron uptake (µg pot -1)

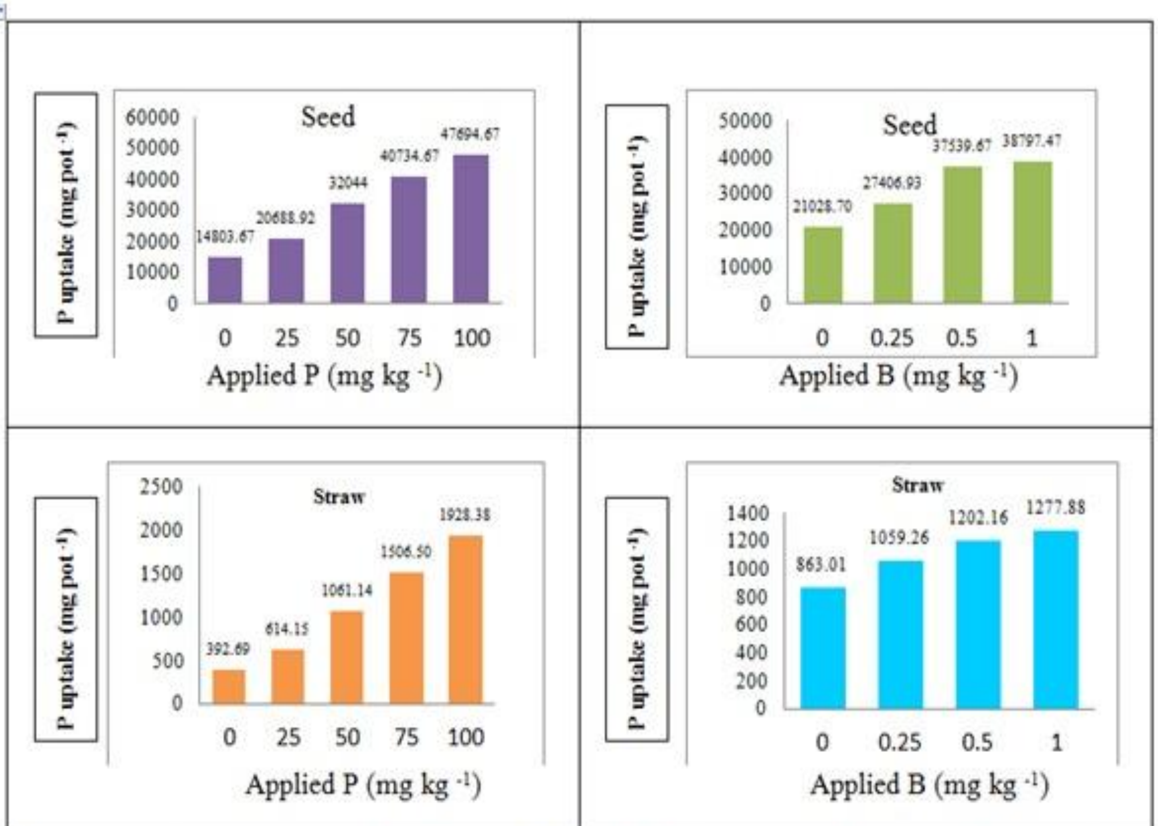

Figure 2: Effect of phosphorus and boron application on green gram seed and straw phosphorus uptake (mg pot-1).

Seed and straw phosphorus uptake

Effect of P and B application on P uptake in seed and straw of green gram was shown in (Figure 2) which revealed that with increase in phosphorus application along with increasing level of B, the uptake of phosphorus increases from 14803.67 mg pot^{-1} in control to 47694.67 mg pot^{-1} with the application of 100 mg P kg^{-1} and from 21028.7 mg pot^{-1} under control to 38797.47 mg pot^{-1} at 1 mg B kg^{-1} in seed. Similarly, in straw also, increased level of both P and B application increase the P uptake and it varies from 392.69 mg pot^{-1} under control to 1928.38 at 100 mg P kg^{-1} application with boron application from 863.01 mg pot^{-1} under control to 1277.87 mg kg^{-1} at 1 mg B kg^{-1}. Mallick and Raj (2015), observed that Phosphorus and boron application increased the seed uptake of P in rapseed and this increased in P uptake could be the response of variation in the availability of these nutrients in the soil and partly due to priming effect of one nutrient on the other on the uptake. Rana *et al.,* (2005), also reported similar effect of nutrient application. YuFan *et al.,* (2012), observed that B application increased P uptake by plant. The interactive effect of P and B application on P uptake in seed of green gram was found significant. Highly significant P uptake by seed of green gram was noticed at $P_{100}B_{0.5}$ level. Whereas, in straw the interactive effect of P and B application was found non-significant.

Seed protein content

The crude protein content in seed of green gram increases significantly from 18.88 to 23.57% when P was applied @ 100 mg kg^{-1} (Table 4). Deo and Khaldelwal (2009), found that application of P increased the number of nodules per plant of chickpea and protein content in grain. Whereas, with the application of boron the crude protein content in seed of green gram increases significantly up to the level of 0.5 mg B kg^{-1} over control i.e. 19.77% and after that there was a decrease in protein content occur with further addition of boron fertilizer. Ganie *et al.,* (2014), reported a significant increase in the crude protein content of French bean with graded level of boron application upto 1 mg B kg^{-1} which is statistically at par with 1.5 mg B kg^{-1} application. This significant rise in crude protein content is probably due to the vital role that boron plays in protein and nucleic acid metabolism Debnath and Ghosh, (2011). No significant difference was found in crude protein content of green gram with the combined application of both phosphorus and boron.

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