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INFLUENCE OF BORON AND MOLYBDENUM ON YIELD ATTRIBUTES OF MUSTARD

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Abstract

Boron and Molybdenum play a remarkable role in crop production and they are especially important for oil seed crops. Mustard is a very important oil seed crop in Bangladesh. The optimum and adequate levels of boron and molybdenum are very important for attaining a higher quality yield of oil seed crops. This study was carried out to investigate the influence of boron, molybdenum, and their interactions on yield and yield attributes of mustard var. Binasarisha-5 at the experimental field of Bangladesh Institute of Nuclear Agriculture, Mymensingh. Three levels of boron (0,1 and 2 kg/ha) and two levels of molybdenum (0 and 20 ppm) were used as treatment variables. Molybdenum was sprayed at the maximum vegetative growth stage. The experiment was laid out in a randomized complete block design with four replications. Results showed that the mean effects of boron and molybdenum significantly influenced the growth and yield of mustard. Application of 2 kg B/ha gave a significant influence on most of the yield contributing characters which resulted in the highest seed yield/ha (1294 kg/ha). Interactions of boron and molybdenum significantly influenced the seeds/siliqua, seed yield/plant, shoot weight/plant, shell weight/plant, seed yield /ha, straw yield/ha, and biological yield /ha. Seed yield (1337 kg/ha) was the highest with the interaction of 2 kg/ha application of boron and foliar spary of 20 ppm molybdenum. So, it is concluded that B and Mo application may increase the seed yield of mustard.

Keywords: Boron and Molybdenum application, Micronutrient, Mustard, Binasarisha-5

Introduction

Edible oil is an integral part of our daily diet and mustard (*Brassica* sp.) is the most important oil seed crop in Bangladesh. In Bangladesh, about 3.01 percent of the total cropped area is used for edible oilseed crop cultivation with an annual production of 358 thousand metric tons covering 763 thousand acres of (BBS, 2021). If mustard covers 70% of the total oil-cropped area and produces 64% of the oil seed production (BBS, 2021). Bangladesh is facing a huge deficit of edible oil. Bangladeshis consume 20 lakh

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tonnes of edible oil a year, while the local production covers around only around 2 lakh tonnes. The imported 18 lakh tonnes of edible oil incorporate 46% soybean and 53% palm oil (Ali and Faruque, 2022). Domestic production of edible oil almost entirely comes from mustard, groundnut, and sesame. Mustard is grown in the rabi season usually under rain-fed and low input conditions with the average yield of mustard being very low 1.15 t/ha (BBS, 2021) only as compared with the world average yield (2.32 t/ha) (USDA, 2022). The poor yield of mustard might be attributed to inappropriate uses of production inputs like fertilizers, and seeds and a lack of knowledge on improved technologies for crop production.

The practice of intensive cropping with modern varieties causes a marked depletion of inherent nutrient reserves in the soils of Bangladesh. Consequently, along with N, P, and K deficiencies, some micronutrient deficiencies *viz*. B, Zn, and Mo have also appeared in some soils and crops (Khanam *et al.*, 2001, Islam *et al.*, 1997; Jahiruddin *et al.*, 1995). Molybdenum deficiency was found in soils with very low p^H and in strongly weathered soil (William and Bennet, 1996). Brassica is sensitive to low boron supply and severe deficiency may result in floral abortion and a significant drop in seed production (Yang *et al*., 1989). The ranges between the deficiency and toxicity of B are quite small and an application of B can be extremely toxic to plants at a concentration only slightly above the optimum rate (Gupta *et al*., 1985). The uptake and requirement of molybdenum differ in different development stages, soil, plant part, sampling dates, and treatment among cultivars and species (Thompson *et al.*, 1970). Keeping the view of the above discussion, the present study was undertaken to standardize the optimum amount of B and Mo required for the growth and development of mustard.

Materials and Methods

The experiment was conducted at the experimental field of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The experimental site is belonging to Agroecological Zone AEZ- 09 of Old Brahmaputra Floodplain. The geographic coordinates of the trial site are $24^{'}75^0$ N latitude and $90^{'}50^0$ E longitude with its elevation about 18 meters above sea level. Three levels of boron (B_1-0, B_2-1, and B_3-2 kg/ha) and two levels of molybdenum (Mo_1-0 and Mo_2-20 ppm) were used as treatments variables the treatments were laid out in a factorial randomized complete block design with four replications and the unit plot size was 3m x 1m. The B fertilizer was applied as a basal dose in the form of borax and the Mo fertilizer as ammonium molybdate. Seeds of mustard var. Binasarisha-5 was sown on 10 October 2006 at the seed rate of 10 kg/ha in a line 15 cm apart. The field was also fertilized with 150, 40, 60, 40, and 4 kg/ha of N, P, K, S, and Zn, respectively as a source of Urea, TSP, MP, Gypsum, and Zinc sulphate (Z_nSo_4). The whole amount of TSP, gypsum, and zinc sulphate was applied as a basal dose. Urea was applied in three splits: $^1/_3$ as basal, $^1/_3$ at 28 DAS, and the rest $^1/_3$ at 50% flowering stage, respectively. Other intercultural operations such as weeding, thinning, water management, and pest management were done as and when necessary.

Soil samples were randomly collected at 0-30 cm soil depth for physical and chemical analysis before the commencement of the experiment. The physicochemical properties of the field experimental plot are summarized in the Table 1.

Table 1. Physical and chemical properties of the soil of the experimental field

Constituents	Sand	Silt	Clay	Textural Class	pH	OC	OM	N	P	S	K	Zn	B	Mb
						Physical properties				Chemical composition				
		(%)					(%)		ppm		(%)		ppm	
Result	22.4	66.5	11.1	Silt loam	6.84	0.74	1.28	0.07	9.3	9.0	0.27	3.3	16	2
				Critical Level				0.12	7.0	10.0	0.12	0.6	0.2	0.1

OC= Organic Carbon; OM=Organic Matter; N= Total nitrogen; P= Available phosphorus; S = Available sulphur; K= Exchangeable potassium; Zn= Available Zinc; B= Available boron, Mb = Available molybdenum and ppm= parts per million.

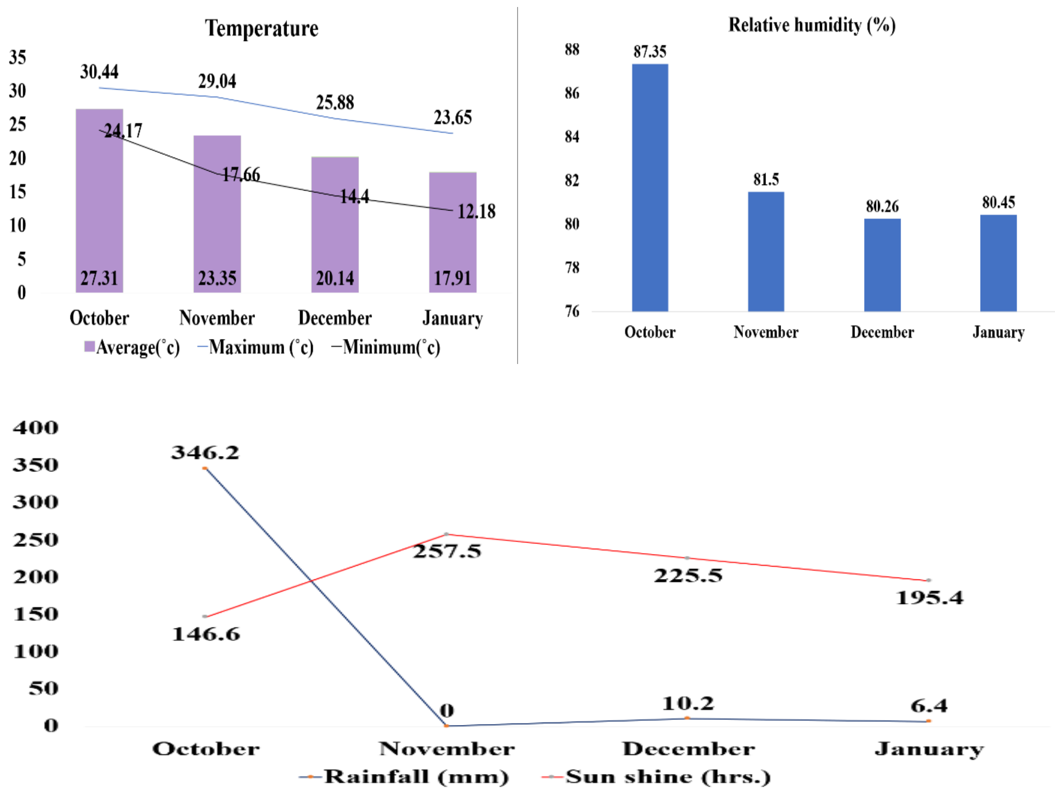

Fig. 1. Distribution of monthly average temperature and relative humidity Rainfall and duration of sunshine of the experiential site during the period from October 2006 to January 2007.

Source: Weather yard, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh.

High temperature and heavy rainfall characterize the climate of the experimental area during the *kharif* season (April to September) and scanty rainfall in *rabi* season

(October to March) is associated with moderately low temperatures and plenty of sunshine. The agro–climatic condition pertaining to monthly mean values of the daily maximum, minimum, and average temperature, relative humidity, monthly total rainfall, and sunshine hours receive at the experimental site during the study period is mentioned below.

Data on yield and yield components such as Plant height (cm), Number of branches/plant, Number of flowers/plant, Number of pod setting /plant, Percentage of siliqua/plant, Number of siliqua/plant, seeds/siliqua, 1000-seed weight (g), Seed yield /plant (g), Seed yield (kg/ha), Shell weight /plant (g), Shoot dry weight /plant (g), Straw yield (kg/ha), Biological yield (kg/ha), Harvest index (%) were recorded. All the collected data were analyzed statistically and mean differences were adjudged by LSD at 5% level of probability.

Results and Discussion

Effects of boron on morphological and yield attributing characters

Boron application had a significant effect on seed yield and yield attributes of all characters except the percentage of pod setting/ plant of mustard (Table 2). Results revealed that the tallest plant (93.57 cm) was produced with B_3 application and the lowest plant height (85.93 cm) was recorded in B_1 (Table 2). Hu *et al.,* (1994) and Pradhan and Sarkar (1993) also reported that the application of B to rape seed mustard significantly increased plant height. The maximum number of branches/plants (3.08) was found in the highest dose of boron application. The results are in agreement with that of Mathew and George (2013), who reported that the application of boron increased the number of branches/plants. The main reason for increasing branches might be the role of boron in cell division, tissue differentiation, carbohydrate metabolism, and maintenance of conducting tissue with regulatory effects on other elements. The highest number of flowers per plant (45.31) was recorded in those plots where 2 kg B/ha was applied as basal dose. The lowest number of flowers per plant (41.23) was found with control (0 kg/ha) which was statistically similar to 1 kg/ha boron application (42.27) (Table 2).

The study stated that 2 kg/ha boron application produced the maximum number of total pod sets/plant (34.58). The minimum number of total pod sets/plant (29.68) was found 1kg/ha boron application which was statistically similar to the control (29.95) (Table 2). Shen *et al*., (1993) also reported that B application markedly increased the pod setting of mustard. The beneficial effect of B on yield attributes may be due to its role in flower development, pollen grain formation, pollen viability, and pollen tube growth for proper pollination and seed development. The percentage of pod setting /plant was affected insignificantly by different levels of boron application and molybdenum spraying (Table2.). From the experimental results, it was evident that the highest percentage of pod setting/plant (76.16) was recorded in those plots where 2 kg B/ha was applied as basal. The lowest number of percentages of pod sets/plants (70.36) was found in 1kg B/ha (Table 2).

The number of siliqua/plant (69.67) obtained in 2 kg/ha differed significantly from the control in respect of the number of siliqua/plants (Table 2). The results were in full agreement with the findings of Yadav *et al*., (2016) who reported that number of siliqua/plants increased significantly with increasing B levels. The number of seeds/siliquae ranged from 15.35 to 18.54. The maximum number of seeds/siliqua (18.54) was recorded with 2 kg/ha boron application and it was followed by 1 kg/ha boron (Table 2). But seeds/siliqua of control plots was identical to 1 kg B/ha although there were numerical differences. The lowest number of seeds/siliqua (15.35) was obtained with the control. Bowszys (1996) reported that the effect of boron on rape seed formation was good and it significantly increased seed yield. Yadav *et al*., (2016) mentioned some significant positive effects of B application on mustard seed yield attributes such as the number of siliquae per plant, length of siliqua, and the number of seeds per siliqua. The results presented in Table 2 indicated that the 1000-seed weight was the highest (3.78 g) when 2 kg B/ha has applied and the lowest 1000-seed weight in control (3.07 g). Similar results were found by Subbaiah and Mittra (1996) who reported that 1000-seed weight was increased by boron application. The maximum shell weight/plant (8.89 g) was found from 2 kg/ha boron which was statistically different from other treatments and the lowest in control (7.93 g) (Table 2). The highest shoot dry weight/plant (12.86 g) was found from 2 kg B/ha which was statistically different from 1 kg B/ha (11.66 g). The control plant showed significantly the lowest shoot dry weight/plant (10.68 g). Application of 2 kg/ha boron produced the highest seed yield /plant (10.70 g) which was statistically superior to other treatments (Table 2). The seed yield/plant (10.38 g) was obtained from 1 kg/ha boron which is statistically better than to control (10.22 g).

Table 2. Effects of boron on morphological and yield attributing characters of mustard (var. Binasarisha-5)

Treatment	Plant height (cm)	Number of branches/ plants	Number of flowers/ plants	Number of pod sets/ plant	Percentage of pod setting/ plant	Number of siliqua/ plant	Seeds/ siliqua	1000-seed weight (g)	Seed yield/ plant (g)	Shell weight (g)	Shoot dry weight (g)
B_1	85.93b	3.08c	41.23b	29.95b	72.75	60.93c	15.35c	3.07c	10.22 c	7.93 b	10.68 c
B_2	87.90b	3.47b	42.27b	29.68b	70.36	65.15b	17.45b	3.44b	10.38 b	8.44 ab	11.66 b
B_3	93.57a	3.81a	45.31a	34.58a	76.16	69.67a	18.54a	3.78a	10.70 a	8.89 a	12.86 a
LSD (0.01)	3.01	0.05	2.52	3.05	NS	3.07	0.17	0.15	0.11	0.25	0.14
CV (%)	4.12	2.13	2.63	4.12	3.00	2.31	2.43	3.26	9.12	3.45	2.42

Different levels of boron application showed a significant influence on the seed yield of mustard (Fig.2). The highest seed yield (1.29 t/ha) was recorded from 2 kg/ha boron application. The lowest seed yield was observed in control (B_1) (91.24 t/ha), which was significantly different from B_2 and B_3 treatments (Fig. 2).

Differences and Means in a column followed by the same letter(s) are not significantly different at 5% level of significance. B_1= No boron (control), B_2= 1kg B/ha and B_3=2kg B/ha, From the results it was clear that the application of B significantly increased the seed yield of mustard. Similar results were observed by Bora and Hazarika (1997) and Yadav *et al*., (2016) who reported that boron application increased the seed yield of mustard. The increase in seed yield might be due to the positive effect of B application on yield-attributing characters. The maximum straw yield (1.61 t/ha) was observed when 2 kg boron was applied as basal which was statistically different from 1 kg boron/ha (1.53 t/ha) and also from the control. The minimum straw yield was observed with control (1.43 t/ha) which differed significantly from B_1 and B_2 treatments (Fig. 2). Biological yield is the sum of seed yield and stover (straw) yield (Bijalwan and Dobriyal, 2014). The application of 2 kg B/ha gave the highest biological yield (2.90 t/ha) and it was the lowest in control (2.67 t/ha) (Fig.2). The biological yield increased with increasing boron rates, which might be due to the cumulative and favorable effect of the seed and straw yield of mustard. The Harvest index helps to measure the difference between the potential and actual yield. It is the ratio between grain yield and plant yield. The highest harvest index (46.31%) was recorded in control and the lowest harvest index (44.65%) was in 2 kg B/ha which was similar to 1 kg B/ha (45.14%) (Fig. 2) application.

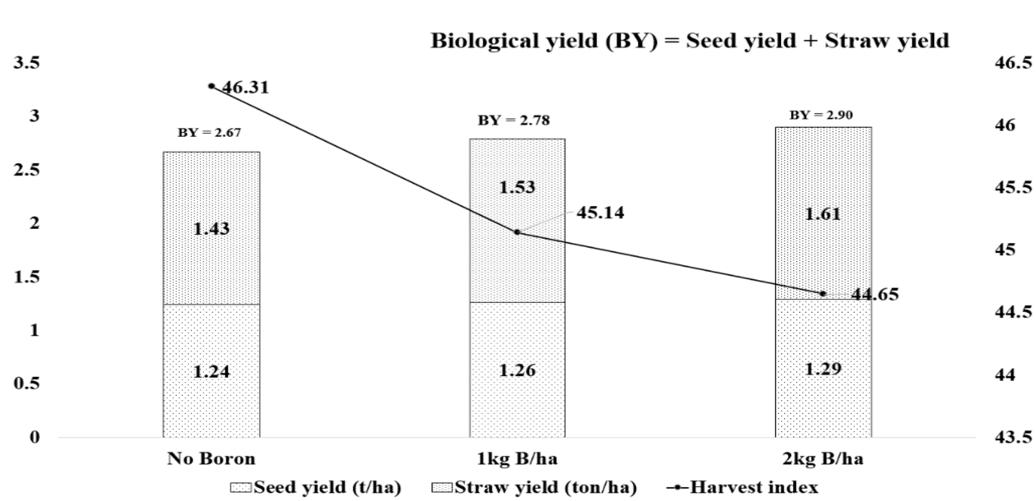

Fig. 2. Effects of Boron dosses on seed yield(t/ha), Straw yield (t/ha), Biological yield (t/ha), and Harvest Index (%) of mustard. B_1= No boron (control), B_2= 1kg B/ha and B_3=2kg B/ha

Effects of Molybdenum on morphological and yield attributing characters

Table 3, showed that molybdenum application had a significant effect on Plant height (cm), Number of branches /plant, Number of flowers /plant, Number of pod setting /plant, seeds /siliqua, 1000-seed weight (g), Seed yield /plant (g), Seed yield (kg/ha), Shell weigh t/plant (g) and Shoot dry weight /plant (g). But the percentage of pod setting /plant and no. of siliqua /plant gave statistically similar responses against molybdenum application. Rao *et al.,* (2006) also reported that the improvement of crop growth and additional yield depends on the additional application of micronutrients along with molybdenum. The plant height (90.50 cm), branches /plant (3.55), flowers /plant (44.74), total pod sets /plant (33.25), seeds /siliqua (17.60), 1000- seed weight (3.56 g), seed yield/plant (10.63 g), shell weight /plant (8.80 g), shoot dry weight /plant (12.13 g) were exhibited highest where molybdenum was sprayed @ 20 ppm at the maximum vegetative growth stage. But pod setting /plant and number of siliqua /plants showed no effect on molybdenum application.

Table 3. Effects of molybdenum on morphological and yield attributing characters of mustard (var. Binasarisha-5)

Treatment	Plant height (cm)	Number of branches / plants	Number of flowers/ plants	Number of pod sets/ plant	Pod setting/ plant (%)	Number of siliqua / plant	Seeds/ siliqua	1000-seed weight (g)	Seed yield/ plant (g)	Shell weight (g)	Shoot dry weight (g)
Mo_1	87.77b	3.36b	41.14b	29.55b	71.92	64.72	16.82b	3.30b	10.23 b	8.03 b	11.34 b
Mo_2	90.50a	3.55a	44.74a	33.25a	74.26	65.79	17.60a	3.56a	10.63 a	8.80 a	12.13 a
LSD (0.01)	2.46	0.04	2.061	2.49	5.04	2.51	0.14	0.13	0.09	0.21	0.12
CV (%)	4.12	2.13	2.13	4.12	3.00	2.31	2.43	3.25	9.12	3.45	2.42

Means in a column followed by the same letter(s) are not significantly different at 1% level of significance. Mo_1 = No molybdenum (control) and Mo_2 = 20 ppm molybdenum spray

When molybdenum was applied @ 20 ppm at the maximum vegetative stage, the seed yield (1.29 t/ha), straw yield (1.59 t/ha), and biological yield (2.69 t/ha) remained superior over control (Bo_1) Similar result was observed by Hugar and Kurdikeri (2002) who reported that in molybdenum application increased seed yields. But in the case of harvest index (%), the treatment Bo_2 showed the lowest result (44.72%). (Fig.3)

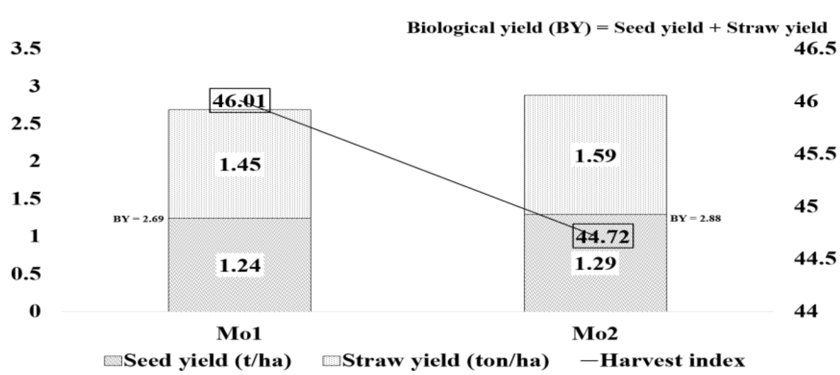

Fig. 3. Effects of Molybdenum dosses on seed yield (t/ha), Straw yield (t/ha), Biological yield (t/ha), and Harvest Index (%) of mustard. Mo_1 = No molybdenum (control) and Mo_2 = 20 ppm molybdenum spray

Interaction effect of boron and molybdenum on morphological and yield attributing characters of mustard

The result showed that basal application of 2 kg/ha boron fertilizer with one spray of molybdenum @ 20 ppm at maximum vegetative growth stage produced the tallest plant of 95.32 cm. Results also indicated that boron in combination with molybdenum had higher plant height and it was more prominent with a higher boron rate

(Table 4). The interaction of boron and molybdenum application did not show a significant effect on the number of branches per plant, number of total pod sets /plant, percentage of pod setting /plant, number of siliqua /plant, and 1000- seed weight (Table 4). The number of seeds/siliquae was influenced significantly by the combined application of boron and molybdenum where the basal application of 2 kg/ha boron with 1 spray of 20 ppm molybdenum at the maximum vegetative growth stage produced the maximum number of seeds/siliqua (19.13). Results also indicated that control plots had the lowest number of seeds/siliqua (14.80) (Table 4). So, boron in higher doses with molybdenum had a positive effect on seeds /siliqua in mustard. The interaction of boron and molybdenum had also a significant effect on seed yield /plant, shell weight /plant, and shoot dry weight /plant. The highest seed yield /plant (11.05 g) was found with B_3Mo_1 treatment combination and the lowest in B_1Mo_1 (10.15 g) (Table 4).

Table 4. Effect of molybdenum on morphological and yield attributing characters of mustard (var. Binasarisha-5)

Treatment	Plant height (cm)	Number of branches/ plants	Number of flowers/ plants	Number of pod sets/ plant	Percentage of pod setting/ plant	Number of siliqua/ plant	Seeds/ siliqua	1000-seed weight (g)	Seed yield/plant (g)	Shell weight (g)	Shoot dry weight (g)
B_1Mo_1	84.98	2.97	40.85	28.41	69.71	60.18	14.08f	2.99	10.15 d	7.68 d	10.14 f
B_1Mo_2	86.88	3.19	41.62	31.49	75.80	61.67	15.90e	3.15	10.28 cd	8.18 c	11.21 e
B2Mo1	86.51	3.40	40.40	29.15	72.29	64.69	17.11d	3.33	10.20 cd	8.15 c	11.43 d
$B2Mo_2$	89.30	3.53	44.15	30.22	68.42	65.62	17.78c	3.55	10.55 b	8.73 b	11.90 c
$B3Mo_1$	91.82	3.69	42.17	31.10	73.76	69.27	18.55b	3.58	10.35 c	8.27 c	12.44 b
B_3Mo_2	95.32	3.94	48.45	38.06	78.57	70.07	19.13a	3.97	11.05 a	9.50 a	13.27 a
LSD (0.01)	4.26	0.08	3.56	4.31	8.74	4.35	0.24	0.22	0.15	0.36	0.21
CV (%)	4.12	2.13	2.63	4.12	3.00	2.31	2.43	3.25	9.12	3.45	2.42

Means in a column followed by the same letter(s) are not significantly different at 1 % level of significance.

B_1= No boron (control), B_2= 1kg B/ha and B_3=2kg B/ha, Mo_1 = No molybdenum (control) and Mo_2 = 20 ppm molybdenum spray

The increase in seed yield /plant was mainly due to an increase in the seed/siliqua. Seed yield (t/ha), straw yield (t/ha), and biological yield (t/ha) responded significantly to the interactive application of boron and molybdenum. (Fig. 4). Biological yield increased due to an increase in seed yield and shoot dry weight. But interaction effect of boron and molybdenum had no significant effect on the harvest index. However, numerically maximum harvest index (46.93%) was recorded in control and the lowest harvest index (43.76%) in B_3Mo_2 (Fig. 4).

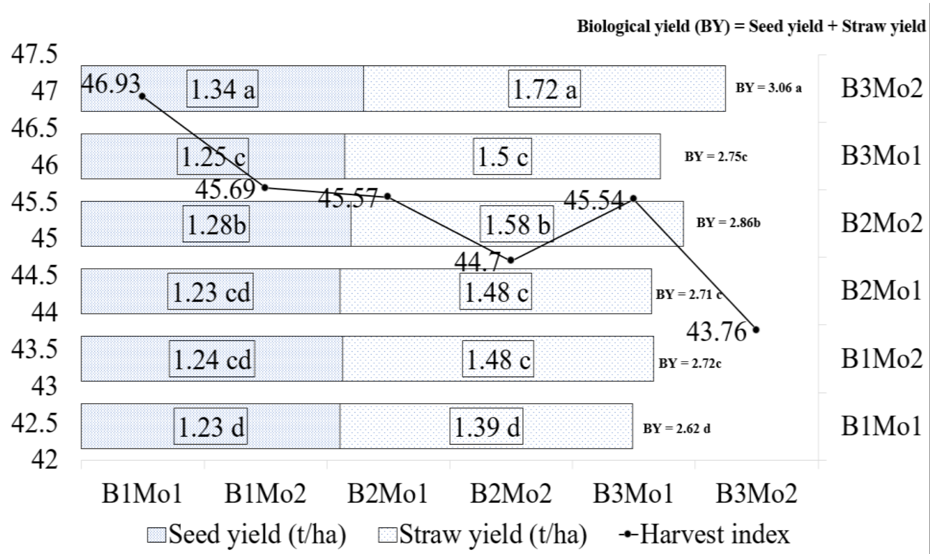

Fig. 4. Interaction effects of seed yield (t/ha), straw yield (t/ha), biological yield (t/ha), and harvest index (%) of mustard. B_1= No boron (control), B_2= 1kg B/ha and B_3=2kg B/ha, Mo_1 = No molybdenum (control) and Mo_2 = 20 ppm molybdenum spray

Conclusion

Boron fertilizer increased the yield. Molybdenum also influenced the yield. The highest seed yield was obtained by using 2 kg/ha boron ads basal and 20 ppm molybdenum spraying at the maximum vegetative stage.

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Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

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