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Research Article

Yield and yield attributes of black gram (*Vigna mungo* L. Hepper) as influenced by phosphorus and boron in acid Inceptisol

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ABSTRACT

A field experiment was conducted to investigate the effect of phosphorus and boron on yield and yield attributes of black gram. Four levels of phosphorus (0, 25, 50, 75 kg ha^{-1}) and four levels of boron (0, 0.5, 1.0, 1.5 kg ha^{-1}) were laid in split plot design with three replications. . The native soil had a pH 4.99, E.C. 0.42 dS m^{-1}, organic carbon 1.32%, available nitrogen 251.35 kg ha^{-1}, available phosphorus 13.68 kg ha^{-1}, available potassium 233.24 kg ha^{-1} and hot water soluble boron 0.054 ppm. The results revealed that application of phosphorus and boron have a synergistic effect on yield, content and uptake in seed and straw of black gram. Significant highest seed yield was found when 50 kg P_2O_5 ha^{-1} along with 1.5 kg B ha^{-1}. Significant plant height at 30 DAS (20.04 cm) and 60 DAS (39.31 cm) was found with the application of $P_{50}B_{1.5}$ whereas at maturity, the plant height was recorded maximum (43.01 cm) at $P_{50}B_{0.5}$. Whereas, highest number of pods per plant was recorded with combination of 75 kg P_2O_5 ha^{-1} and 1 kg B ha^{-1} (19.89) and lowest was recorded in control (11.93) where no phosphorus and boron has been applied. The highest seed index was obtained with combination of as 50 kg P_2O_5 ha^{-1} and 0.5 kg B ha^{-1} as 4.64 whereas, lowest as 2.54 in control respectively.
Keywords: Phosphorus, boron, acid soil, yield and yield attributes.

INTRODUCTION

Pulses are a significant commodity category of crops that provide the country's primarily extensive vegetarian population with high-quality proteins complementing cereal protein. Pulses account for 6-7% of the total food grain production in the nation. Its cultivation provides the means for fixing atmospheric nitrogen in their root nodules @ 72 to 350 kg ha^{-1} year^{-1} (Tiwari and Shivhare, 2016). Pulses have many attributes, such as protein richness, improves soil quality and physical structure suitable for crop rotations and dry farming, and green pods for vegetables and nutritious cattle fodder. Pulse productivity depends mainly on appropriate nutrient management practices (Kumpawat, 2010). The entire area under pulses in India during 2013-14 was 25.23 M ha with the production of 19.27 million tonnes and an average productivity of about 764 kg ha^{-1} (Tiwari and Shivhare, 2016). Black gram (*Vigna mungo* L. Hepper) is an important pulse crop cultivated in India. It holds about 25-26 percent protein, 60 percent carbohydrates, 1.3 percent fat, and is loaded in phosphoric acid among all the pulses (Tamang and Sanjay-Swami, 2017). Being a legume crop, black gram not only builds soil fertility but also often plays a significant role for the successor crop in the nitrogen economy. It is essential to supply phosphorus, as it has beneficial effects on nodulation, nitrogen fixation, root production, growth and yield. Phosphorus (P) is the second important macronutrient necessary for growth and development of plants (Brady and Weil, 2008). It involves in the development of seedlings, growth of early roots, early head formation and speed up crop maturity (Alinajoati and Mirshekari, 2011). Black gram also responds well to the fertilization of boron (B) in B deficient soils as boron is an important micronutrient that have crucial role in multiple physiological and biochemical functions in plants such as cell wall formation, cell division and enlargement, sugar translocation, metabolism of nitrogen, metabolism of carbohydrates and water relations (Oyinlola, 2007; Marschner, 2012). It is also essential in cell division and cell elongation (Camacho-

Cristobal *et al.,* 2015). More pronounced increase in the activity of polyphenol oxidase and peroxidase in the combined deficiency of boron and phosphorus may be due to the potential accumulation of o-diphenol like substances in deficiency of B (Hewitt, 1983). The combined deficiency of boron and phosphorus further increases the activity of enzymes, acid phosphatase, peroxidase, and polyphenol oxidase, which results in phosphorus deficiency. The growth and metabolism of plants was more inhibitory than the combined abundance of boron and phosphorus alone. This will show another synergistic effect of excess P and a combination of excess boron and phosphorus. Decline in (starch, sugar content, DNA, RNA and ribonuclease activity) have been intensified by a combined excess of B and P (Chatterjee *et al.,* 1987).

MATERIALS AND METHODS

A field experiment was conducted at CPGSAS, CAU, Umiam , Meghalaya during *kharif* 2019 with four levels of phosphorus (0, 25, 50 , 75 kg ha^{-1}) and four levels of boron (0, 0.5, 1.0, 1.5 kg ha^{-1}) in split plot design with three replications. Geographically, the experiment site was located at 91^{0}18' to 92^{0}18' E longitude and 25^{0}40' to 26^{0}20' N latitude with an altitude of 950 m above the mean sea level with Agro-Climatic zone of mixed subtropical hill and falls in AES-III zone (Choudhury *et al.,* 2012). Annual climate of Umiam is divided into three different seasons: pre-monsoon (March to May), monsoon (June to September) and post-monsoon (October to February) months. The temperature of this region varies between 10 - 30^{0}C and precipitation of 2410 mm (Ray *et al.,* 2012). The initial experimental soil is sandy clay loam in texture, pH (4.99), EC (0.42 dSm^{-1}), high in organic carbon (1.32%), low in available nitrogen (251.35 kg ha^{-1}), low in available phosphorus (13.68 kg ha^{-1}), high in available potassium (233.24 kg ha^{-1}), low in available boron (0.054 ppm). The meteorological parameters observed during the crop period are mentioned in Fig.1.

RESULTS AND DISCUSSION

Plant height (cm):

The plant height of black gram observed under different phosphorus and boron combinations is presented in Table.1. It increased with crop development stages i.e. 30 DAS, 60 DAS and at maturity. Increasing phosphorus and boron doses also increased plant height over control at all crop development stages i.e. 30 DAS, 60 DAS and at maturity. At 30 DAS, under different phosphorus doses, the highest plant height (20.48 cm) was recorded at 75 kg P_2O_5 ha^{-1}, however, the significant increase was observed up to 50 kg P_2O_5 ha^{-1} with 20.01 cm height. Similarly, under different boron doses, the highest plant height (20.13 cm) was observed at 1.5 kg B ha^{-1}. The lowest plant height was recorded in control plots of P and B as 15.64 and 16.24 cm, respectively.

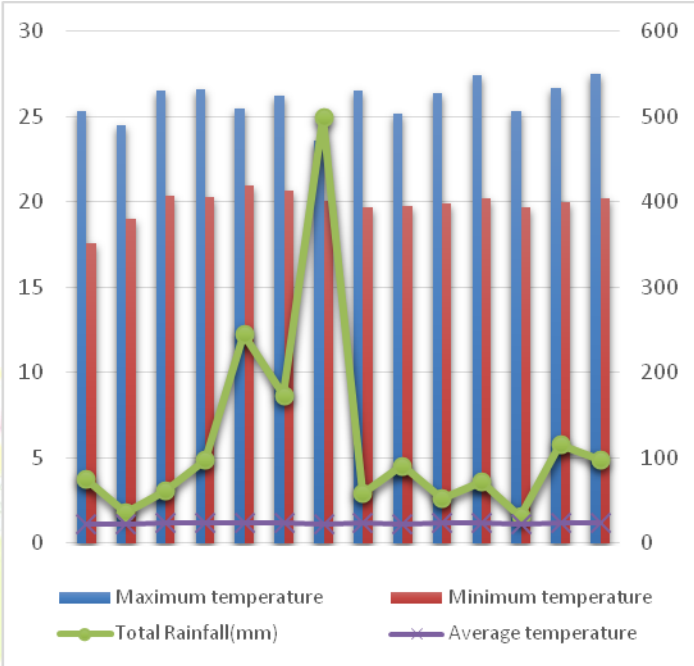

Fig.1 Standard week wise meteorological data during the crop season

The similar trend in plant height of black gram was observed at 60 DAS and at maturity. Under different phosphorus doses, the highest plant height at 60 DAS was recorded at 75 kg P_2O_5 ha^{-1} as 38.44 cm but the significant increase was observed up to 50 kg P_2O_5 ha^{-1} with 37.58 cm height. Similarly, under different boron doses, the highest plant height (37.22 cm) was observed at 1.5 kg B ha^{-1}. Opposing to this, the lowest height of plants was recorded in control plots of P and B as 30.45 and 32.50 cm, respectively. Similar to this, under different phosphorus doses, the highest plant height at maturity was recorded at 75 kg P_2O_5 ha^{-1} as 43.43 cm. Here also, the significant increase was observed up to 50 kg P_2O_5 ha^{-1} with 42.89 cm height. Similarly, the highest plant height (42.60 cm) under different boron doses was observed at 1.5 kg B ha^{-1} whereas, in control plots of P and B, the lowest plant height was recorded as 36.58 and 38.17 cm, respectively at maturity. The increase in plant height by phosphorus might be attributed to enhanced photosynthetic rate thereby encouraging the vegetative growth (El-Habbasha *et al.,* 2007). Similarly, increased plant height of black gram with the application of boron might be due to more cell division and cell elongation resulting in enhanced plant growth and plant height (Camacho-Cristóbal *et al.,* 2015; Satya and Sanjay-Swami, 2020).

Table 1: Effect of phosphorus and boron on plant height (cm) of black gram at 30, 60 DAS and at maturity

	30 DAS					60 DAS					Maturity				
Treatments	B_0	$B_{0.5}$	$B_{1.0}$	$B_{1.5}$	Mean	B_0	$B_{0.5}$	$B_{1.0}$	$B_{1.5}$	Mean	B_0	$B_{0.5}$	$B_{1.0}$	$B_{1.5}$	Mean
P_0	13.213	15.783	16.487	17.103	15.647	27.140	28.993	31.953	33.720	30.452	34.243	35.663	37.000	39.417	36.581
P_{25}	16.387	17.690	18.380	19.123	17.895	32.013	34.057	35.567	35.953	34.398	36.303	38.360	41.637	42.470	39.693
P_{50}	17.447	19.190	21.360	22.037	20.008	34.890	37.247	38.870	39.310	37.579	40.767	43.013	43.763	44.017	42.890
P_{75}	17.907	19.903	21.863	22.263	20.484	35.950	38.367	39.563	39.887	38.442	41.377	43.583	44.270	44.503	43.433
Mean	16.238	18.142	19.523	20.132	18.509	32.498	34.666	36.488	37.218	35.218	38.173	40.155	41.668	42.602	40.649
	SE(m)±		C.D (p<0.05)			SE(m)±		C.D (p<0.05)			SE(m)±		C.D (p<0.05)		
P	0.589		2.037			0.910		3.148			0.887		3.068		
B	0.164		0.478			0.215		0.627			0.288		0.841		
P within B	0.654		2.195			0.983		3.325			1.017		3.388		
P within B	0.328		0.957			0.430		1.255			0.576		1.681		

The interaction effect of phosphorus and boron on plant height was found to be significant at all crop development stages. Within the same level of boron, the plant height increased with the increasing phosphorus doses, but significantly highest plant height at 30 DAS (20.04 cm) and 60 DAS (39.31 cm) was recorded with the application of $P_{50}B_{1.5}$ whereas at maturity, the plant height was recorded maximum (43.01 cm) at $P_{50}B_{0.5}$. Similarly, within the same level of phosphorus, the increasing boron doses increased the plant height of black gram but the significant increase in plant height was recorded at $P_{75}B_1$ as 21.86 cm, $P_{50}B_1$ as 38.87 cm and $P_{75}B_{0.5}$ as 43.58 cm at 30, 60 DAS and at harvesting. The lowest height of black gram was observed in control i.e. P_0B_0 as 13.21 cm, 27.14 cm, 34.24 cm at 30, 60 DAS and at maturity. The similar results were observed by Sentimenla *et al.* (2012) who reported that different levels of phosphorus and boron increased plant height of soybean significantly. The increased plant height of groundnut was also reported with the combined application of P and B over control plots (Kabir *et al.,* 2013). Similar findings in French bean were also reported by Singh *et al.,* (1989).

Number of pods per plant:

The number of pods per plant increases with increasing phosphorus and boron doses and data are presented in Table 2. Among the main plot (phosphorus) treatments, highest number of pods per plant (18.71) was observed at 75 kg P_2O_5 ha^{-1}, however significant increase in number of pods was observed only up to 50 kg P_2O_5 ha^{-1} (17.13). Control plot had recorded lowest number of pods i.e. 12.88 pods per plant. The significant increased number of pods per plant was observed up to 1.5 kg B ha^{-1} as 17.20 and lowest as 14.27 pods per plant in control. The per cent increase of number of pods over control to successive levels of P was 17.10, 33.00, 45.25 per cent and with successive increase in B levels over control was 10.29, 16.30, 20.56, respectively. The interaction effect of phosphorus and boron on number of pods per plant was found to be significant. The lowest number of pods was recorded in control at P_0B_0 with 11.93 pods per plant and significantly highest number of pods was observed at $P_{75}B_1$ as 19.89 at phosphorus within boron and boron within phosphorus. The per cent increase of $P_{75}B_1$ over P_0B_0 was 66.72.

Choudhary *et al.* (2017) reported that numbers of pods $plant^{-1}$ were significantly affected by phosphorus and boron application. Significantly maximum (42.46) number of pods $plant^{-1}$ were obtained by N3 (20:60:20 NPK) + 35 DAS (0.2% foliar spray of borax). The significant minimum (30.40) numbers of pods $plant^{-1}$ were obtained in N1 (20:40:20 NPK). This might be due to boron helps in pollen formation and grain formation. According to Dutta *et al.* (1984), numbers of pods per plant increased with the application of boron. These results are in line with Kaisher *et al.,* (2010); Satya and Sanjay-Swami (2021). Numbers of pods per plant were significantly affected by boron application. Ali *et al*. (2011) reported that boron treatment achieved a significant increase in the number of pods with a percentage increase of 10% compared to control. Moreover, Reddy *et al*. (2007) indicated that application of micronutrients including boron significantly influenced total yield in pigeon pea through the modification of plant growth morphology and physiology. The increase in pod yield observed in this study might be attributed to flower inhibition, pod abscission and improvement in morpho-physiological characteristics such as plant height, number of branches, leaf area, pod yield and increased dry matter accumulation and its portioning to increase pod per plants. Sentimenla *et al.* (2012) reported highest number of pods per plant with application of 1.5 kg B ha^{-1} and interaction effect of P and B on number of pods per plant. Positive influence of P and B application on number of pods per plant was also reported by Sharma (1992), Pradhan *et al.* (1995) in soybean. This might be attributed to significant increase in nodulation, nitrogenase activity, growth and efficient nutrient uptake (Srivastava *et al.,* 1998). Combined application of phosphorus and boron also significantly influenced the number of pods $plant^{-1}$.

Table 2: Effect of phosphorus and boron on number of pods per plant of black gram

Treatments	Number of pods per plant				
	B_0	$B_{0.5}$	$B_{1.0}$	$B_{1.5}$	Mean
P_0	11.93	12.46	13.36	13.78	12.882
P_{25}	13.64	14.73	15.54	16.43	15.084
P_{50}	15.56	17.03	17.60	18.34	17.133
P_{75}	15.95	18.74	19.89	20.26	18.710
Mean	14.270	15.738	16.597	17.203	15.952

	SE(m)±	C.D (p≤0.05)
P	0.540	1.870
B	0.169	0.493
P within B	0.615	2.051
B within P	0.338	0.987

Seed yield (q ha^{-1})

The data pertaining to seed yield of black gram is presented in Fig 2. The seed yield increased with increasing phosphorus and boron doses. The highest seed yield (9.52 q ha^{-1}) among different phosphorus doses was observed at 75 kg P_2O_5 ha^{-1}. However, seed yield increased significantly up to 50 kg P_2O_5 ha^{-1} with 9.52 q ha^{-1}. The lowest seed yield was recorded in control plots as 6.41 q ha^{-1}. With successive boron doses, the lowest seed yield was obtained at control (7.19 q ha^{-1}), although significant increased seed yield was observed up to 1.0 kg B ha^{-1} as 9.13 q ha^{-1} yet the highest seed yield was recorded as 9.43 q ha^{-1} at 1.5 kg B ha^{-1}. The phosphorus and boron interaction on seed yield was also found significant. The lowest seed yield were observed in control at P_0B_0 as 5.56 q ha^{-1} and significantly highest seed yield was observed at $P_{50}B_{1.5}$ as 10.35 q ha^{-1} at phosphorus within boron and in boron within phosphorus as 11.03 q ha^{-1} at $P_{75}B_1$. The increase in seed yield with the increasing phosphorus application might be due to improvement in plant growth and vigour as phosphorus plays important role in plant metabolism finally leading to enhanced seed yield. The improvement in dry matter yield can be attributed to the role of boron in stabilizing certain constituents of cell wall and plasma membrane, enhancement of cell division and tissue differentiation, metabolism of carbohydrates, proteins, nucleic acids, auxins and phenols (Marschner 1986). Kamboj and Malik (2018) reported that increase in phosphorus and boron doses increases the seed yield of black gram with highest yield recorded on combined application of 100 mg P kg^{-1} along with 1.0 mg B kg^{-1} in green gram. Higher grain yield of mungbean (1583 kg ha^{-1}) was also reported by Subedi and Yadav (2013). Similarly, Chowdhury *et al.*, (2015) reported that interaction effect of P and B significantly influenced the quality attributes of lettuce seeds and also found that application of 120 kg P_2O_5 kg ha^{-1} and 2 kg B ha^{-1} was better combination for better growth, yield and quality of lettuce.

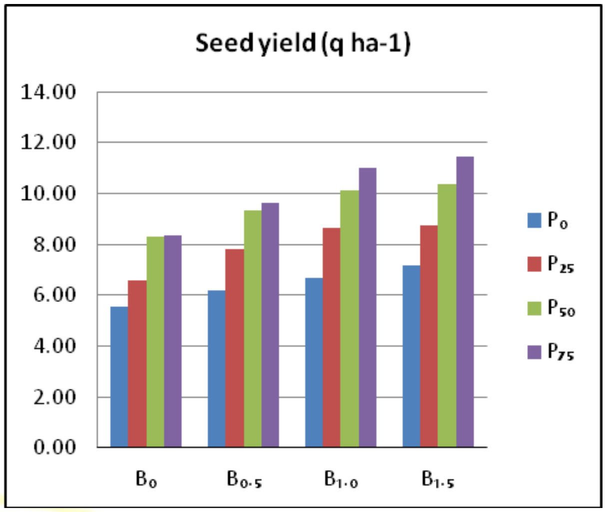

Fig. 2: Effect of phosphorus and boron on seed yield of black gram

Seed index:

The Fig. 3 illustrates that the individual effect of phosphorus on seed index of black gram was highest (4.40) at 75 kg P_2O_5 ha^{-1} which was statistically at par with 50 kg P_2O_5 ha^{-1} with seed index value 4.12, lowest was observed at control (3.14). Likewise, 1.5 kg B ha^{-1} has recorded significantly highest seed index (4.22) and lowest (3.34) was observed in control plot treatment. The per cent increase in seed index in successive levels of P over control was 16.78, 31.19, 40.00 per cent and in successive levels of boron over control was 11.61, 20.66, 26.26, respectively. The interaction effect of phosphorus and boron on seed index was found to be significant. Significantly lowest seed index were observed in control at P_0B_0 as 2.54 and significantly highest seed index were observed at $P_{50}B_{1.5}$ as 4.64 at phosphorus within boron and in boron within phosphorus the significantly highest value was observed at $P_{75}B_1$ as 4.58. The percentage increase of $P_{50}B_{1.5}$, $P_{75}B_1$ over P_0B_0 was 82.80 and 80.44 percent, respectively.

Mouri *et al.* (2018) reported that the effect of phosphorus on weight of 100-seeds was significant. Weight of 100-seeds was the highest (43.31g) in 60 kg P ha^{-1} followed by 40, 20 and 0 kg P ha^{-1}, respectively. This finding is in agreement with El-Habbasha *et al.* (2005). He reported that increasing phosphorus levels increased 100-seeds weight. Timotiwu *et al.* (2018) reported that fertilization of P_2O_5 with dose of 0 kg/ha, weight of 100 grain produced was 11.27 g and increased as 0.005 g of every additional 1 kg of P_2O_5. This is in parallel with research of Thoyyibah *et al.* (2014) who stated that application of various doses of phosphate fertilizers in two soybean varieties had significant effect on grain weight per plant, Detam-1 variety which was cultivated 200 kg/ha of phosphate fertilizers produced the highest weight 42.02 g, equivalent to 3.5 ton/ha and had great significance with other combinations. Soybean plants with the application of 5 ppm B increased weight 100 grain 6.41% higher than those without B. The research of Bellaloui *et al.* (2013) also showed that application of B through the leaves can increase the seed weight of 16.1 g (100 grain weight) higher than that obtained without B of 13.2 g of soybean on treatment given water. This is in line with Rio Tinto (2012) who stated that the addition of boron in plants could increase the success of flower pollination and played a vital role in seed formation. He further stated that application of boron on soybean increased the weight of 100 grains.

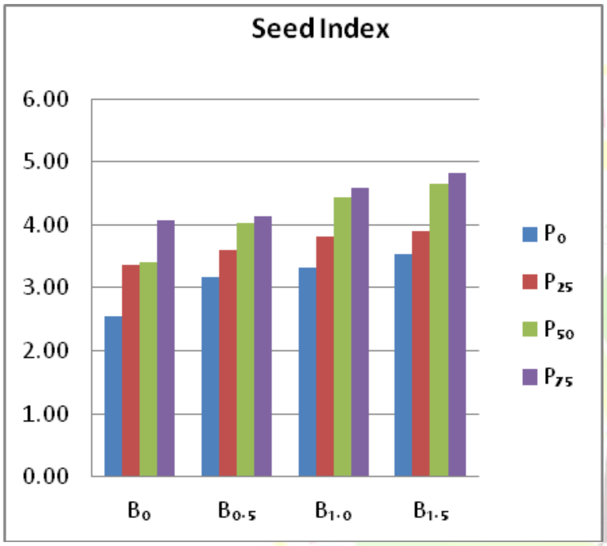

Fig. 3: Effect of phosphorus and boron on seed index of black gram

CONCLUSION

The results of the above experiment suggested that highest seed yield was found when 50 kg P_2O_5 ha^{-1} along with 1.5 kg B ha^{-}1. Significant plant height at 30 DAS (20.04 cm) and 60 DAS (39.31 cm) was found with the application of $P_{50}B_{1.5}$ whereas at maturity, the plant height was recorded maximum (43.01 cm) at $P_{50}B_{0.5}$, 75 kg P_2O_5 ha^{-1} and 1 kg B ha^{-1} had significant effect on number of pods per plant, where as 50 kg P_2O_5 ha^{-1} and 0.5 kg B ha^{-1} has significant effect on seed index of black gram plant.

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