Effect of variety and boron fertilizer on the growth and yield performance of French bean (*Phaseolus vulgaris* L.)

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**ABSTRACT**

The experiment was conducted at the Agronomy Field laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh to evaluate the effect of variety and boron on the growth and yield of French bean (*Phaseolus vulgaris* L.) during November 2017 to March 2018. The experiment was comprised two factors involving three varieties viz. BARI Jharseem-1, BARI Jharseem-2, BARI Jharseem-3, and four Boron doses viz. 0 (No boron), 0.5, 1.0 and 1.5 kg B ha⁻¹. Borax was used as a source of boron. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The result exhibited that yield and its contributing characters were significantly influenced the variety and boron applications. The experimental findings revealed that the highest number of pods plant⁻¹ (4.73), effective pods plant⁻¹ (4.01), seeds pod⁻¹ (3.98), 1000-seeds weight (416.53g), seed yield (1.53 t ha⁻¹), stover yield (2.69 t ha⁻¹), biological yield (4.22 t ha⁻¹), and harvest index (36.03%) were highest for the variety BARI Jharseem-3. At the same time, highest number of pods plant⁻¹ (5.02), number of effective pods plant⁻¹ (4.03), number of seeds pod⁻¹ (4.04), 1000-seed weight (412.74 g), seed yield (1.54 t ha⁻¹), stover yield (3.05 t ha⁻¹), biological yield (4.59 t ha⁻¹), and harvest index (36.98%) were recorded under boron level at 1.5 kg B ha⁻¹. Again incase of interaction of variety and boron, highest number of pods plant⁻¹ (4.95), number of effective pods plant⁻¹ (3.98), number of seeds pod⁻¹ (3.69), 1000-seeds weight (413.15g), seed yield (1.76 t ha⁻¹), stover yield (3.11 t ha⁻¹), biological yield (4.87 t ha⁻¹) and harvest index (37.19%) were recorded in BARI Jharseem-3 under boron level 1.5 kg ha⁻¹. Plant dry matter found positively correlated (r²=0.8126) with seed yield. So, it may be concluded from this experiment that cultivation of var. BARI Jharseem-3 along with 1.5 kg B ha⁻¹ could be applied to obtain higher yield of French bean.

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**INTRODUCTION**

French bean (*Phaseolus vulgaris* L.) is an important legume crops cultivated worldwide belonging to the leguminosae family and sub family papilionaceae (Rashid and Hossain, 2014). It is also known as kidney bean, snap bean, common bean, haricot bean, tepary bean, bush bean and fresh bean. French bean is a potential source of protein, carbohydrates and minerals and particularly vitamin B (Broughton, 2003; Kumar et al., 2019). French bean is traditionally a crop of temperate region and is planted at hill and plain area in February-March and October-November. Bangladesh Agricultural Research Institute (BARI) released BARI Jharseem-1, BARI Jharseem-2 and BARI Jharseem-3 in the year 1996 and 2002 (BARI, 2014). French bean can be grown well at 19-27°C. The pod set of French bean was poor at day temperature of 30°C and night temperature of 25°C. The seed yield of French bean varies in different sowing dates (Uddin et al., 2017). The farmers sometimes sow the seeds of French bean early or late without knowing the optimum sowing time. During the winter a short cool season prevails in...
Bangladesh, which starts with the fall of temperature, humidity and ends with sudden rise in temperature (Banglapedia, 2014). Therefore, in Bangladesh, French bean is sown in winter season usually.

According to FAO (2019), the production of French bean in the year 2017 was 137495 tonnes from an area of 20880 hectors in Bangladesh. Nitrogen, phosphorus, potassium and sulphur are the major plant nutrients required in relatively large amounts and at the same time, boron is also one of the essential micronutrients required for the normal growth of French bean. Boron plays an important role for the optimum growth, development, yield, and quality of crops (Brown et al., 2002). Boron deficiency is one of the major constrains limiting the production of bean in Bangladesh (Mani and Haldar, 1996), which can be mitigated by the supplementation of inorganic fertilizer (Shireen et al., 2018). Boron concentrations varies from 2-200 mg B kg⁻¹ soil, but generally <5-10% available to plants (Diana, 2006).

Boron is required for proper development and malformation in reproductive organs (Singh and Kumar, 2006). Boron helps in the normal growth of plant and in absorption of nitrogen from soil, translocation of sugars, cell wall synthesis, root elongation and nucleic acid synthesis (Marschner, 1990). The boron improves the grain and straw yield, nutrient content, nutrient uptake and quality in legume crops and at the same time limits the production of pulse crops. Boron plays role in affecting anther development, pollen germination, pollen tube growth, sugar translocation and lignin synthesis (Loomis and Durst, 1992).

Like other legume crops e.g. mungbean and lentil, French bean production depends on many factors such as quality seed, variety, sowing date, fertilizer and proper management practices (Uddin et al., 2010a; Uddin et al., 2010b,c; Uddin et al., 2013; Datta et al., 2013; Uddin et al., 2017; Uddin et al., 2018; Usha et al., 2019). Crop yield varies from variety to variety due to internal and external factors of the plant (Kumar and Chopra, 2014). A suitable variety is of primary importance for harnessing potential yield (Amanullah et al., 2002). Those varieties which are high yielding, less prone to disease incidence and mature in a short period of time are preferred by the growers (Tania et al., 2019). French bean has a high nutritive value. Common beans are important for nutritional well-being as well as poverty alleviation among consumers and farmers with few other food or crop options (Broughton et al., 2003). 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 (Katungi et al., 2009). 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 (Karanja et al., 2011). Therefore, it is necessary to find out a suitable variety for higher yield as well as higher economic return. Thus, proper variety selection with optimum fertilizer (boron) application should be the principle for higher yield of French bean. In view of above mentioned information the research work was undertaken with the objectives to investigate the effect of variety, boron and their interaction on the performance of French bean.

**MATERIALS AND METHODS**

**Experimental site**

The experimental site at 24°75′ N latitude and 90°50′ E longitude at 18m above the mean sea level. The experimental area is characterized by non-calcareous dark grey floodplain soil belonging to the Sonatola Soil Series under the Old Brahmaputra Floodplain, Agro-Ecological Zone 9. The soil of the experimental field was slightly acidic having pH value 6.8, low in organic matter and fertility level with medium high land and silty loam in texture. During the experimental period the maximum, minimum and average temperature ranges from 23.90°C-30.60°C, 13.50°C-21.14°C and 18.90°C-26.00°C, respectively. While the average relative humidity, total sunshine and total rainfall ranged from 74.5-82.80%, 122.2-217.10 hours month⁻¹ and 10.7-206.5mm, respectively which is favorable for French bean cultivation.

**Treatments and crop husbandry**

The experiment comprised of two factors namely variety and boron level: Factor A: V₁=BARI Jharseem-1, V₂=BARI Jharseem-2, V₃=BARI Jharseem-3, and Factor B: B₀=0 kg B ha⁻¹ (no Boron), B₁=0.5 kg B ha⁻¹, B₂=1.0 kg B ha⁻¹ and B₃=1.5 kg B ha⁻¹. Seeds were collected from Bangladesh Agricultural Research Institute (BARI). The experiment was laid out in a randomized complete block design (RCBD) with three replications. Total number of unit plots was 36 (3×4×3) with size of 10 m² (4.0 m × 2.5 m) per plot. Seeds were sown in the month of November with a standard dose of biofertilizer (Uddin et al., 2018) in line maintaining the row spacing 25 cm × 15 cm. The distance maintained between the individual unit plots was 0.5 m and that between the replications was 1.0 m. The land was ploughed with a power tiller 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 to bring the land under good tillth for seed sowing. Triple super phosphate (TSP) (200 kg ha⁻¹) and borax (According to treatment) were used as source of Phosphorous and Boron. The whole amount of Muriate of Potash (MoP) (150 kg ha⁻¹) and half amount of urea (150 kg ha⁻¹) was applied during final land preparation (BARC, 2012) and another half amount of urea was top dressed at 30 days after sowing (DAS) of seeds. Before sowing, seeds 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 weeding 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 provided with a watering can to the plots once immediately after germination in every alternate day and further irrigation was done as needed. The crops were harvested when dry pods reached at maturity by hand picking.
Data collection
Data on the yield and its contributing characters were recorded. The biological yield was calculated with the following formula:

\[
\text{Biological yield} = \text{Seed yield + Stover yield.}
\]

Harvest index (HI) was calculated from the ratio of grain yield to biological yield and expressed in percentage. It was calculated by using the following formula.

\[
\text{HI} (\%) = \frac{\text{Seed Yield}}{\text{Biological Yield}} \times 100
\]

Statistical analysis
The collected data were compiled and analyzed statistically using the analysis of variance technique with computer package program MSTAT (2012). Besides MSTAT, other statistical package such as Microsoft excel was also used.

RESULTS AND DISCUSSION

Effect of variety on the yield and contributing characters of French bean
The highest number of pods plant\(^{-1}\) (4.78), number of effective pod plant\(^{-1}\) (4.01), number of non-effective pods plant\(^{-1}\) (1.01), number of seeds pod\(^{-1}\) (4.40), 1000-seed weight (412.74 g), seed yield (1.54 t ha\(^{-1}\)), stover yield (3.05 t ha\(^{-1}\)), biological yield (4.59 tha\(^{-1}\)) and harvest index (36.98\%) were found under boron level at 1.5 kg ha\(^{-1}\). Whereas the lowest number of pods plant\(^{-1}\) (3.06), number of effective pods plant\(^{-1}\) (2.18), number of seeds pod\(^{-1}\) (2.63), 1000-seed weight (381.93g), seed yield (1.18 t ha\(^{-1}\)), stover yield (2.15 t ha\(^{-1}\)), biological yield (3.33 tha\(^{-1}\)), and harvest index (32.51\%) were recorded not boron application (0 kg B ha\(^{-1}\)). The minimum number of non-effective pods plant\(^{-1}\) (0.76) was found from 0.5 kg B ha\(^{-1}\) (Table 2 and Figure 1). The influence of boron was found non-significant on plant height and pod length.

Effect of boron on the yield and contributing characters of French bean
The influence of Boron was found significant on most of the studied yield and its contributing characters of French bean except few one. The highest number of pods plant\(^{-1}\) (5.02), number of effective pods plant\(^{-1}\) (4.01), number of non-effective pods plant\(^{-1}\) (1.01), number of seeds pod\(^{-1}\) (4.04), 1000-seed weight (412.74 g), seed yield (1.54 t ha\(^{-1}\)), stover yield (3.05 t ha\(^{-1}\)), biological yield (4.59 tha\(^{-1}\)) and harvest index (36.98\%) were found under boron level at 1.5 kg ha\(^{-1}\). In BINA mung-6, the highest number of pods plant\(^{-1}\) (4.78) was produced while other experimental local variety gave lowest pod plant\(^{-1}\).

Table 1. Effect of variety on yield and yield contributing characters of French bean.

| Variety        | Plant height (cm) | Number of pod plant\(^{-1}\) | Number of effective pod plant\(^{-1}\) | Number of non-effective pod plant\(^{-1}\) | Pod length (cm) | Number of seed pod\(^{-1}\) | 1000 seed weight (g) | Stover yield (tha\(^{-1}\)) | Biological yield (tha\(^{-1}\)) | Harvest index (%) |
|----------------|-------------------|-----------------------------|-------------------------------------|----------------------------------------|----------------|-----------------------------|------------------------|------------------------|---------------------|-------------------|
| BARI Jharseem-1 | 41.35             | 4.5ab                       | 3.42b                               | 1.08a                                  | 11.75         | 3.13b                       | 403.57b                | 2.43b                  | 3.64ab              | 35.12ab           |
| BARI Jharseem-2 | 41.58             | 4.33b                       | 3.58ab                              | 0.75b                                  | 11.71         | 3.27ab                      | 410.62ab               | 2.56ab                 | 3.96ab              | 33.25b            |
| BARI Jharseem-3 | 41.71             | 4.73a                       | 4.01a                               | 0.72b                                  | 11.89         | 3.98a                       | 416.53a                | 2.69a                  | 4.22a               | 36.03a            |
| LSD\(_{0.05}\)   | 3.48              | 0.31                        | 0.31                                | 0.31                                   | 0.53          | 0.16                        | 8.85                   | 0.09                   | 0.26                | 2.06              |
| Sx              | 1.68              | 0.25                        | 0.15                                | 0.36                                   | 0.26          | 0.08                        | 4.27                   | 0.19                   | 0.13                | 0.99              |
| Level of significance | NS | * | * | * | NS | * | * | * | * | * |
| CV%             | 9.92              | 10.1                        | 11.41                               | 8.79                                   | 5.32          | 5.48                        | 2.55                   | 8.78                   | 8.09                | 6.99              |

In a column, figures with the same letter do not differ significantly as per DMRT. ** = Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Non significant.
Interaction effect of variety and Boron on the yield contributing characters and yield of French bean

The interaction of variety and Boron showed significant on most of the studied yield and contributing characters of French bean except few one. The highest number of pods plant\(^{-1}\) (5.92), number of effective pods plant\(^{-1}\) (4.95), number of seed pod\(^{-1}\) (3.69), 1000-seed weight (413.15 g), seed yield (1.76 t ha\(^{-1}\)), stover yield (3.11 t ha\(^{-1}\)), biological yield (4.87 t ha\(^{-1}\)), and harvest index (37.19%) were found from BARI Jharseem-3 fertilized with 1.5 kg B ha\(^{-1}\). Whereas minimum number of pods plant\(^{-1}\) (3.27), number of effective pods plant\(^{-1}\) (3.06), number of seed pod\(^{-1}\) (2.72), 1000-seed weight (372.71 g), seed yield (1.02 t ha\(^{-1}\)), stover yield (1.85 t ha\(^{-1}\)), biological yield (2.87 t ha\(^{-1}\)), and harvest index (30.68%) were recorded in BARI Jharseem-1 which was not fertilized with boron (0 kg B ha\(^{-1}\)) (Table 3). The interaction effect between variety and boron showed non-significant influence on the plant height, non-effective pods plant\(^{-1}\) and pod length. Highest plant (43.46 cm), non-effective pods plant\(^{-1}\) (0.97) and pod length (12.27 cm) were found from the interaction of BARI Jharseem-3 fertilized with 1.5 kg B ha\(^{-1}\) and lowest plant (39.53 cm), non-effective pods plant\(^{-1}\) (0.21) length of pod (11.24 cm) were found from the interaction of BARI Jharseem-1 fertilized with 0 kg B ha\(^{-1}\) (Table 3 and Figure 1). Mia et al. (2015) conducted an experiment with three bean genotypes to varying B application doses. There were significant differences among the varieties i.e. BARI Jharsheem-1, BARI Jharsheem-2 and Nick. The highest number of tender pods plant\(^{-1}\) (39.67), pod weight plant\(^{-1}\) (146.33 g) and pod yield (24.40 t ha\(^{-1}\)) were obtained from BARI Jharsheem-2 combined with 3 kg B ha\(^{-1}\) and the lowest number of pods (22.63) plant\(^{-1}\), pod weight (91.43 g) plant\(^{-1}\) and pod yield (15.23 t ha\(^{-1}\)) were found from BARI Jharsheem-1 combined with control. This result was in harmony with the findings of Noor et al., 2016 where it was reported that the differences in vegetative growth of cultivars are due to not only the genotype of each cultivar and but also varying rate of B application. Afrin et al. (2012) observed that increase in the phosphorus content with the increase in boron application could be due to favorable influence of boron on various metabolic processes like photosynthesis, respiration, enzyme activity which augments the production of metabolites and their translocation to different parts including seed which ultimately increases the concentration of nutrients in seed and stover. Uptake of phosphorus at pod picking stage increases up to 1.0 kg B ha\(^{-1}\) but at harvesting stage uptake of phosphorus increases up to 1.5 kg B ha\(^{-1}\) which is because of greater increase in dry matter at harvesting stage up to 1.5 kg B ha\(^{-1}\).

Correlation study

It has been observed that seed yield of French bean has a higher significant positive correlation with dry matter. This relationship indicates that dry matter was one of the most important factors in producing higher yield in French bean (Figure 2). An increase in the plant dry matter will ultimately lead to an increase in seed yield of French bean. Afrin (2012) also reported that seed yield of mung bean had a higher significant positive correlation with dry matter. An increase in plant dry matter leads to an increase in seed yield of mung bean. Uddin et al. (2010c) conducted an experiment on mung bean and found that seed yield of mung bean had higher significant positive correlation with dry matter.
Table 2. Effect of boron on yield and yield contributing characters of French bean.

| Level of Boron (kg B ha⁻¹) | Plant height (cm) | Number of pods plant⁻¹ | Number of effective pods plant⁻¹ | Number of non-effective pods plant⁻¹ | Pod length (cm) | Number of seeds pod⁻¹ | 1000 grain weight (g) | Stover yield (t ha⁻¹) | Biological yield (t ha⁻¹) | Harvest index (%) |
|---------------------------|-------------------|-------------------------|----------------------------------|--------------------------------------|----------------|------------------------|----------------------|----------------------|------------------------|-----------------|
| 0                         | 40.86             | 3.06d                  | 2.18d                            | 0.88ab                               | 11.64         | 2.63c                  | 381.93c              | 2.15d                 | 3.33d                  | 32.51c          |
| 0.5                       | 41.11             | 4.03c                  | 3.27bcd                          | 0.76c                                | 11.79         | 3.21b                  | 403.95bc             | 2.38c                 | 3.68c                  | 34.52bc         |
| 1.0                       | 41.63             | 4.58bc                 | 3.81bc                           | 0.77c                                | 11.82         | 3.83bc                 | 410.45bc             | 2.66b                 | 4.08b                  | 35.75b          |
| 1.5                       | 42.57             | 5.02a                  | 4.01a                            | 1.01a                                | 11.89         | 4.04a                  | 412.74a              | 3.05a                 | 4.59a                  | 36.98a          |
| LSD(0.05)                 | 4.03              | 0.37                   | 0.36                             | 0.41                                 | 0.61          | 0.19                   | 10.21                | 0.22                  | 0.31                   | 2.38            |
| Sx                        | 1.94              | 0.18                   | 0.17                             | 0.20                                 | 0.30          | 0.09                   | 4.93                 | 0.11                  | 0.15                   | 1.15            |
| Level of significance     | NS                | *                      | *                                | NS                                   | **            | **                     | **                  | **                   | **                     | **              |
| CV%                       | 9.92              | 9.02                   | 11.41                            | 28.79                                | 5.32          | 5.48                   | 2.55                 | 8.78                  | 8.09                   | 6.99            |

In a column, figures with the same letter do not differ significantly as per DMRT. ** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant.

Table 3. Interaction effect of variety and boron on yield and yield contributing characters of French bean.

| Interaction (variety × boron dose) | Plant height (cm) | Number of pods plant⁻¹ | Number of effective pods plant⁻¹ | Number of non-effective pods plant⁻¹ | Pod length (cm) | Number of seeds pod⁻¹ | 1000 seeds weight (g) | Stover yield (t ha⁻¹) | Biological yield (t ha⁻¹) | Harvest index (%) |
|------------------------------------|-------------------|-------------------------|----------------------------------|--------------------------------------|----------------|------------------------|----------------------|----------------------|------------------------|-----------------|
| V₁ × B₀                            | 39.53             | 3.27i                   | 3.06i                            | 0.21                                 | 11.24         | 2.72i                  | 372.71i              | 1.85f                | 2.87i                  | 30.68c          |
| V₁ × B₁                            | 41.06             | 4.55gh                 | 4.18efg                          | 0.37                                 | 11.33         | 3.12gh                 | 401.52gh             | 2.31de               | 3.63gf                 | 32.93bc         |
| V₁ × B₂                            | 42.20             | 5.11ghf                | 4.26de                           | 0.85                                 | 11.76         | 3.25ef                 | 407.89cd             | 2.69bcd              | 4.17ef                 | 34.13abc        |
| V₁ × B₃                            | 42.60             | 5.31ef                 | 4.45cd                           | 0.86                                 | 11.89         | 3.53bc                 | 410.98bc             | 3.02ab               | 4.61cd                 | 35.86ab        |
| V₂ × B₀                            | 39.93             | 3.91hi                 | 3.19h                            | 0.72                                 | 11.50         | 2.83h                  | 381.72h              | 1.98ef               | 3.00h                  | 31.58c          |
| V₂ × B₁                            | 41.40             | 5.04efg                | 4.32fg                           | 0.72                                 | 11.66         | 3.21ef                | 404.63fgf            | 2.29e                | 3.71gh                 | 32.95bc        |
| V₂ × B₂                            | 42.06             | 5.31cd                 | 4.57bc                           | 0.74                                 | 11.79         | 3.42cd                 | 409.75cd             | 2.56cde              | 4.09efg                 | 35.89ab        |
| V₂ × B₃                            | 42.93             | 5.73ab                 | 4.85ab                           | 0.88                                 | 11.90         | 3.57ab                 | 411.15ab             | 3.03ab               | 4.66bc                 | 36.62ab        |
| V₃ × B₀                            | 40.06             | 3.83h                  | 3.13h                            | 0.70                                 | 11.89         | 2.79h                  | 385.73hi             | 1.97cde              | 3.06hi                  | 31.12c          |
| V₃ × B₁                            | 40.86             | 5.02fgh                | 4.21de                           | 0.81                                 | 12.02         | 3.19gh                 | 403.31efg            | 2.54cde              | 3.88fg                 | 32.78bc        |
| V₃ × B₂                            | 42.44             | 5.37de                 | 4.55ef                           | 0.82                                 | 12.16         | 3.37de                 | 407.12de             | 2.75abc              | 4.28de                 | 34.98abc       |
| V₃ × B₃                            | 43.46             | 5.92a                  | 4.95a                            | 0.97                                 | 12.27         | 3.69a                  | 413.15a              | 3.11a                | 4.87a                  | 37.19a         |
| Sx                                 | 3.36              | 0.30                   | 0.31                             | 0.35                                 | 0.51          | 0.16                   | 8.53                 | 0.18                 | 0.26                   | 1.98           |
| Level of significance             | NS                | **                     | *                                | NS                                   | **            | **                     | **                  | **                   | **                     | **              |
| CV%                                | 9.92              | 11.41                  | 9.02                             | 8.79                                 | 5.32          | 5.48                   | 2.55                 | 8.78                 | 8.09                   | 6.99           |

In a column, figures with the same letter do not differ significantly as per DMRT. ** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Non significant. V₁=BARI Jharseem-1, V₂= BARI Jharseem-2, V₃= BARI Jharseem-3, B₀= No boron, B₁= 0.5 kg B ha⁻¹, B₂= 1.0 kg B ha⁻¹ and B₃=1.5 kg B ha⁻¹.

Conclusion

From the above result of the present study it may be concluded that, most of the yield and its contributing characters of French bean varieties showed significant variation due to boron application. The variety BARI Jharseem-3 along with 1.5 kg boron per hectare could be planted to obtain higher yield of French bean. However, the research should be conducted in different Agro-ecological zone of Bangladesh to draw a valid conclusion.

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