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Growth and Yield Response of Bush Bean (*Phaseolus vulgaris* L.) as Influenced by Different Levels of Nitrogen and Phosphorus Application

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SN and MNHS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MAA and AKMGM managed the analyses of the study. Author MNHS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted at Horticulture Farm at Sher-e-Bangla Agricultural University, Bangladesh during the period December, 2014 to March 2015 to evaluate the effect of different levels of nitrogen and phosphorous on the growth and yield of bush bean. The two factor experiment was laid out in Randomized Complete Block Design with three replications. The treatment was comprised of two factors- Factor A: levels of nitrogen i) 0 kg/ha, ii) 20 kg/ha, iii) 40 kg/ha and Factor B: levels of phosphorous (P_2O_5) – i) 0 kg/ha, ii) 50 kg/ha, iii) 75 kg/ha, iv) 100 kg/ha. The results revealed that most of the growth and yield contributing parameters were significantly influenced by the different levels of nitrogen and phosphorous application. The maximum promotive effect on growth and yield of bush bean was associated with 40 kg N/ha and

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75 kg P_2O_5/ha. Again their combined application enhanced maximum vegetative growth and with higher pod yield and seed yield. Therefore, application of 40 kg N/ha with 75 kg P_2O_5/ha can be conductive for bush bean cultivation in Bangladesh with higher yield.

Keywords: Growth; yield; bush bean; nitrogen; phosphorous.

1. INTRODUCTION

Bush bean (*Phaseolus vulgaris* L.) is a versatile short duration legume crop with high grain yielding potential and can be used both as pulses and vegetable. Although the crop has originated in South America it has gained popularity all over the world for its high yielding potential and diversified use. Immature pods are marketed fresh, frozen and canned. Its dry seeds are used in preparations with fish, meat and other vegetables. Foliage of the plant may also provide hay, silage and green manures. After harvest, plants can be used as fodder to feed the cattle, sheep and horses. Its edible pods supply huge protein, carbohydrate, fat, fiber, thianin, riboflavin, Ca and Fe [1]. Due to its sublime nutritional quality and diversified use, it has gained huge popularity in Bangladesh over the recent years. Besides these, the crop has eminent export potential which has drawn the attention of Agriculture industry and exporters. So there is tremendous scope for the cultivation of this important vegetable crop in our country with the export potential. However, to ensure proper growth and yield, the crop needs optimum nutrient management. Nitrogen is one of the key elements for growth and development of a crop plants [2]. Meanwhile, it has been reported that, unlike other leguminous crops, it does not nodulate with the native rhizobia [3]. Therefore, nitrogen input during production is very crucial for this crop. Nitrogen deficiency constraints leaf area expansion, enhances leaf senescence, inhibits photosynthetic rate in most of the crops and consequently reduces the crop productivity [4,5]. In addition to this, deficiency of phosphorous is now considered as one of the major constraints to successful production of legumes and upland crops in Bangladesh [6]. The most obvious effect of phosphorus is on the root development particularly of the lateral and fibrous rootlets that are essential to fix the atmospheric nitrogen in legume crops. Phosphorous also make its contribution through seed formation. In case of application of various fertilizer doses, there were significant differences in pod number per plant in bush bean [7]. In experiment, the plant height, number of branches, length of pod per plant and seed yield per pod increase with successive increase in the dose of nitrogen as well as phosphorous [8]. Therefore, optimum combination of nitrogen and phosphorous may bring about considerable increase in the yield of Bush bean due to their complementary effects. A detailed systematic study is needed to find out the requirements and effect of nitrogen and phosphorous for maximizing the yield of bush bean in Bangladesh. Considering the above, the present investigation was undertaken to study the growth and yield response of bush bean under different levels of nitrogen and phosphorous to find out the best combination of nitrogen and phosphorous for maximizing the production of Bush bean.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the Horticultural farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from December 2014 to March 2015. The location of the experimental site was 23074/N latitude and 90035/E longitude and at an elevation of 8.2 m from sea level. The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October. The soil of the experimental area belongs to the Modhupur Tract (AEZ No 28). It had shallow red brown terrace soil. The selected plot was medium high land and the soil series was Tejgaon.

2.2 Planting Material

The variety of bush bean used in the experiment was BARI jharsheem. The seeds were collected from Horticulture Research Centre, Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh.

2.3 Experimental Design and Treatments

The two factor experiment was laid out in Randomized Complete Block Design with three

replications. The experimental plot was first divided into three blocks. Each block consisted of 12 unit plots. Thus the total number of plots was 36. The treatment was comprised of two factors- Factor A: levels of nitrogen i) 0 kg/ha, ii) 20 kg/ha, iii) 40kg/ha and Factor B: levels of phosphorous – i) 0 kg/ha, ii) 50 kg/ha, iii) 75 kg/ha, iv) 100 kg/ha. Different combinations of nitrogen and phosphorous (P_2O_5) were assigned randomly to each block as per design of the experiment. The size of the unit plot was 3m×4. A distance of 0.75m between the plots and 1m between the blocks were kept.

2.4 Growth Condition of Bush Bean and Measurement of Parameters

Seedlings were grown following proper methods and all of the cultural practices were done properly. Application of manure and fertilizers were applied as per treatment. Healthy and uniform sized seedlings were transplanted in the main field. Intercultural practices were done as per requirements. For controlling leaf caterpillars Nogos @ 1 ml/L water were applied two times at an interval of 10 days starting soon after the appearance of infestation. Immature green pods were harvested at tender stage, suitable for use as vegetable. First harvest was done at 55 days after sowing (DAS) and was weighted to estimate the fresh pod yield. Again the rest of the pods were harvested at mature stage when the pods become yellow and fully dry. These seeds were collected from the pods and sun dried seeds were weighted to estimate the seed yield.

2.5 Data Collection and Statistical Analysis

Different yield contributing data have been recorded from the mean of five harvested plants which was selected at random of each unit plot of every harvesting stage. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The height of the plants was measured from the ground level to the tip of the highest leaves. Green pods were harvested from each unit plot at 4 days interval and their total weight was recorded. Harvesting was done for four times and their weight was recorded in each unit plot and expressed in kilogram (Kg). The green pod yield per plant was finally converted to yield per hectare and expressed in ton (t). The data obtained for different parameters were statistically analyzed to find out the significance difference of variety and different fertilizer application on yield and yield contributing characters of Bush bean. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Different levels of nitrogen and phosphorous exhibited significant variation in respect of plant height of bush bean at different days after sowing (Table 1). In all the dates of observation plant height gradually increased with the increasing nitrogen level. At final harvest the maximum plant height (43.82cm) was obtained from the plant grown with 40kg N/ha and the minimum (37.85cm) was recorded from control treatment. Nitrogen is the most essential nutrient for plant growth and development. Nitrogen is part of the chlorophyll molecule, which gives plants their green color and is involved in creating food for the plant through photosynthesis. Nitrogen is also the primary building block for plant protoplasm. Protoplasm is the translucent substance that is the living matter in cells. It is needed for flower differentiation, speedy shoot growth and all these might have facilitated the highest plant height N_2. Similar result was supported by Ferdous et al. [9] who reported that plant height increased with increasing rate of N doses up to 120 kg/ha.

Plant height was also significantly influenced by the application of different levels of phosphorous at different growth stages (Table 2). Plant height was gradually increased with the passage of time up to the final harvest. At harvest, the tallest plant (41.98 cm) was produced on soil application of 100 kg P_2O_5/ha whereas the shortest plant was recorded in the controlled treatment. This might be due to the fact that phosphorus is required for photosynthesis and also in the storage and transportation of the nutrients throughout the plant which boosts the development of plant. Similar result was reported by [10,11].

In case of combined effect of nitrogen and phosphorous, the maximum plant height (44.60 cm) was observed from the treatment

combination N_2P_2 whereas the minimum plant height was observed from the control treatment. The present result is in agreement with the findings of Ferdous et al. [9].

3.2 Number of Pod/Plant

The number of pod per plant differed significantly due to the application of different levels of nitrogen (Table 1). The maximum number of pods per plant (13.26) was produced from the 40kg N/ha. On the contrary, minimum number of pod per plant was recorded from the control treatment. It might be due to the adequate supply of nitrogen which facilitated the increased number of pod bearing branches.

The number of pod per plant was also showed significant effect on increasing the number of pod per plant (Table 2). The maximum number of pods per plant (13.62) was recorded from 50 kg P_2O_5/ha meanwhile the minimum number of pod per plant was recorded from the control treatment. The result is in conformity with the [11,12,13].

Combined effect of different levels of nitrogen and phosphorous on the number of pod per plant showed significant variation (Table 3). The maximum number of pods per plant (13.90) was recorded from the combined treatment of 40kg N/ha and 50 kg P_2O_5/ha. On the contrary minimum number of pods per plant was found from the N_2P_3. It has been reported that P uptake reduced above 60 kg P_2O_5/ha.

3.3 Pod Length (Cm)

Nitrogen had significant influence in respect to pod length (Table 1). Pod length gradually increased with the increasing dose of nitrogen fertilizer. The highest length of green pod of bush bean (17.51 cm) was found in the crop grown with the higher dose of nitrogen (40 kg N/ha) and lowest was observed from the control treatment. Length of the green pod was also influenced significantly by the different doses of phosphorous (Table 2). The maximum length of green pod (16.99 cm) was obtained from 100 kg P_2O_5/ha. On the other hand minimum pod length was recorded from50 kg P_2O_5/ha. It was observed that the interaction effect of different doses of nitrogen and phosphorous on green pod length was significant (Table 3). The highest pod length (18.05 cm) was recorded from the treatment combination 40 kg N/ha and 75 kg P_2O_5/ha and the lowest was recorded from the control treatment.

3.4 Pod Weight/Plant

A significant variation was observed in respect of pod weight per plant ad different level of nitrogen (Table 1). The highest pod weight per plant (85.26 g) was obtained from 40 kg N/ha and the lowest pod weight (48.57 g) per plant was recorded from the control. The level of phosphorous was also significantly influenced the pod weight per plant of bush bean in the similar way. The highest pod weight (72.27 g) was obtained from the plant which was treated with 75 kg P_2O_5/ha and the lowest (62.10 g) from the control treatment. The combined effect of different levels of nitrogen and phosphorous on pod weight per plant was found statistically significant (Table 3). The maximum pod weight per plant (89.16 g) was obtained from the treatment N_2P_1 whereas the minimum was obtained from the control treatment.

3.5 Pod Yield

The result indicated that nitrogen had significant effect on pod yield per hectare (Table 1).The maximum pod yield (16.56 t/ha) was obtained from 40 kg N/ha and the minimum pod yield (10.04 t/ha) in control. Phosphorous also influenced significantly the pod yield per hectare (Table 2).The combined effect of different level of nitrogen and phosphorous on pod yield per hectare was found to be statistically significant (Table 3). The highest pod yield per hectare (18.61 t/ha) was achieved from the treatment combination 40 kg nitrogen per hectare with 75 kg P_2O_5/ha whereas the lowest value per hectare (9.22 t/ha) was found from the control combination. Similar kind of result was reported by [14,15].

3.6 Number of Seeds/Pod

The number of mature seeds per pod was significantly influenced by the application of nitrogen (Table 1). The highest seed per pod (5.85) was obtained from the plant receiving 40 kg N/ha. The lowest number of mature seed per pod (5.31) was recorded from control treatment. This result might be due to the better growth and development and larger pod formation with higher rate of N application. Similar kind of result was reported by Kumar et al. [10].

Table 1. Effect of nitrogen on the growth and yield contributing attributes of bush bean

Nitrogen Level	Plant height (cm)	Number of pod plant^{-1}	Pod length (cm)	Pod weight plant^{-1}	Pod yield (t ha^{-1})	Number of seeds pod^{-1}	1000 seed weight (g)	Seed yield plot-^{1} (kg)	Seed yield (tha^{-1})
N_0	37.85 c	13.22 b	14.85 b	48.57 c	10.04 c	5.13 c	225.00 b	2.65 c	2.23 c
N_1	41.34 ab	13.24 ab	16.58 ab	66.93 b	13.62 ab	5.35 b	228.50 ab	2.94 ab	2.42 b
N_2	43.83 a	13.26 a	17.51 a	85.26 a	16.56 a	5.85 a	230.75 a	3.23 a	2.71 a
LSD (0.05)	0.988	0.065	0.488	0.065	0.100	0.088	1.955	0.037	0.046
CV	4.25	3.20	4.16	6.40	2.21	1.63	7.56	3.54	4.12

Means in a same column followed by different letter (s) are significantly different at P<0.05

Table 2. Effect of phosphorous on the growth and yield contributing attributes of bush bean

Phosphorus Level	Plant height (cm)	Number of pod plant^{-1}	Pod length (cm)	Pod weight plant^{-1}	Pod yield (tonha^{-1})	Number of seeds pod^{-1}	1000 seed weight (g)	Seed yield plot-^{1} (kg)	Seed yield (tonha^{-1})
P_0	39.83 c	13.20 b	16.29 b	62.10 c	10.76 c	5.13 b	223.33 c	2.65b	2.17 b
P_1	40.66 b	13.62 a	15.93 c	68.25 b	13.51 b	5.44 b	227.00 bc	2.94 b	2.48 b
P_2	41.55 ab	13.12 b	16.03 bc	72.27 a	15.35 a	5.56 ab	236.00 b	3.08 a	2.58 a
P_3	41.98 a	12.99 c	16.99 a	65.08 bc	14.55 ab	5.63 a	226.00 bc	3.06 a	2.58 a
LSD (0.05)	1.142	0.075	0.564	0.415	0.115	0.10	2.258a	0.043	0.053
CV	4.55	1.19	4.65	5.87	4.12	3.07	8.67	2.43	4.11

Means in a same column followed by different letter (s) are significantly different at P<0.05

Table 3. Combined effect of nitrogen and phosphorous on the growth and yield contributing attributes of bush bean

Nitrogen level	Plant height (cm)	Number of pod plant^{-1}	Pod length (cm)	Pod weight plant^{-1}	Pod yield (tonha^{-1})	Number of seeds pod^{-1}	1000 seed weight (g)	Seed yield plot-^{1} (kg)	Seed yield (tonha^{-1})
N_0P_0	35.27d	13.20 b	15.04 c	40.66 e	9.22 d	4.73 d	211.00 d	2.21 d	1.89 d
N_0P_1	36.33 cd	13.46 b	13.56 d	42.66 de	9.80 cd	4.97 cd	235.00 b	2.50 cd	2.13 c
N_0P_2	39.82 c	12.83 bc	15.16 c	57.71 c	11.81 c	5.31 c	225.00 bc	2.87 c	2.41 bc
N_0P_3	39.97 c	13.33 b	15.65 c	53.23 cd	10.93 c	5.54 ab	231.00 bc	2.91 bc	2.49 bc
N_1P_0	40.46 bc	12.96 bc	16.09 bc	63.72 bc	10.15 c	5.22 c	219.00 cd	2.77 c	2.19 c
N_1P_1	41.03 bc	13.51 b	16.17 bc	72.95 b	13.58 bc	5.22 c	218.00 cd	2.80 c	2.35 bc
N_1P_2	41.30 b	13.53 b	16.22 bc	71.44 b	15.63 b	5.36 ab	227.00 bc	3.16 b	2.62 bc
N_1P_3	42.57 b	13.45 b	17.82 ab	59.60 c	15.15 b	5.58 ab	236.00 b	3.07 bc	2.52 bc
N_2P_0	43.77 b	13.50 b	17.76 ab	81.93 ab	12.91 bc	5.46 ab	228.00 c	2.95 c	2.42 bc
N_2P_1	43.53 b	13.90 a	18.05 a	89.16 a	17.14 ab	6.16 a	229.00 c	3.53 a	2.96 a
N_2P_2	44.60 a	13.00 b	16.71 bc	87.67 ab	18.61 a	6.01 a	255.00 a	3.22 b	2.73 b
N_2P_3	43.40 b	12.20 c	17.51 ab	82.82 ab	17.57 ab	5.75 ab	223.00 bc	3.19 b	2.73 b
LSD(0.05)	1.978	0.131	0.977	0.720	0.200	0.177	3.910	0.075	0.09
CV (%)	2.85	2.59	3.54	3.44	4.87	1.91	3.01	1.52	2.19

Means in a same column followed by different letter (s) are significantly different at P<0.05; Factor A: levels of nitrogen i) 0 kg/ha, ii) 20 kg/ha, iii) 40 kg/ha and Factor B: levels of phosphorous (P_2O_5) – i) 0 kg/ha, ii) 50 kg/ha, iii) 75 kg/ha, iv) 100 kg/ha

Different doses of phosphorous also significantly influenced the number of seed per pod (Table 2). Number of seed per pod increased with increasing rates of phosphorous fertilizer. It was maximum (5.63) at 100 kg P_2O_5/ha which was statistically similar to 75 kg P_2O_5/ha whereas the minimum number of seed (5.13) was obtained with zero phosphorous. There was also significant interaction between nitrogen and phosphorous in respect of seed per pod (Table 3). The maximum number of seeds per pods (6.16) was recorded from the treatment combination 40 kg N/ha with 50 kg P_2O_5/ha whereas the minimum number of seed per pod was recorded in the control treatment.

3.7 Thousand Seed Weight

A significant variation was observed in respect of 1000 seed weight due to different nitrogen levels (Table 1). Maximum weight of 1000 seed (230.75 g) was recorded from application of 40 kg N/ha. Meanwhile minimum was obtained from the control treatment. The level of phosphorous were also significantly influenced the 1000 seed weight (Table 2). The highest 1000 seed weight (236.00 g) was recorded at 75 kg P_2O_5/ha while the lowest was obtained from the control treatment. The combined effect of nitrogen and phosphorous was found to be significant (Table 3). The highest weight of 1000 seed (255.00 g) was obtained from the treatment combination of 40 kg N/ha with 75 kg P_2O_5/ha. The lowest 1000 seed weight (211.00 g) was recorded from the control treatment.

3.8 Seed Yield/Plot

The result indicated that nitrogen had significant effect on seed yields per plot (Table 1). Seed yields per plot were varied from 2.65 kg to 3.3 kg. The maximum seed yield per plot was produced from the 40 kg N/ha and minimum seed yield per plot was obtained from the control.

Phosphorous also influenced significantly the seed yield per plot (Table 2). Maximum seed yield per plot (3.08 kg) was obtained with the 75 kg P_2O_5/ha while the minimum was recorded in the control treatment.

The combined effect of different levels of nitrogen and phosphorous on seed yield per plot was found to be statistically significant (Table 3). The highest yield per plot (3.53 kg) was obtained from the treatment combination of 40 kg N/ha with 50 kg P_2O_5/ha whereas the lowest value was found from the control treatment.

3.9 Seed Yield (t/ha)

The result indicated that nitrogen had significant effect on seed yield per hectare (Table 1). The maximum seed yield (2.71 t/ha) was obtained from 40 kg N/ha and the minimum (2.23 t/ha) in control treatment.

Phosphorous also influenced significantly the seed yield per hectare (Table 2). The maximum seed yield per hectare (2.58) was obtained with the 75 kg P_2O_5/ha whereas the minimum was obtained from the control treatment. The combined effect of different levels of nitrogen and phosphorous on seed yield per hectare was found to be statistically significant (Table 3). The highest yield per hectare (2.96 t) was obtained from the treatment combination of 40 kg N/ha with 50 kg P_2O_5/ha whereas the lowest value was found from the control treatment. The result is in agreement with [16,17].

4. CONCLUSION

The result of the present study revealed that both nitrogen and phosphorous significantly influenced on the green pod and seed yield of bush bean. Application of 40 kg N/ha with 75 kg P_2O_5/ha has emerged as the best treatment for increasing growth and yield contributing attributes of bush bean and therefore can be conductive for bush bean cultivation in Bangladesh with higher yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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