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Effect of Phosphorus and Boron on the Growth and Yield of French Bean

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Authors' contributions

This work was carried out in collaboration among all authors. Author FMJU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MH and SK conduct and managed the analyses of the study. Author HOR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory of the Department of Agronomy, Bangladesh Agricultural University, and Mymensingh to study the effect of phosphorus and boron on the growth and yield of var. BARI Jharsheem-3 along with French bean during November 2017 to March 2018. The experiment was comprised of two factors involving number of levels viz. phosphorus had four levels 15, 20, 25 and 35 kg ha^{-1} and four levels of boron *viz.* 0, 0.5, 1.0 and 1.5 kg ha^{-1}. Triple super phosphate and Borax were used as source of phosphorus and boron, respectively. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The results exhibited that yield and its contributing characters were significantly influenced by the phosphorus and boron applications. The experimental findings revealed that highest number of pods per plant (4.95), pod length (13.06 cm), number of seeds per pod (4.34), and 1000-seed weight (427.99 g), seed yield (1.40 t ha^{-1}), stover yield (1.76 t ha^{-1}), biological yield (3.16 t ha^{-1}) and harvest index (46%) were recorded under phosphorus level at 25 kg ha^{-1}. The experimental findings also revealed that the highest number of pods per plant (4.91), pod length (14.45 cm), number of seeds per pod (4.36), and 1000-seed weight (427.22 g), seed yield (1.39 t ha^{-1}), stover yield (1.68 t ha^{-1}), biological yield (3.07 t ha^{-1}) and harvest index (45.27 %) were

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recorded under boron level at 1.5 kg ha^{-1}. In case of interaction of phosphorus and boron, the highest number of pods per plant (5.18), pod length (14.35 cm), number of seeds pod^{-1} (4.84), and 1000-seed weight (427.19 g), seed yield (1.86 t ha^{-1}), stover yield (2.05 t ha^{-1}), biological yield (3.91 t ha^{-1}) and harvest index (47.57 %) were recorded under P level at 25 kg ha^{-1} and B level at1.5 kg ha^{-1}. So it may be concluded that 25 kg P ha^{-1} and 1.5 kg B ha^{-1} could be applied to obtain higher yield of bean.

Keywords: Phosphorus; boron; french bean; 1000-seed weight; grain yield; harvest index.

1. INTRODUCTION

French bean (*Phaseolus vulgaris* L.) of family Fabaceae is a nutritious vegetable grown for its tender green pods with high protein, calcium and iron content. It has many synonyms like: common bean, snap bean, dwarf bean, kidney bean, haricot bean, wax bean, field bean, garden bean, string bean pole bean or runner bean etc. South Mexico and Central America are considered as the primary center of origin, which lies in Peru-Bolivia-Ecuador region [1]. Common beans are important for nutritional well-being as well as poverty alleviation among consumers and farmers with few other food or crop options [2]. Bean is widely used in the country to make recipe like Githeri (cooked mixture of beans and maize) due to increased demand among low income population in the urban areas [3]. The protein consumption by individual people in the world is estimated at about 77g of protein per day [4]. Common beans provide the crucial proteins (20%), energy (32%) and generous amounts of micro-nutrients especially Fe and Zn, and vitamins A and B complex to over 50 million resource poor rural and urban consumers in eastern Africa [5]. French bean production was 137495 tonnes from an area of 20880 hectors in Bangladesh in 2017 [6].

French bean production depends on many factors such as quality seed, variety, sowing date, fertilizers and proper management practices [7,8,9]. Crop yield varies from variety to variety due to internal and external factors of the plant. The seed yield varies in different sowing dates [7,10]. A suitable variety is of primary importance for harnessing potential yield [11].

The fertilizer management has vital important roles on the growth, development and yield of legume crops. Among the fertilizers, phosphorus for all crops is of prime importance. Nutrient requirement of different cultivars is usually similar except on poor soils. French bean cultivation requires ample supply of phosphorus. Excessive or under doses of phosphorus can affect the growth and yield of legume crops. So, optimum dose of phosphorus is necessary to produce seed yield of French bean. Beans need P for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division, fat and albumen formation, transfer and storage of energy within plants. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds for later use in growth and reproduction [12,13,14]. Studies have shown that an application of P fertilizer led to an increased legume grain yields, particularly with velvet bean, and soybean [15]. The bean crops require more P because it is important for root nodulation to take place effectively [16].

Boron is one of the essential micronutrient required for normal growth of most of the plants. Boron is required for proper development and differentiation of tissues besides being helpful in reducing sterility and malformation in reproductive organs [17]. Boron helps in the normal growth of plant, absorption of nitrogen from soil, translocation of sugars, cell wall synthesis, root elongation and nucleic acid synthesis [18,19]. The boron improves the grain and straw yield, nutrient content, nutrient uptake and quality in legume crops [17,20]. Boron deficiency limits the production of pulse crops [21]. Keeping in view the importance of phosphorus and boron, this research was carried out with the objective to study that the response of different levels of phosphorous and boron and their interaction for maximizing the growth and yield performance of French bean.

2. MATERIALS AND METHODS

2.1 Experimental Site

The research work was conducted at the Agronomy Field Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh in order to study the effect of phosphorous and boron on the growth and yield of French bean during the period from November

2017 to March 2018. The present research work was conducted in the experimental field is located at 24.75°N latitude, 90.50°E longitude and an average altitude of 18 m above the sea level that belongs to the Old Brahmaputra Floodplain (AEZ-9) soil [22,23]. The soil texture in the experimental site was silty loam type and belongs to the Brahmaputra Alluvial Tract. The topography of the experimental field was medium high land. The soil of the experimental field is slightly acidic (pH 6.80) with low organic matter content (1.19 %) and high soil bulk density (1.64 g cm^{-3}). The geographical location of the experimental area was under the sub-tropical climate. During the winter season average temperature was 8-25°C which is favorable for French bean cultivation.

2.2 Treatments of the Experiment

The experiment was comprised of two factors namely Phosphorus and Boron level.

Factor A: P_1 =15 kg P ha^{-1}, P_2 = 20 kg P ha^{-1}, P_3 = 25 kg P $ha^{-1}$and P_4 = 35 kg p ha^{-1} and Factor B: B_1 = 0 kg B ha^{-1}, B_2 = 0.5 kg B ha^{-1}, B_3 = 1 kg B ha^{-1}, B_4 = 1.5 kg B ha^{-1}. This experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total number of plots was 48 (4×4×3) with size of 5 m^2 (2.5 m×2 m) per plot. Seeds were sown in line maintaining row spacing of 25 cm × 15 cm. The blocks and unit plots were separated by 1 m and 0.75 m spacing, respectively. French bean var. BARI Jharsheem-3 was used as experimental material. The land was prepared by several ploughing and cross ploughing followed by laddering to break the clods and to level the soil. The weeds and stubbles were collected and removed from the plot. Triple Super Phosphate and Borax were used as source of phosphorous and boron. The recommended dose of muriate of potash (150 kg ha^{-1}) and half amount of urea (150 kg ha^{-1}) was applied during final land preparation and remaining amount of urea was top dressed at 30 days after sowing (DAS) of seeds. The recommended dose of triple super phosphate and borax (as per treatments) were applied during final land preparation. Before sowing, seed were treated with Carbendazim @ 5g kg^{-1} uniformly for controlling soil borne diseases. Two seeds were sown per hill at a depth of 5.0 cm. Three weedings were done at 20, 35 and 50 days after sowing (DAS) to keep the plots free from weeds, which ultimately ensured better growth and development. Over-head irrigation was applied once immediately after germination and further as per requirement of water. The crops were harvested by hand picking when they reached maturity.

2.3 Data Collection

Data were collected on the growth and yield contribution parameters. Harvest index (HI) was calculated from the ratio of grain yield to biological yield and expressed in percentage using the following formula:

$$\text{HI (\%)} = \frac{\text{Seed yield}}{\text{Biological yield (Seed yield + Stover yield)}} \times 100$$

2.4 Statistical Analysis

The collected data were compiled and analyzed statistically using the analysis of variance technique with computer package program Minitab statistical software (2010). State college, PA: Minitab, Inc (www.minitab.com).

3. RESULTS AND DISCUSSION

3.1 Effect of Phosphorus on the Yield Contributing Characters and Yield of French Bean

The highest number of pods per plant (4.95), length of pod (13.06 cm), number of seeds per pod (4.34), 1000-seed weight (427.99 g), seed yield (1.40 t ha^{-1}), stover yield (1.76 t ha^{-1}), biological yield (3.16 t ha^{-1}), harvest index (46.00 %) was found at 25 kg P ha^{-1}. Again, lowest number of pods $plant^{-1}$ (4.75), length of pod (12.34), number of seeds pod^{-1} (4.21), 1000-seed weight (420.37 g), seed yield (1.26 t ha^{-1}), stover yield (1.48 t ha^{-1}) and biological yield (2.74 t ha^{-1}) were obtained from 15 kg P ha^{-1}, while harvest index (44.70 %) from 20 kg P ha^{-1} (Table 1). similar results also had significant effect of phosphorus in legume crops like mung bean and lentil [24,25,26]. Grain yield increased significantly by the application of increased levels of phosphorus (0, 15, 30 and 45 kg P ha^{-1}) over control in lentil [25]. In mungbean varieties, phosphorus also plays a significant role for increasing yield contributing characters which leading to raise seed yield (1.13 t ha^{-1}) from 80 kg P_2O_5 ha^{-1} [26,27]. The high dose of phosphorus fertilizer tends to form nutrient interaction and may affect the availability of other nutrients which are essential for growth of the bean [28]. In French bean, the highest pod yield (22.12 t ha^{-1})

z from 60 kg P ha^{-1} and seed yield (12.08 q ha^{-1}) from 60 kg P_2O_5 ha^{-1} application were observed by [29,30]. Whereas, Zebire et al., [31] recommended 46 P kg ha^{-1} for better production of French bean based on their results obtained higher seed yield (7.42 quintal ha^{-1}) from this dose when soil was sandy to sandy loam type with 6.7-7.3 pH. However, responses of French bean production through different doses of phosphorous application probably may vary due to reserves of nutrients contents in different soil type.

3.2 Effect of Boron on the Yield Contributing Characters and Yield of French Bean

The highest number of pods per plant (4.91), pod length (14.45 cm), number of seeds per pod (4.36), 1000-seed weight (427.22 g), seed yield (1.39 t ha^{-1}), stover yield (1.68 t ha^{-1}), biological yield (3.07 t ha^{-1}), harvest index (45.27%) were recorded from the application of 1.5 kg B ha^{-1}. Again, lowest number of pods per plant (4.7), pod length (12.91 cm), number of seeds per pod (4.22), 1000-seed weight (420.32 g), seed yield (1.31 t ha^{-1}), stover yield (1.58 t ha^{-1}), biological yield (2.89 t ha^{-1}) from 0 kg B ha^{-1}, and harvest index (44.20 %) were recorded from 0.5 kg B ha^{-1}. Positive responses of boron on the yield contributing characters were observed and recorded higher yield at the rate of 1.0 kg boron ha^{-1} in mungbean [32]. Boron application directly to the low available boron soil up to 2 kg ha^{-1} enhances French bean yield in case of French bean - Cabbage cropping sequences [33] and pod yield of French bean increments about 40.36% than control treatment (no boron application) [34]. Boron deficiency was established as the dominant nutritional problem causing flower and pod abortion. No pods or grains were formed in the absence of applied boron. Boron either foliar sprays or soil application could increase the green pod yield of French bean than no boron application [35].

Table 1. Effects of phosphorus on the yield parameters and yield of French bean

Level of phosphorus (kg ha^{-1})	Number of pods/ plant	Pod length (cm)	Number of seeds/ pod	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
15	4.75^{b}	12.34^{c}	4.21	420.37^{b}	1.26^{c}	1.48^{c}	2.74^{c}	45.98^{ab}
20	4.83^{b}	13.04^{a}	4.26	422.45^{ab}	1.28^{bc}	1.58b^{c}	2.86^{bc}	44.70^{b}
25	4.95^{a}	13.06^{a}	4.34	427.99^{a}	1.40^{a}	1.76^{a}	3.16^{a}	46.00^{a}
35	4.86^{ab}	12.97^{b}	4.29	423.49^{ab}	1.34^{ab}	1.62^{b}	2.96^{b}	45.27^{ab}
Level of significance	*	*	NS	*	*	*	*	*
SEM	0.06	0.03	0.02	2.21	0.03	0.05	0.08	0.70

Table 2. Effects of boron on yield contributing characters and yield of French bean

Level of boron (kg ha^{-1})	Number of pods/ plant	Pod length (cm)	Number of seeds/ pod	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
0	4.7^{b}	12.91^{c}	4.22^{b}	420.32^{c}	1.31^{b}	1.58^{b}	2.89^{c}	45.17^{b}
0.5	4.88^{ab}	13.00^{bc}	4.24^{b}	420.36^{c}	1.32^{b}	1.59^{bc}	2.91^{bc}	44.20^{c}
1.0	4.9^{a}	13.15^{b}	4.33^{a}	422.38^{b}	1.32^{b}	1.64^{bc}	2.97^{b}	44.44^{ab}
1.5	4.91^{a}	14.45^{a}	4.36^{a}	427.22^{a}	1.39^{ab}	1.68^{a}	3.07^{a}	45.27^{a}
Level of significance	*	*	*	*	*	*	*	*
SEM	0.07	0.50	0.04	2.30	0.003	0.02	0.02	0.67

** = Significant at 5 % level of probability, NS = Non significant, SEM = Standard error mean*

3.3 Interaction Effect of Phosphorus and Boron on the Yield Contributing Characters and Yield of French Bean

The interaction effect of phosphorus and boron observed significant effect on most of the studied yield contributing characters and yield of French bean. The highest number of pods per plant (5.18), pod length (14.35 cm), number of seeds per pod (4.84), grain yield (1.86 t ha^{-1}), stover yield (2.05 t ha^{-1}), biological yield (3.91 t ha^{-1}) and harvest index (47.57 %) were found from the interaction of 25 kg P ha^{-1} and 1.5 kg B ha^{-1}. On the other hand, lowest number of pods per plant (4.32), pod length (12.62 cm), number of seeds per pod (4.01), grain yield (1.11 t ha^{-1}), stover yield (1.39 t ha^{-1}), biological yield (2.50 t ha^{-1}) obtained from the interaction of 15 kg P ha^{-1} with no boron application (P_1B_1), while harvest index (42.68 %) from the interaction of 25 kg P ha^{-1} and 1.0 kg B ha^{-1} (P_3B_3). Interaction effect between phosphorous and boron showed non-significant variation on the 1000-seed weight. Numerically the highest 1000-seed weight (427.19 g) was observed from the combination of interaction of 25 kg P ha^{-1} and 1.5 kg B ha^{-1} (P_3B_4) and the lowest one (420.13 g) was found from the interaction of 15 kg P ha^{-1} and 0.0 kg B ha^{-1} (P_1B_1) (Table 3). Researchers reported that interaction of boron application with other nutrients also increase yield in case of other legume crops like mungbean [36,37]. Ganie et al*.,* [38] found significantly higher seed and stover yield of French bean from the combination Boron with Sulphur (45 kg S + 1.0 kg B ha^{-1}). Researchers also found that the combined effect of phosphorus and boron showed significant variation of grain yield in mungbean as for example higher grain yield (1.81 t ha^{-1}) from P30 and B1.5 kg ha^{-1} in var. BARI Mung-6 were recorded [39]. Boron in combination with other nutrients (e.g. B1.5 Zn1.0 kg ha^{-1} produce nearly double seed yield than control of boron [40] and B1.0 Zn1.5 kg ha^{-1} found congenial for mungbean cultivation as the most of the yield contributing characters and yield [41]) also played positive responses with the growth and yield contributing characters leading to increase seed/grain yield of mungbean.

Table 3. Interacting effects of phosphorus and boron yield contributing characters and yield of French bean

Interaction (P×B)	Number of (pods/ plant)	Pod length (cm)	Number of seeds/ pod	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
P_1×B_1	4.32^{g}	12.62^{e}	4.01^{e}	420.13	1.11^{cd}	1.39^{c}	2.50^{d}	44.40^{b}
P_1×B_2	4.78^{d}	12.79^{e}	4.27^{c}	420.47	1.25^{cd}	1.42^{bc}	2.67^{d}	46.81^{ab}
P_1× B_3	4.78^{d}	12.97^{d}	4.31^{c}	420.51	1.25^{cd}	1.49^{bc}	2.74^{cd}	45.62^{ab}
P_1× B_4	4.91^{c}	13.45^{b}	4.34^{c}	420.62	1.32^{bcd}	1.67^{ab}	2.94^{a-d}	44.89^{ab}
P_2× B_1	4.85^{bc}	12.72^{e}	4.21^{c}	422.19	1.25^{cd}	1.52^{bc}	2.78^{cd}	44.96^{b}
P_2× B_2	4.85^{bc}	13.02^{d}	4.29^{c}	420.26	1.29^{bcd}	1.60^{abc}	2.89^{a-d}	44.63^{b}
P_2× B_3	4.92^{b}	13.15^{c}	4.40^{b}	420.37	1.31^{bcd}	1.57^{bc}	2.88^{b-d}	45.48^{ab}
P_2× B_4	4.92^{b}	13.22^{bc}	4.42^{b}	420.38	1.40^{ab}	1.68^{ab}	3.08^{a-c}	45.45^{ab}
P_3× B_1	4.65^{e}	13.11^{c}	4.10^{d}	420.18	1.31^{bcd}	1.58^{abc}	2.90^{bcd}	45.17^{ab}
P_3× B_2	4.71^{e}	13.12^{c}	4.32^{b}	420.21	1.34^{a-d}	1.62^{abc}	2.96^{a-d}	45.27^{ab}
P_3× B_3	5.05^{ab}	13.31^{bc}	4.40^{b}	420.42	1.40^{ab}	1.87^{a}	3.28^{ab}	42.68^{b}
P_3× B_4	5.18^{a}	14.35^{a}	4.84^{a}	427.19	1.86^{a}	2.05^{a}	3.91^{a}	47.57^{a}
P_4× B_1	4.65^{f}	12.68^{e}	4.06^{d}	420.36	1.28^{bcd}	1.47^{bc}	2.80^{cd}	45.71^{ab}
P_4× B_2	4.98^{b}	12.91^{e}	4.20^{c}	420.39	1.36^{abc}	1.66^{ab}	3.00^{a-d}	45.33^{ab}
P_4× B_3	4.98^{b}	13.07^{c}	4.22^{c}	420.65	1.37^{abc}	1.63^{abc}	2.95^{a-d}	46.44^{ab}
P_4× B_4	5.05^{ab}	13.22^{bc}	4.37^{b}	420.67	1.37^{abc}	1.68^{ab}	3.06^{a-c}	44.77^{ab}
Level of significance	*	*	*	NS	*	*	*	*
SEM	0.05	0.11	0.05	0.45	0.02	0.03	0.05	0.61

** = Significant at 5 % level of probability, NS = Non significant, P_1 = 15 kg ha^{-1}, P_2 = 20 kg ha^{-1}, P_3 = 25 kg ha^{-1}, P_4 =35 kg ha^{-1}, B_1 = 0 kg ha^{-1} B_2 = 0.5 kg ha^{-1} B_3 = 1 kg ha^{-1} B_4 = 1.5 kg ha^{-1}, SEM = Standard error mean*

4. CONCLUSION

From the present study, it may be concluded that single application of phosphorus and boron had significant effect on yield of French bean (var. BARI Jharsheem-3). The treatments showed the positive effect in most cases and hence may be used for the improvement of yield and quality of French bean. From the above findings it can also be concluded that the treatment combination of 25 kg ha^{-1}phosphorus and 1.5 kg ha^{-1} boron along with recommended doses of N, K and Zn fertilizers had significantly increased the plant growth and yield of French bean (var. BARI Jharsheem-3). This combination can be treated as the best treatment considering all other combination of phosphorus and boron in respect of yield and yield contributing characters of French bean (var. BARI Jharsheem-3).

DISCLAIMER

There is absolutely no conflict of interest between the authors and others for the advancement of knowledge.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Smartt J. Tropical pulses Longman Press, London. 1976;348.
2. Broughton WJ, Hernandez G, Blair M, Beebe S, Gepts P, and Vander LJ. Beans (*Phaseolus* spp.). Model food legume. Plant Soil. 2003;252:55–128.
3. Katungi E, Farrow A, Chianu J, Sperling L, and Beebe S. Common bean in Eastern and Southern Africa: A situation and outlook analysis. CIAT Publication; 2009.
4. FAO, Statistics division 2010, Food Balance Sheet; 2010.
5. Karanja D, Setegn GE, Capitoline R, Kimani PM, Kweka SO, Butare L. Value added bean technologies for enhancing food security, nutrition, income and resilience to cope with climate change and variability challenges in Eastern Africa (ILRI); 2011.
Available:https://hdl.handle.net/10568/108226
6. FAO (Food and Agriculture organization). Production of green bean by countries. UN Food and Agriculture Organization, 2017. FAO, Rome, Italy; 2019.
7. Uddin FMJ, Kashem MA, Islam AM, Sarkar MAR. Optimizing sowing date for French bean varieties under Bangladesh condition. Annual Research & Review in Biology. 2017;1-7.
8. Uddin FMJ, Hassan N, Rahman MR, Uddin MR. Effect of bio fertilizer and weeding regimes on yield performance of bush bean (*Phaseolus vulgaris* L.). Archives of Agriculture and Environmental Science. 2018;3(3):226-231.
9. Usha SA, Uddin FMJ, Rahman MR, Akondo MRI. Influence of nitrogen and sulphur fertilization on the growth and yield performance of French bean. Journal of Pharmacognosy and Phytochemistry. 2019;8(5):1218-1223.
10. Vyas JS, Autkar KS, Wanjari KB. Effect of sowing rates on French bean in nontraditional area of Maharastra. Annals of Plant Physiology.1990;4(1):2935.
11. Amanullah JI, Hayat TF, Khan AI, Khan N. Effect of sowing dates on yield and yield components of mash bean varieties. Asian Journal Plant Science. 2002;42(1):622-624.
12. McKenzie RH, Middleton A. Phosphorus fertilizer application in crop production. Agriculture and Rural development. 1997; 542:3
13. Georgina H, Mario R, Oswaldo VL, Mesfin T, Michelle AG, Tomasz C, Armin S, Maren W, Alexander E, Foo C, Hank CW, Miguel L, Christopher DT, Joachim K, Michael KU, Carroll PV. Phosphorus stress in common bean: Root transcript and metabolic responses. Plant Physiology. 2007;144: 751-757.
14. Sixbert M, George MT. Evaluation of common bean (*Phaseolus vulgaris* L.) genotypes for adaptation to low phosphorus. International Scholarly Research Network. 2012;9:10.
15. Kamanga BCG, Whitbread A, Wall P, Waddington SR, Almekinders C, Giller KE. Farmer evaluation of P fertilizer application to annual legumes in Chisepo, Central Malawi. African Journal of Agricultural Research. 2010;8:668-680.

16. Ssali H, Keya SO. The effect of P and nitrogen fertilizer level on nodulation growth and dinitrogen fixation of three bean cultivars. Tropical Agriculture. 1986; 63:105-109.
17. Singh RN, Singh S, Kumar B. Interaction effect of sulphur and boron on yield and nutrient uptake and quality characters of soybean (*Glycine max* L. Merill) grown in acidic upland soil. Journal of the Indian Society of Soil Science. 2006;54(4):516-518.
18. Das PC. Manures and fertilizers. 1st edition. Kalyani Publishers, Ludhiana. 1993;13.
19. Chadha KL. Handbook of horticulture ICAR Publication New-Delhi. 2003;52-64.
20. Singh RN, Kumar B, Singh S. Effect of lime and boron application on gram (*Cicer arietinum*) in acid soils of Jharkhand. Journal of the Indian Society of Soil Science. 2004;52(3):283-285.
21. Mani PK, Haldar M. Effect of dolomite on boron transformation in acid soil in relation to nutrition of green gram. Journal of Indian Society of Soil Science.1996;44:458-461.
22. UNDP and FAO. 1988. Land resources appraisal of Bangladesh for agricultural development report No. 2. Agro-ecological Regions of Bangladesh. United Nations Development Programme and Food and Agriculture Organization, Rome, Italy. 1988;212–221.
23. Islam AKMM, Meirvenne V, Islam MM. Proximal soil sensing system for paddy field variability mapping: The potential of a proximal soil sensor for soil properties mapping. Saarvucken, Germany: VDM Verlag Dr. Mulleer; 2011.
24. Uddin FMJ, Sarkar MAR, Mamun AA. Effect of variety, date of planting and level of phosphorus on shoot dry matter and yield of mung bean. Journal Agroforestry Environment. 2010a;4:121-124.
25. Datta SK, Sarker MAR, Uddin FMJ. Effect of variety and level of phosphorus on the yield and yield components of lentil. International Journal of Agricultural Research, Innovation and Technology. 2013;3(1):78-82.
26. Uddin FMJ, Sarkar MAR, Rashid MH. Level of phosphorus and varietal effect with planting time on seed yield and yield contributing characters of mungbean. Bangladesh Research Publication and Journal. 2013;9(2):141-146.
27. Uddin FMJ, Sarkar MAR, Mamun AA. Effect of variety, date of planting and level of phosphorus on shoot dry matter and yield of mungbean. Journal Agroforestry Environment. 2010b;4(2):121-124.
28. Turuko M, Mohammed A. Effect of different phosphorus fertilizer rates on growth, dry matter yield and yield components of common bean (*Phaseolus vulgaris* L.). World Journal of Agricultural Research. 2014;2(3):88-92.
29. Rahman MS, Kabir MA, Halder BC, Haque ME, Rahman MA. Response of french bean (*Phaseolus vulgaris* L.) varieties to phosphorus levels in the active Tista flood plain. International Journal of Agronomy and Agricultural Research (IJAAR). 2018;12(1):20-25.
Available:https://journals.indexcopernicus.com/api/file/viewByFileId/685165.pdf
30. Singh VK, Kumari C, Kumar M, Nirala DP, Singh RK. Effect of different levels of nitrogen, phosphorus and sulphur on growth and yield of Rajmash (*Phaseolus Vulgaris* L.) Variety HUR 15. Journal of Pharmacognosy and Phytochemistry. 2018;SP1:1138-1141.
31. Zebire DA, Gelgelo S. Effect of phosphorus fertilizer levels on growth and yield of haricot bean (*Phaseolus vulgaris.* L.) in South Ommo Zone, Ethiopia. Agricultural Science Digest-A Research Journal. 2019;39(1):55-58.
32. Tania SA, Uddin FMJ, Sarkar MAR. Responses of selected mungbean (*Vigna radiata* L.) varieties to boron fertilization. Fundamental and Applied Agriculture. 2019;4(1):655–660.
DOI: 10.5455/faa.815
33. Ganeshamurthy AN. Effect of directly-applied and residual boron on nutrition in french bean-cabbage cropping sequence under alfisol. Journal of Horticultural Sciences. 2014;9(2):185-190.
34. Abebe M, Beshir HM, Gobena A. Improving yield and pod quality of green bean (*Phaseolus vulgaris* L.) through application of nitrogen and boron fertilizers in the central Rift Valley of Ethiopia. Journal of Applied Sciences. 2019;19:662-674.
DOI: 10.3923/jas.2019.662.674
35. Mahadule PA, Jagdhani AD, Jagtap PB, Tamboli BD, Kadam M. Effect of foliar sprays of boron on growth and yield of French bean (*Phaseolus vulgaris* L.) in

Entisol. International Journal of Chemical Studies. 2019;7(2):1885-1888.
Available:http://www.phytojournal.com/archives/2018/vol7issue5/PartB/7-4-545-360.pdf

36. Kaisher MS, Rahman MT, Amin MHA, Amanullah ASM, Ahsanullah ASM. Effects of sulphur and boron on the seed yield and protein content of mungbean. Bangladesh Research Publication Journal. 2010;3(4): 1181-1186.
37. Quddus MA, Rashid MH, Hossain MA, Naser HM. Effect of zinc and boron on yield and yield contributing characters of mungbean in low Ganges river floodplain soil at Madaripur, Bangladesh. Bangladesh Journal of Agricultural Research. 2011; 36(1):75-85.
38. Ganie M, Akhter F, Bhat A, Najar GR. Sulphur and boron application to french bean (*Phaseolus vulgaris* L.) under inceptisols of Kashmir? economic feasibility and impact on soil nutrient status. Applied Biological Research. 2014; 16:86-94.
DOI: 10.5958/0974-4517.2014.00052.4
39. Mia MA. Effect of different combinations of phosphorus and boron on growth and yield of a selected BARI Mung-6. Department of Soil Science. Sher-E-Bangla Agricultural University, Dhaka. 2015;41-45.
40. Alam MS, Islam MF. Effect of zinc and boron on seed yield and yield contributing traits of mungbean in acidic soil. Journal of Bioscience and Agriculture Research. 2016;11(02):941-946.
DOI: 10.18801/jbar.110216.115
41. Islam MS, Hasan M, Sarkar N, ELSabagh A, Rashwan E, Barutçular C. Yield and yield contributing characters of mungbean as influenced by zinc and boron. Agricultural Advances. 2017;6:391-397.
DOI: 10.14196/aa.v6i1.2362

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