

Influence of coupled application of potassium and boron on growth and yield of late sown mungbean

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World Journal of Advanced Research and Reviews, 2021, 11(01), 256–264

Publication history: Received on 18 June 2021; revised on 27 July 2021; accepted on 29 July 2021

Article DOI: <https://doi.org/10.30574/wjarr.2021.11.1.0343>

Abstract

To ensure both food and nutritional security of teeming millions of Bangladesh, cropping intensity must be increased along with nutritional food production. Mungbean, which is an important source of protein, can easily cope with the intensive cropping system due to short duration. But sometimes, to obtain maximum productivity per unit area in a calendar year, mungbean cannot be sown in optimum time. Considering this, a field study was carried out at Sher-e-Bangla Agricultural University to explore the effect of additional potassium and boron application to increase the yield of late sown mungbean which was sown on 25 October. The experiment was laid out in randomized complete block design with three replications and five treatments. Results revealed that additional potassium and boron along with recommended fertilizer dose had significant influence on growth, yield and yield contributing characters of late sown mungbean. The growth and yield of late sown mungbean is hampered due to temperature stress which cannot be overcome by recommended dose only but can be by addition of extra potassium and boron with recommended dose. The highest seed yield (1.12 t ha^{-1}) was obtained from recommended dose along with 10 Kg K and 2 Kg B ha^{-1} which was 40% higher than recommended dose only. Similar results were recorded for other parameters also. So, supplementation of recommended dose with 10 Kg K and 2 Kg B may be suggested to increase growth and yield of late sown mungbean.

Keywords: Biological yield; Fertilizer; Harvest index; Pulse crop; Sowing time

1. Introduction

Pulses are traditionally popular as poor man's meat in Bangladesh because of being the cheapest source of protein [1]. But as price hikes due to less production, now it has gone beyond the reach of poor people. In Bangladesh, per capita consumption of pulses is only 14.72 g [2] against the World Health Organization recommended requirement of 45.0 g. So time demands to increase pulse production immediately to attain the daily intake requirement. Mungbean (*Vigna radiata L.*), a leguminous crop is the third most important pulse crop in Bangladesh in both area and production [2]. It contains 51% carbohydrate, 26% protein, 4% minerals and 3% vitamins [3]. Due to its short duration and year-round cultivation, mungbean can well fit in cropping system while improve the physical, chemical and biological properties and overall soil fertility status due to its nitrogen fixing ability [4]. But to fit in the intensive cropping system for ensuring food security, sometimes mungbean has to be sown in October instead of September which causes the yield reduction due to temperature stress. But the yield loss can be overcome by supplementation with potassium and boron fertilizer. K fertilizer enhances sugar metabolism, increases osmotic cell concentration, regulates stomatal guard cell turgor, helps in stomatal opening and photosynthesis, improves drought resistance, and increases yield [5]. On the other hand, boron

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has profound impact on plant nutrition and recognized as major yield limiting factor in pulses [6]. It plays a vital role in chlorophyll synthesis as well as carbohydrates metabolism. The most crucial role of boron is in activating the germination of pollen, accelerating the growth of pollen tube and increasing the number of flowers and fruits formation [7]. In Bangladesh, many studies have been conducted on nutrient requirements of mungbean, but reports are very few on the combined supplementation of potassium and boron fertilizer to improve the yield of late sown mungbean. Therefore, the experiment was conducted to explore the optimum doses of potassium and boron supplement to ameliorate the growth and yield of late sown mungbean.

2. Material and methods

2.1. Experimental site

The field experiment was laid out at Sher-e-Bangla Agricultural University Farm, Bangladesh during the period during Rabi season. The experimental area was situated between $23^{\circ}74'$ latitude and $95^{\circ}35'$ longitude. It belongs to sub-tropical climate. The land of the selected experimental plot is under Madhupur Tract with shallow red brown terrace soil [8].

2.2. Experimental design and treatments

BARI Mung-6, a photo insensitive, high yield variety, developed by Bangladesh Agricultural Research institute, was used as a test crop. The experiment was conducted following Randomized Complete Block Design (RCBD) with three replications. The experiment consisted of five treatments *viz.* F_0 = Recommended dose (R) [9], F_1 = R + Additional 10 kg K ha^{-1} + 1 kg B ha^{-1} , F_2 = R + Additional 20 kg K ha^{-1} + 1 kg B ha^{-1} , F_3 = R + Additional 10 kg K ha^{-1} + 2 kg B ha^{-1} and F_4 = R + Additional 20 kg K ha^{-1} + 2 kg B ha^{-1} . The unit plot size was 3 m^2 (2 m \times 1.5 m).

2.3. Sowing and management of crop

The land of the experimental plot was prepared with a power tiller on 23 October, 2013. The full amount of N, P, K and B was applied at the time of final land preparation in the forms of urea, triple super phosphate, muriate of Potash and boric acid, respectively. The experimental plots were fertilized according to treatments. Mungbean (var. BARI Mung-6) seed was sown on 25 October in rows maintaining row to row distance 30cm and seed to seed distance 10 cm. Crop management activities were done when needed. Thinning was done at 7 days after emergence of seed for every sowing time. Weeding was done at 20-25 days after emergence of seed. Mulching was done at 30-35 days after emergence of seedlings. Irrigation and pesticide were given as per necessity.

2.4. Harvesting and Data collection

Data on plant height, dry matter of leaves and stem was measured from 20 to 60 DAS with 10 days interval. Dry matter was determined by uprooting three plants from each plot and drying them in oven. Days to flowering, pod length (cm), no. of pods plant $^{-1}$, and no. of seeds pod $^{-1}$ were recorded from ten pre-selected plant. Thousands seed weight, seed yield, stover yield, biological yield and harvest index were recorded after harvesting, threshing and drying. Harvesting was done when 90% of the pod became blackish in color. Before harvesting 3 sampling plants from each plot was selected randomly and harvested for recording the data on different yield contributing characters. The crop was harvested from central 1.0 m^2 area excluding border area. The pods from were collected at each harvest time plot wise and were bagged separately, tagged and brought to the threshing floor for yield data. Seed yield was determined at 12% moisture content. The stover yield was taken from the plants of the same area by sun-drying. Harvest index is the ratio of economic yield to biological yield and was calculated with the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

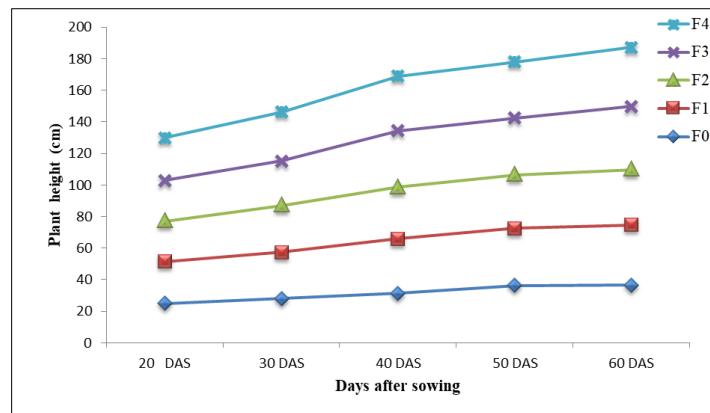
2.5. Data analysis

The collected data was compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help MSTAT-C software and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% probability level [10].

3. Results and discussion

3.1. Plant height

Plant height varied significantly by different levels of potassium and boron fertilizer doses (Figure 1) throughout the growing period except 20, 40 and 50 DAS. At 30 DAS, F₄ (R+ Additional 20 kg K ha⁻¹ + 2 kg B ha⁻¹) gave the tallest plant (30.96 cm) which was statistically similar with F₃ (28.1 cm) and at 60 DAS F₃ (R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹) gave the tallest plant (40.03 cm). At 30 DAS F₀ (Recommended dose) gave the shortest plant (27.96 cm). At 60 DAS, F₂ gave the shortest (35.23 cm) plant which was statistically similar with F₀.



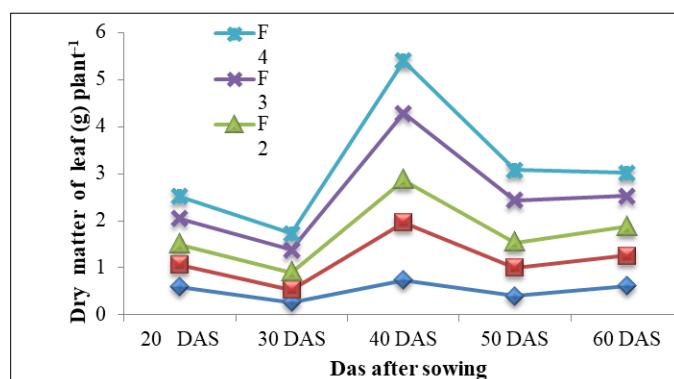
F₀ = Recommended dose (R), F₁ = R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹, F₂ = R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹, F₃ = R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹, F₄ = R+ Additional 20 kg K ha⁻¹ + 2 kg B ha⁻¹

Figure 1 Plant height of mungbean at different DAS as influenced by different level of potassium and boron fertilizer dose (LSD value = 3.90, 2.88, 5.78, 3.25 and 1.75 at 20, 30, 40, 50 and 60 DAS, respectively)

Gowthmi and Rama [11] stated that application of potassium nitrate and boric acid increased the plant height. Hussain et al. [12] stated that increased amount of potassium levels significantly affected the plant height. Significant increase in plant height induced by different doses of B was observed in mungbean [13]. The increase in plant height by K might be due to enhanced photosynthetic rate thereby encouraging the vegetative growth [14]. Furthermore, B is essential for cell division and cell elongation resulting in enhanced plant growth and plant height [15].

3.2. Dry matter of leaf

Figure 2 depicted dry matter of leaf influenced by additional application of potassium and boron throughout the growing period. Maximum dry matter was obtained at 40 DAS among all the sampling dates. At 30, 40, 50 DAS, highest dry matter of leaf (0.48, 1.42, 0.89 g, respectively) was found from F₃ (R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹) fertilizer dose. At 30 DAS lowest dry matter of leaf (0.26 g) was recorded from F₁ which is statistically similar with F₀.



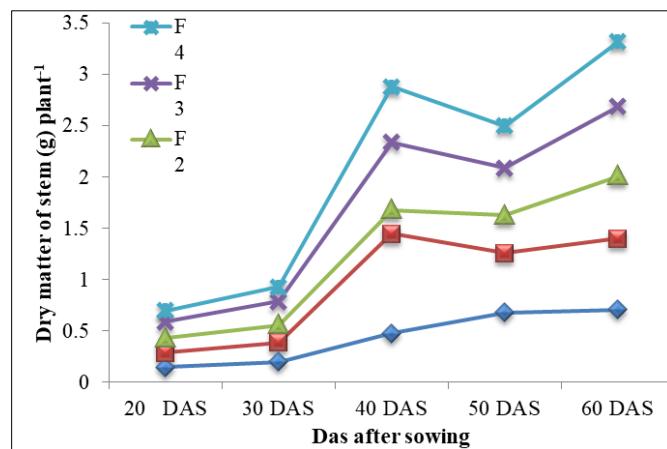
F₀ = Recommended dose (R), F₁ = R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹, F₂ = R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹, F₃ = R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹, F₄ = R+ Additional 20 kg K ha⁻¹ + 2 kg B ha⁻¹

Figure 2 Effect of different levels potassium and boron fertilizer dose on dry matter of leaf of mungbean plant at different DAS (LSD = 0.19, 0.05, 0.16, 0.17, 0.18 at 20, 30, 40, 50 and 60 DAS, respectively)

The lowest dry matter of leaf (0.74, 0.40 g) was obtained from F_0 (Recommended dose) at 40, 50 DAS, respectively. Gowthmi and Rama [11] stated that application of potassium nitrate and boric acid increased the total dry matter of plant. This result is in agreement with [16] who reported that B showed greater performance to leaf-stem, total dry matter weight of plant. Muhlbachova *et al.* [17] have found positive correlation between dry matter yield and B contents in Barley. According to Han *et al.* [18], B deficiency influence plant growth by reducing enzymatic activities and lowering stomatal conductance and CO_2 assimilation in plant leaves.

3.3. Dry matter of stem

Figure 3 illustrated dry matter of stem of mungbean at 20, 30, 40, 50 and 60 DAS. Significant variation was observed by different levels of potassium and boron fertilizer doses for dry matter production of stem throughout the growing period except 20, 30, 60 DAS. At 40 DAS the highest dry matter of stem (0.97 g) was recorded from F_1 ($R + \text{Additional } 10 \text{ kg K ha}^{-1} + 1 \text{ kg B ha}^{-1}$). At 50 DAS the highest dry matter of stem (0.68 g) was recorded from F_0 which was statistically similar with F_1 and F_3 . At 40 and 50 DAS the lowest (0.23 and 0.37 g) was found from F_2 . The ability of potassium to improve dry matter was reported by [19]. The positive effect of potassium sources and boron combination treatment on starch could be interpreted by multiple physiological functions of both elements. Potassium plays an important role in promoting photosynthesis and increasing transport its products to sink [20] while boron increases the rate of photosynthesis by affecting photophosphorylation process inside chloroplasts and shifts the hormonal balance in leaves and stem especially IAA which is important for growth [21]. Boron has positive role in transporting carbohydrates from source to sink while its deficiency retards the synthesis of nucleic acids, carbohydrates metabolism and ultimately reduce biomass [22].



F_0 = Recommended dose (R), F_1 = $R + \text{Additional } 10 \text{ kg K ha}^{-1} + 1 \text{ kg B ha}^{-1}$, F_2 = $R + \text{Additional } 20 \text{ kg K ha}^{-1} + 1 \text{ kg B ha}^{-1}$,
 F_3 = $R + \text{Additional } 10 \text{ kg K ha}^{-1} + 2 \text{ kg B ha}^{-1}$, F_4 = $R + \text{Additional } 20 \text{ kg K ha}^{-1} + 2 \text{ kg B ha}^{-1}$

Figure 3 Effect of different levels potassium and boron fertilizer dose on dry matter of stem mungbean plant at different DAS (LSD = 0.05, 0.11, 0.13, 0.23 and 0.33 at 20, 30, 40, 50 and 60 DAS, respectively)

3.4. Pod length

Due to different levels of potassium and boron fertilizer doses, pod length of mungbean did not vary significantly (Table 1). But numerically, the longest pod (5.76 cm) was obtained from F_1 ($R + \text{Additional } 10 \text{ kg K ha}^{-1} + 1 \text{ kg B ha}^{-1}$) and shortest (5.35 cm) was found in F_3 ($R + \text{Additional } 10 \text{ kg K ha}^{-1} + 2 \text{ kg B ha}^{-1}$). These findings were similar with Jahan *et al.* [23].

3.5. No. of pods plant⁻¹

Statistically non-significant variations in no. of pods plant⁻¹ was observed at different levels of potassium and boron fertilizer dose (Table 1). But numerically, the treatment F_1 ($R + \text{Additional } 10 \text{ kg K ha}^{-1} + 1 \text{ kg B ha}^{-1}$) gave the highest no. of pods plant⁻¹ (11.53) and the treatment F_4 ($R + \text{Additional } 20 \text{ kg K ha}^{-1} + 2 \text{ kg B ha}^{-1}$) gave the lowest no. of pods plant⁻¹ (9.72). The results are almost same as reported by Samiullah and Khan [24].

Table 1 Yield contributing character of mungbean influenced by different levels of potassium and boron fertilizer dose

Treatment	Pod length (cm)	No. of pods plant ⁻¹	No. of seeds pod ⁻¹	1000-seed weight (g)	Days to flower
F ₀	5.61	10.05	6.14 ab	30.38 c	37.17a
F ₁	5.76	11.53	7.10 a	36.90 ab	34.67 ab
F ₂	5.52	10.05	5.22 b	34.98 b	32.00 cd
F ₃	5.34	11.44	6.84 ab	37.53 a	29.83 d
F ₄	5.63	9.72	7.16 a	32.43 c	34.00 bc
LSD _(0.05)	NS	NS	1.85	2.15	2.62
CV (%)	12.64	22.74	15.19	3.32	4.16

F₀ = Recommended dose (R), F₁ = R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹, F₂ = R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹, F₃ = R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹, F₄ = R+ Additional 20 kg K ha⁻¹ + 2 kg B ha⁻¹

3.6. No. of seeds pod⁻¹

No. of seeds pod⁻¹ was significantly influenced by different levels of potassium and boron fertilizer dose (Table 1). Results showed that the maximum no. of seeds pod⁻¹ (7.16) was recorded from F₄ (R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹) fertilizer dose which was statistically similar with F₃ and F₁. The minimum no. of seeds pod⁻¹ (5.22) was obtained with F₂ which was statistically at par with F₀ (Recommended dose). This result was supported by Valenciano *et al.* [16] who reported boron increased the no. of Seeds pod⁻¹. Haque [25] reported that number of seeds pod⁻¹ increased with increasing levels of K. On the other hand, improved B nutrition lowers the sterility in bread wheat from 42.6 – 45% thereby increases grain yield [26].

3.7. 1000-seed weight

Weight of 1000-seed was significantly influenced by different levels of potassium and boron fertilizer dose (Table 1). Result showed that the highest 1000-seed weight (37.53 g) was observed from F₃ (R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹) fertilizer dose and the lowest (30.38 g) from F₀ (Recommended dose). Kaisher *et al.* [27] documented higher 1000 seed weight due to boron application. Haque [25] stated that weight of 1000 seeds increased with increasing levels of K. Alam *et al.* [28] have observed the increase in 1000-seed weight of summer mungbean under the combined fertilization of K and B.

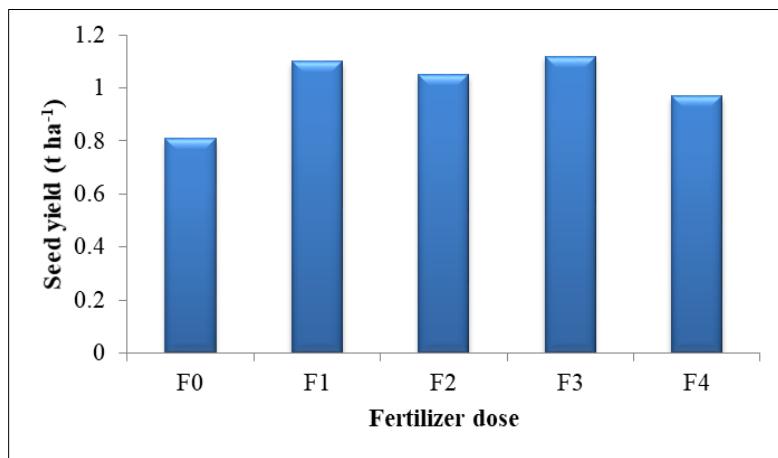
3.8. Days to flower

Significant variation was observed in days to flower due to different levels of potassium and boron fertilizer dose (Table 1). Results showed that the highest days to flower (37.17 days) was recorded with F₀ (Recommended dose) fertilizer dose which was statistically at par with F₁ (R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹) and the lowest days to flower (29.83 days) with F₃ (R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹) which was statistically similar with F₂ (R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹) fertilizer dose. Maqbool *et al.* [29] also found that B had significant influence on flowering habit of mungbean.

3.9. Seed yield

Seed yield showed significant difference due to application of different levels of potassium and boron fertilizer dose on mungbean (Figure 4). All other doses showed highest seed yield than recommended doses. The highest seed yield (1.12 t ha⁻¹) was recorded with F₃ (R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹) fertilizer dose which was statistically similar with F₁, F₂ and the lowest seed yield (0.80 t ha⁻¹) was with F₀ (Recommended dose). Addition of 10 kg K ha⁻¹ + 2 kg B ha⁻¹ with recommended dose provided 40% higher yield than recommended dose only. Kaisher *et al.* [27] and Quddus *et al.* [13] found that B significantly increased the yield of mungbean. Gowthmi and Rama [11] stated that application of potassium nitrate and boric acid increase the seed yield. The role of foliar application of different sources of potassium in increasing the yield and its components might be attributed to its function in plants which includes energy metabolism and enzyme activation that increase exchange rate and nitrogen activity as well as enhance carbohydrates movement from shoots to storage organs. This may be due to increase in the amount of chlorophyll in leaves and photosynthetic area which in turn leads to enhanced photosynthetic rate and ultimately accumulation of nutrients in seeds which improves yield. On

the contrary, boron improves photosynthetic activity, enhances activity of enzymes and plays significant role in protein and nucleic acid metabolism [30]. In addition, the effect of B application on increased K uptake may be related to synergistic relationship between K and B at sugar and carbohydrate transport [31].

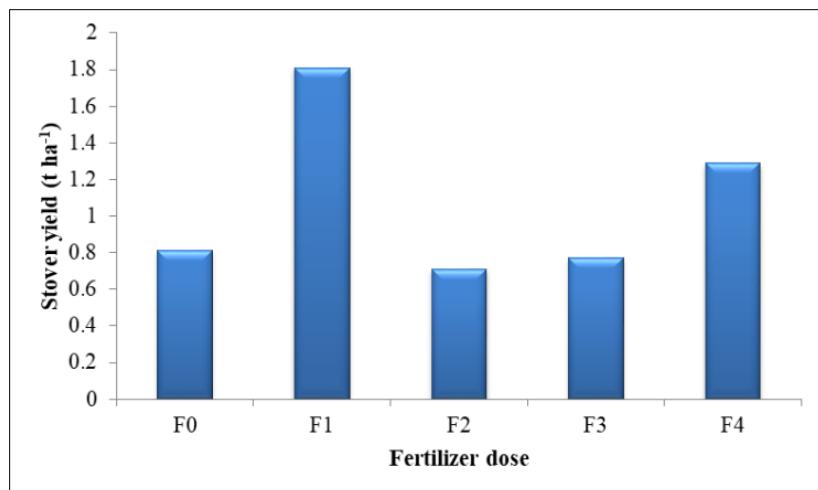


F_0 = Recommended dose (R), F_1 = R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹, F_2 = R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹, F_3 = R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹, F_4 = R+ Additional 20 kg K ha⁻¹ + 2 kg B ha⁻¹

Figure 4 Seed yield of mungbean plant influenced by different levels of potassium and boron fertilizer doses (LSD=0.08)

3.10. Stover yield

Application of different levels of potassium and boron fertilizer showed significant variation in term of stover yield (Figure 5). Results showed that the highest stover yield (1.81 t ha⁻¹) was recorded from F_1 (R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹) and the lowest (0.71 t ha⁻¹) was observed from F_2 (R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹) which was statistically at par with F_0 (Recommended dose). Similarly, this result was in line with Quddus *et al.* [13] and Haque [25].

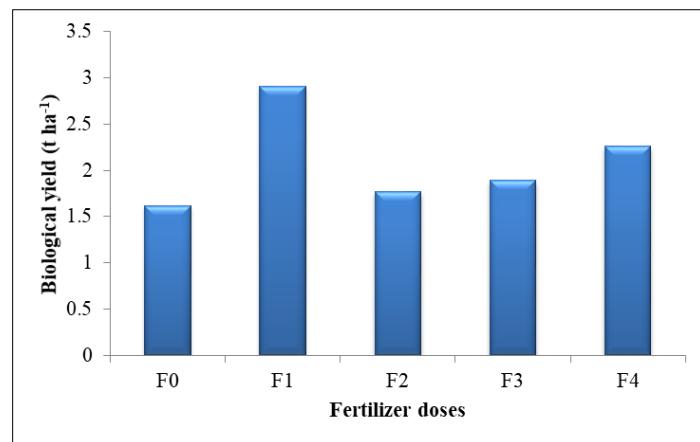


F_0 = Recommended dose (R), F_1 = R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹, F_2 = R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹, F_3 = R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹, F_4 = R+ Additional 20 kg K ha⁻¹ + 2 kg B ha⁻¹

Figure 5 Stover yield of mungbean plant influenced by different levels of potassium and boron fertilizer doses (LSD=0.18)

3.11. Biological yield

Different levels of potassium and boron fertilizer application significantly influenced the biological yield of mungbean in the present study (Figure 6). Application of F_1 (R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹) fertilizer dose showed the highest biological yield due to higher grain and stover yield and F_0 (Recommended dose) showed the lowest biological yield due to poorer grain and stover yield. The present result is agreement with findings of Jahan *et al.* [23].

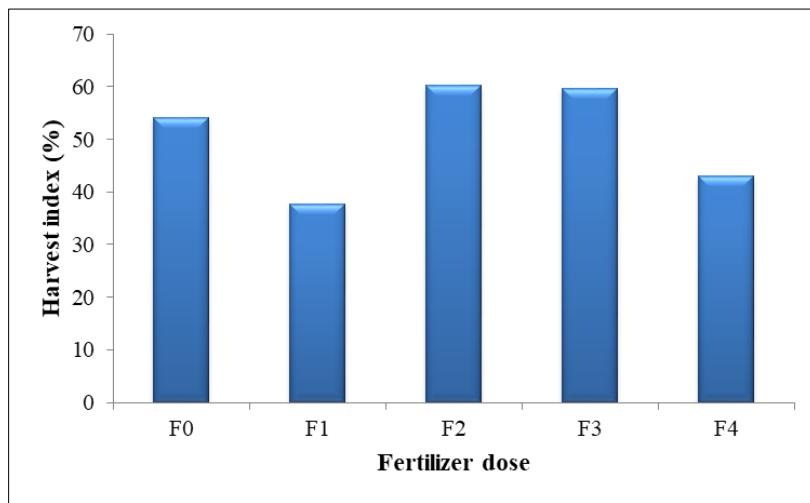


F_0 = Recommended dose (R), F_1 = R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹, F_2 = R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹,
 F_3 = R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹, F_4 = R+ Additional 20 kg K ha⁻¹ + 2 kg B ha⁻¹

Figure 6 Effect of different levels potassium and boron fertilizer doses on biological yield of mungbean (LSD value= 0.1)

3.12. Harvest index

Harvest index was significantly varied by different levels of potassium and boron fertilizer (Figure 7). The Highest harvest index (60.2 %) was recorded from F_2 (R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹) which was statistically similar with F_3 (R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹) due to higher grain yield and poorer stover yield. The lowest (37.73 %) was found from F_1 (R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹) due to poorer grain yield and higher stover yield. Hamza *et al.* [4] also found similar results with the present study.



F_0 = Recommended dose (R), F_1 = R+ Additional 10 kg K ha⁻¹ + 1 kg B ha⁻¹, F_2 = R+ Additional 20 kg K ha⁻¹ + 1 kg B ha⁻¹,
 F_3 = R+ Additional 10 kg K ha⁻¹ + 2 kg B ha⁻¹, F_4 = R+ Additional 20 kg K ha⁻¹ + 2 kg B ha⁻¹

Figure 7 Effect of different levels potassium and boron fertilizer doses on harvest index (LSD value= 4.53)

4. Conclusion

Considering the above results, it may be concluded that, 10 kg K and 2 kg B with recommended dose might be helpful to overcome the yield loss and improve the growth and yield of late sown mungbean which is sown on 25 October. Further study will be required to find out suitable amount of potassium and boron supplementation for improving yield of mungbean sowing on different times of the year.

Compliance with ethical standards

Acknowledgments

Authors would like to express their sincere gratitude to Head of the department of Agronomy and other concerned personnel of the department for valuable guide and support. The authors also like to thank the officials of Farm Division, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for their support to conduct the research.

Disclosure of conflict of interest

All the authors declare that there is no conflict of interest.

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