Journal of Agroforestry and Environment

Volume 16, Issue 2, 2023

Journal DOI: https://doi.org/10.55706/jae
Journal homepage: www.jagroforenviron.com

Effect of Boron and Zinc Fertilization on Yield of Mustard (cv. BARI sarisha-14)

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Received: 13/08/2023

Accepted: 30/12/2023

Available online: 08/02/2024

Abstract: Bangladesh has to import a significant quantity of mustard seeds to meet its growing demand due to the seeds' high oil content and the oilcake, which is rich in protein and used as animal feed. The impact of zinc and boron on mustard (cv. BARI sarisha-14) output was investigated in a field experiment that was carried out at Bangladesh Agricultural University (BAU), Mymensingh, from October 2017 to March 2018. There are five levels of zinc (0, 2.5, 5, 7.5, and 10 kilograms per hectare) and boron (0, 0.5, 1.0, 1.5, and 2.0 kilogram per hectare) in this experiment. Three replications of the experiment, each with a plot size of three meters by two meters, were set up using a Randomized Complete Block Design (RCBD Height of the plant, number of branches per plant, total number of pods per plant, number of effective pods per plant, number of ineffective pods per plant, length of pod (cm), number of seeds per pod, weight of 1000 grains, seed yield, Stover yield, biological yield, harvest index and controlled treatment performed the lowest for these attributes were found when 2.5 kilogram per hectare of zinc were given. The treatment of 1.5 kilogram per hectare boron produced the highest plant height, number of branches per plant, total number of pods, number of effective pods per plant, number of non-effective pods per plant, length of pod (cm), number of seeds per pod, weight of 1000 grains, seed yield, stover yield, biological yield, and harvest index, while the controlled treatment produced the lowest performance. It is noticeable from the growth, yield, post-harvest procedures, and analytical results that the Zn 2.5 kilogram per hectare and B 1 kilogram per hectare combinations were appropriate for mustard farming.

Keywords: Nutrient; Fertilizer; Boron; Zinc; Mustard.

INTRODUCTION

The mustard crop is a member of the Crucriferae family, namely the genus *Brassica*. Bangladesh cultivates a variety of oil crops, some of which are significant ones and include soybean, peanut, sunflower, mustard, and rapeseed. For the people of Bangladesh, mustard is an excellent source of oil. It's essential for improving the flavor of several different foods. Its oil is frequently used as a culinary and therapeutic ingredient (Halim *et al*., 2023). Additionally, manure made from mustard oilcake is utilized. Fish and animal feed can also be made from dry mustard sticks. Important raw materials for industrial applications, like paints, varnishes, soaps, and the like, are also made from it. Among oil seed crops, mustard is the most productive crop in terms of hectares planted. In particular, Bangladesh produces 3,62,860 tons and 8,31,260 acres of planted land for rape and mustard seed, respectively (BBS, 2018). Against a 1.4-million-ton annual requirement, the nation produces just about 0.36 million tons of edible oil (FAO, 2018). As a result, Bangladesh continues to be a net importer of oil, and as the population grows and food habits and awareness of nutrition change, so too will the demand for oil. Since Bangladesh is a developing nation with a growing population and decreasing land, we must produce more food on the little area we have. More cereal crops are being grown by farmers in order to supply the fundamental demand for food. Due to farmers are unwilling to utilize their fertile land for mustard agriculture, mustard cultivation is now limited to marginal ground. Its decreased yield is another factor contributing to the decline in mustard farming. However, mustard grows well in Bangladesh due to its favorable agroclimatic conditions. Because of its lower production, their low socioeconomic status, and lack of understanding, Bangladeshi farmers typically cultivate mustard with just one plowing and very little usage of fertilizers and irrigations. There is a lot of potential improvement in mustard yield with better management techniques.

Micronutrients, such as B, Zn, Mo, and Mg, are crucial for raising the productivity of mustard farming. The development of seeds, cell division, and the absorption of water are all highly dependent on boron. According to Brown *et al*. (2002), several boron-sensitive crops exhibit indications of shortage such as browning and chlorosis in immature leaves, destroyed growth tips, roots and deformed flower growth. According to Goldberg *et al*. (2000), a number of soil parameters, comprising the contents of organic matter, temperature, pH, moisture, texture, oxide, and carbonate, might alter a plant's availability of B.

Zinc is a necessary component for the proper growth and development of plants. It is crucial for several plant metabolic processes, including the production of chlorophyll, respiration, cell wall growth, enzyme activity, and other biochemical processes. It is a necessary component of numerous enzymes, including carbonic anhydrase, superoxide dismutase, alcohol dehydrogenase, and RNA polymerase. A zinc deficit in plants impairs the nitrogen metabolism process, which in turn lowers plant growth, yield, and quality. Finally, the relationship between zinc and boron may be quite significant, although research in this area is extremely rare.

MATERIALS AND METHODS

Experimental site

This investigation was conducted from October 2017 to March 2018 at the Bangladesh Agricultural University, Mymensingh, in its Agronomy Field Laboratory. The experimental field was 18 inches above sea level and situated at 24°75'N latitude and 90°50'E longitude. The area is part of the Sonatola soil series and is classified as Agro-Ecological Zone (AEZ 9) of the Old Brahmaputra Floodplain contains non-calcareous Dark Grey Floodplain soil (FAO, 1998). The land had a pH of 6.9, was moderately high, and had the texture of sandy loam.

Experimental Design

Three replications were included in the RCBD design of the trial. The main plot's seed rates and the sub-plots' sulphur levels were assigned at random. Every unit plot has a 6 m2 (2 m x 3 m) space. The experiment comprised 75-unit plots. Plot to plot and block to block distances were kept to 75 cm and 1 m, respectively.

Experimental Treatment

Two components were used in the experiment's design. Elevations of boron in Factor A are as follows: 0-kilogram B per hectare (B_1), 0.5 kilograms B per hectare (B_2), 1 kilogram B per hectare (B_3), 1.50-kilogram B per hectare (B_4), and 2 kilograms B per hectare (B_5). Factor B: Zinc levels: 0-kilogram Zn per hectare (Z_1) 2 kilograms Zn per hectare (Z_2), 5 kilograms Zn per hectare (Z_3), 7.5 kilograms Zn per hectare (Z_4), and 10 kilograms of Zn per hectare (Z_5).

Land preparation

Plows and cross ploughs were used to prepare the surface, and then country ploughs and power tillers were used to plough and ladder. Weeds and the residue of past crops were cut down. On October 24, 2017, the first plowing was completed, and on November 2, 2017, the last land preparation. On November 3, 2018, the plots were laid out on the field. The experimental plot was fertilized at rates of 250, 180, and 100 kilogram per ha with urea, TSP, and MoP, respectively. During the last stage of land preparation, half of the entire dosage of urea, the full dosage of triple super phosphate, and the full dosage of potash muriate was given. After 30 days of seeding, urea was top dressed in the remaining half. In accordance with experimental treatments, zinc and boron were added during the last stages of land preparation in the forms of gypsum and zinc sulphate.

Sample collection, harvesting and threshing

Samples were collected on February 12, 2019, when 90% of the siliquae had reached maturity. On February 16–22, 2019, sample collection was followed by harvesting and threshing. The gathered plants were brought to the threshing floor in bundles. By spreading out the bundles on the plants were dried by the sun on the threshing floor. By striking the bundles with a bamboo staff, the seeds were extracted from the stover. Following sun-dried plant drying, threshing, and cleaning, per-plot yields of seed and straw were noted. Plot-by-plot seed yield data was recorded at harvest and expressed in hectares.

Collection of experimental data

Following records were generated of the yield and yield attribute data. Plant height (cm), number of branches, number of total pods, number of effective pods, number of non-effective pods, Number of sterile seeds, number of seed pods, length of pod (cm), and weight of 1000 grains (g), Biological yield (kilogram per hectare), Harvest index (%), Stover yield (kilogram per hectare), and Seed yield (kilogram per hectare).

Harvest Index (%)

The harvest index is a measure of the relationship among biological production and grain production.

$$\text{Harvest Index (\%)} = \frac{\text{Grain Yield}}{\text{Biological Yield}} \times 100$$

DOI: https://doi.org/10.55706/jae1638

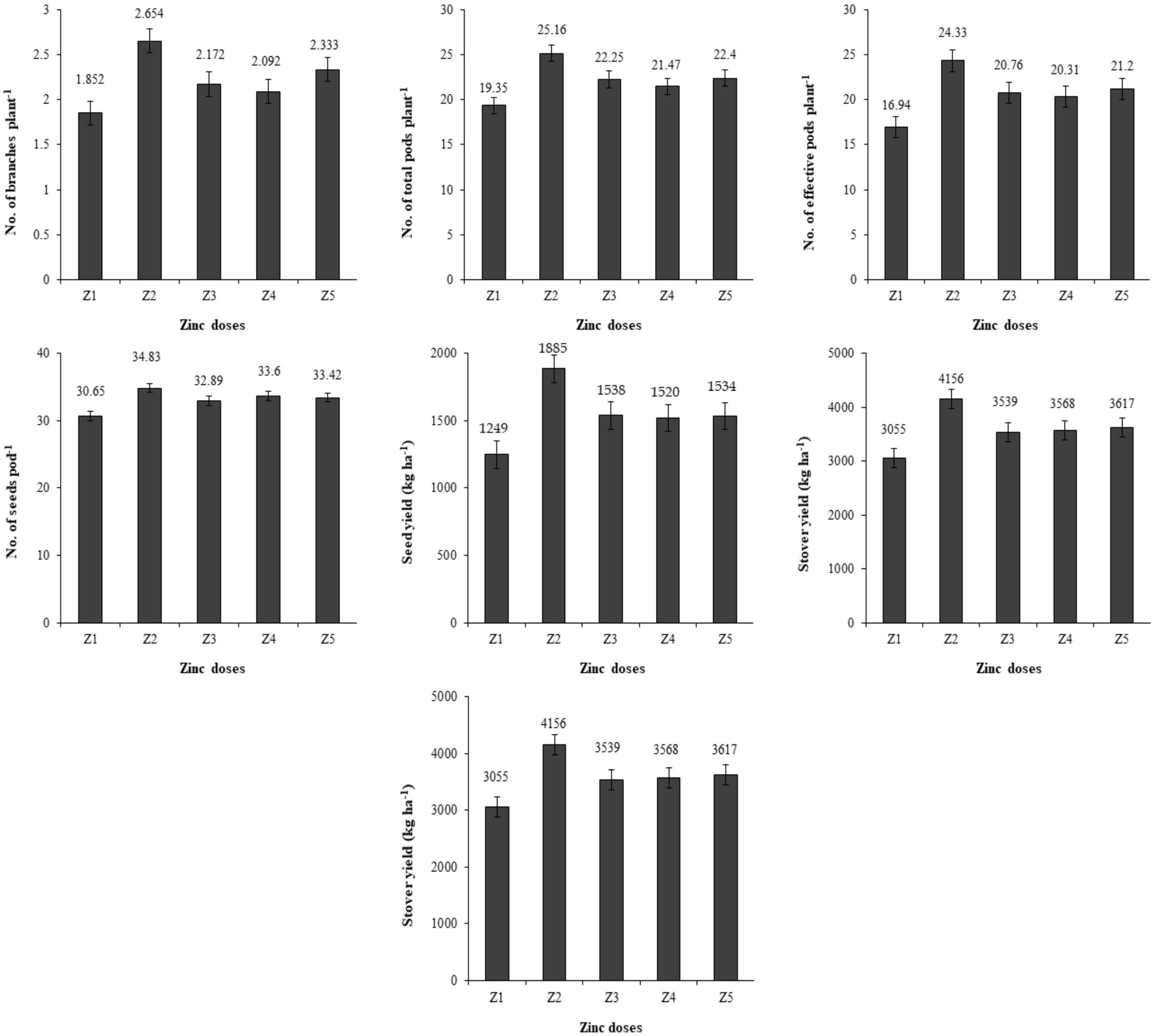
Statistical analysis

The analysis of variance approach was used to gather, tabulate, and scientifically evaluate the yield and yield parameter data. After doing an analysis of variance, the mean differences were determined using a computer package programs (M-STAT) and Duncan's Multiple Range Test (DMRT), according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of zinc application

Branches plant^{-1} responded significantly to various levels of zinc application. The number of branches per plant influenced due to fertilization. When compared to other treatments, the application of zinc (2.50 kilogram per hectare) generated the greatest amount of branches per plant (2.172). (Fig. 1).



$Z_{1=}$ 0-kilogram Zn per hectare, $Z_{2=}$ 2.5-kilogram Zn per hectare, $Z_{3=}$ 5-kilogram Zn per hectare, $Z_{4=}$ 7.5-kilogram Zn per hectare, $Z_{5=}$ 10-kilogram Zn per hectare.

Fig 1: Effect of zinc application on different parameters.

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In the control treatment, there were the fewest branches per plant (1.852). Because of the control of zinc, the total number of mustard pod plants developed significantly. When 2.50-kilogram Zn per hectare was applied, the maximum pod per plant (22.25) was observed. The findings confirm the results of Yadav *et al.* (2007). The control treatment showed the fewest pod plants (19.35) of any treatment (Fig. 1). The application of zinc caused a considerable variation in the number of effective pods per plants. The application of 2.50-kilogram Zn per hectare resulted in the highest effective pod per plant recorded (20.76). The least amount of effective pod per plant (19.94) was noted in control. (Fig. 1). 1.49 was the lowest number of ineffective pod plants per plant when 2.50 kg of zinc was applied per hectare. Most ineffective pod per plants (2.41) were seen in control. Zinc concentration has a considerable influence on the quantity of seeds in each pod. When 2.50 kg of Zn ha^{-1} was given, the most percentage of seed pods (34.83) was found, and the lowest value (30.65) came from the control measure (Fig. 1). Jat and Mehra (2007) corroborate the results of the current study. The seed yield was shown to have been greatly impacted by the varying zinc levels. The largest seed production (1885.0 kilogram per hectare) was achieved with a 2.50-kilogram Zn per hectare application (Fig. 1), while the lowest recorded seed produce (1249.0 kilogram per hectare) without zinc application. Yadav *et al.* (2007) published similar results. Application of varying zinc levels greatly affected the lingering yield per hectare (Fig. 1). Maximum stover output was achieved at a zinc rate of 2.50 kilogram per hectare (4156.0 kilogram per hectare). The least amount (3055.0 kilogram per hectare) was produced by the control treatment. The biological yield of mustard varied significantly depending on the control of zinc. 2.50-kilogram Zn per hectare was applied, and the highest biological yield (6041.0 kilogram per hectare) was noted. The control treatment produced the lowest biological yield (4304.0 kilogram per hectare). Variations in zinc levels had a major impact on the harvest index (Fig. 1). 2.5-kilogram zinc per hectare had the greatest harvest index (31.09%). The lowest result (28.97%) was attained with the treatment in control.

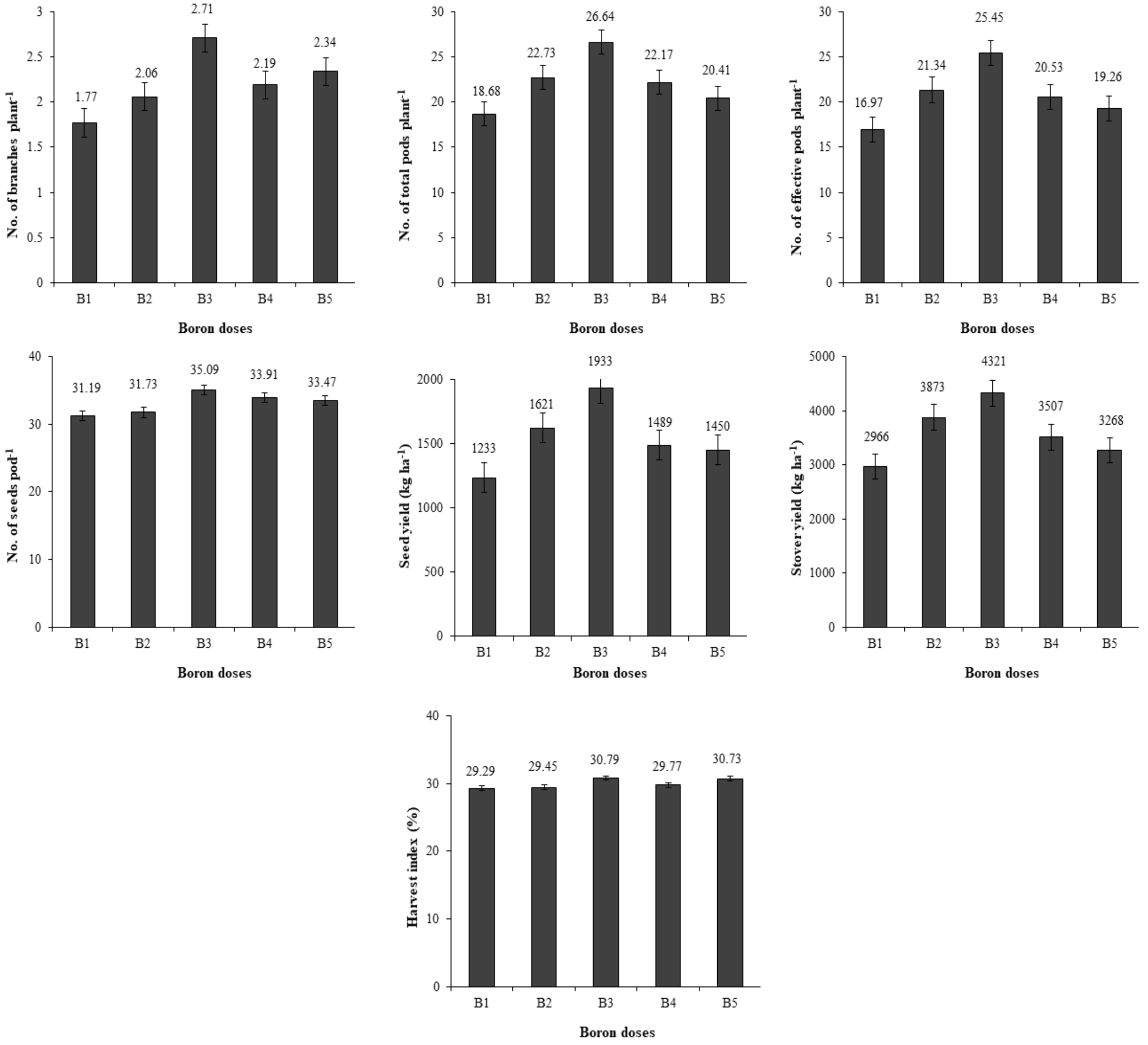
Effect of boron application

Plant per branch count was significantly affected by the boron application technique. There were 2.71 branches per plant in the case of the use of 1 kilogram per hectare of boron, while 1.77 branches per plant were seen in the control (Fig. 2). The treatment of boron resulted in a notable variation in the entire quantity of pod per plant. The largest quantity of pod plants per hectare (26.64) was seen when applying 1 kilogram of B per hectare. In the control treatment, the smallest amount of pod per plant (18.68) was noted. The results support the conclusions attained by Asad et al. (2003). Among the various boron applications, there existed a notable variation in the quantity of effective pod per plant (Fig. 2). With a 1-kilogram B per hectare application, the highest number of effective pods per plants was recorded (25.45). Fig. 2 shows that the control had the lowest amount of effective pod per plants (19.97). After applying 2-kilogram B per hectare, the least amount of ineffective pod plants per plant (1.19) was recorded. The control treatment had the highest recorded amount of ineffective pod per plants (1.70). The number of seeds per pod was highly impacted by the level of boron (Fig. 2). When 2.5 kilogram of Zn per hectare was applied, the highest number of seed pods seen (35.09) was recorded, and the lowest find (31.19) came from the control measure. The results validate the conclusions reached by Yadav *et al.* (2007). Various boron levels had a substantial impact on seed per plant output (Fig. 2). The highest seed yield (1933.0 kilogram per hectare) was achieved with a 1-kilogram B per hectare application, while the fewest seed yield (1233.0 kilogram per hectare) was obtained without any boron application. The outcomes concur with those of Lu Xiao Nan *et al.* (2000). Application of varying boron doses considerably affected the remaining yield per hectare (Fig. 2). The maximum stover production of 4321.0 kilogram per hectare was attained at a boron concentration of 1 kilogram per hectare. The least amount (2966.0 kilogram per hectare) generated by the controlled treatment. The results support those of Malewar *et al.* (2001). There were notable variations in the biological output of mustard depending on the effect of boron management. When 1 kg of B was applied per hectare, the largest biological yield (6254.0 kilogram per hectare) was noted. The controlled treatment yielded the lowest biological production of 4199.0 kilogram per hectare. Significant differences in boron levels were seen in the harvest index. At 2.5-kilogram zinc per hectare, the maximum harvest index (30.79%) was recorded (Fig. 2). The fewest result (29.59%) was obtained with the controlled treatment.

Interaction of zinc and boron

At harvest, the height of the plants was measured, and there was no noticeable effect of zinc-boron management (Table 1). Despite zinc and boron management, plant height increased as the growing season progressed. In relation to numbers, however, the mixture of 2.50-kilogram Zn per hectare and 1 kilogram B hectare treatment produced the tallest plant (76.20 cm), whereas the combination of 0-kilogram Zn per hectare and 0-kilogram B per hectare treatment produced the shortest plant (63.53 cm). The interaction effect of applying zinc and boron resulted in a significant difference in the number of branches per plant (Table 1). The interaction of 2.50-kilogram Zn per hectare and 1 kilogram per hectare B treatment produced the largest number of branches per plant (3.13), while the interaction control treatment produced the lowest number of branches per plant (1.40). Due to zinc and boron management, statistically significant changes were observed for the total number of mustard pods per plant (Table 1). The treatment using 2.50-kilogram Zn per hectare and 1 kilogram B per hectare produced the greatest number of total pod plants per plant (29.13). The control treatment yielded the lowest number of pod plants overall (16.53). The interaction effect of applying zinc and boron caused a considerable difference in the number of effective pods per plants (Table 1).

DOI: https://doi.org/10.55706/jae1638



B_{1}= 0-kilogram B per hectare, B_{2}= 0.5-kilogram B per hectare, B_{3}= 1.00-kilogram B per hectare, B_{4}= 1.50-kilogram B per hectare, B_{5}= 2.00-kilogram B per hectare.

Fig 2: Effect of boron application on different parameters

An effective pod per plant combination of 2.50-kilogram Zn per hectare and 1 kilogram B per hectare produced the greatest number of pod plants (28.66). The control treatment generated the lowest number of total pods per plants (12.66). No. non-effective pods per plant was significantly impacted by the effects of zinc and boron (Table 1). The combination of 2.50-kilogram Zn per hectare and 1 kilogram B per hectare treatment produced the fewest non-effective pod per plant (0.47). The control treatment generated the highest amount of total pod per plants (3.87) of all of the treatments. There was no significance difference in pod length of mustard plant (Table 1). The interaction effect of applying zinc and boron caused a considerable variation in the quantity of seeds per pod (Table 1). The combination of 2.50-kilogram Zn per hectare and 1 kilogram B per hectare produced the greatest number of seeds per pod (36.81). The control treatment yielded the lowest number of pod plants overall (27.77). The effect of applying zinc and boron on the number of sterile seeds per plant was determined to have no significant affect (Table 1). Regarding the application of zinc and boron in 1000-grain weight, no significant difference was discovered (Table 1). The combination of 2.50-kilogram Zn per hectare and 1 kilogram B per hectare treatment produced

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the maximum seeds yield (2573.0-kilogram per hectare). The control treatment yielded the lowest number of seeds (828.0-kilogram per hectare). Application of zinc and boron had a statistically significant interaction effect on the amount of leftover yield. The combination of 2.50-kilogram Zn per hectare and 1 kilogram B per hectare treatment produced the maximum stover production (5330.0-kilogram per hectare). The control treatment yielded the lowest stover output (2110.0-kilogram per hectare) (Table 1).

Table 1. Interaction effects of zinc and boron doses on yield and yield contributing characters of mustard

Interaction (Zinc x boron doses)	Plant height (cm)	No. of branches plant^{-1}	No. of total pods plant^{-1}	No. of effective pods plant^{-1}	No. non-effective pods plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	No. of sterile seeds	1000 grain weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Z_1x B_1	63.53	1.40i	16.53n	12.66m	3.87a	3.62	27.77i	1.92	3.44	828.3m	2110.0m	2938.0o	28.21h
Z_1x B_2	64.53	1.67gh	19.07jkl	16.88l	2.19b	3.64	28.63i	1.76	3.60	1310.0jk	3313.0hij	4623.0jk	28.33gh
Z_1x B_3	70.07	2.33e	23.47e	21.68ef	1.78bcde	3.91	33.29cdef	1.45	4.08	1549.0fg	3670.0def	5219.0g	29.76bcdef
Z_1x B_4	65.67	1.93fg	18.67klm	16.50l	2.17b	3.68	32.00efgh	1.63	4.00	1389.0hijk	3330.0hij	4719.0ijk	29.44cdef
Z_1x B_5	67.33	1.93fg	19.00jkl	16.97l	2.03bc	3.67	31.57fgh	1.83	3.50	1169.0l	2850.0l	4019.0n	29.09fgh
Z_2x B_1	66.53	2.40e	20.93ghi	19.89h	1.04fghij	3.77	33.49bcdef	1.55	3.85	1440.0ghi	3350.0hij	4790.0ij	30.06bcdef
Z_2x B_2	69.13	2.47de	27.00bc	26.50bc	0.500ij	3.81	33.96bcde	1.41	3.89	1950.0b	4470.0b	6420.0b	30.37bcd
Z_2x B_3	76.20	3.13a	29.13a	28.66a	0.47j	4.03	36.81a	1.24	4.50	2573.0a	5330.0a	7903.0a	32.56a
Z_2x B_4	72.33	2.47de	26.67c	25.48c	1.19efgh	3.94	35.44ab	1.39	4.42	1750.0c	4000.0c	5750.0d	30.44bcd
Z_2x B_5	74.27	2.80bc	22.07fg	21.14fg	0.93fghij	3.81	34.45bcd	1.38	4.24	1712.0cd	3631.0efg	5343.0fg	32.04a
Z_3x B_1	65.47	1.80fg	19.80ijk	18.22jk	1.58bcdef	3.66	30.52h	1.84	3.63	1270.0kl	3013.0kl	4283.0m	29.65bcdef
Z_3x B_2	65.87	2.33e	22.67ef	20.49gh	2.18b	3.76	30.49h	1.52	3.72	1561.0efg	3693.0def	5254.0g	29.76bcdef
Z_3x B_3	71.73	2.40e	25.00d	23.85d	1.14efghi	4.01	35.47ab	1.15	4.26	1980.0b	4500.0b	6480.0b	30.56bc
Z_3x B_4	66.00	2.33e	23.73e	21.76ef	1.97bcd	3.79	34.11bcd	1.51	4.20	1409.0hij	3359.0hij	4768.0ij	29.55bcdef
Z_3x B_5	67.53	2.00f	20.07ij	19.50hi	0.57hij	3.73	33.85bcde	1.52	3.81	1469.0gh	3130.0jk	4599.0jkl	31.93a
Z_4x B_1	66.33	1.47hi	18.40lm	17.22kl	1.18efgh	3.69	33.20cdef	1.71	3.75	1330.0ijk	3233.0ijk	4563.0kl	29.15efgh
Z_4x B_2	64.53	1.93fg	21.33gh	20.33gh	1.00fghij	3.74	32.76defg	1.56	3.85	1612.0def	3890.0cd	5502.0ef	29.30defg
Z_4x B_3	75.27	2.80bc	28.07ab	26.89b	1.18efgh	3.96	34.65bcd	1.32	4.37	1680.0cd	3807.0cde	5487.0ef	30.61b
Z_4x B_4	70.93	1.93fg	20.20hij	18.75ij	1.45cdefg	3.81	33.61bcde	1.48	4.33	1497.0fgh	3500.0fgh	4997.0h	29.95bcdef
Z_4x B_5	70.60	2.33e	19.33jkl	18.34jk	0.99fghij	3.70	33.77bcde	1.48	4.00	1480.0gh	3410.0ghi	4890.0hi	30.27bcde
Z_5x B_1	63.93	1.80fg	17.73m	16.88l	0.85ghij	3.72	30.95gh	1.87	3.51	1299.0jk	3121.0jk	4420.0lm	29.40def
Z_5x B_2	68.13	1.93fg	23.60e	22.50e	1.10fghij	3.92	32.80defg	1.61	3.61	1670.0cde	4000.0c	5670.0de	29.51bcdef
Z_5x B_3	72.73	2.93ab	27.53bc	26.15bc	1.38defg	3.96	35.23abc	1.35	4.19	1881.0b	4300.0b	6181.0c	30.45bcd
Z_5x B_4	67.93	2.33e	21.60fg	20.15gh	1.45cdefg	3.78	34.37bcd	1.48	4.12	1400.0hij	3347.0hij	4747.0ijk	29.49bcdef
Z_5x B_5	69.87	2.66cd	21.56fg	20.34gh	1.22efgh	3.74	33.73bcde	1.41	3.75	1420.0hij	3317.0hij	4737.0ijk	30.32bcd
$S\bar{x}$	2.06	0.084	0.407	0.375	0.196	0.055	0.600	0.111	0. 103	37.83	74.69	61.51	0.337
Level of sig.	**NS**	**	**	**	**	**NS**	*	**NS**	**NS**	**	**	**	*
CV (%)	**5.20**	**6.54**	**3.19**	**3.13**	**24.05**	**2.57**	**3.14**	**12.55**	**4.53**	**4.24**	**3.61**	**2.08**	**1.95**

The biological production of mustard was shown to be significantly impacted by the interaction between the zinc and boron levels (Table 1). With 2.50-kilogram Zn per hectare and 1 kilogram B per hectare treatment combined, the biological output was maximum (7903.0-kilogram per hectare), while the interaction of control treatment produced the lowest biological yield (2938.0 kilogram per hectare). Significance influence was found in harvest index of mustard (Table 1). The interaction of 2.50-kilogram Zn per hectare and 1 kilogram B per hectare treatment produced the highest harvest index (32.56%), while the interaction of control treatment produced the lowest harvest index (28.21%).

CONCLUSION

Bangladesh has a high demand for edible oil production. When it comes to both production and acreage, mustard is the most widely produced oilseed crop in the nation. The results of the experiment suggest that boron and zinc were important factors in raising mustard output. In order to increase production, BARI Sarisha-14 may be advised to apply zinc and boron at rates of 2.5 kilogram per hectare and 1 kilogram per hectare, respectively, given the agroclimatic conditions of the Mymensingh area (AEZ 9).

DOI: https://doi.org/10.55706/jae1638

Conflict of Interest

No conflicts of interest have been revealed by the authors.

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