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Growth and seed yield of faba bean (*Vicia faba* L.) as influenced by zinc and boron micronutrients

Susmita Roy, Shrabani Das, Kallyan Kanty Saha, Md Rashedur Rahman, Shubroto Kumar Sarkar, Md Harun Rashid, Swapan Kumar Paul*

Department of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

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Sabina Yeasmin
sabinayeasmin@bau.edu.bd

*Corresponding Author
Swapan Kumar Paul
skpaul@bau.edu.bd

ABSTRACT

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh during November 2019 to March 2020, to study the effect of Zn and boron on growth and yield of faba bean (*Vicia faba* L.). The experiment consisted with three levels of zinc (Zn) *viz.* 0, 1.0 and 2.0 kg Zn ha^{-1} and four levels of boron *viz.* 0, 1.0 kg B ha^{-1}, 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) and 0.5 kg B ha^{-1} (foliar application at 30 days after sowing (DAS)) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage). The experiment was laid out in randomized complete block design with three replications. In case of Zn, the highest plant height (67.9 cm), pods plant^{-1} (33.3), seed yield (2.24 t ha^{-1}) and stover yield (2.55 t ha^{-1}) of faba bean was observed when fertilized with 1 kg Zn ha^{-1}, whereas the corresponding lowest values were recorded from control treatment. In case of B, the highest number of branches plant^{-1} (6.51), pods plant^{-1} (39.1), seed yield (2.14 t ha^{-1}) and stover yield (2.42 t ha^{-1}) were obtained from application of 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage). In interaction, the highest number of branches plant^{-1} (7.22), pods plant^{-1} (41.93), seed yield (2.46 t ha^{-1}) and stover yield (3.05 t ha^{-1}) were recorded from application of 1.0 kg Zn ha^{-1} with 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) whereas the lowest seed and stover yields were recorded from control treatment. Based on the present study, it can be concluded that application of 1.0 kg Zn ha^{-1} coupled with 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) appears as the promising combination in respect of seed yield of faba bean

Keywords: Micronutrients, faba bean, growth, yield, zinc, boron

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1 Introduction

Faba bean (*Vicia faba* L.) is one of the first domesticated food legumes (Caracuta et al., 2016) which is currently produced in more than 66 countries over the world (Merga et al., 2019; Paul and Gupta, 2021). Faba beans are widely grown for food and feed as a generous source of high-quality protein, dietary fibre and other other valuable nutrients (Khazaei and Vandenberg, 2020). it is considered an excellent protein crop due to its ability ot provide nitrogen inputs into temperate agricultural systems on account of its wide adaptation (Rispail et al., 2010), as well as its high yield potential and nitrogen-fixing capacity even when nitrogen is present in the soil (Herridge et al., 2008), compared with other grain legumes (Cernay et al., 2015). Faba bean is grown in some limited locally of Central and Northern part of Bangladesh under rabi season (Sheikh et al., 2020; Paul et al., 2021, 2022). There is a high dietary demand in Bangladesh due to its high population density. Due to cropping intensification, soil has become significantly poor in micronutrients content. So, additional micronutrient is necessary for effective crop cultivation.

Zinc (Zn) is one of the most important essential micronutrients required for optimum crop growth (Rashid et al., 2021; Hanifuzzaman et al., 2022; Rion et al., 2022). Zinc has important functions in protein and carbohydrate metabolism and activates many enzymes; tryptophan synthetase, superoxide dismutase, and dehydrogenase (Hassan et al., 2020). Low Zn reduces the plant protein content (Parihar et al., 2021; Joshi-Saha et al., 2022). It is directly influencing yield and quality because of its activity in biological membrane stability, enzyme activation capacity and auxin synthesis (Marschner, 1997; Ullah et al., 2020) and a vital element for root and shoot growth during the growing season (Rengel, 2001; Priyanka et al., 2019). Boron (B) has significant role in cell wall formation (Turan et al., 2018), cellular membrane functions (Wu et al., 2020), and anti-oxidative defense systems (Riaz et al., 2021a,b) and sugar translocation. Boron deficiency is a worldwide problem for field crop production (Landi et al., 2019; Brdar-Jokanović, 2020; Pereira et al., 2021) and availability of boron to plants is affected by a variety of soil factors (Das and Purkait, 2020; Brdar-Jokanović, 2020). Boron deficiency is responsible to poor podding due to flower dropping in soybean and other leguminous plants plants (Hajiboland et al., 2012; Uddin et al., 2020). Foliar application could restore the adverse effect of nutrients uptake from soil, and would be a key element of soil fertility sustainability (Salem et al., 2014). Application of B (El-Yazied and Mady, 2012) and Zn (Salama et al., 2012) to plants as essential microelements could play major roles in growth, metabolism and development (Khalifa et al., 2011). Therefore, the present study was undertaken to evaluate the growth and yield performance of faba bean under various level of Zn and B.

2 Materials and Methods

2.1 Experimental duration and site

The experiment was conducted at the Agronomy Field Laboratory (24°43′11.1″N, 90°25′42.2″E) of Bangladesh Agricultural University, Mymensingh, Bangladesh. The experimental area belongs to non-calcareous dark grey soil under Old Brahmaputra Floodplain soil (AEZ-9) (UNDP and FAO, 1988). The land was medium high with a silty-loam texture having pH 6.9, EC 0.4 dS m^{-1}, OC 1.00%, N 0.09%, P 1.60 ppm, K 0.10% meq per 100 g soil, Ca 8.30 meq per 100 g soil, Mg 3.29 meq per 100 g soil, S 2.98 ppm, Zn 0.21 ppm and B 0.23 ppm (Bithy et al., 2020; Das et al., 2022).

2.2 Experimental treatments and design

The experiment consists of two three level of Zn, *viz*. 0 kg Zn ha^{-1} (Z0), 1.0 kg Zn ha^{-1} (Z1) and 2.0 kg Zn ha^{-1} (Zn2); and four levels of B, *viz* 0 kg B ha^{-1} (B0), 1.0 kg B ha^{-1} (basal application) (B1), 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) (B2) and 0.5 kg B ha^{-1} (foliar application at 30 DAS) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) (B3). The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 12 treatment combination and 3 replications, with a total of 36 plots where treatments were allotted at random. The size of each plot was 2.5 m $\times$ 2.0 m.

2.3 Crop husbandry

Faba bean seeds used in the experiment were collected from Mithapukur (Rangpur District), Bangladesh. The experimental field was prepared by ploughing and cross ploughing followed by laddering by a power tiller. Urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, and boric acid was applied as a source of nitrogen, phosphorus, sulphur, and boron respectively. The fertilizers, urea, TSP and MoP were applied at the rate of 60, 175 and 120 kg ha^{-1}, respectively. The whole amount of TSP and MoP and 50% of urea was applied during final land preparation. The remaining urea was applied 30-day after germination of seedlings. Zinc and basal dose of boron were applied at final land preparation as per treatments. Foliar application was done at 30-day after sowing and pre-flowering stage according to the treatment. The seeds were sown in the furrow maintaining spacing of 30 cm $\times$ 20 cm and the furrows were covered with the soils soon after seeding. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the faba bean. During seed sowing, few seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap where seeds failed to germinate. All gaps were filled up within two weeks after germination of seeds. When the plants established, one healthy plant per hill was kept and remaining one was plucked. Overhead irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was done when needed. Stagnant water was effectively drained out at the time of heavy rains. Weeding's were done at 20, 35 and 50 DAS to keep the plots free from weeds, which ultimately ensured better growth and development.

2.4 Data collection

Four plants were randomly selected excluding border rows to record the data on plant height, number of branches plant^{-1}, chlorophyll content (SPAD value), number of nodules plant^{-1}, nodules dry weight plant^{-1}, shoot fresh weight plant^{-1}, and shoot dry weight plant^{-1}. Chlorophyll content of five fully expanded young leaves from each four plants was measured by using a portable SPAD meter (model SPAD-502, Minolta crop, Ramsey, NJ). Two plants were uprooted randomly from each plot (excluding border rows) to determine the dry matter plant^{-1}. Nodules plant^{-1} was calculated, detached and dried in an oven at 70 °C until constant weight was reached. Shoot dry weight and nodules dry weight plant^{-1} were taken by using an electric balance after proper drying. Prior to harvest four plants from each plot were collected at randomly excluding border rows and central area (1.5 m × 1.5 m). Data on crop characters and yield components were collected from these samples. Central 1.5 m × 1.5 m was harvested and dried properly. After threshing and cleaning, the yields of seed and straw were recorded and converted to t ha^{-1}.

2.5 Data Collection at harvest

Prior to harvest five plants from each plot were collected randomly excluding boarder plants and central 1.5 m × 1.5 m and tagged for the data collection. Data on crop characters and yield components were collected from these samples. Central 1.5 m × 1.5 m was harvested and dried properly. After threshing and cleaning, the yields of seed and straw were recorded and converted to kg ha^{-1}.

2.6 Data analysis

The recorded data were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done following the RCBD with the help of computer package MSTAT (Power, 1985). The mean differences were judged by Duncans Multiple Range Test (Gomez and Gomez, 1984).

3 Results and Discussion

3.1 Vegetative characters at 75 DAS

Vegetative characters of faba bean were significantly influenced by different doses of Zn application. The tallest plant (44.25 cm) and maximum number branches plant^{-1} (5.72) were recorded in 1.0 kg Zn ha^{-1} which was at ap with 2.0 kg Zn ha^{-1} while the shortest plant (42.54 cm) and maximum branches plant^{-1} (5.36) were found in control treatment (0 kg Zn ha^{-1}). Application of 1.0 kg Zn ha^{-1} gave the highest SPAD value (37.04) which was at par with 2.0 kg Zn ha^{-1} and the lowest value was recorded in control (0 kg Zn ha^{-1}). Aysen (2011) reported that application of Zn @ 1.0 kg ha^{-1} significantly enhanced the chlorophyll content in chickpea. The maximum number of nodules plant^{-1} (55.44) was obtained from application of 2.0 kg Zn ha^{-1}, which was at par with 1.0 kg Zn ha^{-1} (55.14). Similar trend was found by Quddus et al. (2011), who found that maximum number of nodules plant^{-1} was recorded from the application of 3.0 kg Zn ha^{-1} compared to other treatments. Application of 2.0 kg Zn ha^{-1} produced maximum nodules fresh weight (2.09 g) and dry weight (0.16 g) followed by 1.0 kg Zn ha^{-1}, however, minimum value of nodules fresh weight (0.15 g) and dry weight (0.12 g) plant^{-1} were found in control (0 kg Zn ha^{-1}) treatment (Table 1).

Different doses of boron application also significantly influenced the vegetative characteristics of faba bean (Table 2). Application of 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) produced the tallest plant (45.38 cm), highest number of branches plant^{-1} (6.00), maximum SPAD value (41.60), maximum number of nodules (57.64), maximum nodules fresh weight plant^{-1} (2.14 g). Quddus et al. (2018) also observed that nodulation increased with increase in rate of B application and the highest number of nodules was observed, when B was applied @ 2.0 kg ha^{-1}. Maximum nodules dry weight (0.17 g) was obtained when fertilized with 0.5 kg B ha^{-1} (foliar application at 30 DAS) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) which was at par with 0.5 kg B ha^{-1} (basal) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage). On the contrary, the lowest plant height (40.73 cm), the lowest number of branches plant^{-1} (5.22), minimum SPAD value (34.70), the lowest number of nodules plant^{-1} (45.37), the lowest nodules fresh weight (1.47 g), dry weight (0.12 g plant^{-1}) were found in control (0 kg Zn ha^{-1}) treatment (Table 1).

All the parameters under studied were significantly influenced by the interaction effect between Zn and B fertilizers (Table 2). At 75 DAS, combined application of Zn and B affects plant height non-significantly. Whereas, numerically the tallest plant (47.01 cm) was recorded from the application of 1.0 kg Zn ha^{-1} with 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage). The maximum number of branches plant^{-1} (6.44) was found in application of 1.0 kg Zn ha^{-1} with 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage). Similarly, application of 1.0 kg Zn ha^{-1} with 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) gave maximum SPAD value (44.29), maximum number of nodules plant^{-1} (59.11), maximum fresh weight (2.50 g) and dry weight-1 (0.19 g) of nodules plant^{-1}. Application of B or Zn was reported

Table 1. Effect of zinc and boron on vegetative characters of faba bean at 70 DAS

	Plant height (cm)	Branches plant^{-1}	SPAD value	Nodules plant^{-1}	Nodule FW (g plant^{-1})	Nodule DW (g plant^{-1})
Level of Zn						
Zn0	42.54b	5.36b	34.70b	48.10b	1.53c	0.13c
Zn1	44.25a	5.72a	37.04a	55.14a	1.976b	0.14b
Zn2	43.62ab	5.69a	36.86a	55.44a	2.09a	0.16a
Sig. level	*	**	**	**	**	**
Level of B						
B0	40.73c	5.55d	32.38d	54.26c	1.47d	0.12b
B1	43.95b	5.89b	34.42c	55.00c	1.84c	0.13b
B2	45.82a	6.51a	41.60a	72.72a	2.14a	0.16a
B3	43.38b	5.85c	36.39b	64.79b	1.47d	0.17a
Sig. level	**	**	**	**	**	**
CV (%)	3.3	4.42	2.89	6.52	3.78	6.05

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** = Significant at 1% level of probability; Zn0 = 0 kg ha^{-1}, Zn1 = 1 kg ha^{-1}, Zn2 = 2 kg ha^{-1}, B0 = 0 kg ha^{-1}, B0 = 0 kg ha^{-1}, B1 = 1 kg ha^{-1} (basal application), B2 = 0.5 kg ha^{-1} (basal application) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage), B3 = 0.5 kg ha^{-1} (foliar application at 30 days after sowing) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage)

Table 2. Effect of interaction between level of zinc and boron on vegetative characters of faba bean at 70 DAS

Interaction (Zn × B)	Plant height (cm)	Branches plant^{-1}	SPAD value	Nodules plant^{-1}	Nodule FW (g plant^{-1})	Nodule DW (g plant^{-1})
Zn0 × B0	39.07	4.88e	30.94f	30.60d	1.133	0.103fg
Zn0 × B1	42.68	5.22de	32.13ef	56.33ab	1.75e	0.146d
Zn0 × B2	45.29	5.89b	39.94b	57.16ab	1.62f	0.110ef
Zn0 × B3	43.13	5.44bcd	35.79cd	48.29c	1.61f	0.166bc
Zn1 × B0	40.91	5.33cd	33.02e	53.51abc	1.49g	0.090g
Zn1 × B1	45.47	5.55bcd	35.02d	52.33bc	1.92cd	0.106f
Zn1 × B2	47.01	6.44a	44.29a	59.11a	2.50a	0.193a
Zn1 × B3	43.61	5.55bcd	35.8cd	55.60ab	1.98c	0.180b
Zn2 × B0	42.21	5.44bcd	33.19e	52.00bc	1.81de	0.173b
Zn2 × B1	43.71	5.89b	36.12cd	56.32ab	1.84de	0.123be
Zn2 × B2	45.15	5.66bcd	40.56b	56.66ab	2.32b	0.173b
Zn2 × B3	43.4	5.78bc	37.57c	56.77ab	2.38ab	0.153cd
Sig. level	NS	**	**	**	**	**
CV (%)	3.3	4.42	2.89	6.52	3.78	6.05

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** = Significant at 1% level of probability; Zn0 = 0 kg ha^{-1}, Zn1 = 1 kg ha^{-1}, Zn2 = 2 kg ha^{-1}, B0 = 0 kg ha^{-1}, B0 = 0 kg ha^{-1}, B1 = 1 kg ha^{-1} (basal application), B2 = 0.5 kg ha^{-1} (basal application) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage), B3 = 0.5 kg ha^{-1} (foliar application at 30 days after sowing) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage)

Table 3. Effect of level of zinc on crop characters, yield components and yield of faba bean

Level of Zn (kg ha^{-1})	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	1000-seed wt. (g)	HI (%)
Zn0	61.92c	5.58b	31.41b	4.45c	3.10c	234.1b	47.56a
Zn1	67.97a	6.08a	33.38a	4.90a	3.47b	239.7a	46.56a
Zn2	65.01b	6.19a	33.28a	4.62b	3.59a	238.9a	44.38b
Sig. level	**	**	**	**	**	**	**
CV (%)	2.97	3.52	4.89	3.51	4.11	1.5	3.82

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** = Significant at 1% level of probability; Zn0 = 0 kg ha^{-1}, Zn1 = 1 kg ha^{-1}, Zn2 = 2 kg ha^{-1}

Table 4. Effect of level of boron on crop characters, yield components and yield of faba bean

Level of B (kg ha^{-1})	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	1000-seed wt. (g)	HI (%)
B0	63.46	5.55c	27.42d	4.15c	2.92c	233.6b	47.38a
B1	66.12	5.89b	34.02b	4.69b	3.22b	238.9a	45.58ab
B2	65.23	6.51a	39.16a	5.00a	3.69a	239.5a	47.13a
B3	65.04	5.85b	30.17c	4.78b	3.74a	238.2a	44.57b
Sig. level	NS	**	**	**	**	**	**
CV (%)	4.92	3.52	4.89	3.51	4.11	1.5	3.82

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); NS = not significant, ** = Significant at 1% level of probability; B0 = 0 kg ha^{-1}, B0 = 0 kg ha^{-1}, B1 = 1 kg ha^{-1} (basal application), B2 = 0.5 kg ha^{-1} (basal application) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage), B3 = 0.5 kg ha^{-1} (foliar application at 30 days after sowing) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage)

Table 5. Effect of interaction between level of boron on crop characters, yield components and yield of faba bean

Interaction (Zn × B)	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	1000-seed wt. (g)	HI (%)
Zn0 × B0	59.90f	5.22f	24.87g	3.69f	2.65f	229.4	46.41cde
Zn0 × B1	62.49ef	5.44ef	33.27de	4.56cde	3.00de	233	46.97bcd
Zn0 × B2	61.40ef	6.11c	37.40bc	4.79bc	3.22d	237.6	50.97a
Zn0 × B3	63.89cde	5.55ef	30.10f	4.79bc	3.55c	236.1	45.90cde
Zn1 × B0	66.18bcd	5.44ef	31.40ef	4.41de	2.89e	236.8	50.06ab
Zn1 × B1	67.53bc	5.66de	33.80de	4.82bc	3.55c	244.9	48.20abc
Zn1 × B2	71.41a	7.22a	41.93a	5.44a	3.79bc	239.5	44.71def
Zn1 × B3	66.75bc	6.00cd	26.40g	4.93b	3.66c	237.6	43.25ef
Zn2 × B0	64.31cde	6.00cd	26.00g	4.36e	3.22d	234.7	45.67cde
Zn2 × B1	68.33ab	6.55b	35.00cd	4.71bcd	3.11de	238.6	41.58f
Zn2 × B2	62.90def	6.21bc	38.13b	4.78bc	4.05a	241.3	45.71cde
Zn2 × B3	64.49cde	6.00cd	34.00de	4.63b-e	4.00ab	240.9	44.56def
Sig. level	**	**	**	**	**	NS	**
CV (%)	2.97	3.52	4.89	3.51	4.11	1.5	3.82

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); NS = not significant, ** = Significant at 1% level of probability; Zn0 = 0 kg ha^{-1}, Zn1 = 1 kg ha^{-1}, Zn2 = 2 kg ha^{-1}, B0 = 0 kg ha^{-1}, B0 = 0 kg ha^{-1}, B1 = 1 kg ha^{-1} (basal application), B2 = 0.5 kg ha^{-1} (basal application) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage), B3 = 0.5 kg ha^{-1} (foliar application at 30 days after sowing) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage)

to increase the contents of chlorophyll a, chlorophyll b and total chlorophyll in *Vicia faba* (cv. Giza- 716) was reported by Sharaf et al. (2009). On the other hand, the shortest plant (39.07 cm), minimum number of branches plant^{-1} (4.88), minimum SPAD value (30.94), the lowest nodules number plant^{-1} (30.60), the lowest fresh weight (1.33 g) and dry weight (0.09 g) of nodules plant^{-1} were obtained in control treatment (0 kg B ha^{-1}).

3.2 Crop growth and yield

Application of Zn affected almost all the parameters under studied (Table 3). At harvest, plant height and branches plant^{-1} of faba bean showed statistically significant variation due to application of different doses of Zn. the tallest plant (67.97 cm) was recorded in 1.0 kg Zn ha^{-1} followed by 2.0 kg Zn ha^{-1}. Quddus et al. (2011) found almost similar result, where 1.5 kg Zn ha^{-1} produced the tallest plant (45.9 cm) in mung bean. The highest number of branches plant^{-1} (6.19) was recorded from application of 2.0 kg Zn ha^{-1} which was at par with 1.0 kg Zn ha^{-1}. This probably due to the composition of the branches and the buds need to carbohydrate which depends basically on process synthesis and this process is increased by increasing the supply of Zn, which led to an increase in the number of branches. The maximum number of pods plant^{-1} (33.38) was recorded from application of 1.0 kg Zn ha^{-1}, which at par with application of recorded from 2.0 kg Zn ha^{-1}. This observation was in close conformity with the observations of Yirga et al. (2013) and Hossain et al. (2010) who found that number of pods plant^{-1} was increased significantly by the addition of Zn. The maximum number of seeds pod^{-1} (3.59) was recorded from application of 2.0 kg Zn ha^{-1}. Yirga et al. (2013) and Hossain et al. (2010) reported that application of Zn significantly increased number of seeds pod^{-1}. Application of 1.0 kg Zn ha^{-1} produced the longest pods (4.90) and the maximum value of 1000-seed weight (239.7 g) which was statistically identical with 2.0 kg Zn ha^{-1}. Comparable results were reported by Ali et al. (2017), who found that application of Zn application affects significantly on 1000-seed weight in lentil. The highest seed yield (2.24 t ha^{-1}) was obtained from application of 1.0 kg Zn ha^{-1} (Fig. 1). Similar trends were also observed by several authors in chickpea (Ryan and El-Moneim, 2007; Valenciano et al., 2011). The highest stover yield (2.55 t ha^{-1}) (Fig. 2) was obtained from application of 1.0 kg Zn ha^{-1} while maximum harvest index (47.56%) was recorded in 1.0 kg Zn ha^{-1} and control treatment (0 kg Zn ha^{-1}) while minimum one (43.96 %) was obtained in 2.0 kg Zn ha^{-1} (Table 3). The lowest value of all attributes under study were found in control treatment (0 kg Zn ha^{-1}). Application of Zn showed significant variation on harvest index was stated by Togay et al. (2004).

Different level of boron application showed statistically significant variation on various crop characters, yield components and yield except plant height (Table 4). Numerically the tallest plant (66.1 cm) was

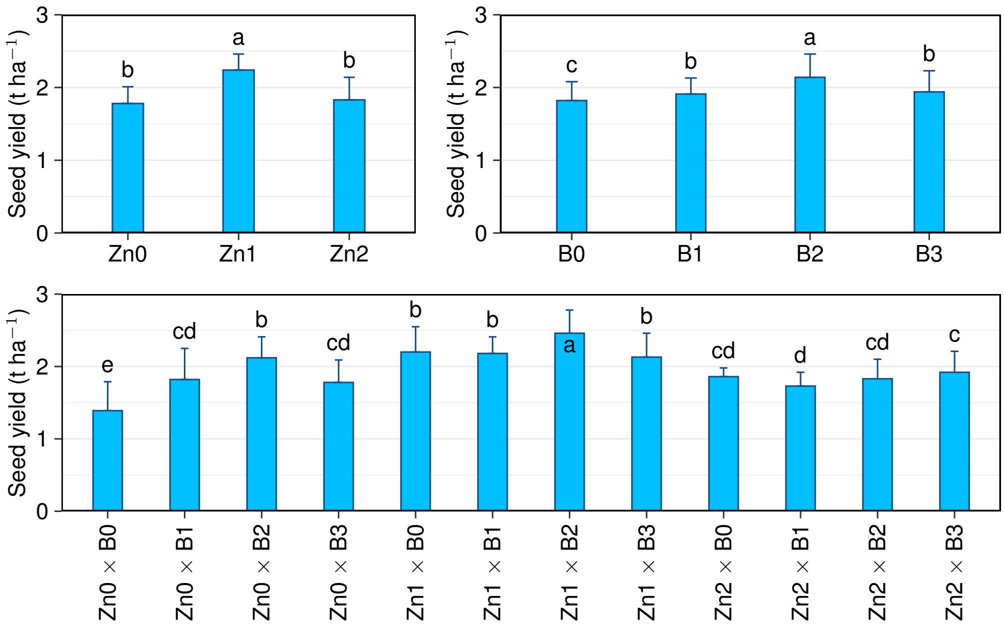

Figure 1. Effect of level of B, Zn and their interaction on seed yield of faba bean. Bars with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly at 5% level of probability; Zn0 = 0 kg ha^{-1}, Zn1 = 1 kg ha^{-1}, Zn2 = 2 kg ha^{-1}, B0 = 0 kg ha^{-1}, B0 = 0 kg ha^{-1}, B1 = 1 kg ha^{-1} (basal application), B2 = 0.5 kg ha^{-1} (basal application) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage), B3 = 0.5 kg ha^{-1} (foliar application at 30 days after sowing) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage)

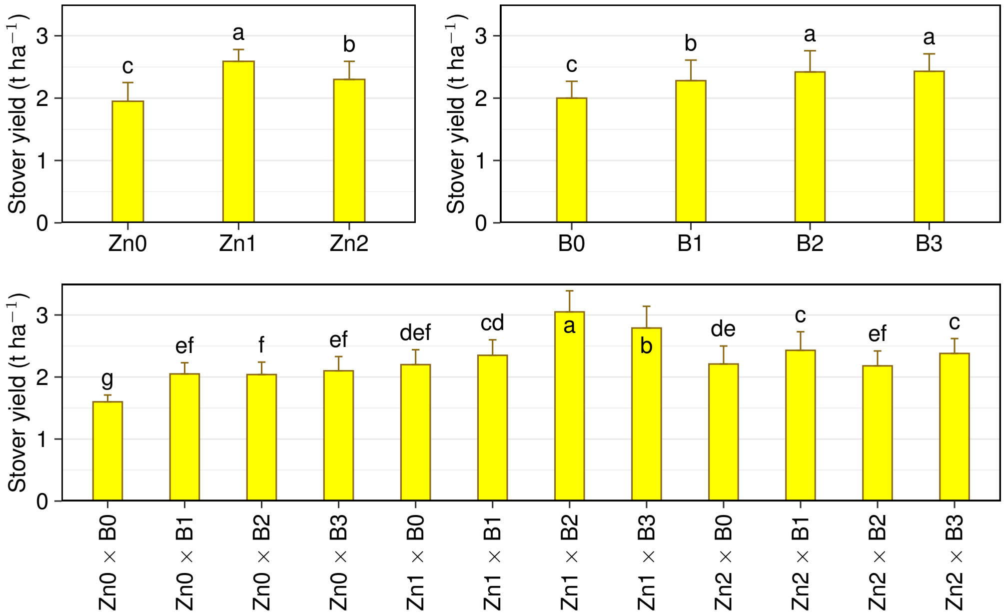

Figure 2. Effect of level of B, Zn and their interaction on stover yield of faba bean. Bars with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly at 5% level of probability; Zn0 = 0 kg ha^{-1}, Zn1 = 1 kg ha^{-1}, Zn2 = 2 kg ha^{-1}, B0 = 0 kg ha^{-1}, B0 = 0 kg ha^{-1}, B1 = 1 kg ha^{-1} (basal application), B2 = 0.5 kg ha^{-1} (basal application) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage), B3 = 0.5 kg ha^{-1} (foliar application at 30 days after sowing) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage)

recorded in application of 1.0 kg B ha^{-1} (basal). Application of 0.5 kg B ha^{-1} (basal dose) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) produced the highest number of branches plant^{-1} (6.51) and the maximum number of pods plant^{-1} (39.16) followed by 1.0 kg B ha^{-1}. The maximum seeds pod^{-1} (3.74) was obtained from 0.5 kg B ha^{-1} (foliar application at 30 days after sowing) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage), which is statistically identical (3.69) with application of 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stag). On the other hand, the application of 0.5 kg B ha^{-1} (basal) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) gave the maximum length of pod (5.00 cm) and maximum 1000-seed weight (239.5 g). Vimalan et al. (2017) depicted that application of B increased yield components of green gram. Boron application 0.5 kg ha^{-1} (basal dose) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage) produce the highest seed yield (2.14 t ha^{-1}) (Fig. 1). While the maximum stover yield (2.43 t ha^{-1}) was recorded in 0.5 kg B ha^{-1} (foliar application at 30 days after sowing) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) which was as good as treatment 0.5 kg ha^{-1} (basal dose) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage) (Fig. 2). Maximum harvest index (47.38%) was recoded in control which was at par with 1.0 kg B ha^{-1} (basal) and 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stag). Similar result was found by Mahajan et al. (1994) who noticed that the soil application of B @ 0.5 kg ha^{-1} increased harvest index significantly of groundnut. However, the lowest values of all attributes under study were found control boron (1.0 kg B ha^{-1}).

Interaction of Zn and B fertilizers showed significant variation among the parameters under studied (Table 5). Application of 1.0 kg Zn ha^{-1} with 0.5 kg B ha^{-1} foliar application (basal application) + 0.5 kg B ha^{-1} (foliar application) produced the tallest (71.41 cm). This result indicates that, plant height increased due to the combined combination of Zn and B application. Plant height of a crop depends on the plant vigor, cultural practices, growing environment and agronomic management. In the study since faba bean was grown in the same environment and were given same cultural practices except micronutrients. So, the variation of plant height might be due to the combined effect of different level of Zn and B fertilizer combinations. Similar result was found by Quddus et al. (2011) that is application of 1.5 kg ha^{-1} Zn with 1 kg B ha^{-1} produced maximum plant height (47.0 cm). The maximum branches plant^{-1} (7.22) and the highest number of pods plant^{-1} (41.93) were found from the application of 1.0 kg Zn ha^{-1} with 0.5 kg B ha^{-1} foliar application (basal application) + 0.5 kg B ha^{-1} (foliar application). On the other hand, the maximum seeds pod^{-1} (4.05) was found in 2.0 kg Zn ha^{-1} along with 0.5 kg B ha^{-1} (basal application) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage). Interaction effect of different levels of Zn and B showed statistically non-significant variation in terms of 1000-seed weight of faba bean. Numerically the maximum value of 1000-seed weight (244.9 g) was recorded from application of 1.0 kg Zn ha^{-1} along with 1.0 kg B ha^{-1}. Table 5 shows that application of 1.0 kg Zn ha^{-1} along with boron 0.5 kg ha^{-1} (basal) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage) produced bigger pods (5.44 cm), the highest seed (2.46 t ha^{-1}) (Fig. 1) and stover (3.05 t ha^{-1}) yields (Fig. 2). The reason of increased seed yield was due to increase number of branches plant^{-1}, pods plant^{-1} and seeds pod^{-1}. On the other hand, maximum harvest index (50.97%) is obtained from application of 0 kg Zn ha^{-1} with 0.5 kg B ha^{-1} (basal dose) + 0.5 kg B ha^{-1} (foliar application at pre-flowering stage). On the contrary, shortest plant (59.90 cm), lowest number of branches plant^{-1} (5.22), the lowest number of pods plant^{-1} (24.87), the lowest number of seeds pod^{-1} (2.65), the shortest pod (3.69 cm), the lowest value of 1000-seed weight (229.4 g), minimum seed yield (1.39 t ha^{-1}), stover yield (1.60 g) and the lowest harvest index (37.99%) found from control treatment. The lowest value of plant height, branches number plant^{-1}, pods plant^{-1}, seeds plant^{-1}, seed yield from control treatment was also found by Alhasany et al. (2019). From the present study, it can be supposed that the application of different levels of Zn and B and their interaction effect has significant impact on faba bean yield, where combined application of these two fertilizers is more effective than the single application of Zn or B.

4 Conclusion

Results indicated that Zn and B played a significant role on growth and seed yield of faba bean. The highest seed and stover yields were produced in Zn 1.0 kg ha^{-1}. Boron application 0.5 kg ha^{-1} (basal) + 0.5 kg ha^{-1} (foliar at pre-flowering stage) gave the highest seed and stover yields. In interaction, Zn 1.0 kg ha^{-1} along with 0.5 kg ha^{-1} (basal) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage) produced the highest seed and stover yields. Therefore, Zn and B at the rate of 1.0 kg ha^{-1} along with 0.5 kg ha^{-1} (basal) + 0.5 kg ha^{-1} (foliar application at pre-flowering stage) seems to be a promising combination in terms of seed yield of faba bean.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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