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Maximizing yield of mustard through zinc and boron fertilization

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Abstract

A field experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during November 2021 to January 2022 to evaluate the varietal response of mustard to zinc (Zn) and boron (B) fertilization. The experiment comprised two varieties viz., BARI Sharisa-14 and Binasharisa-11, and nine doses of Zn & B viz., Zn 0 kg ha^{-1} + B 0 kg ha^{-1} (control), Zn 2 kg ha^{-1}, Zn 4 kg ha^{-1}, B 2 kg ha^{-1}, B 4 kg ha^{-1}, Zn 2 kg ha^{-1} + B 2 kg ha^{-1}, Zn 2 kg ha^{-1} + B 4 kg ha^{-1}, Zn 4 kg ha^{-1} + B 2 kg ha^{-1} and Zn 4 kg ha^{-1} + B 4 kg ha^{-1}. The experiment was laid out in a randomized complete block design with three replications. Binasharisa-11 produced taller plants (115.09 cm), the highest number of branches plant^{-1} (7.85), 1000-seed weight (3.81 g), seed yield (1.76 t ha^{-1}) and stover yield (4.02 t ha^{-1}) while BARI Sharisa-14 gave the lowest values of all parameters. Application of Zn 2 kg ha^{-1} + B 2 kg ha^{-1} produced the highest number of branches plant^{-1} (8.82), total number of siliqua plant^{-1} (59.11), 1000-seed weight (4.29 g), seed yield (1.84 t ha^{-1}) and stover yield (4.23 t ha^{-1}) and lowest values were found in control. In case of interaction the highest number of branches plant^{-1} (9.62), effective siliqua plant^{-1} (54.08), number of seeds siliqua^{-1} (31.55), seed yield (2.0 t ha^{-1}) and stover yield (4.51 t ha^{-1}) were found in Binasharisa-11 fertilized with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} while the lowest values were recorded in BARI Sharisa-14 at control fertilization of Zn & B. Therefore, Binasharisa-11 fertilized with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} appears as the promising technique in terms of higher seed yield of mustard. However, further trials can be conducted at different agro-ecological zones of the country to confirm this result.

Keywords: Zinc, boron, yield performance, mustard

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1 Introduction

Mustard (*Brassica juncea* L.) is an important oilseed crop of the family cruciferae. Mustard cultivation covers 329671 ha with average yield 1.2 t ha^{-1} in Bangladesh (BBS, 2022). The main reason behind the low production of mustard in the country is the lack of good and improved varieties of seed (Miah et al., 2015). Depending on the varieties, the mustard seed contains about 40-44% oil and has around 40% protein in its cake, which always seeks the attention of farmers and the researchers (BARI, 2019). Among the mustard varieties in Bangladesh, BARI Sharisa-14 is very popular for its short duration and Binasharisa-11 is also recently released by BINA due to its short duration with other good characteristics.

Soil fertility is known to be the management of essential nutrient for plant growth, plant metabolism, completion of plant's life cycle and to achieve the selected objectives (McGrath et al., 2014). The mustard crop requires primary, secondary, and micronutrients in an adequate amount for higher production. Zinc and boron are the micronutrients essential for the growth and development of mustard plants. Zinc is essential for the growth, yield characteristics, quality, oil content, grain yield, seed quality and transportation of minerals and nutrients from the root surface to the plant's parts through diffusion (Sahito et al., 2014). Zinc is required for chlorophyll production, pollen function, fertilization and is involved in diverse metabolic activities, influences the actions of hydrogenase and carbonic anhydrase, synthesis of cytochrome, the stabilization of ribosomal fractions, and nitrogen metabolism, component of dehydrogenase, proteinase, promotes starch formation, seed maturation and has role in activation of enzymes in biosynthesis of oil. Deficiency of zinc causes marked decrease in number of pods, size of pods and boldness of seed (Adkine et al., 2017) and harms biomass production, seed yield, carbohydrate content, and certain enzymes in the plant more importantly, it also affects the oil content of mustard (Sinha et al., 2000). Mustard is very responsive to the boron application in the soil and many study shows numerous reports on positive response to boron application (Halim et al., 2023). Boron fertilization is necessary for the improvement of crop yield as well as nutritional quality (Das et al., 2022; Rashid et al., 2012). Boron application produced the best quality of seeds in respect of the protein content of mustard (Yanthan and Singh, 2021). The rate of water adsorption and carbohydrate transaction restricts due to boron deficiency (Mounika et al., 2021) and reproductive growth stage, especially flowering, fruit and seed sets are more sensitive than vegetative growth. Several factors like soil solution, pH, texture, moisture, temperature, oxide content, carbonate content, and clay mineralogy affect the availability of boron to the plants (Hossain et al., 2012). Boron is vital for the development and differentiation of sugar content in the plant. It also helps in the expected uptake of nitrogen (N) and makes up the calcium (Ca) deficiency. Thus, a suitable combination of zinc and boron must be applied in soil for quality production and yield development of mustard crops. The main objective of the research is to assess the varietal response of mustard to zinc and boron application and their interactions.

2 Materials and Methods

2.1 Experimental site

The site is located at 24°43′8.3″N, 90°25′41.2″E, in the South- West part of Old Brahmaputra river at an altitude of 18 m. The site belongs to non-calcareous dark grey floodplain soil under Old Brahmaputra Floodplain 'AEZ-9' (UNDP, 1988). The land type was medium high with silty loam in texture. The experimental area belongs to a sub-tropical climate and is characterized by moderate temperature accomplished by moderately high rainfall during the Rabi season (October to March) and high temperature in Kharif season (March to October).

2.2 Experimental design and treatments

The experiment was laid out in a two factor randomized complete block design (RCBD) design with three replications. The treatment comprised of two varieties BARI Sharisa-14 (V1) and Binasharisa-11 (V2) and nine levels of application of zinc and boron viz. Zn0B0 (Control) (F0), Zn 2 kg ha^{-1} (F1), Zn 4 kg ha^{-1} (F2), B 2 kg ha^{-1} (F3), B 4 kg ha^{-1} (F4), Zn 2 kg ha^{-1} + B 2 kg ha^{-1} (F5), Zn 2 kg ha^{-1} + B 4 kg ha^{-1} (F6), Zn 4 kg ha^{-1} + B 2 kg ha^{-1} (F7) and Zn 4 kg ha^{-1} + B 4 kg ha^{-1} (F8). Each block was divided into 18-unit plots, where the 18 treatment combinations were allocated at random. Altogether there were 54-unit plots in the experiment. The net size of each unit plot was 2.5 m × 2.0 m.

2.3 Crop husbandry

Mustard variety BARI Sarisha-14 and Binasharisa-11 were used as test crop. The land was prepared on 25 October 2021 after ploughing and cross ploughing followed by laddering. The plots were laid out in the field on 9 November 2021. The experimental plot was fertilized with urea, triple super phosphate, muriate of potash and gypsum at the rate of 260, 170, 90 and 160 kg ha^{-1}, respectively. Half of the total dose of urea and the full dose of triple super phosphate, muriate of potash and gypsum were applied at the time of final land preparation. The rest of half dose of urea was top dressed during pre-flowering stage of mustard. Zinc and boron were applied in the form of zinc sulphate and boric acid at the time of final land preparation along with other fertilizers as per experimental treatments. The seeds of both varieties were sown on 9 November 2021 continuously (@ 7 kg ha^{-1}) by hand as uniform as possible in the 30 cm apart rows. After sowing, the seeds were covered with soil. Weeds of different types were found to infest the crops and were controlled manually for the first time and removed from the field on 24 November 2021. At the same time first thinning was done. The final weeding and thinning were done after 25-day of sowing, on 19 December 2021. The regular care was taken to maintain constant plant population plot^{-1}. The crop wasn't supplied with any insecticide and pesticide throughout the entire research because of any significant infestation with insects and pests.

2.4 Harvesting and data collection

The crop was harvested plot wise when 90% siliqua were matured. Prior to harvest five plants were randomly collected from each plot to data recording on crop characters and yield components. After collecting the sample plants, both the varieties were harvested on 31 January 2022. Harvesting was done in the morning to avoid shattering. The harvested plants were tied into bundles and carried to the threshing floor. The plants were sun dried by spreading the bundles on the threshing floor. The seeds were separated from the stover by beating the bundles with bamboo sticks. Seed and stover yields were recorded after drying the plants in the sun followed by threshing and cleaning. The grains were cleaned and sun dried and finally grain and straw yields plot^{-1} were recorded and converted to t ha^{-1}.

2.5 Statistical analysis

Data on different parameters were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done with the help of computer package MSTAT. The mean differences among the treatments were tested with Duncan's Multiple Range Test (Gomez and Gomez, 1984).

3 Results

3.1 Plant height

The study shows that there is significant (P<0.01) difference in plant height in response to variety (Table 1). Binasharisa-11 (115.09 cm) was the taller in comparison to BARI Sharisa-14 (101.78 cm) (Table 1). The variation in plant height as assessed might be due to varietal characters. The study didn't reveal any significant (P>0.05) difference in plant height in response to doses of Zn & B. Numerically the tallest plant (111.39 cm) was observed with plant treated with Zinc (4 kg ha^{-1}) and the shortest plant height (105.27 cm) was observed in control treatment (Table 1). The plant height was found to be significantly (P<0.01) different in various treatment group in response to interaction between variety and doses of Zn & B (Table 2). The tallest plant (119.09 cm) was observed in Binasharisa-14 with 4 kg Zn ha^{-1} which is also statistically identical with same variety treated with B 2 kg ha^{-1}, 2 kg Zn, 4 kg B, 2 kg Zn + 2 kg B, 2 kg Zn + 4 kg B, 4 kg Zn + 2 kg B and 4 kg Zn + 4 kg and shortest plant (100.30 cm) was found in BARI Sharisa-14 with 4 kg B ha^{-1}.

3.2 Number of branches plant^{-1}

There was significant (P<0.01) variation in the number of branches plant^{-1} between the varieties. The large number of branches plant^{-1} (7.85) were found in the Binasharisa-11 as compared to BARI Sharisa-14 (6.31) (Table 1). The study showed significantly (P<0.01) differences in the number of branches plant^{-1} in response to doses of Zn & B. The lower number of branches plant 1 (8.82) was recorded in mustard treated with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} followed by 4 kg Zn ha^{-1} and the least one (5.66) was observed in control treatment (Table 1). The result was supported by Sahito et al. (2014) who found number of branches plant^{-1} (10.86) was maximize with the application of Zn and B. Significant (P<0.001) differences in the number of branches plant^{-1} was found due to the interaction effect of variety and doses of Zn & B. The higher number of branches plant^{-1} (9.62) were observed in Binasharisa-11 with Zn 2 kg ha^{-1} +B 2 kg ha^{-1} which is also statistically identical with same variety (9.05 cm) treated with Zn 4 kg ha^{-1} and less number of branches plant^{-1} (5.17) was observed in BARI Sharisa-14 with control treatment (Table 2).

3.3 Number of total siliqua plant^{-1}

Varieties didn't show any significant (P>0.05) difference in producing number of total siliqua plant^{-1}. Although numerically BARI sharisa-14 produces higher number of total siliqua plant^{-1} (47.16) and Binasharisa-11 produces lower number of total siliqua plant^{-1} (45.97) (Table 1). The study showed significant (P<0.001) difference in producing number of total siliqua plant^{-1} in response to different doses of Zn and B. The highest number of total siliqua plant^{-1} (59.11) was observed in mustard treated with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} followed by 2 kg B and 4 kg B ha^{-1} and the lowest number of total siliqua plant^{-1} (37.69) was observed in mustard with control treatment (Table 1). The highest number of total siliqua plant^{-1} (59.44) was observed in Barisharisa-11 with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} which was at par with BARI Sharisa-14 (58.79) with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} and least number of total siliqua plant^{-1} was recorded in BARI Sharisa-14 (36.66) which is statistically similar with Barisharisa-11 (38.37) in control treatment (Table 2).

3.4 Number of effective siliqua plant^{-1}

Effective siliqua plant^{-1} was not significantly (P>0.005) influenced by variety (Table 1). However, numerically higher number of effective siliqua plant^{-1} (41.43) was produced in Binasharisa-11 compared to BARI Sharisa-14 (40.01) (Table 1). The number of effective siliqua plant^{-1} produced was significantly (P<0.001) different among the mustard treated with doses of Zn & B. The highest number of effective siliqua plant^{-1} (53.43) was produced by the mustard treated with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} followed by 2 kg B and 4 kg B and the lowest number of effective siliqua plant^{-1} (31.97) was produced in control treatment (Table 1). Number of effective siliqua plant^{-1} was significantly (P<0.001) increased by the interaction of variety and doses of Zn & B. The maximum number of effective siliqua (54.08) plant^{-1} was observed in Binasharisa-11 with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} treatment which is statically identical with BARI Sharisa-14 (52.78) with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} and the minimum number of effective siliqua plant^{-1}

Table 1. Effect of variety and application of zinc and boron on crop characters and yield contributing characters of mustard

Treatment	PH	BP	TS	ES	SL	SS	WTS	SY	BY	HI
Variety										
V1	101.78b	6.31b	47.16	40.01	4.3	25.2	3.72b	3.13b	4.55b	31.29
V2	115.09a	7.85a	45.97	41.43	4.39	26.16	3.81a	4.02a	5.79a	30.7
Sig. level	**	**	NS	NS	NS	NS	25.2	3.72b	**	NS
Zn & B doses										
F0	105.27	5.66f	37.69d	31.97e	4.33ab	22.75c	3.30e	2.70f	4.13e	34.48a
F1	108.7	6.36e	44.33c	38.12cd	4.52a	25.41bc	3.73bcd	3.13e	4.82d	35.31a
F2	111.39	7.74b	46.99bc	39.93c	4.56a	25.98bc	3.71cd	3.37d	4.93d	31.60b
F3	109.36	7.39bc	49.15b	43.93b	4.32ab	24.57bc	3.74bcd	3.58c	5.16c	30.89bc
F4	105.99	7.16c	50.16b	43.90b	4.60a	25.59bc	3.74bcd	3.78b	5.31b	28.86d
F5	108.28	8.82a	59.11a	53.43a	4.30ab	29.73a	4.29a	4.23a	6.07a	30.34bcd
F6	108.37	7.11c	45.75c	40.65bc	3.93b	26.04b	3.84bc	3.83b	5.40b	29.16cd
F7	109.7	6.98cd	40.41d	35.55de	4.53a	25.91bc	3.69d	3.78b	5.37b	29.52cd
F8	108.88	6.49de	45.49c	39.00cd	4.05ab	25.14bc	3.86b	3.80b	5.34b	28.77d
Sig. level	NS	**	**	**	*	**	**	**	**	**
CV%	5.19	6.89	5.87	7.85	5.49	3.11	5.47	3.32	2.24	5.16

Table 2. Interaction effect of varieties and doses of zinc and boron on crop characters and yield contributing characters of mustard

Treatment	PH	BP	TS	ES	SL	SS	WTS	SY	BY	HI
V1F0	101.14d	5.17h	36.66h	30.65g	2.49j	23.15cd	3.30i	2.49j	3.75k	33.46bc
V1F1	101.53d	5.75fgh	43.78ef	37.82def	2.70i	25.15bcd	3.80c-f	2.70i	4.32ij	37.45a
V1F2	103.70cd	6.42ef	48.39bcd	42.16bcd	2.96h	25.03bcd	3.88bcd	2.96h	4.30j	30.99c-g
V1F3	101.24d	7.62bcd	49.21bc	43.62bc	2.93h	24.67bcd	3.64fgh	2.93h	4.31j	31.99c-f
V1F4	100.30d	6.42ef	47.94b-e	42.21bcd	3.47ef	24.59bcd	3.58gh	3.47ef	4.88f	28.93gh
V1F5	100.96d	8.02b	58.79a	52.78a	3.95cd	27.91ab	4.25a	3.95cd	5.64d	29.94e-h
V1F6	102.68cd	6.11f	46.44c-f	40.76bcd	3.20g	27.44abc	3.64fgh	3.20g	4.60gh	30.41e-h
V1F7	100.76d	5.99fg	38.18gh	32.91fg	3.33fg	23.93bcd	3.64fgh	3.33fg	4.72fg	29.45fgh
V1F8	103.73cd	5.28gh	44.36def	37.18def	3.16g	24.95bcd	3.75d-g	3.16g	4.45hij	28.95gh
V2F0	109.39bcd	6.15f	38.73gh	33.30efg	2.91h	22.34d	3.29i	2.91h	4.51hi	35.50ab
V2F1	115.87ab	6.97de	44.88c-f	38.43de	3.55e	25.66bcd	3.65e-h	3.55e	5.32e	33.17bcd
V2F2	119.08a	9.05a	45.60c-f	37.70def	3.78d	26.94bcd	3.54h	3.78d	5.57d	32.22cde
V2F3	117.48ab	7.15cde	49.10bc	44.23b	4.22b	24.47bcd	3.84cde	4.22b	6.01c	29.78e-h
V2F4	111.67abc	7.90bc	52.38b	45.59b	4.09bc	26.60bcd	3.91bcd	4.09bc	5.74d	28.79gh
V2F5	115.60ab	9.62a	59.44a	54.08a	4.51a	31.55a	4.32a	4.51a	6.51a	30.74d-g
V2F6	114.07ab	8.12b	45.06c-f	40.54bcd	4.47a	24.64bcd	4.05b	4.47a	6.20bc	27.91h
V2F7	118.64ab	7.97b	42.64fg	38.18def	4.24b	27.90ab	3.74d-g	4.24b	6.03c	29.59e-h
V2F8	114.02ab	7.70bcd	46.62c-f	40.82bcd	4.44a	25.32bcd	3.97bc	4.44a	6.22b	28.58gh
Sig. level	**	**	**	**	**	**	**	**	**	**
CV (%)	5.19	6.89	5.87	7.85	3.32	7.88	3.11	3.32	2.24	5.16

PH = plant height, BP = number of branches plant^{-1}, TS = number of total siliqua plant^{-1}, ES = number of effective siliqua plant^{-1}, SL = siliqua length (cm), SS = number of seeds siliqua^{-1}, WTS = weight of 1000 seeds (g), SY = stover yield (t ha^{-1}), BY = biological yield (t ha^{-1}), and HI = harvest index (%); Figures in a column under each factor of treatment having the 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, *= Significant at 5% level of probability, NS = Not significant, V1 = BARI sharisa-14, V2 = Binasharisa-11, F0 = No B & Zn, F1 = 2 kg Zn ha^{-1}, F2 = 4 kg Zn ha^{-1}, F3 = 2 kg B ha^{-1}, F4 = 4 kg B ha^{-1}, F5 = 2 kg Zn + 2 kg B ha^{-1}, F6 = 2 kg Zn + 4 kg B ha^{-1}, F7 = 4 kg Zn + 2 kg B ha^{-1}, and F8 = 4 kg Zn + 4 kg B ha^{-1}

(30.65) was observed in BARI sharisa-14 which was statically identical with Barisharisa-11 (33.30) with control treatment (Table 2).

3.5 Length of siliqua

The study didn't reveal any significant (P<0.001) difference in the length of siliqua between the varieties. Numerically longer siliqua (4.39 cm) observed in

Binasharisa-11 and shorter siliqua (4.30 cm) was observed in BARI sharisa-14 (Table 1). The study revealed that the application of different doses of Zinc and Boron had significant (P<0.005) difference among the length of siliqua (Table 1). Mustard treated with B 4 kg ha^{-1} was produced the longest siliqua (4.60 cm) while treatment of Zn 2 kg ha^{-1} + B 4 kg ha^{-1} produced shortest (3.93 cm) siliqua. There was significant (P<0.001) difference with the interaction of variety and different doses of Zn & B for the length of the siliqua. The longest siliqua (4.51 cm) was found in Binasharisa-11 treated with B 4 kg ha^{-1} which was statically identical with Barisharisa-11 with same treatment and the shortest one (2.49 cm) was found in BARI Sharisa-14 with Zn 4 kg ha^{-1} + B 4 kg ha^{-1} (Table 2).

3.6 Number of seeds siliqua^{-1}

The study revealed that the number of seed per siliqua wasn't significant (P>0.005) between the verities. However, numerically Binasharisa-11 produced higher number of seeds siliqua^{-1} (26.16) compared to BARI Sharisa-14 (25.20) (Table 1). The study showed that the number of seeds siliqua^{-1} produced was significantly (P<0.001) different between the varieties. Mustard treated with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} was found to be higher number of seeds siliqua^{-1} (29.73) and lower number of seeds siliqua^{-1} produced by the mustard with control treatment. Variety and doses of Zn and B interact significantly (P<0.001) different with each other in producing number of seed siliqua^{-1} (Table 2). The highest seeds siliqua^{-1} (31.55) was produced by Binasharisha-11 with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} which is also statistically identical with BARI Sharisa-14 with the same treatment and the lowest seed siliqua^{-1} (22.34) was produced by Binasharisha-11 with control treatment (Table 2).

3.7 1000-seed weight

Significant (P<0.001) difference was found in 1000-seed weight between the varieties. Table 1 showed that Binasharisa-11 had the higher 1000-seed weight (3.81 g) compared to BARI Sharisa-14 (3.72 g). These differences might be due to variations in the genetic make-up of the varieties. Significant (P<0.001) difference was found in 1000-seed weight (g) of mustard treating with different doses of Zn & B as shown in (Table 1). Mustard treated with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} was found to have higher 1000-seed weight (4.29 g) and lower weight (3.30 g) was found in control treatment. Variety and different doses of Zn and B interact significantly (P<0.001) different with each other on 1000-seed weight (Table 2). The highest 1000-seed weight (4.32 g) was found in Binasharisa-11 with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} which is statistically identical with BARI Sharisa-14 (4.25 g) with the same treatment and lowest 1000-seed weight (3.29 g) was found in Binasharisa-11 which is also statistically significant with BARI Sharisa-14 (3.30 g) with control treatment.

3.8 Seed yield

The study showed that the seed yield of mustard was significantly (P<0.001) influenced by variety. The variety Binasharisa-11 produces the higher seed yield (1.76 t ha^{-1}) as compared to BARI Sharisa-14 which produces significantly lower seed (1.41 t ha^{-1}) (Fig. 1A). This deviation might be due to variation in the genetic make-up of the varieties. The highest seed yield of Binasharisa-11 is due to the contribution of higher number of branches plant^{-1}and heavier seeds of this variety. Fig. 1B shows that mustard treated with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} produced higher seed yield (1.84 t ha^{-1}) followed by 2 kg Zn $^{-1}$ (1.69 t ha^{-1}) and the lowest seed yield (1.42 t ha^{-1}) was found in control. Variety and different doses of Zn and B interact significantly (P<0.001) different with each other in producing seed yield. The highest seed yield (2.00 t ha^{-1}) was produced in Binasharisa-11 with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} treatment and lowest seed yield (1.25 t ha^{-1}) was produced by BARI Sharisa-14 with control treatment (Fig. 1C).

3.9 Stover yield

The highest stover yield (4.02 t ha^{-1}) was found in Binasharisa-11 and the lowest stover yield (3.13 t ha^{-1}) was found in BARI sharisa-14 (Table 1). The highest stover yield of Binasharisa-11 is due to the contribution of taller plant and higher number of branches plant^{-1}. Effect of different doses of Zn and B in stover yield of mustard was found to be significant (P<0.001) difference. The highest stover yield (4.23 t ha^{-1}) was found in mustard treated with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} while lower stover yield (2.70 t ha^{-1}) was found in control treatment (Table 1). Variety and different doses of Zn and B interact significantly (P<0.001) in producing stover yield. The highest stover yield (4.51 t ha^{-1}) was produced by Binasharisha-11 with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} treatment which is statistically identical with same variety with Zn 2 kg ha^{-1} + B 4 kg ha^{-1} (4.47 t ha^{-1}) and Zn 4 kg ha^{-1} + B 4 kg ha^{-1} (4.44 t ha^{-1}) while the lowest stover yield (2.49 t ha^{-1}) was produced by BARI Sharisa-14 with control treatment (Table 2).

3.10 Biological yield

The study revealed that the biological yield was significantly (P<0.001) different. The highest biological yield (5.79 t ha^{-1}) was found in the Binasharisa-11 and lowest (4.55 t ha^{-1}) was found in BARI Sharisa-14 (Table 1). Biological yield was found to be significantly (P<0.001) different among the different doses

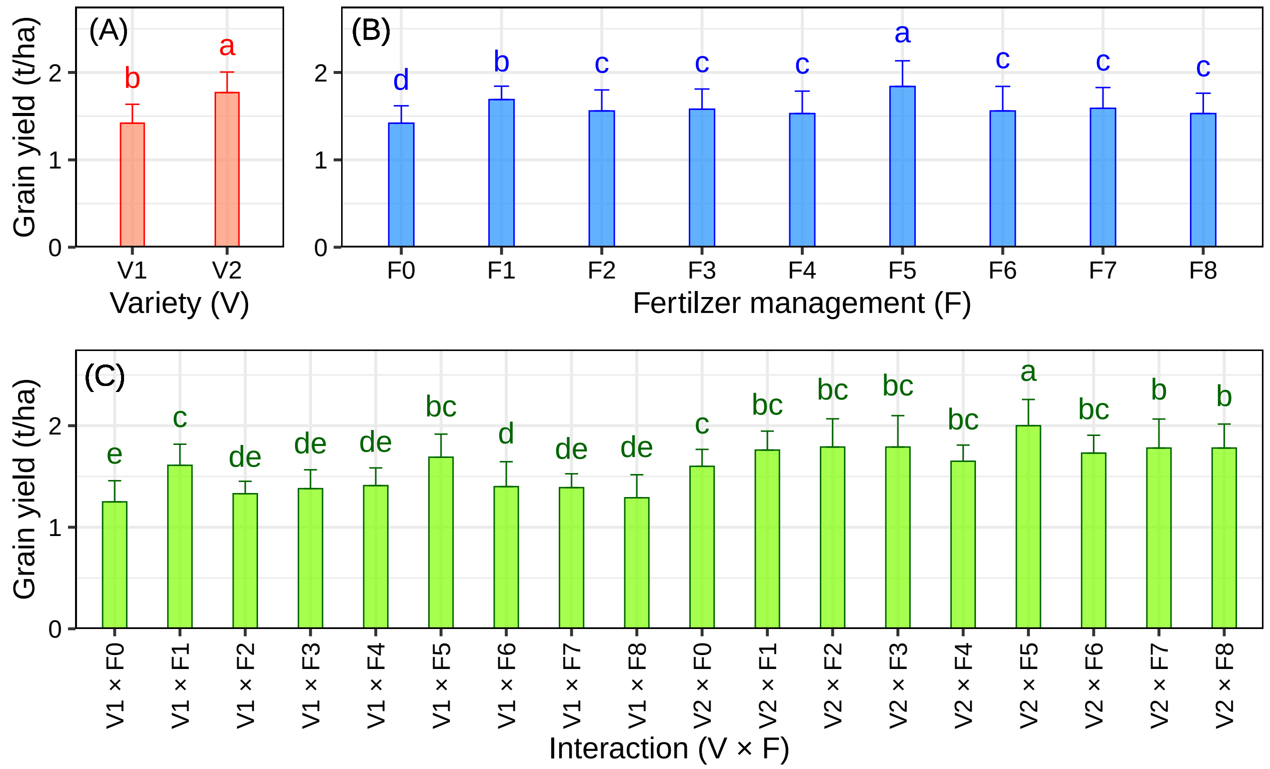

Figure 1. Effect of (A) variety, (B) fertilizer management, and (C) interaction of variety and fertilizer management on seed yield with values represented as mean±SE. Bar with different superscript alphabet differs significantly ($p<0.05$); V1 = BARI sharisa-14, V2 = Binasharisa-11, F0 = No B & Zn, F1 = 2 kg Zn ha^{-1}, F2 = 4 kg Zn ha^{-1}, F3 = 2 kg B ha^{-1}, F4 = 4 kg B ha^{-1}, F5 = 2 kg Zn + 2 kg B ha^{-1}, F6 = 2 kg Zn + 4 kg B ha^{-1}, F7 = 4 kg Zn + 2 kg B ha^{-1}, and F8 = 4 kg Zn + 4 kg B ha^{-1}

of mustard. The result showed that higher biological yield (6.07 t ha^{-1}) was found in mustard treated with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} while lower biological yield (4.13 t ha^{-1}) was found in control treatment (Table 1). Variety and different doses of Zn and B interact significantly (P<0.001) different with each other in producing biological yield. The highest biological yield (6.51 t ha^{-1}) was produced by Binasharisa-11 with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} treatment and lowest biological yield (3.75 t ha^{-1}) was produced by BARI Sharisa-14 with control treatment (Table 2).

3.11 Harvest index

The harvest index wasn't found any significant (P>0.001) difference between the variety. numerically higher harvest index (31.29%) was found in the variety BARI Sharisa-14 while lower harvest index (30.70%) was found in Binasharisa-11 (Table 1). The study showed that the significant (P<0.001) difference was found in harvest index. The highest harvest index (35.31%) was found for the treatment Zn 2 kg ha^{-1} while lower harvest index (28.77%) was found in Zn 4 kg ha^{-1} + B 4 kg ha^{-1} treatment (Table 1). Variety and different doses of Zn and B interact significantly (P<0.001) different with each other in harvest index. The highest harvest index (37.45%) was produced by BARI Sharisa-14 with Zn 2 kg ha^{-1} treatment and lowest harvest index (27.91%) was produced by Binasharisa-11 with Zn 2 kg ha^{-1} + B 4 kg ha^{-1} treatment (Table 2).

4 Discussion

Binasharisa-1 produced tallest plant, higher number of branches plant^{-1}, heavier seed, seed and stover yield compared to BARI Sharisha-14. The varietal attributes and genetic characters may have attributed to the variation of plant characters and yield between these varieties. Sahito et al. (2014) and Singh et al. (2017) also reported significant differences in crop characters, yield components and yield in various varieties of mustard plant. Significant variation of seed yield among the mustard genotypes were reported by Rashid et al. (2012) and Choudhary and Bhogal (2017). Among the micronutrients, zinc is one of the essential plant micronutrients and its importance for crop productivity is similar to that of major nutrients (Singh and Singh, 2017). It is vital component for the biomass production and oil content of the mustard seed (Sinha et al., 2000). In this study, Zn application increases the crop characters, vital yield components and like branches plant^{-1}, siliqua plant^{-1}, seeds siliqua^{-1}, 1000-seed weight, seed yield, stover yield, biological yield and harvest index of both varieties compared to control. The increase of yield components may be attributed to increased seed and stover yields. Similar results were reported by Singh and Singh (2017). It might be due to higher rate of Zn not suitable for mustard plants which depend on soil Zn status. Although Zn has been proven to be challenging factor for the growth and development, high yield, pollen formation and fertilization of the mustard plant (Sultana et al., 2020). Similarly, boron is closely associated with the growth of plants and plays a vital role in cell division. Boron is involved in synthesis of oil and protein (Kumararaja et al., 2015). All characters of plants including yield components and yield increased when fertilized with 2 kg ha^{-1} compared to control. The results were also supported by Mounika et al. (2021) who reported that B 2 kg ha^{-1} produced maximum number of siliqua plant^{-1}. The findings were supported by Yanthan and Singh (2021) with the application of B 1 kg ha^{-1} and also the result was partially supported by Masum et al. (2019) who revealed that with increase in Boron application 1000-seed weight also increases. The study was partially supported by Masum et al. (2019) who found biological yield increases with increased level of boron application which may be due to the cumulative of photosynthate and favorable effect of the seed and stover yield of mustard. The findings were similar to the findings pf Yanthan and Singh (2021) and Kumararaja et al. (2015). The findings were supported by Yanthan and Singh (2021). That indicated boron involves in plant growth and improvement of yield in a certain level. In this study we found that application of Zn @ 2 kg ha^{-1} along with B @ 2 kg ha^{-1} increased plant height, number of branches, total siliqua plant^{-1}, number of effective siliqua plant^{-1}, number of seeds siliqua^{-1} and biological yield increases with the increment in the dose of Zinc @ 4 kg ha^{-1}. Similar trend was reported by Timmi et al. (2023) who reported that combined application of Zn and B may be effective approach in terms of crop characters, yield components, seed yield and oil content of mustard.

5 Conclusion

Binasharisa-11 produced higher yield compare to BARI Sharisa-14. In case of interaction the highest number of branches plant^{-1}, effective siliqua plant^{-1}, number of seeds siliqua^{-1}, seed yield and stover yield were found in Binasharisa-11 fertilized with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} while the lowest values were recorded in BARI Sharisa-14 with control fertilization of Zn & B. Therefore, Binasharisa-11 fertilized with Zn 2 kg ha^{-1} + B 2 kg ha^{-1} appears as the promising technique in terms of higher seed yield of mustard. However, further trials can be conducted at different agro-ecological zones of the country to confirm this result.

Conflict of Interest

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

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