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GROWTH AND YIELD OF MUSTARD AS INFLUENCED BY DIFFERENT COMBINED DOSES OF ZINC AND BORON

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Abstract

A field experiment was conducted at the research field of BINA substation, Gopalganj from November 2022 to February 2023 to evaluate the effect of different doses of micronutrients (Zn and B) on the growth and yield of mustard. The experiment comprised of eight (8) treatments viz. T_0= Control, T_1=100% NPKSZnB as Recommended dose of chemical fertilizer (RDCF), T_2= 100% NPKS, T_3= 100% NPKS+$Zn_{1.5}$$kgha^{-1}$+$B_{1.5}$$kgha^{-1}$, T_4= 100% NPKS+$Zn_{2.0}$$kgha^{-1}$+$B_{2.0}$$kgha^{-1}$, T_5= 100% NPKS+$Zn_{3.0}$$kgha^{-1}$+$B_{3.0}$$kgha^{-1}$, T_6=100% NPKS+$Zn_{2.0}$$kgha^{-1}$, T_7= 100% NPKS+$B_{2.0}$$kgha^{-1}$. The experiment was laid out in a randomized complete block design (RCBD) with three (3) replications. The results revealed that growth and yield were influenced significantly by the rate of 100% NPKS+$Zn_{2.0}$$kgha^{-1}$+$B_{2.0}$$kgha^{-1}$ application. The highest plant height (103.67 cm), primary branch/plant (6), secondary branch/plant (4.67), lowest days to flowering (35.67), days to maturity (83.00), plant population (728.67), siliqua length (7.30 cm), siliqua/plant (52.67), seeds/siliqua (39.00), 1000 seed weight (4.19 g) and yield (1.99 ton/ha) were obtained from 100% NPKS+$Zn_{2.0}$$kgha^{-1}$+$B_{2.0}$$kgha^{-1}$ treatment. The result showed that the growth and yield of mustard increased with increasing levels of Zn and B along with 100% NPKS fertilizers application. It may be concluded that the treatment T_4= 100% NPKS+$Zn_{2.0}$$kgha^{-1}$+$B_{2.0}$$kgha^{-1}$ would be suitable for mustard cultivation for getting higher yield and better performance.

Keywords: Zinc, Boron, Mustard, Yield.

Introduction

Mustard belongs to the family of Brassica ceae (Bayer, 2010). It plays an important role as a highly cultivated oilseed crop in Bangladesh, whereas mustard stood as the major oil-producing crop of both acreage and yield among the several oil crops cultivated in the country (BBS, 2019). Worldwide, 41.50% of mustard seed is produced just in Asia which occupies the first position in terms of percentage share of production followed by the USA (FAO, 2018). In Bangladesh, the demand for edible oil is increasing day by day and oilseeds are on an increasing trend (Alam, 2020) where the daily per capita recommended dietary allowance of oil is 6 gm per day for a diet with

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2700 Kcal (BNNC, 1984). To meet this demand of edible oil, Bangladesh has to import edible oil and oil seeds which were worth USD 544 million in 2002-03 to USD 2371 million in 2018-19 (Bangladesh Bank, 2020). To meet up this demand, in Bangladesh mustard production is not in a favor position (Miah and Rashid, 2015) because of lack of short duration high-yielding varieties which can easily incorporate with cropping pattern, reduce land for oil crop production, improper cultural practices, insufficient nutrient management, soil nutrient depletions, imbalance used of fertilizers and so on. Mustard (*Brassica spp*. L.) is sensible to micronutrients (Zn and B) but in Bangladesh, there is a lack of awareness among farmers regarding the application of micronutrients in mustard fields. The decline in crop yield is due to either inadequate use of fertilizers or imbalanced fertilization practices (Roy *et al*., 2013; Haque *et al*., 2014; Rabbani *et al*., 2023). The growth of a plant can be retained if any of the micronutrients are absent in the soil, even if all other nutrients are available in sufficient quantities. The application of micronutrients is necessary to obtain desirable balance nutrition.

Apart from all the nutrients, zinc is one of the major micronutrients that are essential for the plant growth which is transported to the plant root surface through diffusion (Maqsood *et al.*, 2009). If zinc is deficient in plants, it may last throughout the entire crop season (Asad and Rafique, 2000) and in severe cases, the plant appears to be stunted. Zinc is an important component of numerous enzymes that play a regulatory role in diverse metabolic processes and found to have a stimulating effect on pod and seed development, and oil synthesis in mustard seeds (Halim *et al.*, 2023). Moreover, it has been noticed to enhance the overall formation and oil synthesis in mustard not only for seed but also for stover production (Sultana *et al*., 2020). Zinc application has become necessary for improved crop yields ~~(Kutuk *et al*., 2000)~~ and $ZnSO_4$ application was recommended at the rate of 20 kg ha^{-1} for oilseeds including mustard (Mandal and Sinha, 2004). Reza *et al*. (2023) suggested that the application of zinc with recommended dose chemical fertilizers increased the mustard production.

Boron has an important role in the phenology of mustard production and in promoting the growth and productivity of crops (Karthikeyan and Shukla, 2011). As a result, the yield of mustard has been reduced when cultivated on low boron soils or where availability of boron is restricted under high soil pH, liming, and drought periods during the growth period. For this reason, boron fertilization is required to increase the crop production. Saha *et al*. (2003) stated that mustard responds positively to boron fertilization and a positive correlation between the mustard plant and the use of B fertilization (Jaiswal *et al.,* 2015). In Bangladesh, farmers are unaware of the recommended fertilizer rates where boron and zinc fertilizers are occasionally disregarded and many of them apply fertilizers in quantities that are inconsistent with recommended for mustard. The objective of this study was to know the effects of different doses of micronutrients (Zn and B) on the growth and yield of mustard.

Materials and Methods

The experiment was carried out at the research field of the Bangladesh Institute of Nuclear Agriculture (BINA), located in Gopalganj at coordinates of $23^0$11’57” N latitude and $89^0$76’05” E longitude, during the period from November 2022 to February

2023. The land was of clay loam to sandy clay as a part of the Gopalganj Khulna Beels (AEZ-14) and Arial Beels (AEZ-15) (UNDP and FAO, 1988) and pH ranges from 6.5 to 9.0.

Experimental treatments and design

The experimental treatments are (T_0= Control, T_1=100% NPKSZnB as Recommended dose of chemical fertilizer (RDCF), T_2= 100% NPKS, T_3= 100% NPKS+$Zn_{1.5}$kgha^{-1}+$B_{1.5}$kgha^{-1}, T_4= 100% NPKS+$Zn_{2.0}$kgha^{-1}+$B_{2.0}$kgha^{-1}, T_5= 100% NPKS+$Zn_{3.0}$kgha^{-1}+$B_{3.0}$kgha^{-1}, T_6=100% NPKS+$Zn_{2.0}$kgha^{-1}, T_7= 100% NPKS+$B_{2.0}$kgha^{-1}). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications where the total number of experimental units was 24 (8 × 3). The size of each plot was 6 m^2 (3.0 m × 2.0 m). The distance between plot to plot and block to block was maintained at 0. 75m and 1 m, respectively.

Experimental material and land preparation

Binasarisha-9, a high-yielding variety of *Brassica napus* L. developed by the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh was used as a test crop. The experimental land was prepared by plowing and cross plowing followed by laddering with power tiller and crop debris of the previous season was removed from the field. The plot was fertilizers with urea (N), triple super phosphate (P), murite of potash (K) and gypsum (S) and the rate were 210 kg/ha, 185 kg/ha, 124 kg/ha, 136 kg/ha respectively. All the fertilizers and half of the urea were applied at the final land preparation and the rest half of the urea was top-dressed after 30 days after sowing (DAS). Zinc sulphate (36% Zn) and boric acid (17%) were applied as per treatments and the seed rate was 6 kg ha^{-1}. Seeds were sown manually in a continuous pattern in 25 cm apart rows on 9 November 2022 and after sowing, seeds were then covered with soil. Weeding was done as needed and thinning was done after 15 and 25 DAS. Care was taken to maintain a constant plant population in plot^{-1} and there was no disease or insect was observed in the plots.

Harvesting and data collection

On February 1 to 10, 2023 when 90% of the siliqua were mature, the crop was harvested plot by plot. Data on growth and yield components were recorded randomly by selecting five plants from each plot and bound together into bundles which were then transported to the designated area for threshing. After that, the bundle was laid out on the threshing floor, the plants were dried in the sun, and after sundry, using bamboo sticks to beat the bundles to collect the seeds. After that, cleaning was done and yield was calculated on a hectare basis and documented each plot.

Statistical analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done following the RCBD with the help of the computer package R version 4.3.1. The LSD was used to determine the mean differences (Gomez and Gomez, 1984).

Result and Discussion

Plant height

The highest plant height (103.67 cm) was recorded in T_4 (100% NPKS+$Zn_{2.0kgha^{-1}}$+$B_{2.0kgha^{-1}}$) T_6 (Table 1) while the shortest plant height (74.33 cm) was observed T_0 (control). The height of plants showed a progressive rise in absorption as the concentration of zinc and boron. This finding aligns with the studies conducted by Reza *et al*. (2023) which have elucidated a significant impact of varying doses on plant height.

Flowering days

The results regarding days of flowering of mustard variety as influenced by different zinc and boron doses are presented in (Table 1). The analysis of variance indicated that the days to flowering of mustard were significantly influenced by zinc and boron doses. The highest days (50.67) were taken for flowering T_0 (control) whereas the shortest days (35) were taken T_5, T_4, T_6 and T_7 respectively. Balanced fertilizers along with zinc and boron fertilizers have a positive relation with flowering days (Bhagchand Kansotia *et al*., 2013).

Days to maturity

The highest days (94.67) were taken T_0 and the shorten days (83) were taken at T_4 (Table 1). Application of recommended doses along with zinc and boron for mustard cultivation will improve the maturity days (Sana *et al*., 2003).

Primary branches plant^{-1}

Branches plant^{-1} responded significantly to various doses of zinc and boron application (Table 1). The maximum (6) branch plant^{-1} was observed T_4 which was at par T_2, T_3, T, T_6, T_7 and minimum branch plant^{-1} was recorded T_0 (control). Zinc and boron had significantly increased the primary and secondary branches plant^{-1} (Hossain *et al.*, 2011; Rashid *et al.*, 2012).

Table 1. Effects of different doses zinc and boron on growth attributes of mustard

Treatments	Plant height (cm)	Days to flowering	Days to maturity	Primary branch plant^{-1} (no.)	Secondary branch plant^{-1} (no.)
T_0	74.33 e	50.67 a	94.67 a	4.00 b	1.33 d
T_1	88.33 c	42.00 b	88.33 b	5.67 ab	2.66 bcd
T_2	83.00 d	40.00 bc	88.67 b	4.67 ab	2.00 cd
T_3	92.00 c	39.00 bcd	86.00 c	5.33 ab	3.33 abc
T_4	103.67 a	35.67 d	83.00 d	6.00 a	4.67 a
T_5	98.33 b	35.00 d	85.33 c	4.33 ab	3.00 bc
T_6	101.00 ab	36.00 cd	86.00 c	4.67 ab	4.00 ab
T_7	99.33 b	36.00 cd	86.33 c	5.00 ab	3.33 abc
CV (%)	2.32	5.99	1.02	19.68	25.23

In a column figures having similar letter (s) do not differ significantly at 5% level of probability where (T_0= Control, T_1=100% NPKSZnB as Recommended dose chemical fertilizer (RDCF), T_2= 100% NPKS, T_3= 100% NPKS+$Zn_{1.5}$kgha^{-1}+$B_{1.5}$kgha^{-1}, T_4= 100% NPKS+$Zn_{2.0}$kgha^{-1}+$B_{2.0}$kgha^{-1}, T_5= 100% NPKS+$Zn_{3.0}$kgha^{-1}+$B_{3.0}$kgha^{-1}, T_6=100% NPKS+$Zn_{2.0}$kgha^{-1}, T_7= 100% NPKS+$B_{2.0}$kgha^{-1})

Secondary branch plant^{-1}

The highest secondary branches plant^{-1} (4.67) was observed T_4 and the lowest was recorded (1.33) at T_0 (control). Suitable doses of zinc and boron fertilizers significantly influenced plant height and branches per plant of mustard (Naser and Islam, 2001).

Plant population plot^{-1}

The plant population plot^{-1} varied significantly because of zinc and boron application with recommended doses of fertilizers (The maximum plant population plot^{-1} (728.67) was recorded at T_4 which was statistically significant from other treatments and the minimum plant population plot^{-1} (371.67) was observed at $T_{0.}$

Siliqua length (cm)

The varieties of rapeseed differed significantly in respect of siliqua length (Hossain *et al.* 1996). The effect of zinc and boron fertilizers significantly influenced the siliqua length **(Table 2).** The highest siliqua length (7.30) was observed at T_4 which was statistically significant from other treatments whereas the lowest siliqua length (3.13) was observed from T_0.

Siliqua plant^{-1}

The highest siliqua plant^{-1} was observed (52.67) from T_4 which was statistically significant from others and the minimum siliqua plant^{-1} was observed from T_0 (19). The number of silique plant-1 of mustard was significantly affected by different varieties (Mamun *et al.*, 2014).

Seeds siliqua^{-1}

Effects of zinc and boron significantly influenced the number of seeds siliqua^{-1} (Table 2). It was observed that the highest seed siliqua^{-1} was recorded (39) from T_4 which was statistically significant from others and the lowest number of seeds was recorded (19.33) from T_0 treatment. Significant variation in terms of the number of seed siliqua^{-1} among the varieties was observed due to reason difference in the genetic makeup of the variety, which is primarily influenced by heredity (Helal *et al.* 2016). Mandal and Sinha (2004) stated that the application of Zn and B fertilizers along with NPK fertilizers increased the mustard siliqua per plant, number of seeds per siliquae, and 1000-seed weight.

Table 2. Effects of different doses of micronutrients on yield and yield contributing characteristics

Treatments	Plant population/plot	Siliqua length (cm)	Siliqua/plant (no.)	Seeds/silique (no.)	1000 seed weight (g)
T_0	371.67 d	3.13 e	19.00 d	19.33 e	2.21 e
T_1	500.67 c	6.17 c	27.00 c	26.67 d	2.94 d
T_2	475.67 c	5.50 d	27.67 c	24.67 d	2.70 d
T_3	558.00 b	6.93 b	39.33 b	30.00 b	3.30 c

Treatments	Plant population/plot	Siliqua length (cm)	Siliqua/plant (no.)	Seeds/silique (no.)	1000 seed weight (g)
T_4	728.67 a	7.30 a	52.67 a	39.00 a	4.19 a
T_5	602.67 b	6.82 b	41.67 b	28.33 cd	3.27 c
T_6	589.33 b	6.94 b	41.33 b	31.67 bc	3.63 b
T_7	603.00 b	6.98 b	39.67 b	28.00 cd	3.94 a
CV (%)	5.84	2.64	6.29	8.76	5.04

In a column figures having similar letter (s) do not differ significantly at 5% level of probability where (T_0= Control, T_1=100% NPKSZnB as Recommended dose chemical fertilizer (RDCF), T_2= 100% NPKS, T_3= 100% NPKS+$Zn_{1.5}kgha^{-1}$+$B_{1.5}kgha^{-1}$, T_4= 100% NPKS+$Zn_{2.0}kgha^{-1}$+$B_{2.0}kgha^{-1}$, T_5= 100% NPKS+$Zn_{3.0}kgha^{-1}$+$B_{3.0}kgha^{-1}$, T_6=100% NPKS+$Zn_{2.0}kgha^{-1}$, T_7= 100% NPKS+$B_{2.0}kgha^{-1}$)

1000 seed weight (g)

There was a significant difference found among the treatments. The highest 1000 seed weight was (4.19) observed from T_4 which was statistically significant from all other treatments whereas the lowest 1000 seed weight (2.21) was observed from T_0 (Table 2). Mamun *et al.* (2014) stated that the performance of rapeseed and mustard varieties with the application of zinc and boron response quality and mature seeds which will ultimately affect different seed weight.

Yield (ton/ha)

The highest yield (1.99 ton/ha) was observed from T_4 which was statistically significant from others whereas the lowest yield (0.49 ton/ha) was observed from T_0 treatment. From the finding, the application of $ZnSO_4$ at the rate of 0.05% solution foliar spray at 25 and 40 days after sowing (DAS) resulted in a 9.02% increase in seed yield in mustard (Biswas *et al.*, 2010). There was a positive correlation between the rise in Zn and B content and the mean seed yield.

Application of Zn and B along with other micronutrients improved soil organic matter and resulted in increasing the mustard yield (Maqsood *et al.*, 2009). Effect of Zn and B application in addition to NPK fertilizers on production and with yield of mustard.

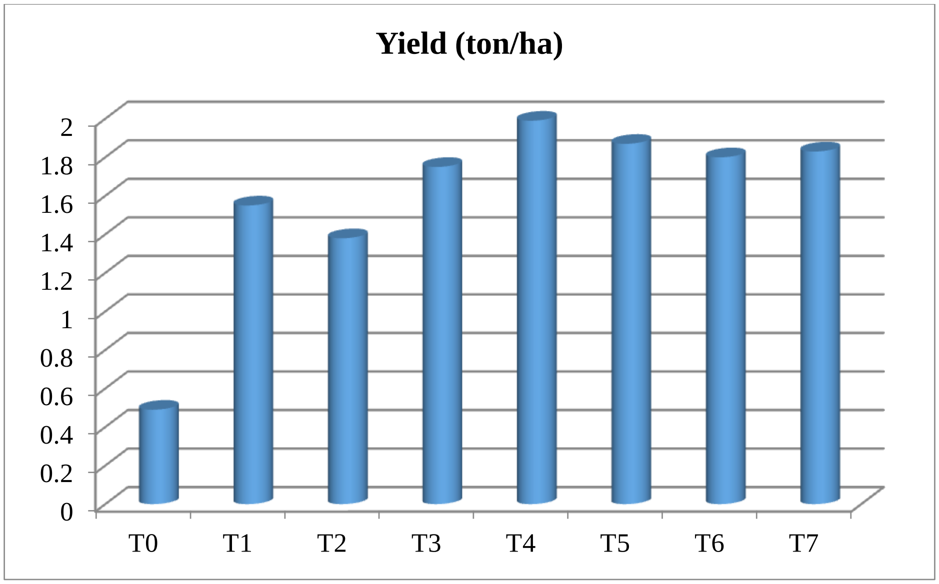
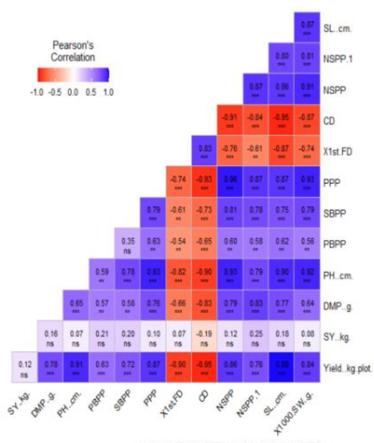


Fig. 1. The effect of different micronutrients (Zn and B) doses on yield of mustard



Legend:
SL=Siliqua length (cm)
NSPP[1]= Number of seeds per plant
NSPP=Number of siliqua per plant
CD= Crop duration (Days)
1st FD= Flowering day (1st)
PPP= Plant population per plot
SBPP= Secondary branches per plant
PBPP= Primary branches per plant
PH= Plant height (cm)
DMP=Dry matter per plot
SY= Straw yield
Yield= Yield

Fig. 2. Correlation among the growth and yield attributes of mustard

The correlation among the parameters (Fig. 2), there was a positive correlation among the yield, straw yield, dry matter, plant height, primary branch/plant, secondary branch/plant, plant population/plot, number of seeds per siliqua, number of siliqua/seeds, siliqua length but there was a negetive correlation between flowering days and maturity days. Jha *et al*. (2023) stated that a positive correlation between the rise of Zn and B content and the seed yield.

Conclusion

In the present study, the results showed that the treatment T_4 (100% NPKS+$Zn_{2.0kgha^{-1}}$+$B_{2.0kgha^{-1}}$) gave the highest yield, the tallest plant, greatest number of branches plant^{-1}, number of total siliqua plant^{-1}, siliqua length, seed siliqua^{-1}. From the experimental findings, it may be concluded that the application of zinc and boron along with NPKS played a significant role in increasing the yield of mustard in Gopalganj region of Bangladesh.

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Author's contribution

M. S. Reza: Conceptualized and designed the experiment, conducted field trials, performed data collection and manuscript preparation. S. A.: Provided assistance in experiment implementation at the research field, contributed to data interpretation and reviewed the manuscript. M. K. A. N: Assisted with the application of methodologies, provided technical guidance during the experimental process and contributed to statistical analysis. M. E. H.: Supported in literature review and manuscript revision.

Conflicts of Interest

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

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