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Effect of Boron And Zinc on the Growth and Yield of Mustard (BARI Sarisha-14)

Umme Hafsa Timmi[1*], Afrose Jahan[2], Sadia Mehrin[3], Atik Hasan[4]

[1]Scientific Officer, Bangladesh Jute Research Institute, Dhaka – 1207.
[2]Professor, Department of Soil Science, Sher e Bangla Agricultural University.
[3,4]Scientific Officer, Bangladesh Jute Research Institute, Dhaka – 1207
[*]Corresponding Author

Abstract

The field experiment was conducted during rabi season, November 2021 to February 2022 in the experimental field of Sher-e-Bangla Agricultural university, Dhaka to determine effects of boron and zinc on growth and yield of mustard (*Brassica campestris*) variety BARI Sarisha-14. The treatments of the experiment was consisted of three levels of boron i.e., 0 kg B/ha (B_0), 1 kg B/ha (B_1) and 1.5 kg B/ha (B_2); three levels of zinc i.e., 0 kg Zn/ha (Zn_0), 3kg Zn/ha (Zn_1), 5 kg Zn/ha (Zn_2). The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. Results of this experiment showed a significant variation among the treatments in respect of the majority of the observed parameters. The 1.5 kg B/ha (B_2) gave the highest plant height, number of branches per plant, number of seeds per siliquae, number of siliquae per plant, length of siliquae and 1000 seed weight. Again, B_2 resulted the maximum seed yield (1.70 t/ha), stover yield, biological yield and harvest index. In addition, except siliquae length andharvest index, 3 kg Zn/ha (Zn_2) resulted highest values in all parameters while the lowest values were found in Zn_0 treatment. The interaction between boron and zinc had significant effect on all the growth and yield parameters. Except the harvest index, the B_2Zn_2 treatment combination or 1.5 kg B/ha with 5 kg Zn/ha gave maximum values on all parameters including seed yield (1.82 t/ha). Based on these results, it can be suggested that 1.5 kg B/ha with the combination of 5 kg Zn/ha increased the growth and yield ofmustard and this may be the best combination for the growth and yield of mustard.

Keywords: B fertilizer, Zn fertilizer, Mustard variety (BARI Sarisha -14)

Introduction

Mustard (*Brassica* spp) is one of the most important oil seed crops throughout the world after soybean and groundnut (FAO, 2004). It has a huge demand for producing edible oil in Bangladesh. Mustard stands at the top of the list among the oilseed crops grown in this country in respect of both production and acreage (BBS, 2015).

Mustard seeds contain 40-45 % oil and 20-25 % protein (Mondal and Wahab, 2001). It is also an important raw material for industrial use such as in soaps, paints, varnishes, hair oils, lubricants, textile auxiliaries, pharmaceuticals etc. Fats and oils are available from different sources like animal and plant. Animal fats are derived from milk, ghee, butter, etc. but these are very costly compared to the oil obtained crops. Oil from oil obtained crops is easily digestible and its nutrition quality is better compared to the animal fats.

Bangladesh is suffering from acute shortage of edible oil in terms of domestic production. Bangladesh is deficit in edible oil, which costs valuable foreign currency for importing seeds and oil. Annually country is producing about 2.80 Lac m tons of edible oil as against the requirement of 9.80 Lac m tons thus import oil is regular phenomenon of this country (BBS, 2010). Every year Bangladesh imports 7 lac m tons of edible oil to meet up the annul requirement of the country, which costs Tk. 64430 million (BBS, 2007). Both the acreage and production of the crop have been decreasing since 1990 mainly due ingression of cereal crops like-rice, maize, wheat etc. Delayed harvest of transplanted aman rice and wetness of soil are another reason which hinders mustard cultivation in rabi season (BARI, 2008).

Mustard plant belongs to the genus Brassica under the family brassicaceae. The brassica has three species that produce edible oil, *B. napus*, *B. campestris, B. juncea*. Of these *B. napus* and *B. campestries* have the greatest importance in the world's oilseed trade. In this subcontinent, *B. juncea* is also an important oilseed crop. Mustard is the most important oilseed crop among other oilseed crops like groundnut, sesame, coconut, castor and linseed of Bangladesh. Moreover, it is very well known to the farmers. Mustard oil is being used as a medium of cooking from time immemorial (Khaleque, 1985).
Mustard is a cold loving crop and grows during Rabi season (October- February) usually under rainfed and low input condition in this country can be attributed to several factors, the nutritional deficiency, among others is highly important. There is very little scope expansion for mustard and other oilseed acreage in the country, due to competition from more profitable alternative crops. Although mustard is the principal oil crop in Bangladesh but its cultivation is neglected. Moreover the yield of mustard is low in Bangladesh as compared to other countries of the world. There is great possibility to increase its production by applying adequate fertilizers, selecting high yielding varieties and adopting proper management practices. One of the common constraints to higher yield is lack of balanced fertilization.

Many previous researches showed that fertilization can be done to boost up growth and yield of crops (Sinha et al. 2003, Shukla et al. 2002, Meena *et al.* 2002 and Zhao *et al*. 1997). Boron is the vital element for plant growth and yield of this crop. Boron increases yield by influencing a number of growth parameters such as number of branches and siliquae plant^{-1}, seeds siliqua^{-1} and 1000-seed weight by producing more vigorous growth and development (Taylor *et al.*, 1991; Qayyum *et al.,* 1998). Again, boron has impacts on seed protein and physiological functions and supports the plant with rapid growth, increasing seed and oil seed yield (Allen and Morgan 2009). Excessive use of boron may reduce seed yield and quality appreciably (Cheema *et al.,* 2001; Laaniste *et al.*, 2004).

Zinc is one of the first micronutrients recognized as essential for plants that transported to plant root surface through diffusion (Maqsood *et al.,* 2009). Zn is a micronutrient and in case of its severe deficiency the symptoms may last throughout the entire crop season (Asad and Rafique, 2000). Zn deficient plant also appears to be stunted (Torun *et al.*, 2001) as a result approximately 2 billion people suffer from Zn deficiency all over the world (Asad and Rafique, 2002).The grain yield can be improved by addition of Zn fertilization (Maqsood *et al.*, 2009). Bora and Hazarika, (1997) reported highest stover yield (2770 kg ha^{-1}) with Zn and almost the same trend of seed yield. The seed yield can be improved by addition of Zn fertilization. Chen and Aviad, (1990) found that application of Zn along with other micronutrients improved soil organic matter and resulted in increasing mustard yields. Kutuk *et al.*, (2000) also suggested that the application of Zn has become necessary for improved crop yields.

Application of proper amount of micro nutrients is essential to maximize crop production. Boron and Zinc fertilizer play an important role to increase the mustard production. Zhu et al. (1996) stated that Zn increased the yield of mustard seed 18% over NPK alone. In addition, the fertilizer requirement for maximum growth and yield of newly developed mustard variety BARI Sarisha- 14 is not much investigated. With a view to determine the Boron and Zinc requirement of this new variety a field study was conducted with the following objectives:

- to study the growth and yield performance of Mustard by using different doses of Boron and Zinc fertilizers.
- to find out suitable combination of B and Zn fertilizers for better growth and yield of Mustard.

Materials and Methods

The experiment was conducted during Rabi season at research farm, Sher e Bangla Agricultural University to determine the effect of Boron and Zinc on the growth and yield of Mustard variety BARI Sarisha-14 (*Brassica campestris).*

2.1 Experimental Site

The field experiment was located at the Agronomy research field, Sher-e- Bangla Agricultural University, Dhaka during the period from November 2021 to February 2022. Geographically the experimental field located at 23°46' N latitude and 90° 22' E longitude at an elevation of 8.2 m above the sea level belonging to the Agro-ecological Zone “AEZ-28” of Madhupur Tract , which falls into Deep Red Brown Terrace Soils. The location of the experimental site has been shown in AppendixI.

2.2 **Soil of the experimental field**

The soil of the experimental field is slightly acidic in reaction with low organic matter content. Top soil was sandy loam in texture. Soil p^H was 5.47-5.63 and has organic carbon 0.89%. The research field was flat having available irrigation and drainage system and above flood levels. The selected plot was medium high land.

2.3 Climate

The experimental area is situated under the sub-tropical climate and is characterized by less rainfall associated with moderately low temperature during rabi season, October- March and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season April- September.

2.4 Plant material

BARI Sarisha-14 (*Brassica campestries*) developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur was used as planting material in this experiment. The seed was collected from the BARI. Before sowing germination test of seeds were done in the laboratory and percentage of germination was found over 95%.

2.5 Experimental treatments

The experiment consisted of two treatment factors as mentioned below:

Factor A: Boron levels designated as: = $B_{0=}$ 0 kg B ha^{-1} (control)
B_1 = 1 kg B ha^{-1} ,B_2 = 1.5 kg B ha^{-1}

Factor B: Zinc levels designated as:

Zn_0=0 kg Zn ha^{-1}(control) Zn_1 = 3 kg Zn ha^{-1}
Zn_2 = 5 kg Zn ha^{-1}

2.6 Treatment combinations:

$T_1=B_0Zn_0$	$T_2= B_1Zn_0$	$T_3= B_2Zn_0$
$T_4= B_0Zn_1$	$T_5= B_1Zn_1$	$T_6= B_2Zn_1$
$T_7 = B_0Zn_2$	$T_8= B_1Zn_2$	$T_9= B_2Zn_2$

2.7 Design and layout

The two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. The size of the individual plot was 2 m × 1.5 m = 3 m^2 and total numbers of plots were 27. There were 9 treatment combinations. Layout of the experiment was done on November 19, 2021 with inter plot spacing of 0.75 m and inter block spacing of 0.75 m. Plant spacing was maintained with 30 cm and 5 cm, as of line to line and plant to plant distance, respectively.

2.8 Land preparation

The land of the research field was first opened on November 10, 2021 with a power tiller. Then it was exposed to the sun for 7 days prior to the next ploughing. Then, the land was ploughed and cross-ploughed to have a good tilth. Laddering was done for breaking the soil clods into small pieces after each ploughing. All the weeds and stubbles were removed from the research field. The land operation was completed on 17 November 2022. According to the layout of the experiment, the entire experimental area was divided into blocks and sub divided into plots for the sowing of mustard. Irrigation and drainage channels were also made around the plots.

2.9 Fertilizer application

In this experiment fertilizers were used according to BARI recommendation as follows:

Fertilizers	Rate of application per ha
Urea	250 kg/ha
TSP	170 kg/ha
MoP	80 kg/ha
Gypsum	150 kg/ha
$ZnSO_4$	As per treatment
Boric Acid	As per treatment

The amounts of fertilizer as per treatment in the forms of urea, triple super phosphate, murate of potash, gypsum, zinc sulphate and boric acid required per plot were calculated. Half of urea and total amount of all other fertilizers of each plot were applied and incorporated into soil during final land preparation. Rest of the urea was top dressed after 30 days after sowing (DAS).

2.10 Seed Sowing

Sowing was done on 19th November, 2021 in rows 30 cm apart. Seeds were sown continuously in rows at a rate of 8 kg ha^{-1}. After sowing, the seeds were covered with the soil and slightly pressed by hand. Plant population was kept constant through maintaining plant to plant distant 5 cm in row.

2.11 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

2.11.1 Weeding and thinning

Weeds of different types were controlled manually for the first time and removed from the field on 30 November 2021. At the same time first thinning was done. The final weeding and thinning were done after 25 days of sowing, on 13 December 2021. Care was taken to maintain constant plant population per plot.

2.11.2 Irrigation

Irrigation was done at three times. The first irrigation was given on the post sowing. The second irrigation was given at 15 DAS on 2th December, 2021. The final irrigation was given at the stage of seed formation (50 DAS), on 10th January,2022.

2.11.3 Crop protection

The crop was sprayed with Malathion 57 EC@ 2 ml L^{-1} of water at siliquae formation stage to control aphids.

2.11.4 Sampling

Ten sample plants were collected randomly from each plot. These 10 plants were used for taking data for yield attributes.

2.11.5 Harvest and post-harvest operation

Previous randomly selected ten plants, those were considered for the growth analysis was collected from each plot to study the yield and yield contributing parameters. Rest of the crops was harvested when 80% of the siliquae in terminal raceme turned golden yellow in colour. After collecting sample plants, harvesting was done on February 20. To avoid shattering, harvesting was done in the morning. The harvested crops from each plot were tied into bundles separately and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

2.11.6 Drying and weighing

The seeds and stover thus collected were dried in the sun for couple of days. Dried seeds and Stover of each plot was weighed and subsequently converted into yield kg ha^{-1}.

2.11.7 Data Collection

Ten (10) plants from each plot were selected as random and were tagged for the data collection. Some data were collected from sowing to harvesting with 20 days interval and some data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those taken from selected plants which were marked by tag. Final field data were collected at harvesting stage.

Data were collected on the following parameters:

1. Plant height(cm)
2. Number of branches per plant
3. Number of siliquae per plant
4. Number of seed per siliquae
5. Length of siliquae (cm)
6. Thousand seed weight (g)
7. Seed yield (t/ha)
8. Stover yield (t/ha)
9. Biological yield (t/ha)
10. Harvest Index (%)

3.1 Methods of recording data

3.2.1 Plant height(cm)

The height of the mustard plants was recorded at harvest. The height of 10 preselected sample plants were taken from the ground level to the tip of the shoot. Then the mean of the data were taken and expressed in cm.

3.2.2 Number of branches per plant

Total number of branches was taken at harvest. All the branches present on randomly selected plants were counted and average number of branches per plant was taken.

3.2.3 Number of siliquae per plant

Number of siliquae was counted from randomly selected ten plants after harvest and averaged them to have number of siliquae per plant.

3.2.4 Number of seeds per siliquae

Number of total seeds of 10 randomly preselected sample plants from each plot was recorded and the average number was expressed per siliquae basis.

3.2.5 Length of siliquae (cm)

Number of siliquae was recorded from randomly selected 10 sample plants after harvest and mean number was expressed in cm

3.2.6 Number of siliquae per plant

Number of siliquae was counted from randomly selected ten plants after harvest and averaged them to have number of siliquae preplant.

3.2.7 Number of seeds per siliquae

Number of total seeds of 10 randomly preselected sample plants from each plot was recorded and the average number was expressed per siliquae basis.

3.2.8 Length of siliquae (cm)

Number of siliquae was recorded from randomly selected 10 sample plants after harvest and mean number was expressed in cm.

3.2.9 Thousand seed weight (g)

One thousand sun dried and cleaned seeds were counted randomly from the seed stock and weighed of seeds. Then the weight of 1000 seeds were recorded by means of a digital electrical balance and expressed in gram.

3.2.10 Seed yield(t/ha)

Seeds obtained from harvested area of each unit plot were dried in the sun and weighed. The seed weight was expressed in t/ha.

3.2.11 Stover yield (t/ha)

The Stover obtained from the harvested area of each unit plot was dried separately and weight was recorded. These values were expressed in t/ha.

3.2.12 Biological yield(t/ha)

Biological yield was calculated by using the following formula: Biological yield= Seed yield + Stover yield

3.2.13 Harvest index(%)

Harvest index is the ratio of seed yield and biological yield (Gardner *et al.*, 1985). It was calculated by using the following formula: Harvest index = (Seed yield / Biological yield) × 100

3.3 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P and K contents. The soil samples were analyzed by the following standard methods as follows:

3.4 Textural class

Mechanical analysis of soil were done by hydrometer method (Bouyoucos, 1926)and the textural class was estimated by plotting the values of % sand,% silt and % clay to the Marshall's textural triangular co-ordinate following the USDA system.

3.5 Soil pH

pH of soil was estimated with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 (Jackson, 1973).

3.6 Organic carbon

Soil organic carbon was determined by Walkley and Black's wet oxidation method as outlined by Jackson (1973).

3.7 Organic matter

Soil organic matter content was determined by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724.

% organic matter = % organic carbon × 1.724

3.8 Total nitrogen

Total nitrogen content in soil was estimated by Kjeldahl method by digesting the soil sample with conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965).

The amount of N was calculated using the following formula:
% N = (T-B) × N × 0.014 × 100 / S

Where,

T = Sample titration (ml) value of standard H_2SO_4 B = Blank titration (ml) value of standard H_2SO_4 N = Strength of H_2SO_4
S = Sample weight in gram

3.9Available Phosphorus(ppm)

Available phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ solution pH 8.5 (Olsen et al., 1954). Phosphorus in the extract was measured spectrophotometrically after development of blue colour (Black,1965).

3.10 Exchangeable Potassium (meq/100 gsoil)
Exchangeable potassium (K) content of the soil sample was determined by flame photometer on the NH_4OAc extract (Black, 1965).

3.11 Total nitrogen
Total nitrogen content in soil was estimated by Kjeldahl method by digesting the soil sample with conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965).

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S = Sample weight in gram

3.12 Available Phosphorus(ppm)
Available phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ solution pH 8.5 (Olsen et al., 1954). Phosphorus in the extract was measured spectrophotometrically after development of blue colour (Black,1965).

3.13 Exchangeable Potassium (meq/100 gsoil)
Exchangeable potassium (K) content of the soil sample was determined by flame photometer on the NH_4OAc extract (Black, 1965).

3.14 Available Zinc
Available Zinc content was estimated by extracting the soil with Zncl2 solution as described by Page et al. 1982. The digested Zn was determined by developing turbidity by adding Zncl2 solution. The intensity of turbidity was measured by spectrophotometer at 420 mm wavelengths (Hunter, 1984).

3.15 Statistical Analysis
The collected data were statistically analyzed by using the ANOVA technique. The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel, 1986). The mean values for all the parameters were calculated and the analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test at 5 % levels of probability (Gomez and Gomez, 1984).

Result and Discussion

Effect of boron levels on plant height of mustard :

The results of this study showed that mustard plant height (Fig. 1) was significantly affected by boron (B) levels. Here, the tallest plant (76.69 cm) was recorded with $B_{2,}$ 1.5 kg B ha^{-1}. In contrast, the shortest plants were recorded from control, B_0 and it was 62.20 cm. Above all, these findings suggest that higher doses of B increase plant height of mustard.

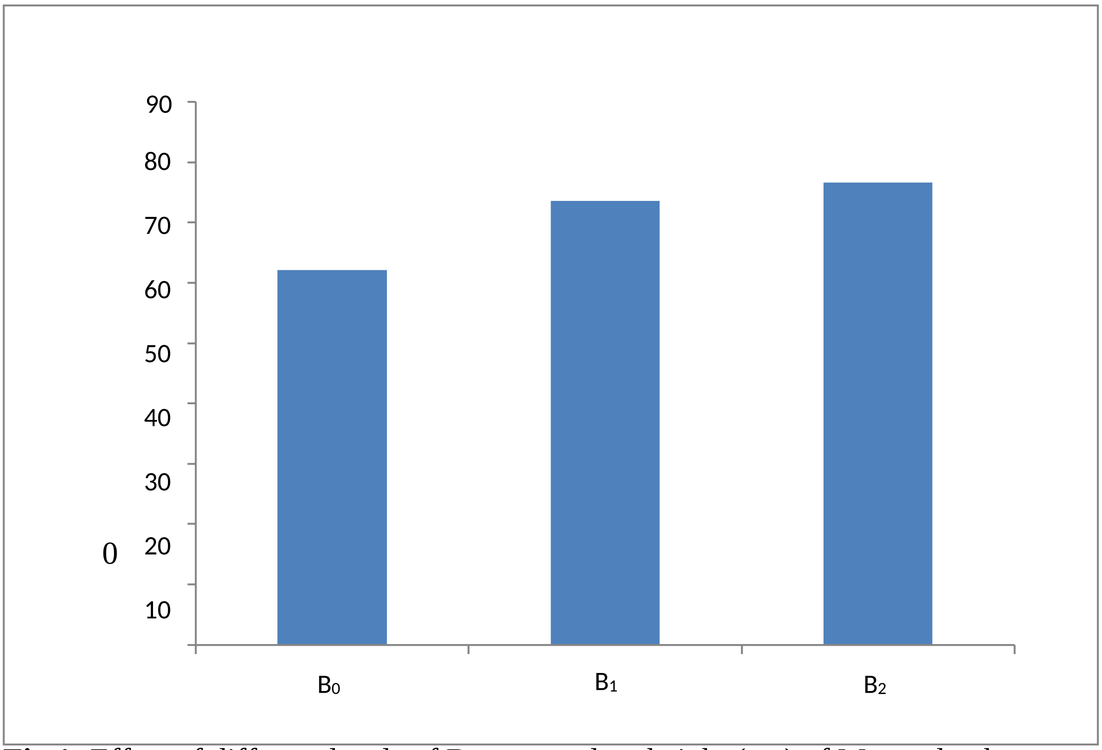

Fig 1: Effect of different levels of Boron on plant height (cm) of Mustard at harvest.

Effect of zinc levels on plant height of mustard:

Again, the results showed that Zinc (Zn) levels showed significant effect on mustard plant height. It can be observed from the figure (Fig. 2) that Zn_2 , 3 kg Zn ha^{-1} showed the tallest plant (77.10 cm) and the control, 0 kg Zn ha^{-1} produced the shortest plant (62.94 cm) .

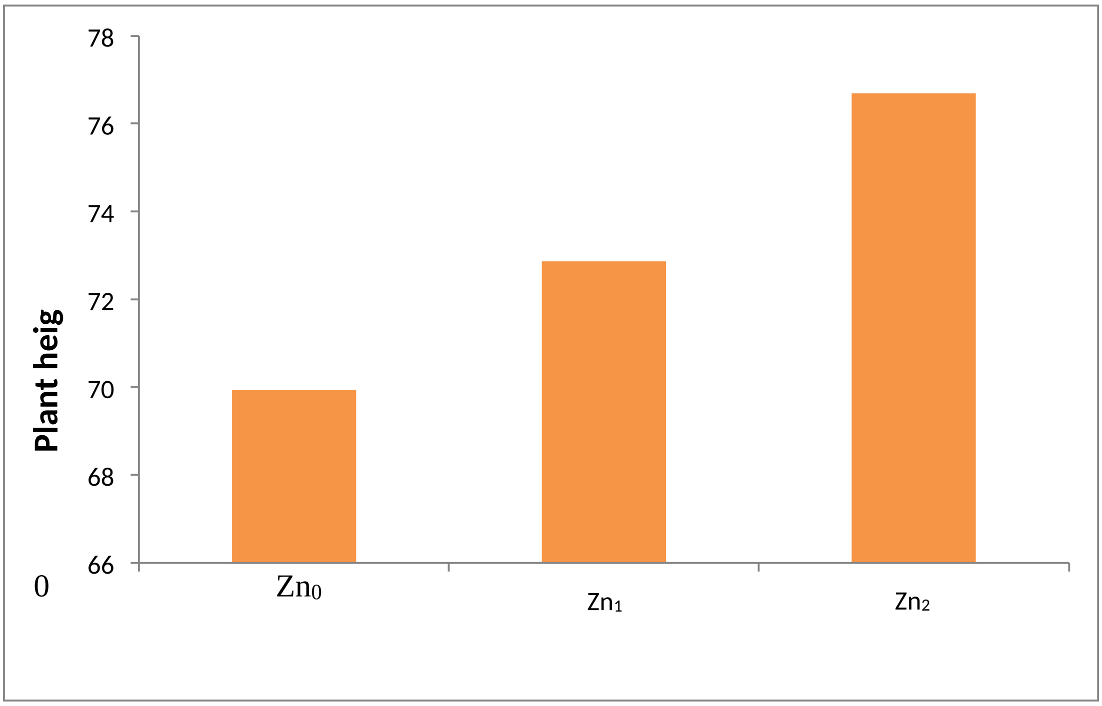

Fig 2: Effect of different levels of Zinc on plant height (cm) of Mustard at harvest.

Effect of boron levels of branches per plant:

The significant result was found in branches per plant of mustard by the different levels of boron application. The figure (Fig. 3) indicated that B_2 1.5 kg B ha^{-1} produced the maximum number branches per plant (5.18) whereas B_0 , the control produced the minimum number of branches per plant (3.99).

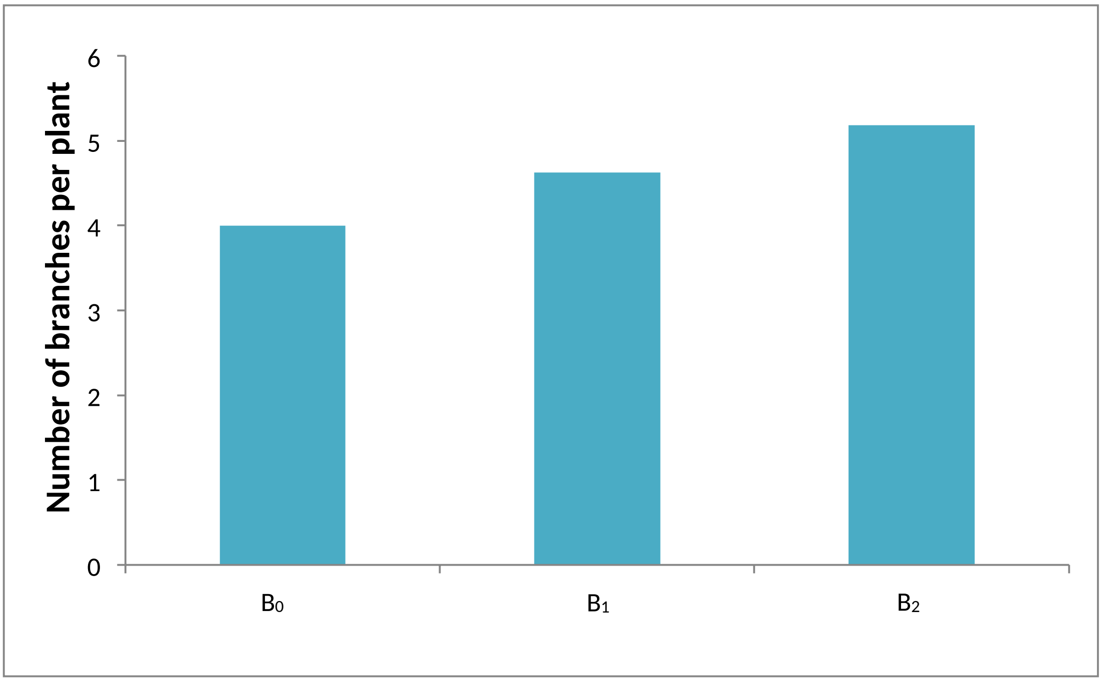

Fig 3: Effect of different levels of Boron on number of branches per plant of Mustard.

Effect of zinc levels of branches per plant:

The maximum number of branches per plant (4.85) was recorded by Zn_2, 5 kg Zn ha^{-1}. On the other hand minimum number of branches per plant (4.65) was recorded by Zn_0, the control (Fig. 4).

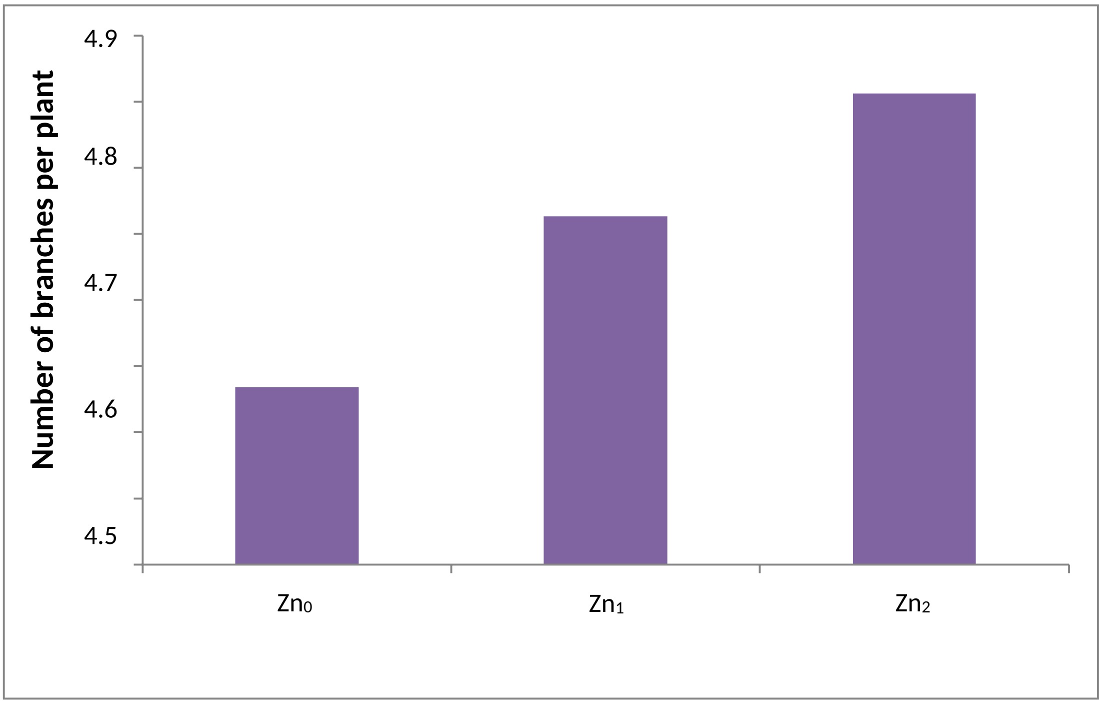

Fig 4: Effect of different levels of Zinc on number of branches per plant of Mustard.

Table 1: Combined effect of boron and zinc levels on plant height and number of branches per plant of mustard:

Treatment	**Plant height (cm)**	**Number of branches per plant**
T_1	59.97 h	3.66 d
T_2	62.35 g	4.11 cd
T_3	63.40 f	4.22 c
T_4	69.68 e	4.33 c
T_5	77.50 b	5.33 b
T_6	73.65 d	4.22 c
T_7	77.17 b	5.11 b
T_8	74.53 c	4.44 c
T_9	78.37 a	5.99 a
$LSD_{(0.05)}$	0.3677	0.46
CV (%)	0.31%	5.98%

Table 2: Effect of different levels of boron on number of seeds per siliquae, number of siliquae per plant, siliquae length and 1000 seed weight of mustards

B Dose	Number of siliquae per plant	Number of seeds per siliquae	Siliquae length (cm)	1000 seed weight (g)
B_0	41.00 a	20.92 c	4.33 c	2.11 c
B_1	47.44 a	22.33 b	4.44 b	2.74 b
B_2	48.89 a	23.56 a	4.53 a	2.88 a
LSD(0.05)	8.50	0.11	0.07	0.07
CV (%)	19.18%	0.53%	1.80%	3.01%

Table 3: Effect of different levels of zinc on number of seeds per siliquae, number of siliquae per plant, siliquae length and 1000 seed weight of mustard

Zn Dose	Number of siliquae per plant	Number of seeds per siliquae	Siliquae length (cm)	1000 seed weight (g)
Zn_0	46.00 a	21.72 c	4.37 b	2.40 c
Zn_1	43.81 a	22.19 b	4.48 a	2.60 b
Zn_2	47.52 a	22.91 a	4.45 ab	2.72 a
LSD0.05	8.50	0.11	0.07	0.07
CV (%)	19.18%	0.53%	1.80%	3.01%

Table 4: Combined effect of different levels of boron and zinc on number of seeds per siliquae, number of siliquae per plant, siliquae length and 1000 seed weight of mustard

Treatment	Number of siliquae per plant	Number of seeds per siliquae	Siliquae length (cm)	1000 seed weight (g)
T_1	39.33bc	20.11g	4.30 d	1.92 g
T_2	41.44 abc	20.54 f	4.34 cd	2.13 f
T_3	42.22 abc	22.12 c	4.35 cd	2.27 e

T_4	43.44 abc	21.38 e	4.35 cd	2.49 d
T_5	55.55 ab	23.78 b	4.59 a	2.98 b
T_6	43.33 abc	21.83 d	4.40 bcd	2.75 c
T_7	55.22 ab	23.67 b	4.48 abc	2.79 c
T_8	34.44 c	22.24 c	4.53 ab	2.71 c
T_9	57.00 a	24.77 a	4.60 a	3.14 a
LSD0.05	14.73	0.1986	0.13	0.13
CV(%)	19.18%	0.53%	1.80%	1.84%

Table 5: Effect of different levels of boron on Seed yield, Stover yield (t/ha), Biological yield (t/ha), Harvest index (%) of mustard

B Dose	**Seed yield (t/ha)**	**Stover yield (t/ha)**	**Biological yield (t/ha)**	**Harvest index (%)**
B_0	1.03 c	2.06 c	3.09 c	33.11 c
B_1	1.52 b	2.65 b	4.18 b	36.48 b
B_2	1.70 a	2.79 a	4.49 a	37.87 a
LSD0.05	0.03	0.04	0.05	0.50
CV (%)	1.84%	1.59%	1.31%	1.45%

Table 6: Effect of different levels of zinc on Seed yield (t/ha), Stover yield (t/ha), Biological yield (t/ha), Harvest index (%) of mustard

Zn Dose	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Zn_0	1.31 c	2.37 c	3.69 c	34.97b
Zn_1	1.45 b	2.52 b	3.97 b	36.27 a
Zn_2	1.49 a	2.60 a	4.10 a	36.23 a
LSD0.05	0.03	0.04	0.05	0.50
CV (%)	1.84%	1.59%	1.31%	1.45%

Table 7: Combined effect of different levels of boron and zinc on Seed yield, Stover yield (t/ha), Biological yield (t/ha), Harvest index (%) of mustard

Treatment	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
T_1	1.01 h	1.98 g	2.99 h	33.77 e
T_2	1.04 g	2.04 f	3.08 g	33.80 d
T_3	1.22 f	2.29 e	3.52 f	34.75 c
T_4	1.36 e	2.50 d	3.86 e	35.47 c
T_5	1.78 ab	2.84 ab	4.62 b	38.54 a
T_6	1.44 d	2.61 c	4.04 d	35.41 c
T_7	1.75 b	2.78 b	4.53 b	38.51 a
T8	1.53 c	2.67 c	4.21 c	36.47 b
T_9	1.82 a	2.91 a	4.74 a	38.64 a
LSD0.05	0.07	0.07	0.09	0.87
CV (%)	3.13%	1.59%	1.31%	1.45%

$T_1=B_0Zn_0$ $T_2= B_1Zn_0$ $T_3= B_2Zn_0$

$T_4= B_0Zn_1$ $T_5= B_1Zn_1$ $T_6= B_2Zn_1$

$T_7 = B_0Zn_2$ $T_8= B_1Zn_2$ $T_9= B_2Zn_2$

Conclusions and Recommendations :

The experiment was conducted in the experimental field of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during rabi season, from November 2021 to February 2022 to find the effect of different levels of boron (B) and zinc (Zn) on growth and yield contributing characters of mustard. Data were collected in respect of the plant growth and yield characters for different levels of boron and zinc. Plant height, Number of primary branches per plant, Number of siliquae per plant, Length of siliquae, Number of seed per siliquae, 1000 seed weight, Seed yield, Stover yield, Biological yield and Harvest index were recorded. The data obtained for these characters were statistically analyzed to find out the significance of the boron and zinc. The mean differences among the treatments were compared by Least Significant Difference (LSD) test at 5% level of significance.

Considering the above information of this experiment, it may be summarized that growth and yield contributing parameters of mustard are positively correlated with B and Zn application. Therefore, the present experimental results suggest that the combined use of 1.5 kg B/ha and 5 kg Zn/ha fertilizer combination along with recommended doses of other fertilizer would be beneficial to increase the seed yield of mustard variety BARI sarisha-14 under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka and similar environment elsewhere in Bangladesh.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

➢ Such study is needed in different agro-ecological zones (AEZ) of Bangladesh to investigate regional adaptability and other performance.

➢ It needs to conduct more researches of Boron and Zinc to investigate the growth and yield BARI Sarisha-14.

➢ It needs to conduct more advanced and related experiments with other varieties of mustard and also in different climate and soil condition.

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3.2 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P and K contents. The soil samples were analyzed by the following standard methods as follows:

3.2.3 Textural class

Mechanical analysis of soil was done by hydrometer method (Bouyoucos, 1926) and the textural class was estimated by plotting the value so f%s and, % silt and % clay to the Marshall's textural triangular co-ordinate taken from selected plants which were marked by tag. Final field data were collected at harvesting stage.

Data were collected on the following parameters:

11. Plant height(cm)
12. Number of branches perplant
13. Number of siliquae perplant
14. Number of seed persiliquae
15. Length of siliquae(cm)
16. Thousand seed weight(g)
17. Seed yield(t/ha)
18. Stover yield(t/ha)
19. Biological yield(t/ha)
20. Harvest Index(%)

3.4 Methods of recordingdata

3.4.1 Plant height(cm)

The height of the mustard plants was recorded at harvest. The height of 10 preselected sample plants were taken from the ground level to the tip of the shoot. Then the mean of the data were taken and expressed in cm.

3.4.2 Number of branches perplant

Total number of branches was taken at harvest. All the branches present on randomly selected plants were counted and average number of branches per plant was taken.

3.4.3 Number of siliquae perplant

Number of siliquae was counted from randomly selected ten plants after harvest and averaged them to have number of siliquae perplant.

3.4.4 Number of seeds persiliquae

Number of total seeds of 10 randomly preselected sample plants from each plot was recorded and the average number was expressed per siliquae basis.

3.4.5 Length of siliquae(cm)

Number of siliquae was recorded from randomly selected 10 sample plants after harvest and mean number was expressed incm.

3.4.6 Thousand seed weight(g)

One thousand sun dried and cleaned seeds were counted randomly from the seed stock and weighed of seeds. Then the weight of 1000 seeds were recorded by means of a digital electrical balance and expressed in gram.

3.4.7 Seed yield(t/ha)

Seeds obtained from harvested area of each unit plot were dried in the sun and weighed. The seed weight was expressed in t/ha.

3.4.8 Stover yield(t/ha)

The Stover obtained from the harvested area of each unit plot was dried separately and weight was recorded. These values were expressed in t/ha.

3.4.9 Biological yield(t/ha)

Biological yield was calculated by using the following formula: Biological yield= Seed yield + Stover yield

3.4.10 Harvest index(%)

Harvest index is the ratio of seed yield and biological yield (Gardner *et al.*, 1985). It was calculated by using the following formula: Harvest index = (Seed yield / Biological yield) × 100

3.5 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P and K contents. The soil samples were analyzed by the following standard methods as follows:

3.5.1 Textural class

Mechanical analysis of soil were done by hydrometer method (Bouyoucos, 1926)and the textural class was estimated by plotting the values of %s and, % silt and % clay to the Marshall's textural triangular co-ordinate following the USDA system.

3.5.2 SoilpH

pH of soil was estimated with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 (Jackson, 1973).

3.5.3 Organic carbon

Soil organic carbon was determined by Walkley and Black's wet oxidation method as outlined by Jackson (1973).

3.5.4 Organic matter

Soil organic matter content was determined by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724.

% organic matter = % organic carbon × 1.724

3.5.5 Total nitrogen

Total nitrogen content in soil was estimated by Kjeldahl method by digesting the soil sample with conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965).

The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100 / S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4 B = Blank titration (ml) value of standard H_2SO_4 N = Strength of H_2SO_4
S = Sample weight in gram

3.5.6 Available Phosphorus(ppm)

Available phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ solution pH 8.5 (Olsen et al., 1954). Phosphorus in the extract was measured spectrophotometrically after development of blue colour (Black,1965).

3.5.7 Exchangeable Potassium (meq/100 gsoil)

Exchangeable potassium (K) content of the soil sample was determined by flame photometer on the NH_4OAc extract (Black, 1965).

3.5.8 Available Zinc

Available Zinc content was estimated by extracting the soil with Zncl2 solution as described by Page et al. 1982. The digested Zn was determined by developing turbidity by adding Zncl2 solution. The intensity of turbidity was measured by spectrophotometer at 420 mm wavelengths (Hunter, 1984).

3.6 Statistical Analysis

The collected data were statistically analyzed by using the ANOVA technique. The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel, 1986). The mean values for all the parameters were calculated and the analysis of variance was performed.

The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test at 5 % levels of probability (Gomez and Gomez, 1984).

- To study the growth and yield performance of Mustard by using different doses of Boron and Zinc fertilizers.
- To find out suitable combination of B and Zn fertilizers for better growth and yield of Mustard.

ingression of cereal crops like-rice, maize, wheat etc. Delayed harvest of transplanted aman rice and wetness of soil are another reason which hinders mustard cultivation in rabi season (BARI, 2008).

Mustard plant belongs to the genus Brassica under the family brassicaceae. The brassica has three species that produce edible oil, *B. napus, B. campestris, B. juncea*. Of these *B. napus* and *B. campestries* have the greatest importance in the world's oilseed trade. In this subcontinent, *B. juncea* is also an important oilseed crop. Mustard is the most important oilseed crop among other oilseed crops like groundnut, sesame, coconut, castor and linseed of Bangladesh. Moreover, it is very well known to the farmers. Mustard oil is being used as a medium of cooking from time immemorial (Khaleque, 1985).

Mustard is a cold loving crop and grows during Rabi season (October- February) usually under rainfed and low input condition in this country can be attributed to several factors, the nutritional deficiency, among others is highly important. There is very little scope expansion for mustard and other oilseed acreage in the country, due to competition from more profitable alternative crops. Although mustard is the principal oil crop in Bangladesh but its cultivation is neglected. Moreover the yield of mustard is low in Bangladesh as compared to other countries of the world. There is great possibility to increase its production by applying adequate fertilizers, selecting high yielding varieties and adopting proper management practices. One of the common constraints to higher yield is lack of balanced fertilization.

Many previous researches showed that fertilization can be done to boost up growth and yield of crops (Sinha et al. 2003, Shukla et al. 2002, Meena *et al.* 2002 and Zhao *et al*. 1997). Boron is the vital element for plant growth and yield of this crop. Boron increases yield by influencing a number of growth parameters such as number of branches and siliquae plant^{-1}, seeds siliqua^{-1} and 1000-seed weight by producing more vigorous growth and development
(Taylor *et al.*, 1991; Qayyum *et al.*, 1998). Again, boron has impacts on seed protein and physiological functions and supports the plant with rapid growth, increasing seed and oil seed yield (Allen and Morgan 2009). Excessive use of nboron may reduce seed yield and quality appreciably (Cheema *et al.*, 2001; Laaniste *et al.*, 2004).

Zinc is one of the first micronutrients recognized as essential for plants that transported to plant root surface through diffusion (Maqsood *et al.*, 2009). Zn is a micronutrient and in case of its severe deficiency the symptoms may last throughout the entire crop season (Asad and Rafique, 2000). Zn deficient plant also appears to be stunted (Torun *et al.*, 2001) as a result approximately 2 billion people suffer from Zn deficiency all over the world (Asad and Rafique, 2002). The grain yield can be improved by addition of

Zn fertilization (Maqsood *et al.*, 2009). Bora and Hazarika, (1997) reported highest stover yield (2770 kg ha^{-1}) with Zn and almost the same trend of seed yield. The seed yield can be improved by addition of Zn fertilization. Chen and Aviad, (1990) found that application of Zn along with other micronutrients improved soil organic matter and resulted in increasing mustard yields. Kutuk *et al.*, (2000) also suggested that the application of Zn has become necessary for improved cropyields.

Application of proper amount of micro nutrients is essential to maximize crop production. Boron and Zinc fertilizer play an important role to increase the mustard production. Zhu et al. (1996) stated that Zn increased the yield of mustard seed 18% over NPK alone. In addition, the fertilizer requirement for maximum growth and yield of newly developed mustard variety BARI Sarisha- 14 is not much investigated. With a view to determine the Boron and Zinc requirement of this new variety a field study was conducted with the fallowing objectives:

- to study the growth and yield performance of Mustard by using different doses of Boron and Zinc fertilizers.
- to find out suitable combination of B and Zn fertilizers for better growth and yield of Mustard.