Archives of Agriculture and Environmental Science 5(3): 241-246 (2020)
https://doi.org/10.26832/24566632.2020.050302

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes

ORIGINAL RESEARCH ARTICLE

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

F.M. Jamil Uddin*, Hasna Hena Mira, Uttam Kumer Sarker and Md. Robiul Islam Akondo

Department of Agronomy, Bangladesh Agricultural University, Mymensingh - 2202, BANGLADESH
*Corresponding author E-mail: drjamil@bau.edu.bd

ARTICLE HISTORY

Received: 21 July 2020
Revised received: 11 September 2020
Accepted: 21 September 2020

Keywords

Boron
French bean
Harvest Index
Variety
1000-seed weight
Yield

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 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 (r^2=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.

Citation of this article: Uddin, F.M.J., Mira, H.H., Sarker, U.K. and Akondo, M.R.I. (2020). Effect of variety and boron fertilizer on the growth and yield performance of French bean (*Phaseolus vulgaris* L.). *Archives of Agriculture and Environmental Science*, 5(3): 241-246, https://dx.doi.org/10.26832/24566632.2020.050302

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-1in 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: V_1=BARI Jharseem-1, V_2 =BARI Jharseem -2, V_3=BARI Jharseem-3, and Factor B: B_0=0 kg B ha^{-1} (no Boron), B_1 =0.5 kg B ha^{-1}, B_2 =1.0 kg B ha^{-1} and B_3 =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 10m^2(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 tilth 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:

Biological yield = 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.

$$HI\ (\%) = \text{Seed Yield} / \text{Biological Yield} \times 100$$

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} (4.73), number of effective pod plant^{-1} (4.01), number of seeds pod^{-1} (3.98), 1000-seed weight (416.53 g), 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 found from the var. BARI Jharseem-3. The maximum number of non-effective pods plant^{-1} (1.08) was found from BARI Jharseem-1. On the other hand, lowest plant height (41.35), number of effective pods plant^{-1} (3.42), number of seeds pod^{-1} (3.13), 1000-seed weight (403.57 g), seed yield (1.21 t ha^{-1}), stover yield (2.43 t ha^{-1}), biological yield (3.64 t ha^{-1}) and harvest index (33.25%) were obtained from BARI Jharseem-1, while number of pods plant^{-1} (4.33) and number of non-effective pod plant^{-1} (0.72) were recorded from the BARI Jharseem-2 and the BARI Jharseem-3, respectively (Table 1). Variety showed non-significant influence on the plant height and pod length. The highest plant height (41.71 cm) and longest pod (11.89 cm) were found from BARI Jharseem-3 and shortest plant (41.35cm) and pod (11.71 cm) from BARI Jharseem-2 were identified (Table 1 and Figure 1). The variety had a significant influence on number of effective pods plant^{-1} (Noor *et al.*, 2016). Among the two-cultivated variety BARI Jharseem-1 and BARI Jharseem-2, BARI Jharseem-2 gave maximum number of effective pod plant^{-1} (3.97) while lowest effective pod plant^{-1} (2.36) was found from BARI Jharseem-1. Afrin (2012) reported that variety had a significant influence on number of pods plant^{-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}.

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 (3.05t ha^{-1}), biological yield (4.59 tha^{-1}) and harvest index (36.98%) were obtained 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 no 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. The highest plant height (42.57) and longest pod (11.89 cm) were found under boron level at 1.5 kg ha^{-1} and shortest plant (40.86) and pod (11.64 cm) were found at no boron application (0 kg B ha^{-1}) (Table 2). The influence of boron application also observed significant in mung bean by increased seed yield (1.55 t ha^{-1}) at boron level 1.5 kg ha^{-1} (Alam and Islam, 2016). Mia (2015) observed the highest stover yield was BARI Mung bean-6 (2.86 t ha^{-1}) from 30 kg P ha^{-1} and 1 kg B ha^{-1}. Similar effect of Boron on the seed yield was showed by Turuko (2014) who reported the highest seed yield on application rate of 3 kg B ha^{-1}. This might be due to high dose of boron fertilizer tends to form nutrient interaction and may affect the availability of other nutrients which are essential for growth of the French bean.

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 (t ha^{-1})	Biological yield (t ha^{-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	3.96bb	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.

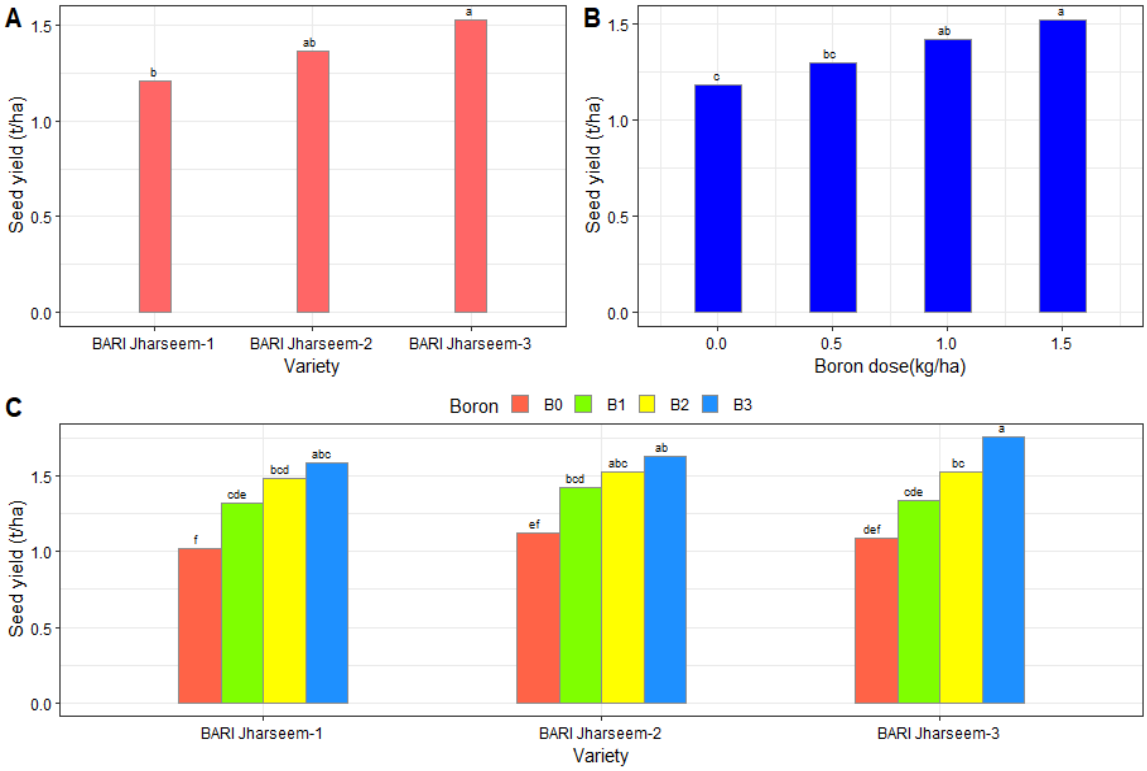

Figure 1. *Effect of variety and boron application and their interaction on the seed yield of French bean.*

Interaction effect of variety and Boron on the yield contributing characters and yield of French

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 (372.71g), 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}) V_1B_0(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 3kg 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 Jhar sheem-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 photo-synthesis, 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 Bha^{-1})	Plant height (cm)	Number of pods plant^{-1}	Number of effective pod 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	4.58b	3.81bc	0.77c	11.82	3.83bc	410.45b	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 (%)
$V_1 \times B_0$	39.53	3.27i	3.06i	0.21	11.24	2.72i	372.71i	1.85f	2.87i	30.68c
$V_1 \times B_1$	41.06	4.55ghi	4.18efg	0.37	11.33	3.12gh	401.52ghi	2.31de	3.63fg	32.93bc
$V_1 \times B_2$	42.20	5.11fgh	4.26de	0.85	11.76	3.25ef	407.89cd	2.69bcd	4.17ef	34.13abc
$V_1 \times B_3$	42.60	5.31ef	4.45cd	0.86	11.89	3.53bc	410.98bc	3.02ab	4.61cd	35.86ab
$V_2 \times B_0$	39.93	3.91hi	3.19h	0.72	11.50	2.83h	381.72h	1.98ef	3.00h	31.58c
$V_2 \times B_1$	41.40	5.04efg	4.32fg	0.72	11.66	3.21efg	404.63fgh	2.29e	3.71gh	32.95bc
$V_2 \times B_2$	42.06	5.31cd	4.57bc	0.74	11.79	3.42cd	409.75cd	2.56cde	4.09efg	35.89ab
$V_2 \times B_3$	42.93	5.73ab	4.85ab	0.88	11.90	3.57ab	411.15ab	3.03ab	4.66bc	36.62ab
$V_3 \times B_0$	40.06	3.83h	3.13h	0.70	11.89	2.79h	385.73hi	1.97cde	3.06hi	31.12c
$V_3 \times B_1$	40.86	5.02fgh	4.21de	0.81	12.02	3.19fgh	403.31efg	2.54cde	3.88fgj	32.78bc
$V_3 \times B_2$	42.44	5.37de	4.55ef	0.82	12.16	3.37de	407.12de	2.75abc	4.28de	34.98abc
$V_3 \times B_3$	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	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, V_1=BARI Jharseem-1, V_2= BARI Jharseem-2, V_3= BARI Jharseem-3, B_0= No boron, B_1= 0.5 kg B ha^{-1}, B_2= 1.0 kg B ha^{-1} and B_3=1.5 kg B ha^{-1}.

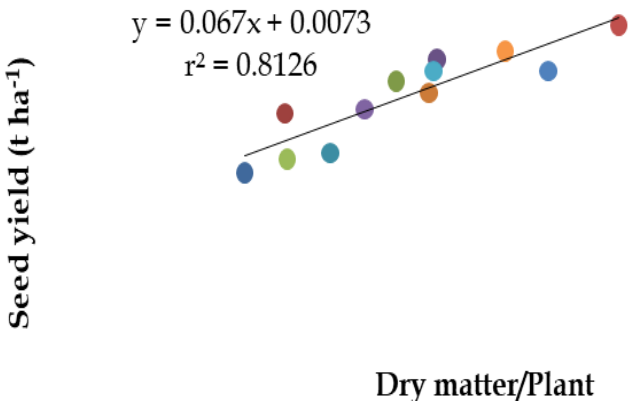

Figure 2. *Relationship between seed yield and dry matter plant^{-1} of French bean.*

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.

ACKNOWLEDGEMENT

The authors are thankful to the University Grants Commission of Bangladesh for providing the grants that really helped in conducting the research including MS student.

REFERENCES

Afrin, M.S. (2012). Effect of variety and boron on the growth and yield of mung bean, Department of Agronomy, Bangladesh Agricultural University, Mymensingh: 22-35.

Alam, M.S. and Islam, M.F. (2016). Effect of zinc and boron on seed yield and yield contributing traits of mung bean in acidic soil. *Journal of Bioscience and Agriculture Research*, 11(02): 941-946, http://doi.org/10.18801/jbar.110216.115

Amanullah, J.I., Hayat, T.F., Khan, A.I. and Khan, N. (2002). Effect of sowing dates on yield and yield components of mash bean varieties. *Asian Journal of Plant Science*, 1(6): 622-624.

Banglapedia. (2014). National Encyclopedia of Bangladesh. pp. 33-34.

BARC (2012). Fertilizer Recommendation Guide-2012. Bangladesh Agricultural Research Council, Farmgate, Dhaka.

BARI. (2014). Bangladesh Agricultural Research Institute: Krishi projukti Hatboi (Handbook on Agro-technology), 6th edition. Bangladesh Agricultural Research Institute, Gazipur, 6: 483-487.

Broughton, W.J., Hernandez, G., Blair, M., Beebe, S., Gepts, P. and Vander Leyden, J.P. 2003: Beans (Phaseolus sp.). *Model food legume. Plant Physiology*, 252(1): 55–128.

Brown, P.H., Bellaloui, N., Wimmer, M.A., Bassil, E.S., Ruiz, J., Hu, H., Pfeffer, H., Dannel F. and Romheld, V. (2002). Boron in plant biology. *Plant Biology*, 4: 205–223, http://doi.org/10.1055/s-2002-25740

Datta, S.K., Sarkar, M.A.R. and Uddin, F.M.J. (2013). Effect of variety and level of Phosphorus on the yield and yield components of lentil. *International Journal of Agricultural Research, Innovation & Technology*, 3 (1): 78-82.

Diana, G. (2006). Boron in the soil, from deficit to toxicity. Informatore Agrario. Vol. 62, pp. 54-58.

FAO. (2019). Food and Agriculture organization: Production of green Bean by countries. UN Food and Agriculture Organization, 2017. FAO, Rome, Italy.

Karanja, D., Setegn, G.E., Capitoline, R., Kimani, P.M., Kweka, S.O. and Butare, L. (2011). Value Added Bean Technologies for Enhancing Food Security, Nutrition, Income and Resilience to cope with Climate Change and Variability Challenges in Eastern Africa (ILRI).

Katungi, E., Farrow, A., Chianu, J., Sperling, L. and Beebe, S. (2009). Common bean in Eastern and Southern Africa, a situation and outlook analysis. *Agricultural System*, 40: 265-282.

Kumar, V. and Chopra, A.K. (2014). Fertigational impact of sugar mill effluent on agronomical practices of Mung bean (*Vigna radiata* L.) in two seasons. International Journal of Agricultural Science Research, 3(4): 52-68.

Kumar, V., Kumar, P. and Khan, A. (2020). Optimization of PGPR and silicon fertilization using response surface methodology for enhanced growth, yield and biochemical parameters of French bean (*Phaseolus vulgaris* L.) under saline stress. *Biocatalysis and Agricultural Biotechnology*, 23, 101463 , https://doi.org/10.1016/j.bcab.2019.101463

Loomis, W.D. and Durst, R.W. (1992): Chemistry and biology of boron. *Bio Factors*, 3: 229-239.

Mani, P.K. and Haldar, M. (1996). Effect of dolomite on boron transformation in acid soil in relation to nutrition of green gram. *Journal of the India Society of Soil Science*, 44: 458-461.

Marschner, H. (1990). Mineral Nutrition of Higher Plants. *Academic Press*, 26: 333-348

Mia, M.A. (2015). 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. 1-45.

Noor, F., Hossain, F. and Ara, U. (2016). Screening of French bean (*Phaseolus vulgaris* L.) genotypes for high yield potential. *Bangladesh Journal of Scientific and Industrial Research*, 49(4): 227-232.

Rashid, A.S., and Hossain, M.M. (2014). Yield and quality of green pod production of Bush Bean (*Phaseolus vulgaris* L.) as influenced by harvesting time. *Eurasian Journal of Agricultural Environmental Science*, 14(11): 1221-1227.

Shireen, F., Nawaz, M. A., Chen, C., Zhang, Q., Zheng, Z., Sohail, H., Sun, J., Cao, H., Huang, Y. and Bie, Z. (2018). Boron: Functions and Approaches to Enhance Its Availability in Plants for Sustainable Agriculture. *International Journal of Molecular Sciences*, 19(7): 1856, https://doi.org/10.3390/ijms19071856

Singh, R.N., Singh, S., and Kumar, B. (2006). 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*, 54(4): 516-518.

Tania, S.A., Uddin, F.M.J. and Sarkar, M.A.R. (2019). Responses of selected mungbean (*Vigna radiata* L.) varieties to boron fertilization. *Fundamental and Applied Agriculture*, 4(1): 655–660, http://doi.org/10.5455/faa.815

Turuko, A.A. (2014). Effect of nitrogen and phosphorus on the growth and seed yield of French bean (*Phaseolus vulgaris* L.). *Journal of Vegetable Science*, 27: 172-175.

Uddin, F.M.J., Sarkar, M.A.R. and Mamun, A.A. (2010a). Effect of variety, date of planting and level of phosphorus on shoot dry matter and yield of mung bean. *Journal Agroforestry Environment*, 4: 121-124.

Uddin, F.M.J., Sarkar, M.A.R., and Mamun, A.A. (2010b). Effect of variety, date of planting and level of phosphorus on shoot dry matter and yield of mung bean. *Journal Agroforestry Environment*, 4:121-124.

Uddin, F.M.J., Sarkar, M.A.R., and Mamun, A.A. (2010c). Effect of variety, date of planting and level of phosphorus on shoot dry matter and yield of mung bean. *Journal of Agroforestry and Environment*, 4(2): 121-124.

Uddin, F.M.J., Sarkar, M.A.R. and Rashid, M.H. (2013). Level of phosphorus and varietal effect with planting time on seed yield and yield contributing characters of mung bean. *Bangladesh Research Publication Journal*, 9(2): 141-146.

Uddin, F.M.J., Kashem, M.A., Islam, A.M., and Sarkar, M.A.R. (2017). Optimizing sowing date for French bean varieties under Bangladesh condition. *Annual Research & Review in Biology*. 1-7.

Uddin, F.M.J., Hassan, N., Rahman M.R, and Uddin, M.R. (2018). Effect of bio fertilizer and weeding regimes on yield performance of bush bean (*Phaseolus vulgaris* L.). *Archives of Agriculture and Environmental Science*, 3(3): 226-231.

Usha, S.A., Uddin, F.M.J., Rahman, M.R. and Akondo, M.R.I. (2019). Influence of nitrogen and sulphur fertilization on the growth and yield performance of French bean. *Journal of Pharmacognosy and Phytochemistry*, 8(5): 1218-1223.