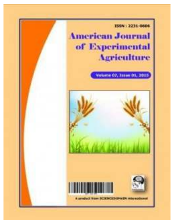

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Growth and Yield Response of Mungbean as Influenced by Phosphorus and Boron Application

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Authors' contributions

This work was carried out in collaboration between all authors. Authors BAH and MAKC designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors MMR and IM reviewed the experimental design and all drafts of the manuscript. Authors UH and MZR performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during the period from February 2012 to May 2012 to investigate the effect of levels of phosphorus (0, 20, 40 and 60 kg ha^{-1}) and boron (0, 1.0, 1.5 and 2.0 kg ha^{-1}) on growth and yield of summer mungbean cv. BINAmung-8. The experiment was laid out in a Randomized Complete Block Design (RCBD) with sixteen treatment combinations having three replications. The results indicated that the crop responded significantly to phosphorus and boron in respect of growth and yield such as plant height, number of branches $plant^{-1}$, pods $plant^{-1}$, pod length, number of seeds pod^{-1}, 1000 seed weight, seed yield, stover yield, biological yield and harvest index. In the combination of phosphorus and boron, all the parameters were significant by

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influence. The highest seed yield (1.19 t ha^{-1}) was obtained from 40 kg P ha^{-1} followed by 60 kg P ha^{-1} (1.13 t ha^{-1}) and 20 kg P ha^{-1} (1.10 t ha^{-1}) while the lowest seed yield (1.01 t ha^{-1}) was obtained from the control plot. In case of boron application, the highest seed yield (1.16 t ha^{-1}) was obtained from 1.5 kg B ha^{-1} followed by 2.0 kg B ha^{-1} (1.14 t ha^{-1}) and 1.0 kg B ha^{-1} (1.09 t ha^{-1}) whereas the lowest seed yield (1.04 t ha^{-1}) was obtained from the control plot. The highest seed yield (1.25 t ha^{-1}) was obtained from the combination of 40 kg P ha^{-1} × 1.5 kg B ha^{-1} while the lowest seed yield (0.95 t ha^{-1}) was obtained from the control plot. The results suggest that mungbean crop may preferably be fertilized with a combination of 40 kg P ha^{-1} × 1.5 kg B ha^{-1} to obtain maximum seed yield in the agroclimatic condition of the study area.

Keywords: Phosphorus; boron; growth; yield and BINAmung-8.

1. INTRODUCTION

Mungbean (*Vigna radiata* L.) belongs to the sub family Papilionaceae under the family Leguminosae. It is popularly known as "Moog" in Bangladesh. Mungbean is the third most important pulse crop in Bangladesh in both area and production [1]. Due to its short duration, mungbean can fit in as a cash crop between major cropping seasons. Cultivation of mungbean can improve the physical, chemical and biological properties of soil as well as increase soil fertility status through nitrogen fixation from atmosphere by symbiotic process with the help of micro-symbionts (Rhizobium).

Crops differ in their sensitivity to boron (B) deficiency. The adsorption of boron (B) varies with the type of clay in determining the amount of adsorption [2]. Boron deficiency commonly occurs in soils during periods of drought. The reduced level of water in the soil also causes a proportionate decrease in rate of boron diffusion to root [2]. Visible symptoms of B deficiency (0.3 µm) initiated on young leaves as internal chlorosis later leading to necrosis [3].

Mungbean is highly responsive to fertilizers and has a considerable response to phosphorus. The soils of Bangladesh are not rich in all essential nutrient elements and organic matter content. The farmers generally grow mungbean almost without fertilizer. So, there is an ample scope of increasing the yield of mungbean per unit area by using balanced fertilization including phosphorus and boron. In Bangladesh, many studies have been conducted on nutrient requirements of mungbean, but reports are very few on the phosphorus and boron fertilizer requirement as well as on the combined effects of these two factors on mungbean. Therefore, the experiment was conducted to study the optimum doses of phosphorus and boron on growth and yield of mungbean.

2. MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from February 2012 to May 2012. Mungbean variety BINA mung-8 was used as a test crop. The experimental soil belongs to the Old Brahmaputra Floodplain under Agro-ecological Zone AEZ-9 having non-calcareous dark grey floodplain soil under Sonatola soil series. The experimental site is located at 24.75°N latitude and 90.50°E longitude at a height of 18 m above the mean sea level. It was a medium high land of silty loam soils having pH 6.8, 1.29% organic matter, 0.101% total N and 13.9 µg g^{-1} soil available P. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were sixteen treatment combinations comprising four levels of phosphorus (0, 20, 40 and 60 kg ha^{-1}) and boron (0, 1.0, 1.5 and 2.0 kg ha^{-1}) and one control. The total number of plots was 48. Each treatment received an equal amount of NKS. All the plots received N, K and S as basal treatment. Urea, muriate of potash and gypsum were used as a source of nitrogen, potassium and sulphur at the rate of 40, 40 and 30 kg ha^{-1}, respectively at the time of final land preparation. Phosphorus was applied in the form of Triple Super Phosphate (TSP) and boron was applied in the form of boric acid. Each plot was irrigated as and when necessary during the period of the experiment. There was heavy rainfall several times during the experimental period. The excess water from the plot was removed. Seeds were sown on 12 February 2012 with line to line distance 30 cm and plant to plant distance of 10 cm. There were 8 rows in each plot. Two seeds were sown per hill. The seed rate was 35 kg ha^{-1} for BINAmung-8 recommended by BINA. Intercultural operations were done as and when necessary. The crop was harvested at 65 days after sowing when the crop attained the full maturity. Data on plant height and number of branches $plant^{-1}$ were observed from ten randomly selected plants from each plot at 30, 45 and 60 days after sowing (DAS) and average values were calculated for each unit plot. Seed and stover yields and other yield contributing characters were recorded from each plot.

Data were analyzed with the help of MSTAT-C [4]. Duncan's Multiple Range Test (DMRT) was used to compare variations among the treatments.

3. RESULTS AND DISCUSSION

3.1 Growth and Yield Attributing Parameters

Plant height was significantly influenced by phosphorus. Plant treated with 60 kg P ha^{-1} gave the tallest plant (84.47 cm). The treatment without phosphorus (control) produced the shortest plant (62.06 cm) (Table 1). Plant height of mungbean showed superiority at 60 kg P ha^{-1} followed by 20 kg P ha^{-1} [5]. Plant height was significantly influenced by boron. The tallest plant (76.22 cm) was found from the application of 1.5 kg B ha^{-1}and the shortest one (72.99 cm) was recorded in control plot (Table 2). This might be due to the application of boron to the plant which ultimately enhanced plant height. The crop of the control plot suffered from boron deficiency. Interaction effect of phosphorus and boron was significant in respect of plant height. However, the tallest plant (86.03 cm) was found from the plant treated with 60 kg P ha^{-1} × 1.0 kg B ha^{-1} followed by 60 kg P ha^{-1}× 1.5 kg B ha^{-1}, 40 kg P ha^{-1}× 1.5 kg B ha^{-1}, 60 kg P ha^{-1}× 2.0 kg B ha^{-1}while the shortest plant (60.91 cm) was obtained from control plot (Table 3). This might be due to the lack of phosphorus and boron in soil which reduced the cell division, carbohydrate and protein synthesis and also lowers the normal activities of the cambium tissue.

Branches per plant varied significantly due to the different levels of phosphorus (Table 1). The highest number of branches plant^{-1} (3.99) was counted from the treatment 60 kg P ha^{-1} and the lowest number was counted in the control plot (2.28). High level of phosphorus in the soil helps the uptake of other nutrients, which ultimately produces healthy plant with the maximum productive branches of the crop. Lack of phosphorus results in low rate of plant growth and plant branching. Nnumber of branches plant^{-1} of mungbean increased with increased level of phosphorus up to 60 kg ha^{-1} [6,7].

Significant variation was observed in branches plant^{-1} of mungbean when boron was applied at different levels (Table 2). The highest number (3.93) was counted from 2.0 kg B ha^{-1}, which was statistically dissimilar with 1.0 kg B ha^{-1} (3.33) and 1.5 kg B ha^{-1} (3.65). Interaction effect of phosphorus and boron was significant in respect of number of branches plant^{-1}. The highest number of branches plant^{-1} (4.61) was found from the plant treated with 60 kg P ha^{-1} × 2.0 kg B ha^{-1} while the lowest was obtained from control plot (Table 3).

Results of the Table 1 indicated that number of pods plant^{-1} was significantly affected by various levels of phosphorus. Plants not fertilized with phosphorus produced the lowest number of pods plant^{-1} (11.00), whereas 40 kg P ha^{-1} produced the highest number of pods (15.59) plant^{-1}. Number of pods plant^{-1} of mungbean showed superiority at 60 kg P ha^{-1} followed by 20 kg P ha^{-1} [7,8]. The number of pods plant^{-1} was significantly affected by application of various levels of boron (Table 2). Plants not fertilized with boron produced the lowest number of pods plant^{-1} (11.11), whereas application of 1.5 kg B ha^{-1} produced the highest number of pods (15.25). This result might be due to boron helps in flower and pollen grain formation. Interaction effect of phosphorus and boron was significant in respect of number of pods plant^{-1}. The highest number of pods plant^{-1} (16.98) was found from the plant treated with 60 kg P ha^{-1} × 1.5 kg B ha^{-1} while the lowest number of pods plant^{-1} (8.77) was obtained from control plot (Table 3).

Phosphorus exerted a significant effect on pod length. Plant received 40 kg P ha^{-1}and gave the tallest length of pod (7.99 cm) followed by 20 kg P ha^{-1} and 60 kg P ha^{-1}. On the other hand, the shortest pod was recorded from the control plot where phosphorus was not applied (Table 1) [5]. Pod length differed significantly when different levels of boron were applied. Plant received 1.5 kg B ha^{-1} and gave the longest pod (7.69 cm). The shortest pod was recorded from the control plot which was statistically similar with treatment 1.0 kg B ha^{-1} and 2.0 kg B ha^{-1}. It indicated that boron had significant effect on pod length (Table 2). This may be due to boron is essential in cell division which increases pod length. Interaction effect of phosphorus and boron was significant on pod length of mungbean. The tallest pod (8.80 cm) was observed from the plot under the treatment 40 kg P ha^{-1} × 1.5 kg B ha^{-1} and the shortest (6.34 cm) was recorded from the control (Table 3).

Table 1. Effect of phosphorus on growth and yield contributing characters of summer mungbean (cv. BINAmung-8)

Levels of P	Plant height (cm)	No of branch plant^{-1}	No of pods plant^{-1}	Length pod^{-1}	No of seed pod^{-1}	1000-seed wt (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield	Harvest index
P_0	62.06d	2.28d	11.00d	6.39c	14.07d	41.04c	1.01d	2.02c	3.03d	33.74a
P_{20}	71.83c	3.62c	13.16c	7.72b	15.73b	43.68b	1.10c	2.52b	3.62b	31.25b
P_{40}	80.06b	3.89b	15.59a	7.99a	17.78a	47.68a	1.19a	2.86a	4.05a	29.73c
P_{60}	84.47a	3.99a	15.17b	7.77b	15.09c	42.85b	1.13b	2.12c	3.50c	32.29b
CV(%)	3.76	4.23	2.64	3.08	2.42	2.83	2.85	6.29	4.35	4.91
Level of sig.	**	**	**	**	**	**	**	**	**	**

P_o = No phosphorus, P_1= 20 kg P ha^{-1}, P_2 = 40 kg P ha^{-1} and P_3 = 60 kg P ha^{-1}. In a column, same letter (s) do not differ significantly at $P \leq 0.05$ by DMRT,
***- Significant at 1% of probability*

Table 2. Effect of boron on growth and yield contributing characters of summer mungbean (cv. BINAmung-8)

Levels of B	Plant height (cm)	No of branch plant^{-1}	No of pods plant^{-1}	Length pod^{-1}	No of seed pod^{-1}	1000-seed wt (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield	Harvest index
B_0	72.99b	2.87d	11.11c	7.29b	14.32c	41.44c	1.04d	1.99d	3.04d	34.21a
B_1	74.48ab	3.33c	13.32b	7.41b	15.73b	43.34b	1.09c	2.23c	3.31c	33.14b
$B_{1.5}$	76.22a	3.65b	15.25a	7.69a	16.41a	46.39a	1.16a	2.86a	4.02a	28.86c
B_2	74.74ab	3.93a	15.24a	7.48b	16.21a	44.08b	1.14b	2.44b	3.59b	32.29b
CV(%)	3.76	4.23	2.64	3.08	2.42	2.83	2.85	6.29	4.35	4.91
Level of sig.	**	**	**	**	**	**	**	**	**	**

B_0 = No boron, B_1= 1.0 kg B ha^{-1}, B_2 = 1.5 kg B ha^{-1} and B_3 = 2.0 kg B ha^{-1}. In a column, same letter (s) do not differ significantly at $P \leq 0.05$ by DMRT,
***- Significant at 1% of probability*

Table 3. Interaction effect of phosphorus and boron on growth and yield contributing characters of summer mungbean (cv. BINAmung-8)

Interaction	Plant height (cm)	No of branch plant^{-1}	No of pods plant^{-1}	Length pod^{-1}	No of seed pod^{-1}	1000-seed wt (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield	Harvest index
$P_0 \times B_0$	60.91g	1.58L	8.77i	6.34d	13.14h	37.82h	0.95j	1.58g	2.53h	37.63a
$P_0 \times B_1$	61.84g	2.17k	9.99h	6.36d	14.38efg	38.99h	1.00i	1.98ef	2.97g	33.59cd
$P_0 \times B_{1.5}$	63.02g	2.52j	12.67ef	6.37d	13.93fg	45.46cd	1.05h	2.24de	3.29def	32.01de
$P_0 \times B_2$	62.49g	2.85i	12.59f	6.37d	14.81de	41.90fg	1.05h	2.27d	3.32de	31.73def
$P_{20} \times B_0$	69.96f	3.28h	10.30h	7.72bc	14.10fg	39.96gh	1.05h	1.91f	2.96g	35.37bc
$P_{20} \times B_1$	71.17f	3.57g	11.84g	7.68bc	16.10c	44.75cde	1.05h	2.01def	3.06efg	34.65cd
$P_{20} \times B_{1.5}$	72.83ef	3.65f	15.15cd	7.72bc	16.53c	45.49cd	1.17cd	3.34b	4.52b	26.01g
$P_{20} \times B_2$	73.35ef	4.00d	15.34c	7.76b	16.19c	44.52de	1.14e	2.81c	3.95c	28.97f
$P_{40} \times B_0$	76.21de	3.31h	13.20e	7.99b	16.17c	45.25cd	1.11f	2.21de	3.32de	33.51cd
$P_{40} \times B_1$	78.88cd	3.82e	16.80a	7.31c	17.82b	48.37ab	1.18c	2.81c	3.99c	29.71ef
$P_{40} \times B_{1.5}$	84.59a	4.16c	16.21b	8.80a	18.70a	50.07a	1.25a	3.60a	4.85a	25.83g
$P_{40} \times B_2$	80.57bc	4.25b	16.15b	7.85b	18.44ab	47.02bc	1.21b	2.84c	4.05c	29.89ef
$P_{60} \times B_0$	83.28ab	3.31h	12.17fg	7.76b	13.88g	42.73ef	1.08g	2.27d	3.34de	32.20de
$P_{60} \times B_1$	86.03a	3.76e	14.67d	7.83b	14.60ef	41.23fg	1.11f	2.11def	3.23d-g	34.61cd
$P_{60} \times B_{1.5}$	84.46a	4.26b	16.98a	7.86b	16.47c	44.55de	1.17cd	2.24de	3.41d	34.48cd
$P_{60} \times B_2$	84.11ab	4.61a	16.88a	7.64bc	15.42d	42.87ef	1.16d	1.86d	3.42d	33.92cd
CV(%)	3.76	4.23	2.64	3.08	2.42	2.83	2.85	6.29	4.35	4.91
Level of sig.	*	**	**	**	**	**	**	**	**	**

*P_0 = No phosphorus, P_{20} = 20 kg P ha^{-1}, P_{40} = 40 kg P ha^{-1}, P_{60} = 60 kg P ha^{-1}, B_0 = No boron, B_1= 1.0 kg B ha^{-1}, $B_{1.5}$ = 1.5 kg B ha^{-1} and B_2 = 2.0 kg B ha^{-1}. In a column same letter (s) do not differ significantly at P≤0.05 by DMRT, NS- Not significant, **- significant at 1% level of probability*

A significant variation was observed among the levels of phosphorus in respect of number of seeds pod^{-1}. It was observed that 40 kg P ha^{-1} produced the highest number of seeds pod^{-1} (17.78). The lowest number of seeds pod^{-1} (14.42) was counted from the control plot (Table 1). It might be due to insufficiency of phosphorus nutrient which ultimately lowered the nutrient uptake and hampers the growth and development of mungbean. Number of seeds pod^{-1} of mungbean increased with application of increased level of phosphorus up to 40 kg ha^{-1} [5,7]. A highly significant effect of boron was observed on the production of seeds pod^{-1}. It was observed that 1.5 kg B ha^{-1} produced the highest (16.41) number of seeds pod^{-1}, which was statistically similar to the crop treated with 2.0 kg B ha^{-1}. The lowest number of seeds pod^{-1} (14.32) was recorded from the control plot (Table 2). The interaction of phosphorus and boron on seeds pod^{-1} was significant. The highest number of seeds pod^{-1} (18.70) was observed where 40 kg P ha^{-1} coupled with 1.5 kg B ha^{-1} was applied (Table 3). The lowest number of seeds pod^{-1} (13.14) was recorded from the control plot where neither phosphorus nor boron was used. Nnumber of seeds pod^{-1} increased significantly with increasing levels of phosphorus (0-60) kg P ha^{-1} [9].

Phosphorus significantly affected 1000-seed weight (Table 1). BINAmung-8 produced the highest 1000-seed weight (47.68 g) with 40 kg P ha^{-1} while the lowest one (41.04 g) was recorded in the control plot. Weight of 1000 seeds was significantly affected by the different levels of boron (Table 2). BINAmung-8 produced the highest 1000-seed weight (46.39 g) with 1.5 kg B ha^{-1}and the lowest was recorded in the control plot. As boron affects cell division, carbohydrate metabolism, sugar and starch formation, which help to increase in size and weight of seed. The interaction effect of phosphorus and boron was significant in respect of 1000-seed weight of BINAmung-8. Numerically the highest 1000-seed weight (50.07 g) was recorded with 40 kg P ha^{-1} and 1.5 kg B ha^{-1} and the lowest one (37.82 g) was observed in the control treatment where phosphorus and boron were not applied (Table 3).

3.2 Seed Yield

Seed yield was significantly influenced by different levels of phosphorus. It was found that the application of 40 kg P ha^{-1} produced the highest seed yield (1.19 t ha^{-1}) whereas the lowest in control. Seed yield increased due to the application of phosphorus fertilizer (Table 1). Application of 40 kg P ha^{-1} significantly increased the seed yield of mungbean [10]. Seed yield differed significantly due to boron. The highest (1.16 t ha^{-1}) was obtained when the crop was given 1.5 kg B ha^{-1}, while the lowest was recorded from control (Table 2). Boron helps the stigma to become receptive and sticky which increase pollination. As a result fruit setting increases and so as number of seeds per pod. The interaction effect of phosphorus and boron on seed yield was highly significant. The highest seed yield (1.25 t ha^{-1}) was observed when the fertilizer combination was 40 kg P ha^{-1}× 1.5 kg B ha^{-1}. The lowest seed yield (0.95 t ha^{-1}) was obtained from control plot (Table 3).

3.3 Stover Yield

Application of phosphorus increased stover yield significantly (Table 1). The highest stover yield (2.86 t ha^{-1}) was recorded in case of 40 kg P ha^{-1} which was statistically similar with 60 kg P ha^{-1} and lowest in control. Stover yield of mungbean increased with increase of phosphorus up to or equivalent of 40 kg P ha^{-1} [11]. Boron affected stover production of mungbean significantly. The highest (2.86 t ha^{-1}) stover yield was recorded from 1.5 kg B ha^{-1}, which was statistically higher than the other treatments and the lowest obtained in control treatment. The improvement of vegetative growth in terms of number of leaves plant^{-1}, plant height, number of branches plant^{-1} and number of pods plant^{-1} due to the application of boron resulted the improvement of stover yield (Table 2). Interaction effect of phosphorus and boron was highly significant in respect of stover yield production of mungbean. The highest stover yield (3.60 t ha^{-1}) was obtained when the crop was treated with 40 kg P ha^{-1}× 1.5 kg B ha^{-1} (Table 3) and the minimum was produced by the crop under control treatment.

3.4 Biological Yield

The different levels of phosphorus significantly affected the biological yield of mungbean (cv. BINAmung-8). The highest biological yield (4.05 t ha^{-1}) was recorded from the plot treated with 40 kg P ha^{-1} which was statistically different from the other treatments. Biological yield was affected significantly by different levels of boron. It was noticed that the highest biological yield (4.02 t ha^{-1}) was recorded when the crop was fertilized with 1.5 kg B ha^{-1} and the lowest was obtained from control plot (Table 2). Interaction effects of phosphorus and boron was highly significant. Biological yield was highest (4.85 t ha^{-1}) with 40 kg P ha^{-1} and 1.5 kg B ha^{-1}, the lowest biological yield (2.53 t ha^{-1}) was obtained from the control treatment (Table 3).

3.5 Harvest Index

Different levels of phosphorus exerted a significant influence on the harvest index. Harvest index was recorded maximum (33.74%) from the control treatment and the lowest (29.73%) was obtained from 40 kg P ha^{-1} (Table 1). Harvest index was significantly affected by different levels of boron. Maximum harvest index (34.21%) was recorded from the control treatment and lowest (28.86%) was obtained from 1.5 kg B ha^{-1} (Table 2). The interaction of phosphorus and boron on Harvest index was also significant. The highest harvest index (37.63%) was recorded from the control treatment while the lowest (25.83%) was obtained from the combination of 40 kg P ha^{-1} and 1.5 kg B ha^{-1} (Table 3).

4. CONCLUSION

The application of 40 kg P ha^{-1} appears to be the promising rate of phosphorus in terms of growth, yield and yield attributes. Accordingly, the crop receiving 1.5 kg B ha^{-1} showed better performance in respect of growth and yield of plant characters. The mungbean crop may preferably be fertilized with a combination of 40 kg P ha^{-1} × 1.5 kg B ha^{-1} to obtain maximum seed yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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