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RESEARCH PAPER

Effect of Phosphorus on Growth, Yield and Yield Contributing Characters of Mungbean

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ABSTRACT

Phosphorus plays an important role in rooting and fruiting, and most of the biochemical activities in plants. A field experiment was carried out at the farm of Department of Soil Science, Patuakhali Science and Technology University (PSTU), Patuakhali, Bangladesh in 2013 to study the effect of phosphorus on the growth, yield and yield contributing characters of mungbean (*Vigna radiata*). The experiment was laid out in RCBD with three replications. Four levels of P (0, 20, 40, 60 kg/ha) and having a common *Rhizobium* inoculant. Growth, yield and yield contributing characters of mungbean were significantly increased due to P application compared to control. Phosphorus@ 40 kg ha-^{1} showed the highest performance in respect of plant height, leaves plant^{-1}, branches plant^{-1}, root length, leaves area, dry weight of shoot, dry weight of root, yield contributing attributes *viz.* number of pod per plant, pod length, number of seed pod^{-1}, thousand seed weight and seed yield ha^{-1} of mungbean. Judicious application of phosphorus is supposed to result in better nodulation and efficient functioning of nodulated bacteria for fixation of atmospheric nitrogen to be utilized by plant, which in turn leads to increase in seed yield

Key words: Mungbean, phosphorus, *rhizobium*, yield

Introduction

Mungbean is an important source of protein and several essential micronutrients. It contains 24.5% protein and 59.9% carbohydrate. It also contains 75 mg calcium; 8.5 mg iron and 49 mg B–carotene per 100 g of split daul (Bakr *et al*. 2004). Mungbean is one of the important pulses grown in Bangladesh. Unfortunately the yield of mungbean is very low in Bangladesh as compared to other countries of the world (BBS, 1991). It is grown twice a year and due to its short duration can be fitted in our existing cropping system without any major change in the present agricultural practices. Phosphorus is an important plant nutrient and it effects seed germination, cell division, flowering, fruiting, synthesis of fat, starch and in fact most biochemical activities. Judicious use of phosphate fertilizer is supposed to result in better nodulation and efficient functioning of nodules bacteria for fixation of atmospheric nitrogen to be utilized by plant during grain development stage, which in turn leads to increase in grain yield (Sarkar, 1992). The use of biological nitrogen fixation (BNF) technology in the form of *Rhizobium* inoculants in grain legumes can be an alternative of nitrogenous fertilizer. Mungbean, like other legumes improves soil fertility by fixing atmospheric nitrogen through the process of symbiosis with roots of legume crops and makes nitrogen (N) available to plant. Without proper fertilization by phosphorus, *rhizobial* activities and nitrogen fixation is depressed because it promotes early root formation and the formation of lateral, fibrous and healthy roots. It is very important for nodule formation and to fix atmospheric nitrogen. Leguminous crops meet up their N requirement through BNF depending on proper growth, development and also leg hemoglobin content of the root nodules (Chowdhury *et al*. 1998). Research on the effect of phosphorus along with *Rhizobium* inoculation is scanty in Bangladesh. So, it is necessary to observe the effect of different levels of phosphorus with *Rhizobium* inoculant and to assess their best combination in terms of enhanced nitrogen fixation and yield of mungbean. In view of these points, the present study was undertaken to find out the best combination of phosphorus with *Rhizobium* inoculants on growth, yield and yield contributing characters of mungbean.

Materials and Methods

The present research work was carried out on an experimental research farm, of Patuakhali Science and Technology University, Patuakhali during the term from December, 2012 to March 2013, to study the effect of phosphorus (P) with *Rhizobium* inoculation on the growth, yield and yield contributing characters of mungbean (*Vigna radiata*). The experimental location was situated geographically at $22^{0}37'$ N latitude and $89^{0}10'$ E longitudes. The area is covered by Gangetic Tidal Floodplains and falls under Agroecological Zone "AEZ– 13". The area lies at 0.9 to 2.1 meter above mean sea level (Iftekhar and Islam, 2004). Previously soil sample was collected randomly from the experimental site and analyzed for physiochemical properties. However, the soil of the experimental site was found to be silty clay loam .The experiment was laid out in randomized block design (RBD) with four phosphorous levels and *Rhizobium* inoculation which replicated thrice. There were a total of 12 unit plots. The details of different treatments with Phosphorous levels were as follows- T_1: Control, T_2: P@ 40 kg ha^{-1} with *Rhizobium*, T_3: P@ 40 kg ha^{-1} with *Rhizobium* and T_4: P@ 60 ka ha^{-1} with *Rhizobium* and mungbean variety was BARI mung-6. Basal doses of Urea @ 10 kg, MoP @ 40 kg and and gypsum @ 10 kg ha^{-1}, respectively were applied at the time of final land preparation. Data on plant characters were recorded at different stages (30, 45, 60 and 75 DAS). Plant height, leaf per plant, branches per plant, root length, leaf area, dry weight of shoot, dry weight of root, while yield contributing attributes *viz.* number of pod per plant, pod length, number of seed per pod thousand seed weight and seed yield per hectare were recorded at harvest. The data obtained from experiment on various parameters were statistically analyzed in MSTAT–C computer program (Russel, 1986). The mean values for all the parameters were calculate and the analysis of variance for the characters was accomplished by Duncan's Multiple Range Test (DMRT) and the significance of difference between pair of means was tested by the Least Significant Differences (LSD) test at 5 % levels of probability (Gomez and Gomez, 1984).

Results and Discussion

Plant height:

Significant effect was observed due to the application of phosphorus (Table 1). Among the treatments, T_3 (P @ 40kg ha^{-1} with *Rhizobium)* produced the tallest plant (15.9, 22.1, 41.4 and 55.4 cm) at 30, 45, 60 and 75 DAS, respectively, which was significantly different from all other treatments at all stages of growth. The shortest plant height (11.0, 13.8, 31.6 and 38.7 cm) was found in T_1 (*Rhizobium*) treatment at 30, 45, 60 and 75 DAS. These results indicated that, plant height was gradually increased due to the increase in phosphorus doses up to 40 kg ha^{-1} and thereafter it was decreased. Almost similar results were found by Rahman *et al*. (2008) and Bhuiyan *et al*. (2004). Amanullah *et al*. (2012) also reported that the phosphorus application at the rate of 40 kg P_2O_5 ha^{-1} significantly increased plant height.

Table1. Effect of phosphorus with *Rhizobium* inoculant on plant height and number of leaves plant $^{-1}$ of mungbean

Treatment	Plant height (cm) at different DAS				Number of leaves plant $^{-1}$ at different DAS			
	30	45	60	75	30	45	60	75
T_1: Control	11.0 c	13.7 d	31.6 d	38.5 d	5.75 d	13.99 d	16.73 d	18.88 d
T_2: P @ 20 kg ha^{-1}	14.4 b	16.8 c	36.4 c	45.8 c	6.44 c	16.58 c	22.18 c	25.47 c
T_3: P @ 40 kg ha^{-1}	15.9 a	22.1 a	41.4 a	55.4 a	8.01 a	20.73 a	25.32 a	28.70 a
T_4: P @ 60 kg ha^{-1}	14.7 b	19.4 b	39.8 b	52.3 b	7.27 b	19.47 b	24.09 b	27.58 b
CV%	3.28	4.37	5.32	2.89	4.27	3.05	5.41	3.98
Sig. level	**	**	**	**	**	**	**	**

**= significant at 1% level of probability and *= significant at 5% level of probability. The figures in a column having common letter(s) do not differ significantly at 5% level of probability

Number of leaves plant^{-1}

Effect of phosphorus with *Rhizobium* on the number of leaves plant^{-1} was found to be statistically significant (Table 1). Number of leaves plant^{-1} was increased continuously up to 75 DAS. At all the stages (30, 45, 60 and 75 DAS) of growth, the maximum number of leaves plant^{-1} (8.012, 20.73, 25.32 and 28.70) was found in T_3 (P @ 40 kg ha^{-1} with *Rhizobium)* treatment which was significantly different from all other treatments and the lowest number of leaves plant^{-1} (5.75, 13.99, 16.73 and 18.88) was found in T_1 (control) treatment at 30, 45, 60 and 75 DAS, respectively.

Number of branch plant^{-1}

Significant variation was found on branch plant^{-1} production due to various treatments (Table 2). The highest number of branches plant^{-1} (4.6, 6.9, 8.0 and 9.9) at 30, 45, 60 and 75 DAS, was observed in 40 kg P ha^{-1} with *Rhizobium* which was significantly different from and superior to all other treatments. The lowest number of branches plant^{-1} (2.7, 4.3, 5.9 and 6.1) at 30, 45, 60 and 75 DAS was found in control treatment T_1 (*Rhizobium*). Similar results were also reported by Rahman *et al*. (2002).

Leaf area of plant^{-1}

Effect of phosphorus with *Rhizobium* on the leaf area of plant was found to be statistically significant (Table 2). The maximum leaf area of plant (19.36 cm^2, 26.36 cm^2, 33.93 cm^2 and 35.95 cm^2) was found in T_3 (40 kg P ha^{-1} with *Rhizobium*) treatment at 30, 45, 60 and 75 DAS, which was significantly different from all other treatments. The minimum leaves area of plant (10.99 cm^2, 17.65 cm^2, 21.43 cm^2 and 23.17 cm^2) was estimated in control treatment (T_1) at 30, 45, 60 and 75 DAS.

Root length plant^{-1}

A significant variation was found in respect of root length due to the effect of different levels of phosphorus with *Rhizobium* application at 30, 45, 60 and 75 DAS growth stages (Table 3). The tallest root length (6.99, 10.94, 16.55 and 21.57 cm) was recorded in T_3 (40 kg P ha^{-1} with *Rhizobium*) treatment which was significantly different and superior to all other treatments. The shortest root length of 3.59, 5.46, 9.79 and 12.87 cm were recorded in T_1 (control) treatment at 30, 45, 60 and 75 DAS.

Number of nodule plant^{-1}

Among the phosphorus levels, at the rate of 40 kg P/ha with *Rhizobium* produced significant number of nodules 7.88, 15.86, 17.87 and 6.71/plant at growth stages of 30, 45, 60 and 75 DAS and the lowest nodule plant^{-1} (4.45, 8.45, 9.76 and 4.36) was found in T_1 (control) treatment. Similar effect was also reported by Patal *et al*. (2013) and Rahman *et al*. (2008). Chowdhury *et al.* (1998) also found that 50 kg P_2O_5/ha with other fertilizers increased 245% nodule number over control.

Table 2. Effect of phosphorus with *Rhizobium* inoculant on branches plant^{-1} and no. of leaf area plant^{-1} of mungbean

Treatment	Branches plant^{-1} at different DAS				Leaf area plant^{-1} at different DAS			
	30	45	60	75	30	45	60	75
T_1: Control	2.7c	4.3 c	5.9 d	6.1d	10.99 d	17.65 d	21.43 c	23.17 d
T_2: P @20kg ha^{-1}	3.6b	6.7 b	7.6 c	8.62c	14.86 c	22.00 c	24.54 b	32.60 c
T_3: P @ 40kg ha^{-1}	4.6a	6.9 a	8.0 a	9.9a	19.36 a	26.36 a	33.93 a	35.95 a
T_4: P @ 60kg ha^{-1}	3.9 b	6.3 a	7.9 b	8.6 b	18.18 b	24.49 b	26.43 b	34.57 b
CV%	3.59	4.2	3.62	2.86	3.56	4.56	4.23	3.89
Sig. level	**	**	**	**	**	**	*	*

**= significant at 1% level of probability and *= significant at 5% level of probability. The figures in a column having common letter(s) do not differ significantly at 5% level of probability

Table 3. Effect of phosphorus with *Rhizobium* inoculation on root length plant^{-1} and no. of nodule plant $^{-1}$ of mungbean

Treatment	Root length plant^{-1} (cm) at different DAS				Number of nodule plant^{-1} at different DAS			
	30	45	60	75	30	45	60	75
T_1: Control	3.59 d	5.46 c	9.79 d	12.85d	4.45 d	8.45d	9.76 d	4.36 d
T_2: P @20kg ha^{-1}	5.90 c	8.95 b	13.76 c	18.02c	5.52c	12.32c	13.98 c	5.25 c
T_3: P @ 40kg ha^{-1}	6.99a	10.94 a	16.55 a	21.57a	7.88a	15.86a	17.87 a	6.71 a
T_4: P @ 60kg ha^{-1}	6.45 b	10.71 a	15.68 b	20.23 b	7.08b	14.77b	16.75b	5.93 b
CV%	5.18	4.07	3.12	3.87	3.19	3.2	3.32	2.56
Sig. level	**	**	**	**	**	**	**	**

**= significant at 1% level of probability and *= significant at 5% level of probability. The figures in a column having common letter(s) do not differ significantly at 5% level of probability

Shoot dry weight plant^{-1} (g):

Effect of phosphorus with *Rhizobium* on the shoot dry weight was found to be statistically significant (Table 4). The maximum shoot dry weight (2.89 , 4.81,5.88 and 7.05g) per plant was found in 40 kg P ha^{-1} with *Rhizobium* treatment which was significantly different from other treatments but statistically similar with that of 60 kg P ha^{-1} with *Rhizobium* and the minimum dry

weight of shoot (2.27,3.49,4.56 and 5.23 g) was recorded in T_1 (control) treatment. Similar result was reported by Khan *et al.* (2017).

Root dry weight plant^{-1} (g):

Root dry weight of Mungbean was influenced significantly by the application of phosphorus with *Rhizobium*. The results of root dry weight at 30, 45, 60 and 75 DAS have been presented in (Table 4). The highest dry weight of root (0.316, 0.451, 0.570 and 0.717 g) plant^{-1} was found in 40 kg P ha^{-1} with *Rhizobium* inoculant and lowest dry weight of root (0.148, 0.208, 0.368 and 0.422 g) plant^{-1} was found in T_1 (control) treatment. Similar results reported by Khan *et al.* (2017) and Erman *et al.* (2009)

Number of pod plant^{-1}

Number of pods plant^{-1} was significantly influenced by the application of P with *Rhizobium* inoculants. Treatment T_3 produced significantly higher number of pods plant^{-1} (21.48), (Table 5). In contrast, without phosphorus (control) recorded the minimum number of pods plant^{-1} (15.11). The result of the present study was similar with Amanullah *et al.* (2012) who found that phosphorus application at the rate of 40 kg P_2O_5 ha^{-1} increased pot per plant. Muhammad *et al.* (2004) and Malik *et at.* (2002) reported that the number of pods per plant of mungbean increased with *Rhizobuim* inoculant in association with P application.

Pod length (cm)

Significant variation was observed in pod length due to the application of P, with *Rhizobium* inoculant over control (Table 5). The highest pod length (7.99 cm) was obtained with the T_3, where P was applied at the rate of 40 kg/ha along with *Rhizobium* inoculants. The lowest pod length (6.66 cm) was found with control condition.

Table 4. Effect of phosphorus with *Rhizobium* inoculant on shoot and root dry weight plant $^{-1}$ of mungbean

Treatment	Shoot dry weight (g) plant^{-1} at different DAS				Root dry weight (g) plant^{-1} at different DAS			
	30	45	60	75	30	45	60	75
T_1: Control	2.27 c	3.49 c	4.56 c	5.23 d	0.148 c	0.208 c	0.368 c	0.422 c
T_2: P @20kg ha^{-1}	2.59 b	4.31 b	5.53 b	6.53 c	0.259 b	0.377 b	0.465 b	0.586 b
T_3: P @ 40kg ha^{-1}	2.89 a	4.81 a	5.88 a	7.05 a	0.316 a	0.451 a	0.570 a	0.711 a
T_4: P @ 60kg ha^{-1}	2.81 a	4.69 a	5.66b	6.78 b	0.280ab	0.400 b	0.500b	0.636b
CV%	3.28	3.57	4.22	3.37	4.29	3.56	4.12	4.56
Sig. level	**	**	**	**	**	**	**	**

**= significant at 1% level of probability and *= significant at 5% level of probability. The figures in a column having common letter(s) do not differ significantly at 5% level of probability.

Table 5. Effect of phosphorus with *Rhizobium* inoculants on number of pod per plant, pod length, seeds per pod and 1000 seed weight and seed yield of mungbean

Treatment	Number of pod plant^{-1}	Pod length	Number of seed pod^{-1}	1000-seed weight (g)	Seed yield (kg ha^{-1})	Seed yield increase over control (%)
T_1: Control	15.11d	6.66 c	6.78 d	30.01 d	1.37 d	-
T_2: P @20kg ha^{-1}	16.64 c	7.13b	7.47 c	31.83 c	1.66 c	21.17
T_3: P @ 40 kg ha^{-1}	21.48 a	7.99 a	9.98 a	34.43 a	2.12 a	54.74
T_4: P @ 60kg ha^{-1}	18.64 b	7.61 b	9.14 b	32.82 b	1.91 b	39.42
CV%	2.54	1.30	1.35	2.34	2.33	-
Sig. level	**	**	**	**	**	-

**= significant at 1% level of probability and *= significant at 5% level of probability. The figures in a column having common letter(s) do not differ significantly at 5% level of probability.

Number of seed pod^{-1}

Phosphorus with *Rhizobium* inoculants influenced significantly on the formation of seeds pod^{-1} (Table 5). The highest number of seeds pod^{-1} (9.98) was recorded with treatment T_3. The lowest number of seeds pod^{-1} (6.78) was recorded in without phosphorus (T_1) treatment. This result indicated that phosphorus application @ 40 kg ha^{-1} had more efficient effect to produce more seeds. It was observed that *Rhizobium* inoculant in association with P led to increase the number of seeds per pod of mungbean. Similar results were also reported by Landge *et al.* (2002). Amanullah *et al.* (2012) also found that phosphorus application at the rate of 40 kg P_2O_5 ha^{-1} significantly increased the number of seeds plant^{-1}.

1000 Seed weight

Significant effect was observed on 1000 seed weight due to the application of phosphorus with *Rhizobium* inoculants. Significantly higher 1000 seed weight (34.43 g) was obtained with T_3 (P @ 40 kg ha^{-1} with *Rhizobium*) and the lowest (30.01 g) with the control. Malik *et al.* (2002) reported that seed inoculation with *Rhizobium* mungbean.

Seed yield (kg ha^{-1})

Seed yield was significantly influenced due to the application of P with *Rhizobium* inoculants (Table 5). The treatment (T_3) 40 kg P/ha with *Rhizobium* inoculants produced the highest seed yield (2.12 t ha^{-1}), which was 54.74% higher than the control (T_1). Rahman *et al*. (2008) and Muhammad *et al.* (2004) also observed the similar trend. Amanullah *et al.* (2012) found that phosphorus application at the rate of 40 kg P_2O_5 ha^{-1} increased seed yield.

Conclusions

From the investigation it was concluded that, the phosphorus fertilizer with *Rhizobium* inoculants was effective in mung bean cultivation. Application of 40 kg phosphorus ha^{-1} with *Rhizobium* inoculants was observed the most suitable for optimizing the yield of mungbean. There is enough scope to explore and exploit the production of mungbean in Bangladesh through using R*hizobium* technology along with phosphorus.

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