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RESPONSE OF MUNGBEAN VARIETIES TO BORON IN CALCAREOUS SOILS OF BANGLADESH

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Abstract

An experiment was conducted in calcareous soil at the research farm of Regional Pulses Research Station,Madaripur during 2014 and 2015 to determine the suitable dose of B for yield maximization of different varieties of mungbean (*Vigna radiata* L. There were 25 treatment combinations comprising five levels of boron (0, 1.0, 1.5, 2.0 and 2.5 kg ha^{-1}) and five varietiesof mungbean (BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5 and BARI Mung-6) along with a blanket dose of $N_{20}P_{25}K_{30}S_{10}Zn_2$ kg ha^{-1}. The experiment was laid out in factorial randomized complete block design with three replications. Main effect of boron indicated 1.5 kg ha^{-1} B was superior to other doses in respect of yield, protein content and yield traits of mungbean varieties. However, the highest yield increment (31.4%) over control was achieved from 1.5 kg B ha^{-1}. In interactions, the maximum seed yield was achieved from var. BARI Mung-6 with the application of B @ 1.5 kg ha^{-1}. As such cultivation of mungbean var. BARI Mung-6 with the application of boron @ 1.5 kg ha^{-1} along with $N_{20}P_{25}K_{30}S_{10}Zn_2$ kg ha^{-1} (blanket dose) could be found suitable for yield maximization of mungbean in calcareous soils of Bangladesh.

Keywords: Mungbean variety, boron, yield, protein content, yield traits.

Introduction

Mungbean (*Vigna radiata* L.) is one of the promising and important legume crops in Asia under *Fabaceae* family and known as green gram, cultivated during spring and autumn seasons (Hussain *et al*., 2016; Sadaf and Tahir, 2017). The crop is very important in the nutritional point of view containing 24.5% protein, 1.3 % fat and 60.4 % carbohydrate, 75 mg calcium, 8.5 mg iron and 49 mg β-carotene per 100 g split dhal (Quddus *et al*., 2010). The mungbean sprout is rich in vitamins and amino acids (Hussain *et al*., 2011; Saket *et al*., 2018). Mungbean crop also plays a key role in improving the soil fertility through biologically nitrogen fixation from 63 to 342 kg ha^{-1} (Sadaf and Tahir, 2017; Kaisher *et al*., 2010). The retention of mungbean biomass has significant

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effect in contributing residual nitrogen for succeeding crops and could add considerable amount of organic matter to increase soil fertility (Kumar and Yadav, 2018).

The average seed yield of mungbean in Bangladesh is much low (about 867 kg ha^{-1}) compared to potential yield (BBS, 2016). But seed yield can be improve by cultivation of modern high yielding variety with judicial application of macro and micro nutrients, particularly boron application (Uddin *et al*., 2009). Calcareous soils of Bangladesh are more or less deficient in boron as the soil contains sufficient amount of calcium carbonate which caused decrease in B-availability (Padbhushan and Kumar, 2014; Shaaban *et al*., 2004). Boron application plays an important role in plant cell wall formation and membrane constancy (Bassil *et al*., 2004). It facilitates to increase the flowering, germination of pollen, accelerates the growth of pollen tube, pod and seed setting and seed yield of legume (Qamar *et al*., 2016). Boron is useful in chlorophyll synthesis and carbohydrates metabolism (Laxmi *et al*., 2020). In addition, boron positively influences the uptake and acquisition of N, P and K nutrients by the plant.

Hence, using the suitable variety of mungbean with appropriate dose of B is essential for higher seed yield of mungbean. The present study was therefore undertaken to find out suitable mungbean variety and determine the suitable dose of boron for yield maximization of mungbean in calcareous soils of Bangladesh.

Materials and Methods

Field experiment was conducted in research field of Regional Pulses Research Station, Bangladesh Agricultural Research Institute (BARI), Madaripur during summer (Kharif-I) season of 2014 and 2015. The land of Madaripur is medium high with loamy textured calcareous soils. It belongs to Gopalpur series (Soil taxonomy: Aquic Eutrochrepts) under the agro-ecological zone Low Ganges River Floodplain (AEZ-12). The experimental area is characterized by moderately monsoon rainfall, high humidity, and high temperature during March to June. Long day with less clear sunshine, heavy rainfall (about 80% of the total rainfall) during June to October. The site having scanty rainfall, low humidity, and low temperature, short day and clear sunshine during October to March. Average temperature ranged from 12.0 to 38^0 C and average annual rainfall varied from 1500 to 5500 mm around the year

Soil samples (0-15 cm depth) were collected for laboratory analyses at the beginning of the experiment to know the basic soil properties of the experimental soil. The chemical properties of the initial soil are presented in Table 1.

Table 1. Initial soil nutrient status of the experimental field

Nutrient	Soil test value	Critical level	*Soil test interpretation	Method of analysis and reference
pH	7.4	-	Slightly alkaline	Glass electrode pH meter (Page *et al.*, 1982)
Organic carbon (g kg^{-1})	8.33	-	Low	Wet oxidation method (Page *et. al.*, 1982)
Ca (meq.$100g^{-1}$ soil)	14.4	2.0	High	1N NH4OAc extraction (Page *et. al.*, 1982)
K (meq.$100g^{-1}$ soil)	0.14	0.12	Low	1N NH4OAc method (Jackson, 1973)
Total N (g kg^{-1})	0.65	1.2	Very low	Microkjeldahl method (Page *et. al.*, 1982)
Available P (mg kg^{-1})	15	8	Medium	Olsen method (Page *et. al., 1982)*
Available S (mg kg^{-1})	15.3	10	Low	Turbidity method using $BaCl_2$ (Fox *et. al.*, 1964)
Available Zn (mg kg^{-1})	0.85	0.6	Low	DTPA method (Lindsay and Norvell, 1978)
Available B (mg kg^{-1})	0.15	0.2	Low	Azomethine-H method (Page *et. al.*, 1982)

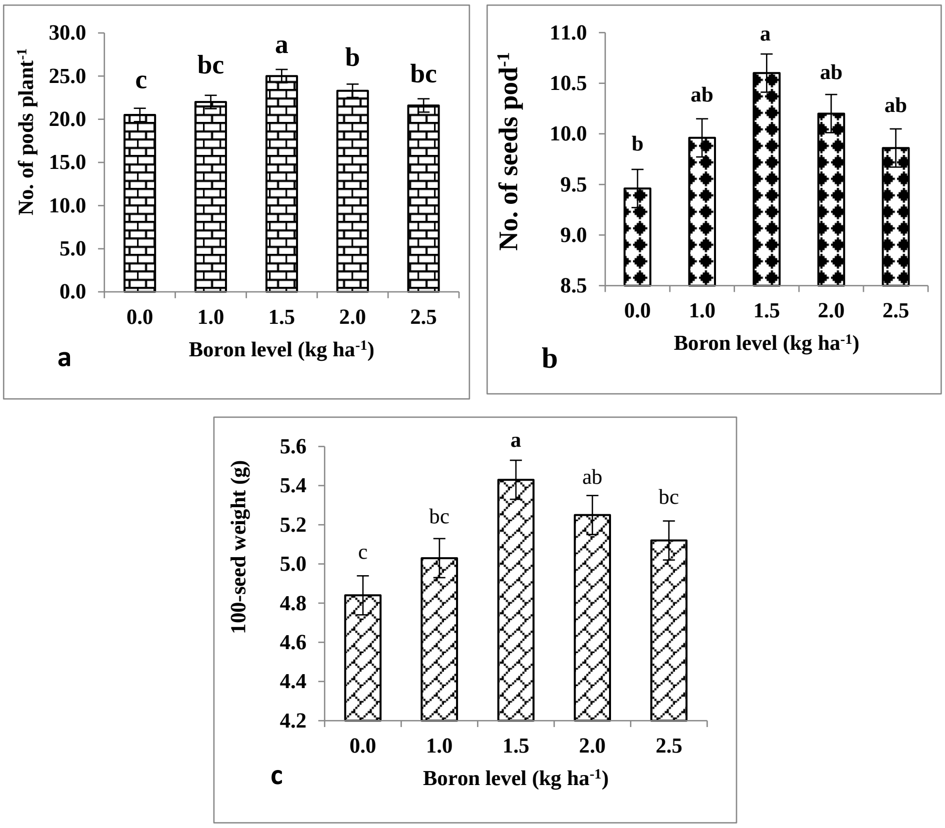
*Anonymous (2012).

There were 25 treatment combinations comprising five levels of boron (0, 1.0, 1.5, 2.0 and 2.5 kg ha^{-1}) and five varieties (V_1=BARI Mung-2, V_2= BARI Mung-3, V_3= BARI Mung-4, V_4=BARI Mung-5 and V_5= BARI Mung-6) along with a blanket dose of $N_{20}P_{25}K_{30}S_{10}Zn_2$ kg ha^{-1}. The experiment was laid out in factorial randomized complete block design with three replications. The land was prepared by 3-4 passes with a tractor driven chisel plough and leveled with tractor driven rotavator. Weeds and stubbles were removed manually. Boron was applied as boric acid (17% B). The source of N, P, K, S and Zn were urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. Full amount of all fertilizers except boric acid as per treatment were applied during final land preparation. Healthy seeds of mungbean varieties lviz., BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5 and BARI Mung-6 were sown @ 30-35 kg seed ha^{-1} with a spacing of 40 cm × 10 cm on 11 March 2014 and 12 March 2015. Two hand weeding were done at 20 and 40 days after sowing. The insects (thrips and pod borer) were controlled by spraying Karate @ 0.2% three times started at flowering with an interval of 10 days. Only one pre-sowing light flood irrigation was done to ensure proper seed germination. The matured crop was harvested duly and seed yield (kg ha^{-1}) was measured. Plant samples (seed) against each treatment were oven-dried at 70°C for 48 h and finely ground using CyclotecTM 1093 sample Mill (Made in Sweden). An amount of 0.1 g ground sample (seeds) was analyzed for N using the Kjeldahl method FOSS (Persson *et al*., 2008). The protein content was estimated by multiplying the %N content of mungbean with constant factor 6.25 that means %N × 6.25 (Hiller *et al*., 1948). The collected data were compiled and analyzed statistically with the help of a computer package program MSTAT-C and the mean differences were adjusted by Duncan's New Multiple Range Test (Gomez and Gomez, 1984). The optimum dose of boron was calculated using the formula: $Y= a + bx + cx^2$ and By = - b/2c (Gomez and Gomez 1984).

Results and Discussion

Main effects of boron application

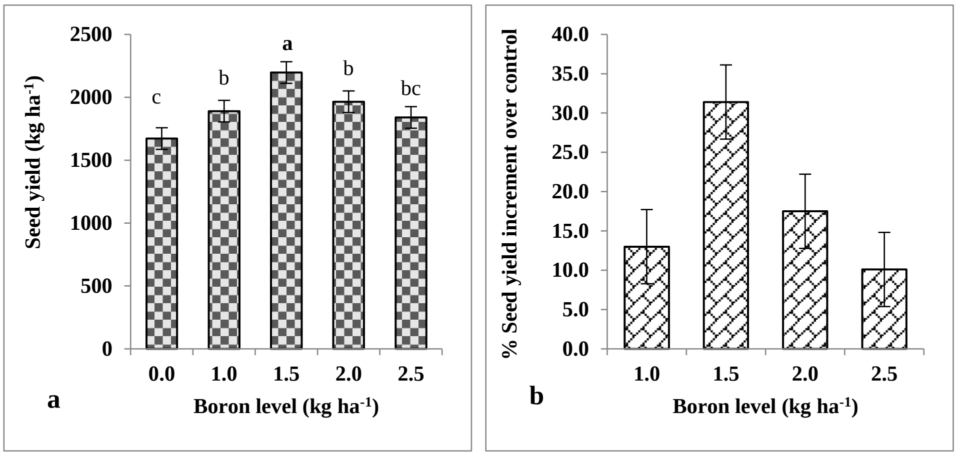
Yield traits viz., pods per plant, seeds per pod and 100-seed weight of mungbean varieties varied significantly due to application of boron (Figure 1a, b, c). The maximum pods per plant (25.0) was recorded from application of B @ 1.5 kg ha^{-1} and the minimum pods per plant (20.5) from control treatment (Figure 1a). Boron application @1.5 kg ha^{-1} has led to attain the highest increment (21.9%) of pods per plant of mungbean over control treatment. Boron helps the formation of more flowers, pollen germination, and speed up the growth of pollen tube, facilitating better pod setting in plant thus resulting increased number of pods per plant under B application @ 1.5 kg ha^{-1}. Similar statement was reported by Qamar *et al*. (2016); Padbhushan and Kumar (2014). The maximum seeds per pod (10.6) was obtained from application of 1.5 kg B ha^{-1} that was comparable to treatments of 2.0, 2.5 and 1.0 kg B ha^{-1} (Figure 1b). Tania *et al*. (2019) also reported similarly that boron application increased the pods per plant and seeds per pod in mungbean. Similar results were also corroborates by Alam *et al*. (2017) in chickpea production. The highest 100-seed weight (5.43 g) was obtained from application of 1.5 kg B ha^{-1} which was 12.2% higher over t control treatment (Figure 1c). Boron enhanced the crop cell division, carbohydrate metabolism, sugar and starch formation which ultimately improved the seed size and seed weight of mungbean. The comparable result was also outlined by Padbhushan and Kumar (2014).



Values followed by the same letter are not significantly different according to the least significant difference (LSD) test at $p \leq 0.05$.

Fig. 1. Main effect of boron on (a) number of pods per plant, (b) number of seeds per pod and (c)100-seed weight of mungbean varieties (Pooled)

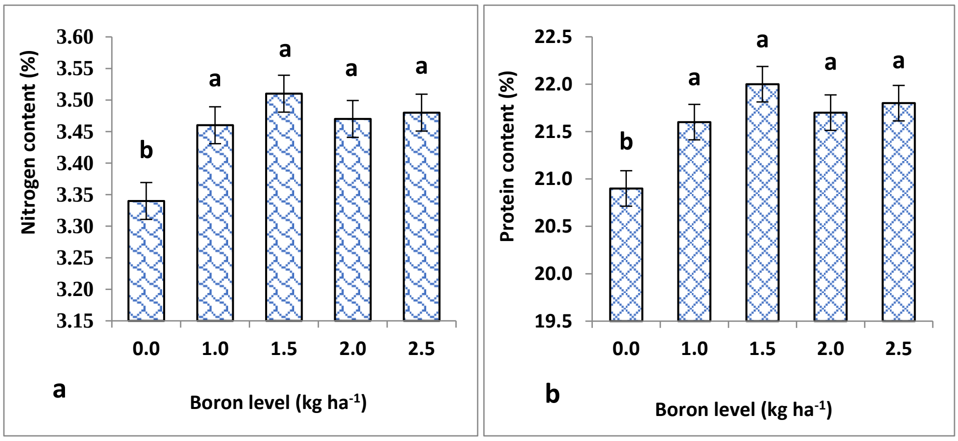
Boron application had positively influenced the seed yield of mungbean varieties (Figure 2a). Seed yield of mungbean was increased due to increase in boron application rate up to 1.5 kg ha^{-1} and then decline up to 2.5 kg ha^{-1}. However, the highest seed yield (2197 kg ha^{-1}) was produced from application of 1.5 kg B ha^{-1} which was significantly higher than other treatments (Figure 2a). Verma *et al.* (2004) also reported that seed yield of mungbean improved with increasing the boron availability in soil. Boron influences the proper function of cell membranes and the transport of K to guard cells for the proper control of internal water balance, encouraged to works the xylem vessels and root hair tips and finally improves the plant growth and yield (Ahmed *et al.* 2020). Percent yield increment of mungbean over B control was highest (31.4%) from B application @1.5 kg ha^{-1} and lowest (10.1%) from B application @ 2.5 kg ha^{-1} (Figure 2b).



Values followed by the same letter are not significantly different according to DMRT at $p \leq 0.05$.

Fig. 2. Main effect of boron on (a) seed yield of mungbean varieties and (b) percent seed yield increment over control (Pooled).

The N and protein content in mungbean was influenced significantly by the B application (Figure 3a, b). The highest N (3.51%) and protein contents (22.0%) were recorded in the treatment 1.5 kg B ha^{-1}.. Maqbool *et al.* (2018) also reported similarly that B application increases the protein content of mungbean. The lowest N and protein content was found in B control treatment (Figure 3a, b). Boron influences the absorption of N, P and K and played a positive role for protein synthesis (Quddus *et al.*, 2018).

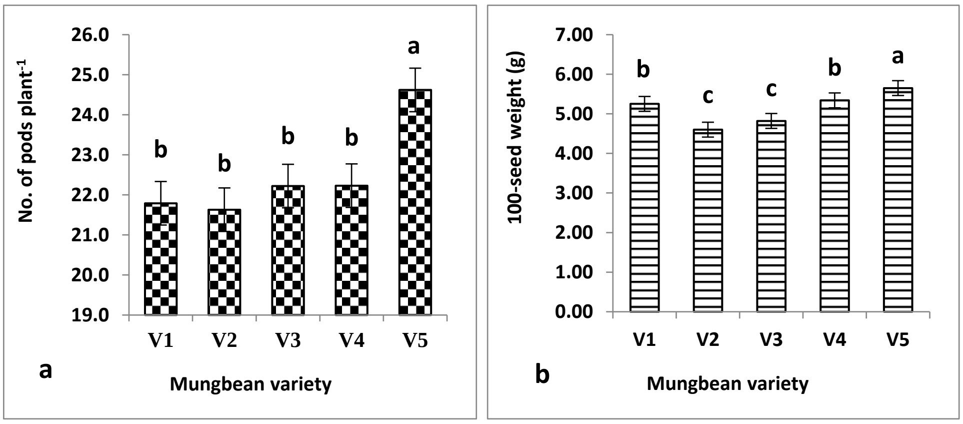


Values followed by the same letter are not significantly different according to DMRT at $p \leq 0.05$.

Fig. 3. Main effect of boron on (a) nitrogen content and (b) protein content in mungbean varieties (Pooled).

Main effects of varieties

Yield traits viz., pods per plant and 100-seed weight exhibited significant variation among mungbean varieties (Figure 4a, b) but number of seeds per pod was statistically similar.. The highest pods per plant (24.6) was obtained from BARI Mung-6 whereas minimum pods per plant was noted from BARI Mung-3 (Figure 4a). The highest 100-seed weight (5.65 g) was recorded from BARI Mung-6 and lowest 100-seed weight from BARI Mung-3 (Figure 4b). The pods per plant and seed weight showed highest in BARI Mung-6 might be related to the contribution of genetic divergence and superiority in nutrient uptake capacity than other mungbean varieties. Similar observation reported by Razzaque *et al*. (2016) in mungbean genotypes.

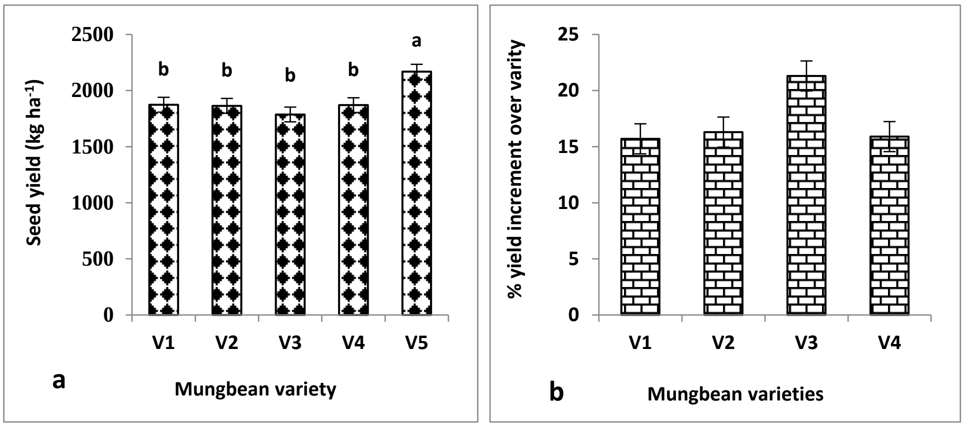


Values followed by the same letter are not significantly different according to DMRT at $p \leq 0.05$.

Fig. 4. Main effect of mungbean varieties on (a) number of pods per plant and (b) 100-seed weight (Pooled).

Note: V_1=BARI Mung-2, V_2= BARI Mung-3, V_3= BARI Mung-4, V_4=BARI Mung-5 and V_5= BARI Mung-6.

Variety had significant influence on seed yield of mungbean (Figure 5a). The highest seed yield (2168 kg ha^{-1}) was produced from BARI Mung-6 and lowest seed yield (1864 kg ha^{-1}) from var. BARI Mung-3 (Figure 5a). The varietal characters might result in higher seed yield of BARI Mung-6 than other varieties. Uddin *et al*. (2010) corroborated the similar findings. In present study, the yield increment of BARI Mung-6 over BARI Mung-2 was 15.7%, BARI Mung-3 (16.3%), BARI Mung-4 (21.3%) and BARI Mung-5 (15.9%) (Figure 5b). This yield increment of BARI Mung-6 over other varieties might be attributed due to pods per plant and heaviest seed weight in BARI Mung-6. Tania *et al*. (2019) and Hossain *et al*. (2016) alsostated that higher pods per plant variation might be due to genetic advantage that has contributed to higher seed yield in BARI Mung-6.

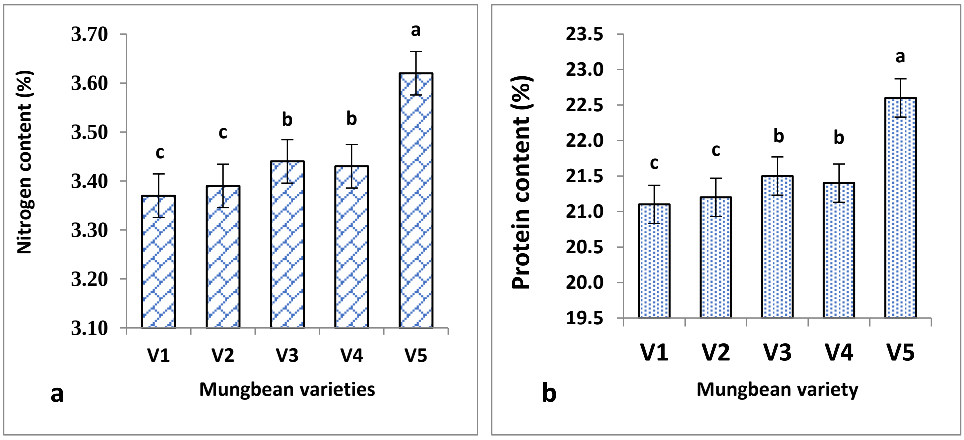


Values followed by the same letter are not significantly different according to DMRT at $p \leq 0.05$.

Fig. 5. Main effect of mungbean varieties on (a) seed yield and (b) % yield increment of BARI Mung-6 over varieties (Pooled).

Note: V_1=BARI Mung-2, V_2= BARI Mung-3, V_3= BARI Mung-4, V_4=BARI Mung-5 and V_5= BARI Mung-6.

Nitrogen and protein content exhibited significant variation among mungbean varieties (Figure 6a, b). Mungbean var. BARI Mung-6 accumulated the higher protein content (22.6%) than the other varieties (Figure 6b).



Values followed by the same letters are not significantly different according to DMRT at $p \leq 0.05$.

Fig. 6. Main effect of mungbean varieties on (a) nitrogen content and (b) protein content in mungbean (Pooled).

Note: V_1=BARI Mung-2, V_2= BARI Mung-3, V_3= BARI Mung-4, V_4=BARI Mung-5 and V_5= BARI Mung-6.

Regression analysis

Regression analysis exhibited positive and quadratic response to mean yield of mungbean varieties and application of B (Figure 7). The optimum dose of B calculated from the quadratic response function was 1.46 kg ha^{-1}. Using the optimum dose (1.46 kg ha^{-1}), the maximum seed yield (2053 kg ha^{-1}) of mungbean could be expected from B deficient soil.

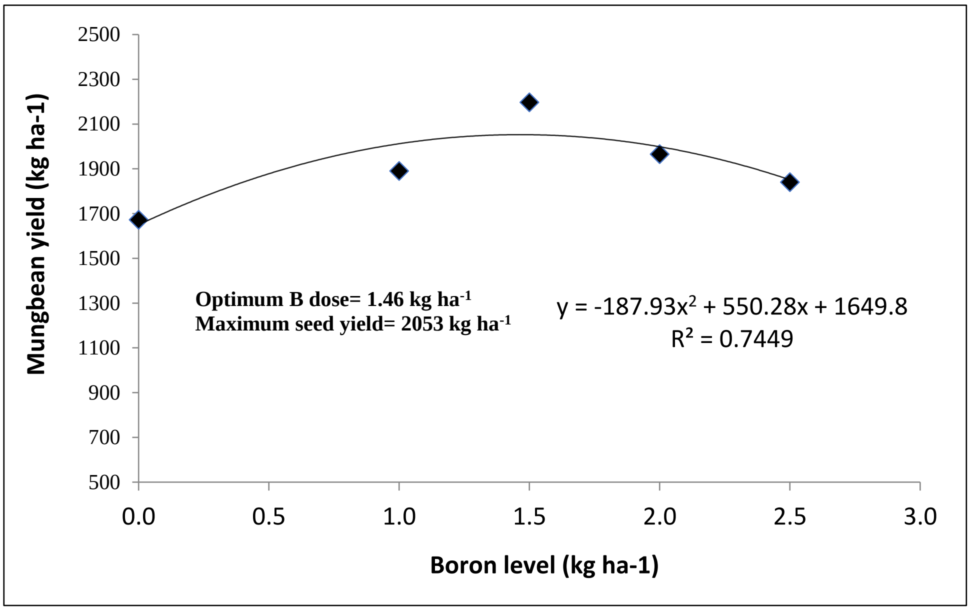


Fig. 7. Relationship between mungbean seed yield and dose of boron

Interaction effect of boron and mungbean varieties

The interaction of variety and level of boron exhibited significant variation in pods per plant, seeds per pod, 100-seed weight and seed yield of mungbean (Table 2).

The highest number of pods per plant (26.7) was documented from $B_{1.5}$ × BARI Mung-6 treatment combination and the lowest pods per plant from treatment combination of B_0 × BARI Mung-3. The maximum seeds per pod was recorded in the treatment $B_{1.5}$ × BARI Mung-6 comparable to $B_{2.0}$ × BARI Mung-6, $B_{1.0}$ × BARI Mung-6, $B_{1.5}$ × BARI Mung-5, $B_{1.5}$ × BARI Mung-4, $B_{1.5}$ × BARI Mung-3, and $B_{1.5}$ × BARI Mung-2. Seeds per pod were minimum in B_0 × BARI Mung-3 treatment (Table 2). The maximum 100-seed weight was found in $B_{1.5}$ × BARI Mung-6 treatment which was statistically identical to $B_{2.0}$ × BARI Mung-6 and $B_{1.5}$ × BARI Mung- (Table 2). Ceyhan and Onder (2007) reported significant variation in varietal response to different B rates. Tania *et al.* (2019) BARI Mung-6 with 1 or 1.5 kg B application performed better result in yield and yield traits. Mungbean var. BARI Mung-6 having the larger seed size with B application @ 1.5 kg ha^{-1} compared to 1.0 or 2.0 kg ha^{-1}Use of suitable variety and optimum dose of B nutrient along with other nutrients might have favored plant growth and development that finally resulted in getting higher seed yield of mungbean In interaction of variety and B application showed that the highest seed yield (2529 kg ha^{-1}) was obtained from t $B_{1.5}$ × BARI Mung-6 and lowest from B_0 × BARI Mung-5 treatment (Table 2). Boron application might have played a key role for getting higher seed yield of mungbean varieties. Ceyhan and Onder (2007) opined that B application has positive effect on pulse crop. The maximum N content (3.68%) and protein content (23.0%) was recorded from the treatment $B_{1.5}$ × BARI Mung-6 which was statistically similar with $B_{2.5}$ × BARI Mung-6, $B_{2.0}$ × BARI Mung-6 and $B_{1.0}$ × BARI Mung-6 treatments. The lowest N and protein content in seed was from B_0 × BARI Mung-2 treatment (Table 2).

Table 2. Interaction effect of boron and variety on yield traits, yield, N and protein content in mungbean (Pooled)

Boron level × Mungbean variety	Number of pods plant^{-1}	Number of seeds pod^{-1}	100-seeds wt. (g)	Seed yield (kg ha^{-1})	N content (%)	Protein content (%)
B_0 × BARI Mung-2	19.8jk	9.38fg	5.00f-j	1639hij	3.15g	19.6h
$B_{1.0}$ × BARI Mung-2	20.6hij	9.93b-g	5.16e-h	1837f-i	3.37ef	21.0efg
$B_{1.5}$ × BARI Mung-2	24.5bcd	10.5a-d	5.55bc	2131bcd	3.46de	21.7de
$B_{2.0}$ × BARI Mung-2	22.5d-h	10.1b-f	5.30c-f	1923d-g	3.41ef	21.3d-g
$B_{2.5}$ × BARI Mung-2	21.5f-j	9.97b-g	5.22d-g	1839f-i	3.47de	21.6de
B_0 × BARI Mung-3	18.5k	9.16g	4.37m	1648hij	3.30f	20.6g
$B_{1.0}$ × BARI Mung-3	20.9g-j	9.67c-g	4.46lm	1878efg	3.40ef	21.3efg
$B_{1.5}$ × BARI Mung-3	24.5bcd	10.3a-f	4.82ijk	2066b-e	3.45de	21.5de
$B_{2.0}$ × BARI Mung-3	22.8c-g	9.90b-g	4.67klm	1916d-g	3.40ef	21.3efg
$B_{2.5}$ × BARI Mung-3	21.5f-j	9.59d-g	4.70jkl	1815f-j	3.41ef	21.2efg
B_0 × BARI Mung-4	20.4ijk	9.55d-g	4.42lm	1620ij	3.39ef	21.1efg
$B_{1.0}$ × BARI Mung-4	22.2e-i	10.1b-g	4.69jkl	1767g-j	3.45de	21.6de
$B_{1.5}$ × BARI Mung-4	24.7bc	10.3a-e	5.15e-h	2034c-f	3.47de	21.8cde

Table 2. Cont'd.

Boron level × Mungbean variety	Number of pods plant^{-1}	Number of seeds pod^{-1}	100-seeds wt. (g)	Seed yield (kg ha^{-1})	N content (%)	Protein content (%)
$B_{2.0}$ × BARI Mung-4	23.3b-f	10.0b-g	4.97g-k	1797g-j	3.44de	21.5de
$B_{2.5}$ × BARI Mung-4	20.6hij	9.91b-g	4.88h-k	1719g-j	3.47de	21.6de
B_0 × BARI Mung-5	20.3ijk	9.47efg	5.09e-i	1607j	3.31f	20.7fg
$B_{1.0}$ × BARI Mung-5	22.2e-i	9.82b-g	5.28c-g	1848fgh	3.46de	21.7de
$B_{1.5}$ × BARI Mung-5	24.8b	10.6abc	5.66ab	2227bc	3.48c-e	21.8cde
$B_{2.0}$ × BARI Mung-5	23.1b-f	10.1b-f	5.37b-e	1918d-g	3.46de	21.6de
$B_{2.5}$ × BARI Mung-5	20.8g-j	9.66c-g	5.29c-g	1753g-j	3.44de	21.5def
B_0 × BARI Mung-6	23.6b-e	9.73c-g	5.31c-f	1846f-h	3.54b-d	22.1bcd
$B_{1.0}$ × BARI Mung-6	24.3bcd	10.3a-f	5.57bc	2119bcd	3.61a-c	22.5abc
$B_{1.5}$ × BARI Mung-6	26.7a	11.1a	5.94a	2529a	3.68a	23.0a
$B_{2.0}$ × BARI Mung-6	24.8b	10.7ab	5.92a	2269b	3.63ab	22.7ab
$B_{2.5}$ × BARI Mung-6	23.7b-e	10.2b-f	5.51bcd	2076b-e	3.64ab	22.8ab
CV (%)	4.68	4.74	4.34	6.02	3.89	3.97

Values within the same column with a uncommon letters differed significantly ($P \leq 0.05$) by DMRT.

Conclusion

All the varieties of mungbean used in the present investigation were found responsive to boron application but munjgbean var. BARI Mungbean-6 was more responsive to boron fertilizer. Among the varieties, BARI Mung-6 was the best on the basis of yield traits, protein content and seed yield. Again, the application of B @ 1.5 kg ha^{-1} along with a blanket dose of $N_{20}P_{25}K_{30}S_{10}Zn_2$ is found suitable dose for mungbean cultivation. Regression analysis of the yield data also indicates that the application of boron at 1.46 kg ha^{-1} is optimum and leads to maximize seed yield of mungbean in B deficient area. Thus to boost up seed yield of mungbean, BARI Mung-6 variety with B application @ 1.5 kg ha^{-1} could be recommended for Madaripur region.

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