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 Rate and Method of Zinc and Boron Application on the Yield Performance of Mustard

Resnat Jannat Raku[1], Shivanand Jha[1], Md. Moshiur Rahman[1], Md. Sadiquzzaman Sarker[2], Md. Harun Rashid[1] and Swapan Kumar Paul[1]*

[1]Department of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
[2] Department of Agricultural Extension, Pirganj, Rangpur, Bangladesh

*Correspondence: skpaul@bau.edu.bd, Phone: +88-01752792457

Received: 20/06/2023
Accepted: 31/08/2023
Available online: 04/09/2023

Copyright: ©2023 by the author(s). This work is licensed under a Creative Commons Attribution 4.0 License. https://creativecommons.org/licenses/by/4.0/

Abstract: Zinc (Zn) and boron (B) deficiency are widespread nutritional disorders in crop plants, including mustard. However, Zn-B interaction on the performance of mustard crops is not well documented. A field experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during November 2021 to February 2022 to evaluate the effect of rate and method of Zn and B application on the yield performance of mustard (BARI Sarisha-18). The experiment comprised nine doses of Zn & B as a basal and foliar application viz., recommended Zn (2 kg ha^{-1}) and B (2 kg ha^{-1}) as basal, 75% Zn and B as basal + 25% Zn and B foliar spray at pre- flowering stage, 50% Zn and B as basal + 50% Zn and B foliar spray, 100% Zn and B as basal + 25% Zn and B foliar spray, 100% Zn and B as basal + 25% Zn foliar spray, 100% Zn and B as basal + 25% B foliar spray, 100% Zn as basal (without B), 100% B as basal (without Zn), control (no Zn and B). The experiment was laid out in a Randomized Complete Block Design with three replications. The result revealed that yield was influenced significantly by the rate and method of Zn and B application. The highest plant height (140.57 cm), the maximum number of branches plant^{-1} (5.84), maximum number of effective pods plant^{-1} (87.57), maximum number of seeds pod^{-1}(31.53), the highest seed yield (1.85 t ha^{-1}) and the highest stover yield (4.47 t ha^{-1}) were obtained from 100% Zn and B as basal + 25% Zn as foliar. The lowest number of seeds pod $^{-1}$ (27.20), 1000-seed weight (3.35 g), seed yield (1.33 t ha^{-1}) and stover yield (3.35 t ha^{-1}) were obtained from the control treatment. The result showed that the seed yield of mustard increased with increasing levels of both Zn and B as basal 100% with only Zn 25% as foliar, respectively. Therefore, 100% zinc combined with 100% B as basal and 25% Zn foliar application may be recommended for higher seed yield of mustard (cv. BARI Sarisha-18).

Keywords: Mustard; Zinc; Boron; Yield.

INTRODUCTION

Mustard (*Brassica* spp.) holds significant prominence as a highly cultivated oilseed crop in Bangladesh, commanding the foremost place in terms of both acreage and yield among the several oil crops cultivated in the country (BBS, 2019). One of the vital causes of lower yield is imbalanced fertilization. There is a lack of awareness among farmers in Bangladesh regarding the application of micronutrients in mustard fields. Mustard exhibits a notable degree of sensitivity to micronutrients such as zinc (Zn) and boron (B), both of which play a significant role in the growth and development of this particular crop. The decline in crop yields is closely associated with the deterioration of soil quality, namely the depletion of nutrients. This can be due to either inadequate use of fertilizers or imbalanced fertilization practices (Roy *et al*., 2013; Haque *et al*., 2014; Rabbani *et al*., 2023). The impact of fertilizers on crop yield and its associated attributes, as well as the importance of rationalizing fertilizer usage and resource management to sustain crop productivity, have been emphasized in previous studies (Sultana *et al*., 2015; Sultana *et al*., 2019). The growth of plants can be restricted if any of the micronutrients in the soil are absent, even if all other nutrients are available in sufficient quantities. Mustard also has the capacity to deplete micronutrients from the soil, and these nutrients cannot be restored solely through the application of NPK fertilisers. The application of micronutrients is necessary in order to attain a state of balanced nutrition. Zinc (Zn) is a crucial component of numerous enzymes that play a regulatory role in diverse metabolic processes within plants. Additionally, it exerts an influence on the synthesis of various growth hormones, such as indole-3-acetic acid (IAA), in plants. Zn has been found to have a stimulating effect on pod development, seed formation, and oil synthesis in mustard seeds (Halim *et al.*, 2023). Additionally, it has been observed to enhance the overall yield of mustard in terms of both seed and stover production (Sinha *et al.*, 2000; Sultana *et al.*, 2020). The significance of zinc fertilisers in augmenting mustard yield is widely acknowledged, albeit with limited research conducted in Bangladesh regarding the impact of these fertilisers on mustard crops. Zinc deficiency is a prevalent nutritional limitation observed in agricultural plants cultivated across many soil types, and it is a characteristic frequently observed in both tropical and temperate climates.

Boron has a vital role in promoting the growth and productivity of crops. In addition to the primary plant nutrients, it plays a significant role in the phenological development of mustard plants, and its application has been observed to elicit a response in this crop (Karthikeyan and Shukla, 2008). Therefore, the application of B fertilization is crucial for enhancing both crop productivity and nutritional value. There have been reports indicating a positive correlation between mustard plants and the use of B fertilization (Jaiswal *et al.*, 2015). Mustard, being a member of the Brassica crop family, has a high degree of responsiveness to the application of B (Mengel and Kirkby, 1987). The siliquae count, seed setting, and seed yield of mustard plants are significantly impacted by boron levels, particularly in cases when the soil exhibits boron deficiency (Dutta *et al.*, 1984; Islam and Sarker, 1993; Lei *et al.*, 2009). The majority of Bangladeshi farmers are unaware of the recommended fertiliser rates for the majority of their crops. The application of Boron and Zinc fertilisers is occasionally disregarded. Many of them apply fertiliser in quantities that are inconsistent with the recommendations for mustard, which negatively impacts yield. However, there is a dearth of study and information regarding the disproportionate utilisation of fertilisers by agricultural practitioners. The objective of this study was to determine the optimal application method and rate for enhancing the grain production of the mustard variety BARI Sarisha-18. Because of these limitations, a field study was conducted to assess the effect of the application method and rate of Zinc and Boron micronutrients on the yield performance of BARI Sharisa-18.

MATERIALS AND METHODS

Experimental location site and soil

The study was carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University, located in Mymensingh at coordinates 24°75’ N latitude and 90° 50' E longitude, during the period from November 2021 to February 2022. The land was of moderate elevation and classified as part of the old Brahmaputra Floodplain Agroecological Zone (AEZ 9) characterized by Non-calcareous Dark Grey Floodplain Soils (UNDP and FAO, 1988). The soil had a sandy loam texture with a pH of 6.5.

Experimental treatments and design

The experimental treatments are as follows: (rate and method of application), Recommended Zn (2 kg/ha) and B (2 kg/ha) as basal (T_1), 75% Zn and B as basal + 25% Zn and B foliar spray at pre-flowering stage (T_2), 50% Zn and B as basal + 50% Zn and B foliar spray (T_3), 100% Zn and B as basal + 25% Zn and B foliar spray (T_4), 100% Zn and B as basal + 25% Zn foliar spray (T_5), 100% Zn and B as basal + 25% B foliar spray (T_6), 100% Zn as basal (without B) (T_7) and 100% B as basal (without Zn) (T_8), Control (no Zn and B) (T_9). The experiment was laid out in a Randomized Complete Block Design with three replications. The total numbers of experimental units were 27 (9 × 3). The size of each plot was 10 m^{-2} (4.0 m × 2.5 m). The distance between plot to plot and block to block was maintained at 0. 75m and 1 m, respectively.

Crop husbandry

BARI Sarisha-18, a high yielding variety of *Brassica napus* developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur was used as test crop. The land preparation was done by ploughing and cross ploughing followed by laddering with power tiller and country plough. The experimental plot was fertilized with urea, triple super phosphate and muriate of potash and gypsum at the rate of 260 kg, 170 kg, 90 kg, and 160 kg ha^{-1} respectively. Half of the total dose of urea and the whole of triple super phosphate and muriate of potash were applied at the time of final land preparation. The rest half of the urea was top dressed after 30 days of sowing. Zinc and boron in the form of zinc sulphate (36% Zn) and boric acid (17 %B) were used. Boric acid and zinc sulphate were applied as per experimental treatment. Seeds at the rate of 7 kg ha^{-1} were sown after final land preparation. Seeds were continuously sown manually in 25 cm apart rows on 9 November 2021. After sowing, the seeds were covered with soil. Weeds of different types were controlled manually two times and at the same time thinning was done after 15 days and 25 days of sowing. Care was taken to maintain constant plant population $plot^{-1}$. Since no infestation of diseases and insect was observed in the plots, so no pest control measure was adopted.

Harvesting and data collection

On February 17, 2022, when 90% of the siliqua were mature, the crop was harvested plot by plot. Data on crop characteristics and yield components were acquired by randomly selecting five plants from each plot, excluding border rows, prior to harvest. The plants that had been

DOI: https://doi.org/10.55706/jae1625

harvested were gathered and bound together into bundles, which were then transported to the designated area for threshing. By laying the bundles out on the threshing floor, the plants were dried in the sun. The process of separating the seeds from the stover involved the utilization of bamboo sticks to beat the bundles. The measurements of seed and stover yield for plot^{-1} were obtained subsequent to the sun-drying of the plants and subsequent processes of threshing and cleaning. At harvest, seed yield was calculated on a hectare basis and documented each plot. The combination of grain yield and stover yield was defined as the biological yield, denoted as biological yield = seed yield + stover yield. The calculation of the harvest index (HI) involved dividing the seed yield by the biological yield of the crop, with the resulting value reported as a percentage.

Harvest Index (%) = (Seed yield/Biological yield) × 100

Statistical analysis

The recorded data were compiled and tabulated in for statistical analysis. Analysis of variance was done following the RCBD with the help of computer package MSTAT. The Duncan's Multiple Range Test was used to determine the mean differences (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

The highest plant height (140.57 cm) was observed T5 (100% zinc and boron as basal and 25% zinc as a foliar application) which was at par with T1, T3, T4, T6, T7 and T9 (Table 1) while the shortest plant (126.54 cm) was recorded in T_8 (100% B as basal). The height of plants exhibited a progressive rise in absorption as the concentration of zinc increased. The observed phenomenon can be attributed to the increased accessibility and utilisation of zinc and boron, which resulted in a gradual improvement in the plant's vegetative development. This finding aligns with the studies conducted by Ali *et al*. (1990), Mondal and Gaffer (1983), and Gaffer and Razzaque (1983), which have demonstrated a significant impact of varying fertiliser doses on plant height.

Table 1. Effect of rate and method of zinc and boron application on the yield performance of mustard

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Total pods plant^{-1} (no.)	Effective pods plant-1	Pod length (cm)	Seeds pod^{-1} (no.)	1000-seed weight (g)	Biological yield(t ha^{-1})	Harvest Index (%)
T1	135.47ab	3.53b	63.70bc	61.2d	6.15ab	27.87bc	3.77	5.39b	28.67
T2	126.98b	3.63b	59.97bc	57.84d	5.91ab	28.2bc	3.52	5.23bc	29.33
T3	135.90ab	4.93ab	85.54ab	83.42b	6.10ab	29.23bc	3.62	5.36bc	30.72
T4	133.58ab	4.87ab	57.30c	54.9e	6.13ab	28.37bc	3.57	5.06bc	30.21
T5	140.57a	5.84a	90.54a	87.57a	6.33a	31.53a	3.63	6.32a	29.37
T6	132.73ab	5.07ab	76.04a-c	74.21c	6.27a	28.67bc	3.52	5.34bc	29.64
T7	132.50ab	4.73ab	77.33a-c	74.88c	6.07ab	28.03bc	3.66	5.29bc	30.02
T8	126.54b	4.87ab	76.52a-c	74.62c	6.20ab	28.67bc	3.59	5.24bc	30.55
T9	127.93ab	3.83b	57.19c	56.30d	5.80b	27.2c	3.35	4.68c	28.79
Sig. level	*	*	*	*	*	*	NS	*	NS
CV (%)	5.91	10.71	10.94	8.5	4.25	8.49	4.49	7.47	13.09

Means with the same letters or without letters within the same column do not differ significantly; * = Significant at 5% level of probability, T1 = Recommended Zn (2 kg ha^{-1}) and B (2 kg ha^{-1}) as basal, T2 =75% Zn and B as basal + 25% Zn and B foliar spray at pre-flowering stage, T3 =50% Zn and B as basal+ 50% Zn and B foliar spray, T4 = 100% Zn and B as basal+ 25% Zn and B foliar spray, T5 =100% Zn and B as basal + 25% Zn foliar spray, T6 =100% Zn and B as basal+ 25% B foliar spray, T7 =100% Zn as basal (without B), T8 =100% B as basal (without Zn) and T9 = Control (No Zn and B)

Number of branches plant^{-1}

Branches plant^{-1} responded significantly to various levels of zinc and boron application (Table 1). The highest number of branches plant^{-1} (5.84) was recorded from the treatment T5 (100% zinc and boron as basal and 25% zinc as a foliar application) which was at par with T6, T3, T4 and T8 (Table 1) while the minimum number was found in T1 (recommended Zn@2 kg ha^{-1} and B@2 kg ha^{-1} as basal. It was evident from the results that the application of zinc increased the number of branches of plant^{-1}. Gaffer and Razzaque (1983) have also observed similar results in mustard. Hossain *et al.* (2011) and Rashid *et al.* (2012) reported that the effect of B had significantly increased the primary and secondary branches of plant^{-1}.

Number of total pods plant^{-1}

The number of total pods plant^{-1} of mustard increased significantly due to the application of zinc and boron (Table 1). The highest number of pods plant^{-1} (90.54) was produced in T5 (100% Zinc and Boron as basal and 25% Zinc as foliar application) which was statistically similar with T3, T6, T7 and T8, and the lowest number (57.19) was produced by T9 (control) treatment (Table 1).

DOI: https://doi.org/10.55706/jae1625

Number of effective pods plant^{-1}

The number of effective pods plant^{-1} varied significantly because of zinc and boron application (Table 1). The highest number of effective pods plant^{-1} (87.57) was observed in T5 (100% Zn and B as basal and 25% Zn as foliar application) which was statistically similar with T3, T6, T7 and T8. The lowest number of effective pods plant^{-1} (54.90) was recorded in T4 treatment (Table 1).

Pod length

The effect of zinc and boron significantly influenced the pod length (Table 1). T5 treatment (100% zinc and boron as basal and 25% Zn as foliar application) produced the largest pod (6.33) compare to other treatments while the shortest pod (5.80) was found in the T9 (control) treatment (Table 1).

Number of seeds pod^{-1}

The effect of zinc and boron significantly influenced the number of seeds pod^{-1} (Table 1). It was observed that the highest number of seeds pod^{-1} (31.53) was obtained in T5 (application of 100% zinc and boron as basal and 25% Zn as foliar spray) followed by T3 and the lowest number of seeds pod^{-1} (27.20) was produced by the control treatment (Table 1).

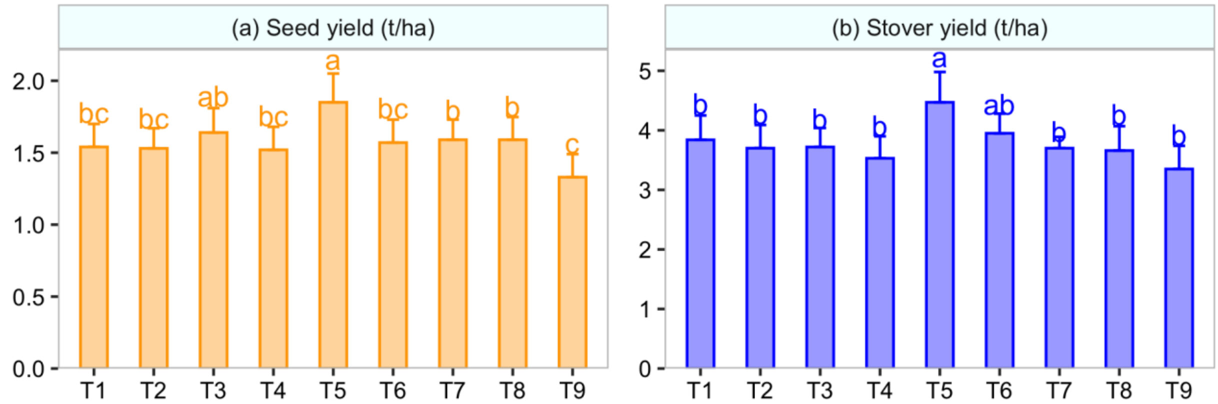

Figure 1. Effect of rate and method of zinc and boron application on seed and stover yield of mustard

Weight of 1000 seeds

There was no significant influence of Zn and B found on 100-seed weight (Data not shown). Numerically the highest 1000-seed weight (3.77g) was found in T1 (recommended Zn @2 kg ha^{-1} and B @2 kg ha^{-1} as basal application compared to other treatment and the lowest 1000-seed weight (3.35) was found in the T9 (control) treatment (Table 1).

Seed yield

It was observed that the different levels of zinc and boron application had significantly influenced the seed yield (Figure 1a). The highest seed yield (1.85 t ha^{-1}) was obtained from the treatment T5 (application of 100% Zn and B as basal and 25% Zn as foliar) which was at par with T3 and the lowest seed yield (1.33 t ha^{-1}) was recorded in T9 (control) treatment (Figure 1a). The improved performance of the yield components viz. the number of effective pod plant^{-1}, number of seeds pod^{-1} were responsible for the higher seed yield of mustard. According to the findings of Biswas *et al*. (2010), the application of a 0.05% ZnSO4 solution through foliar spray at 25 and 40 days after sowing (DAS) resulted in a 9.02% increase in seed yield in mustard. According to the findings of Bharti *et al*. (2002) and Jha *et al*. (2023), it was observed that there was a positive correlation between the rise in Zn and B content and the mean seed yield.

The utilization of boron has been found to enhance crop output by promoting the growth and development of mustard plants. Indeed, the attainment of the largest seed yield can be attributed to both the total number of pods per plant and the number of seeds each pod.

Stover yield

The effect of different doses of zinc and boron also showed a significant effect on stover yield (Figure 1b). The production of highest stover yield was (4.47 t ha^{-1}) obtained in T5 (100% Zn and B as basal and 25% Zn as foliar application) which was statistically similar with T1 and the lowest stover yield (3.35 t ha^{-1}) was obtained in T9 (control) treatment (Figure 1b). The highest stover yield might be due to the fact that Zn and B tends primarily to encourage vegetative growth. On the other hand, zinc and boron are important essential elements present in plant. In the present study, the tallest plant, highest number of branches plant^{-1} and highest amount of fruit walls of mustard obtained in this treatment were mainly responsible for the highest stover yield. According to the findings of Malewar *et al*. (2001), there was a considerable increase in stover and seed yield for each incremental addition of either zinc or boron.

DOI: https://doi.org/10.55706/jae1625

Biological yield

Biological yield is the sum of seed yield and stover yield (Bijalwan and Dobriyal 2014). The biological yield was significantly influenced by zinc and boron application (Table 1). The highest biological yield (6.32 t ha^{-1}) was produced in T5 (100% Zn and B as basal and 25% Zn as foliar application) which was significantly different from other treatments. The lowest (4.68 t ha^{-1}) was observed in the T9 (control) treatment (Table 1). The outcome in this aspect is consistent with the conclusions made by Torun *et al*. (2001) and Grewal *et al.* (1999) who have reported application of zinc and boron results in increased dry matter production than control.

Harvest index

There was not significant effect was found in the harvest index of mustard (Table 1). Numerically the highest harvest index (30.72%) was obtained from the T3 (50% Zn and B as basal and 50% Zn and B as foliar application) and the lowest harvest index (28.67%) was obtained from the control treatment (Table 1).

CONCLUSION

The tallest plant, greatest number of branches $plant^{-1}$, number of total pods $plant^{-1}$, pod length, highest number of seeds pod^{-1}, highest seed yield, stover yield and biological yield were obtained from 100% Zn and B as basal + 25% Zn as foliar application. From the experimental finding, it may be concluded that zinc and boron played a significant role in increasing yield of mustard. Mustard may be grown successfully for obtaining maximum yield with the application of 100% Zn and B as basal + 25% Zn as foliar application under the agroclimatic condition of Old Brahmaputra Floodplain area of Bangladesh

.

Acknowledgements

The financial assistance of the Ministry of Science and Technology, Govt. of the People's Republic of Bangladesh to carry out the research work is thankfully acknowledged

Conflict of Interest

There are no conflicts of interest declared by the authors.

REFERENCES

Ali, M. H., Rahman, A. H., and Ullah, M. J. (1990). Effect of plant population and nitrogen on yield and oil content of rapeseed (*Brassica campestris*). Indian Journal of Agricultural Science, 60(9): 627–630.

BBS. (2019). Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka, Bangladesh.

Bharti, N., Murtaza, M., and Singh, A. P. (2002). Effect of boron-rhizobium relationship on yield, nitrogen and boron nutrition of chickpea. Journal of Research Birsha Agricultural University, 14: 175–179.

Bijalwan, A., and Dobriyal, M. J. (2014). Productivity of Wheat as intercrop in Grewia Optiva Based Traditional Agroforestry system along Altitudinal Gradient and Aspect in MID Hills Garhwal Himalaya, India. American Journal of Environmental Protection, 2: 89–94.

Biswas, P. K., Bhowmick, M. K., and Bhattacharyya, A. (2010). Effect of zinc and seed inoculation on nodulation, growth and yield in mungbean. Journal of Crop and Weed, 5: 119–121.

Dutta, R. K., Uddin, M., and Rahman, L. (1984). Productivity of Mugbean, rice and mustard in relation to boron in Brahmaputra Floodplain Soil. Bangladesh Journal of Soil Science, 20: 77–83.

Gaffer, M. A., and Razzaque, A. H. M. (1983). Response of mustard to different levels of N, P, K [nitrogen, phosphorus, potassium] fertilizers under two methods of seeding. Proceedings of the 8th BAAS confernce, Bangladesh Association for the Advancement of Science.

Grawal, H.S., Graham, R. (1999). Residual effect of subsoil zinc and oilseed rape grnotype on the grain yield and distribution of zinc in wheat. Plant and Soil 207: 29-36.

Gomez, K. A., and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research. A Willy International Science Publication. Jhon Willy and Sons.

Halim, A., Paul, S. K., Sarkar, M. A. R., Rashid, M. H., Perveen, S., Mia, S., Islam, M. L. and Islam, A.M.M. (2023). Field Assessment of Two Micronutrients (Zinc and Boron) on the Seed Yield and Oil Content of Mustard. Seeds, 2(1): 127–137.

Haque, M. M., Saleque, M. A., Sha, A. L., and Waghmode, T. R. (2014). Effect of long term fertilization and soil native nutrient on rice productivity in double rice cultivation system. Journal of Biochemistry and Biochemical Techniques, 103: 1–8.

Hossain, M. A., Jahiruddin, M., and Khatun, F. (2011). Effect of Boron on yield and mineral nutrition of mustard (*Brassica napus*). Bangladesh Journal of Agricultural Research, 36(1): 63–73.

Islam, M. B., and Sarker, M. A. Z. (1993). Effect of different levels of boron on the yield of mustard. On-farm Research Division, Agricultural Research Station, Rangpur. Bangladesh Agricultural Research Institute.

Jaiswal, A. D., Singh, S. K., Singh, Y. K., Singh, S., and Yadav, S. N. (2015). Effect of sulphur and boron on yield and quality of mustard (*Brassica juncea* L.) grown in Vindhy red soil. Soil Science Society of Indian Journal, 63(3): 362–364.

Jha, S., Anwar, M.P., Rashid, M.H. and Paul, S.K. (2023). Maximizing yield of mustard through zinc and boron fertilization. Fundamental and Applied Agriculture 8(1&2): 475–482.

Karthikeyan, K., and Shukla, L. M. (2008). Effect of boron sulphur interaction on their uptake and quality parameters of mustard (*Brassica juncea* L.) and sunflower (*Halianthus annus* L). Journal of the Indian Society of Soil Science, 56: 225–230.

Lei, S.H.I., Yun- Hua, W.A.N.G., Fu- Zhao, N.I.A.N., Jian-Wei, L.U., Jin-Ling, M.E.N.G., Fang-Sen, X.U. (2009). Inheritance of boron efficiency in oilseed rape. Pedosphere 19: 403-408.

Malewar, G. V., Kate, S. D., Waiker, S. L., and Ismail, S. (2001). Interaction effect of zinc and boron on yield, nutrient uptake and quality of mustard (*Brassica juncea* L.) on a typic Haplustert. Journal of the Indian Society of Soil Science, 49: 763–765.

Mengel, K., and Kirby, E. A. (1987). Principles of Plant Nutrition. International Potash Institute.

DOI: https://doi.org/10.55706/jae1625

Mondal, M. R. I., and Gaffer, M. A. (1983). Effect of different levels of nitrogen and phosphorous on the yield and yield contributing characters of mustard. Bangladesh Journal Agricultural Research, 8(1): 37–43.

Rabbani, M.G., Salam, M.A., Paul, S.K., and Kheya, S.A. (2023). Effects of Rhizobium Inoculum on Growth, Yield and Quality of Eight Selected Soybean (*Glycine Max*) Varieties. Journal of Bangladesh Agricultural University, 21(1): 1–11.

Rashid, M. H., Hasan, M. M., Ahmed, M., Rahman, M. T., and Rahman, K. A. M. M. (2012). Response of Mustard to boron fertilization. Bangladesh Journal of Agricultural Research, 37(4): 677–682.

Roy, R. N., Mishra, R. V., and Lesschen, J. P. Smaling EM 2013: Assessment of soil nutrient balance. Approches and methodologies. Food and Agriculture Organization of the United Nations, 14: 101.

Sinha, P., Jain, R., and Chatterjee, C. (2000). Interaction effect of Boron and Zinc on growth and metabolism of mustard. Communication of Soil Science and Plant Analysis, 31(12): 41–49.

Sultana, B. S., Mian, A. H., Jahiruddin, M., Rahman, M. M., Siddique, M. N. E. A., and Sultana, J. (2019). Amendment of acidic soil with lime and manure for Enhancing Fertility, Nutrient uptake and yield of Wheat-Mungbean Monsoon Rice in the Old Himalayan Piedmont Plain. Asian Journal of Soil Science and Plant Nutrition, 4(2): 1–26.

Sultana, J., Siddique, M. N. A., and Abdullah, M. R. (2015). Fertilizer recommendation for Agriculture: practice, practicalities and adaptation in Bangladesh and Netherlands. International Journal of Business, Management and Social Research, 1(1): 21–40.

Sultana, R., Paul, S.K., Sarkar, M.A.R., and Sarkar, S.K. 2020. Response of sulphur and zinc nutrition to the seed yield and oil content of mustard (cv. BARI Sarisha-14). Tropical Agrobiodiversity, 1(2):31-35.

Torun, A., Gultekin, I., Kalayci, M., Yilmaz, A., and Eker, S. (2001). Effect of zinc fertilization on rain yield and shoot concentration of zinc, boron and phosphorous of 25 wheat cultivars grown on a zinc deficient and boron toxic soil. Journal of Plant Nutrition, 24(11): 1817–1829.

UNDP, and FAO. (1988). Appraisal of Bangladesh for Agricultural Report No.2, Agro-Ecological Region of Bangladesh. In United Nations Development Program in Food and Agriculture Organization (pp. 212–221).

DOI: https://doi.org/10.55706/jae1625