

Zinc Effects Yield of Mustard (*Brassica campestris* L.) Under Zero Tillage

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Authors' contributions

This work was carried out in collaboration between both authors. Author SC planned, designed and executed the field experimentation. He also collected, compiled and performed the statistical analysis with the organized data. Author MI gathered the relevant review of literature, prepared the figures and wrote the initial draft of the manuscript. Both authors read and approved the final version of the manuscript.

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ABSTRACT

Zero or no tillage (ZT) mustard (*Brassica campestris* L.) cultivation is being increased and popularized these days in Bangladesh. But micronutrient management specially Zinc (Zn) with recommended dose of NPKSB fertilizers are poorly practiced in this type of cultivation. Micro nutrient deficiency is an emerging problem due continuous usage of soil resources (ground water, intensive cultivation etc.). Thus, to sustain and adopt the potential yield of modern mustard varieties all types fertilization is must. Basing on this problem an investigation was employed at Bangladesh Institute of Nuclear Agriculture (BINA) Sub-station, farm, Ishurdi, Pabna to find out definite dose of zinc application under zero tillage mustard cultivation for maximizing seed yield. The study was laid in a factorial Randomized Complete Block Design (RCBD) with three replicates. Two modern varieties viz. Binasarisha-10 (V_1) and BARI Sarisha-14 (V_2) were tested with six level of Zn doses viz. 0.0 kg ha^{-1} (T_1), 1.5 kg ha^{-1} (T_2), 3.0 kg ha^{-1} (T_3), 4.5 kg ha^{-1} (T_4), 6.0 kg ha^{-1} (T_5) and 7.5 kg ha^{-1} (T_6). Seed were line broadcasted after harvesting T. *aman* rice during Rabi 2020 season. Data on yield parameters were collected after final harvesting and analyzed by Statistix 10. Results divulge that maximum straw and seed yield was attained with treatment combinations V_1T_4

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(3.63 t ha⁻¹) and V₂T₄ (2.24 t ha⁻¹) with V₂T₃ (2.18 t ha⁻¹). Whereas, the minimum was obtained from V₂T₅ (2.51 t ha⁻¹) and V₁T₁ (0.99 t ha⁻¹) along with V₂T₁ (1.01 t ha⁻¹). Hence, soil application of Zn between 3 kg ha⁻¹ to 4.5 kg ha⁻¹ may give satisfactory yield for ZT farming.

Keywords: Zero tillage; zinc doses; Binasarisha-10; BARI Sarisha-14; Pabna.

1. INTRODUCTION

Mustard (*Brassica campestris* L.) is a popular Rabi oilseed crop. Rapeseed-mustard, which belongs to the Cruciferous family under the name Brassica, is one of Bangladesh's most important oilseed crops and a major source of vegetable oil, with 2,70,018 hectares under cultivation and a production of 3,11,740 tonnes in 2019 [1]. Presently it ranks first among oilseed crops; mustard and sesame are the most common sources of edible oil in this country. Between the two primary rice crops i.e. *aman* (grown on rain fed) and *boro* (grown in irrigated condition), mustard cultivation takes place during the dry season (winter). If residual moisture remains after harvesting of T. *Aman* rice, mustard cultivation may be feasible. On the other hand, oil seed-based cropping pattern especially mustard may lead to a higher profit and also contribute to preserve soil fertility [2]. Mustard is a drought-tolerant crop that can be grown in residual soil moisture without the use of additional water. Farmers could increase productivity, reduce cultivation costs, increase cropping intensity and earn an additional income with less investment effort by implementing zero tillage technology of mustard production. Zero tillage also aids in timely sowing (October-November), conserves soil moisture, requires less or no water, saves tillage costs, time, protects the soil from erosion due to the retention of surface residues and the reduction of organic matter depletion. Water scarcity during the post-monsoon season, lack of irrigation facilities, short lag period after rice harvest for seed sowing and a high incidence of pests and diseases in late sown crops are major challenges in the high land regions of Bangladesh. Consequently, farmers practice only monocropping of rice and leave their land fallow. Due to residual soil moisture after rice harvest, the growth and yield parameters in all rapeseed-mustard varieties are better in zero tillage than conventional tillage because there is no rain throughout the crop period. In relatively low and heavy woven soils of Bangladesh it is tough to cultivate mustard as the soil moisture remains high (muddy) after harvesting *aman* paddy. Although, in some cases it's possible to sow mustard late, but the expected yield is not obtained due to prevailing

soil and weather conditions; this lingers subsequent *boro* paddy cultivation as seedlings are planted late. So, farmers face financial loss. However, under the water stress situation (excess or deficit moisture conditions) zero tillage rapeseed-mustard cultivation is increasing and popularized day by day since almost no cost is involved in this method and the outcome is satisfactory.

Zn, which is a divalent cation, was established as an essential micronutrient for higher green plants in 1926 [3]. This plant micro nutrient plays a variety of roles in plant metabolic activities, including the generation of auxin. It is also involved in the control of the shoot's progress and plays a crucial part in the plant system's enzymatic and physiological processes. Zinc also positively effects crop yield. Therefore, qualitative and quantitative production of crops are intensely determined by Zinc in the soil [4]. The addition of Zn fertilizer can boost grain yields [5]. Mandal and Sinha [6] investigated the effect of adding Zn and B to N P K fertilizers on mustard production and found increased plant height, number of branches per plant, number of siliquae/plant and number of seeds/siliquae under appropriate combination of the above fertilizers. Plants with lower uptake of zinc appear to be stunted as well [7]. Plant Zn efficiency involves Zn uptake, transport, and utilization; plants with high Zn efficiency display high yield and significant growth under low Zn supply and offer a promising and sustainable production crops [8]. Due to inefficient Zn fertilizer application and cultivation on marginal areas under rainfed circumstances, crop productivity is significantly reduced. In Bangladesh, soils having high pH (greater than 7) and calcareous soils mostly show Zn deficiency. Moreover, soils, particularly those under constant waterlogging and irrigation have been found to respond to Zinc (Zn) applications. Zinc deficiency increased in Bangladesh's soil according to the demand for Zinc fertilizers has been increased from 3 thousand metric tons in 2000-01 to 42 thousand metric tons in 2010-11 [9]. Sarker et al. [10] reported that, availability of Zn and B in the top soils (0-15 cm soil depth) declined after a decade of time in the Old Meghna Estuarine Floodplain (AEZ 19) soils of the country.

Nowadays cultivation of mustard under zero tillage has been increased but the use of imbalanced and inadequate fertilizers, as well as intense mustard cultivation, has degraded soil health, resulting in a decrease in crop responsiveness to the recommended dose of NPKS fertilizers. It is imperative to use micronutrients required by plants for increased crop yields in order to provide the soil with micronutrient nutrients and to keep it healthy. However, due to a lack of information and the fact that most farmers do not follow the prescribed fertilizer dose, micronutrient application, particularly Zn, is uncommon. It is essential to find out the optimum rate of Zn application for better yield and quality seed production. But the research work for the use of Zn under zero tillage mustard cultivation is rare. Therefore, the present study was conducted to select definite dose of zinc under zero tillage mustard cultivation for maximizing seed yield.

2. MATERIALS AND METHODS

The study was carried out at the experimental field of BINA Sub-station farm, Ishurdi, Pabna, Bangladesh under Agro Ecological Zone (AEZ) 10 which is characterized by, low to medium in organic matter and neutral to slightly alkaline in reaction. Soil fertility level is medium with high CEC and deficit in N, P, B and Zn [11]. It was set in the *Rabi* season (winter) 2020-21 following a factorial Randomized Complete Block Design (RCBD) with 3 replicates having a unit plot size of 3m x 2m (total 6m²). Residual soil moisture (after *aman* season) were utilized to sow the mustard seeds. During the winter season, soil water remains limited in this area as it's the dry season of the year occurring almost no rainfall

(Fig. 1). Treatments of the experimental plot were as follows—

Factor A: Variety (2)-

V₁ = BinaSarisha-10,

V₂ = BARI Sarisha-14

Factor B: Zinc doses (6)->

T₁ = Zn@ 0 kg/ha,

T₂ = Zn@ 1.5 kg/ha,

T₃ = Zn@ 3.0 kg/ha,

T₄ = Zn@ 4.5 kg/ha,

T₅ = Zn@ 6.0 kg/ha,

T₆ = Zn@ 7.5 kg/ha

No land preparation was needed as it was a zero-tillage cultivation; only the unit plots were demarcated with tiner. Experimental plots were prepared after harvesting T. *aman* rice where the rice straw was not removed and height of rice straw was about one third remaining. Seeds were sown in line broadcasting@ 1 Kg/*bigha* (33 decimal) on 19th November 2020 having replication to replication distance 1m and plot to plot distance 60 cm respectively. N, P, K, S and B were applied at the rate of 70 Kg/ha, 24 Kg/ha, 60 Kg/ha, 18 Kg/ha and 1.0 Kg/ha respectively following medium soil fertility interpretation level. Full amount of P, K, S and B were applied as basal dose before sowing [12]. N was applied in two equal doses along with light irrigation after hand thinning (to keep the desired plant population of 70-80/m²) at 20 DAS (days after seeding) and 35 DAS through broadcasting. The treatments of Zn (Grozin of Syngenta company) were employed separately in the unit plots as per the experimental design before sowing of seeds. An overview of the weather factors are given in Fig. 1.

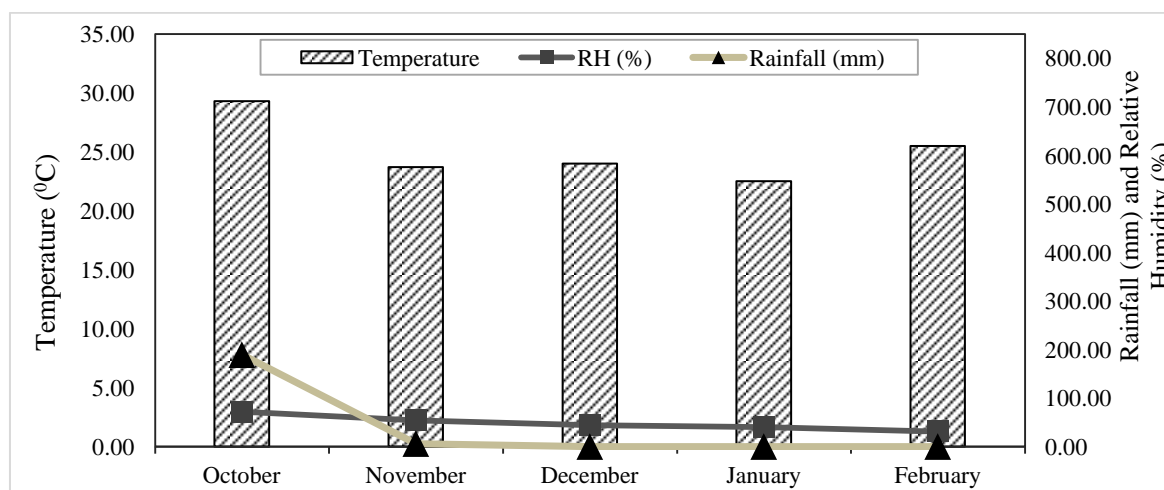


Fig. 1. Average weather data of *Rabi* season (October 2020 to February 2021) at Ishurdi, Pabna. (Source: PRC, [15])

2.1 Data Collection and Analysis

Mustards were harvested when 75% of the siliquae became golden colour. Randomly five plants were selected from each plot and data were collected on plant height (cm), number of primary and secondary branches/plant, days of 1st flowering, number of siliquae/plant, length of siliqua (cm), number of seeds/siliqua, days to maturity, straw yield (t/ha), seed yield (t/ha). Seed yield was adjusted to 10% moisture content and straw yield at sun dry basis. Later, all the collected data were statistically separately analyzed by using ANOVA (analysis of variance) technique through Statistix 10 software [13]. Significance of mean difference was compared by LSD (least significant difference) test [14] at 5% level of probability.

3. RESULTS

3.1 Plant height

It was revealed that combined effect of zinc levels and mustard varieties on plant height was significant. That means the plant height of mustard was notably affected by Zn levels and varieties. The interactive effect of Zn levels and varieties indicates that mustard variety Binasarisha-10 when given 4.5 kg Zn ha⁻¹ resulted in significantly maximum plant height (82.11 cm), while the variety BARI Sarisha-14 resulted in minimum plant height (70.11 cm) when given 7.5 kg Zn ha⁻¹ (Table 1).

3.2 Number of Primary Branches Plant⁻¹

As shown in Table 1, number of primary branches plant⁻¹ of mustard was significantly inclined by interaction of Zn levels and varieties. Combined effect of Zn levels and varieties demonstrated that mustard variety Binasarisha-10 when fertilized with 4.5 kg Zn ha⁻¹ resulted in significantly greatest number of primary branches plant⁻¹ (2.78). Whereas, BARI Sarisha-14 resulted in least number of branches plant⁻¹ (1.11) under control (no Zn).

3.3 Number of Secondary Branches/Plant

Treatment combinations, Binasarisha-10 (V₁) × 3.0 kg Zn ha⁻¹ (T₃) produced significantly greater number of secondary branches plant⁻¹ (0.78). Statistically identical and lesser number of secondary branches plant⁻¹ (0.11) was obtained with treatment coalitions V₂T₁ (BARI Sarisha-14 × 0 kg Zn ha⁻¹), V₂T₅ (BARI Sarisha-14 × 6.0 kg Zn

ha⁻¹) and V₂T₆ (BARI Sarisha-14 × 7.5 kg Zn ha⁻¹) respectively (Table 1).

3.4 Number of Total Siliqua/Plant

Table 1 elucidates that, collaborative impact of Zn levels and varieties exposed that mustard variety Binasarisha-10 when fertilized with 4.5 kg Zn ha⁻¹ resulted in significantly utmost number of total siliqua (46.11) plant⁻¹; which was statistically different to other treatment combinations. Whereas, BARI Sarisha-14 was found with statistically identical least number of total siliqua plant⁻¹ when fertilized with 7.5 kg Zn ha⁻¹ (17.89), 6.0 kg Zn ha⁻¹ (19.00) and 0 kg Zn ha⁻¹ (20.55). Both the mustard varieties were found to be responsive to Zn levels, but Binasarisha-10 performed better than BARI Sarisha-14 in case of number of total siliqua plant⁻¹.

3.5 Siliqua Length

Lowest length of siliqua (4.78 cm) was observed in the combination of BARI Sarisha-14 (V₂) × 0 kg Zn ha⁻¹ (T₁); in addition, rest levels of Zn (T₂ to T₆) gave statistically alike result; Contrary, significantly highest length of siliqua (8.42 cm) was noted in treatment combination Binasarisha-10 (V₁) × 3.0 kg Zn ha⁻¹ (T₃); which was statistically greater than all other treatment combinations as per Table 1.

3.6 Number of Seeds/Siliqua

Table 1 alludes, treatment combinations V₂T₂ (BARI Sarisha-14 × 1.5 kg Zn ha⁻¹), V₂T₃ (BARI Sarisha-14 × 3.0 kg Zn ha⁻¹) and V₂T₄ (BARI Sarisha-14 × 4.5 kg Zn ha⁻¹) generated statistically abundant and equal number of seeds/siliqua which was 27.89, 29.33 and 28.45 respectively. While, V₁T₁ (Binasarisha-10 × 0 kg Zn ha⁻¹) produced sparse number of seeds/siliqua (13.67) and was statistically dissimilar and least than the other treatment blends.

3.7 Days to 1st Flowering

Figure 2 illustrates that, minimum number of days taken to 1st flowering (27.33) was spotted in the combination of Binasarisha-10 (V₁) × 7.5 kg Zn ha⁻¹ (T₆) and significantly maximum number of days taken to 1st flowering (32.00) was observed in the treatment combination of BARI Sarisha-14 (V₂) × 3.0 kg Zn ha⁻¹ (T₃) along with BARI Sarisha-14 (V₂) × 4.5 kg Zn ha⁻¹ (T₄).

Table 1. Interaction effect of mustard varieties to different Zinc doses

Treatment	Plant height (cm)	No. of primary branches/plant	No. of secondary branches/plant	No. of total siliqua/plant	Siliqua length (cm)	No. of seeds/siliqua
V ₁ T ₁	76.44 abc	2.11 abcd	0.44 ab	30.33 abcd	5.17 b	13.67 e
V ₁ T ₂	77.55 abc	2.33 abc	0.56 ab	37.89 abc	5.39 b	14.00 de
V ₁ T ₃	81.33 ab	2.44 abc	0.78 a	44.11 ab	8.42 a	18.44 bcde
V ₁ T ₄	82.11 a	2.78 a	0.67 ab	46.11 a	6.36 ab	17.11 cde
V ₁ T ₅	80.78 ab	2.00 abcd	0.44 ab	26.63 cd	5.73 b	14.56 de
V ₁ T ₆	78.45 abc	2.00 abcd	0.44 ab	25.89 cd	5.46 b	14.22 de
V ₂ T ₁	78.78 abc	1.56 bcd	0.11 b	20.55 d	4.78 b	22.22 abcd
V ₂ T ₂	79.11 ab	2.11 abcd	0.33 ab	24.44 cd	5.07 b	27.89 a
V ₂ T ₃	79.44 ab	2.66 ab	0.44 ab	29.11 bcd	5.17 b	29.33 a
V ₂ T ₄	72.89 bc	2.22 abcd	0.33 ab	24.89 cd	5.16 b	28.45 a
V ₂ T ₅	75.00 abc	1.45 cd	0.11 b	19.00 d	5.01 b	26.28 ab
V ₂ T ₆	70.11 c	1.11 d	0.11 b	17.89 d	4.92 b	24.67 abc
CV	6.79%	32.83%	83.26%	34.47%	23.71%	23.89%
LSD _{0.05}	8.92	1.14	0.56	16.87	2.22	8.45
Level of significance	*	*	*	*	*	*

Means bearing same letter(s) in a column do not differ significantly at 5% level of probability by LSD

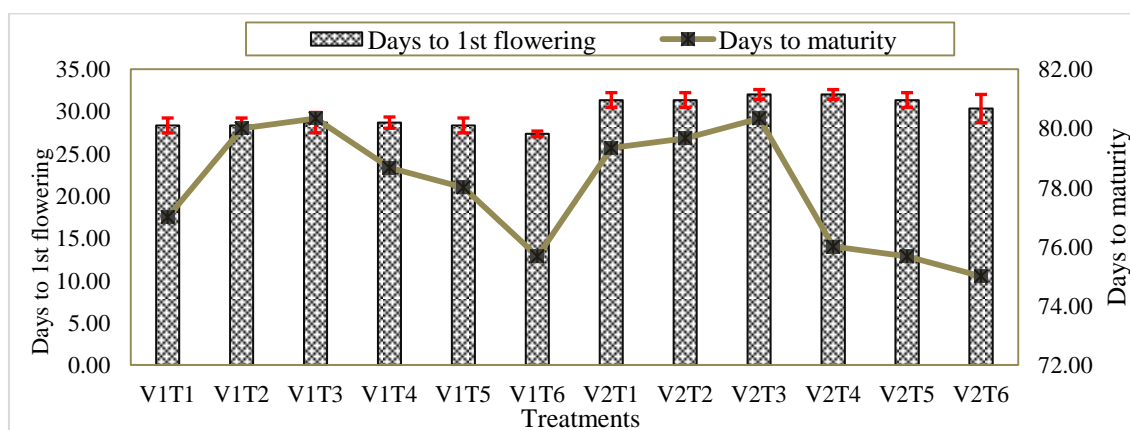


Fig. 2. Combination of varieties with Zinc doses on 1st flowering and days to maturity

3.8 Days to Maturity

As per Figure 2, earliest maturity (75.00) was observed in the combination of BARI Sarisha-14 (V₂) × 7.5 kg Zn ha⁻¹ (T₆) and significantly late maturity (80.33) was observed in the treatment combination of BARI Sarisha-14 (V₂) × 3.0 kg Zn ha⁻¹ (T₃) as well as Binasarisha-10 (V₁) × 3.0 kg Zn ha⁻¹ (T₃).

3.9 Yield

According to Fig. 3, maximum straw yield (3.63 t ha⁻¹) was produced with the interaction of Binasarisha-10 (V₁) × 4.5 kg Zn ha⁻¹ (T₄). But it

was minimum (2.51 t ha⁻¹) in BARI Sarisha-14 (V₂) × 7.5 kg Zn ha⁻¹ (T₆). The straw yield increased up to 4.5 kg Zn ha⁻¹ application and gradually decreased with application of zinc. The interactive effect of Zn levels and varieties indicated that highest seed yield (2.24 t ha⁻¹) was achieved under interaction of BARI Sarisha-14 (V₂) × 4.5 kg Zn ha⁻¹ (T₄) followed by BARI Sarisha-14 (V₂) × 3.0 kg Zn ha⁻¹ (T₃) (2.18 t ha⁻¹) and Binasarisha-10 (V₁) × 3.0 kg Zn ha⁻¹ (T₃) (2.04 t ha⁻¹). While, lowest seed yield (0.99 t ha⁻¹) under interaction of Binasarisha-10 (V₁) × 0 kg Zn ha⁻¹ (T₁) followed by BARI Sarisha-14 (V₂) × 0 kg Zn ha⁻¹ (T₁) (1.01 t ha⁻¹). There was a

simultaneous increase in seed yield ha⁻¹ with increasing Zn levels above 1.5 kg Zn ha⁻¹ (T₂) up to 4.5 kg Zn ha⁻¹ (T₄). Beyond 4.5 kg Zn ha⁻¹ (T₄) both straw and seed yield declined.

4. DISCUSSION

The study showed that application of Zn level 1.5 kg per hectare to 4.5 kg per hectare resulted to increase the plant height, branches per plant, days to flowering and maturity stage, siliqua per plant and seeds per siliqua. But application of Zn level above 4.5 kg ha⁻¹ to 7.5 kg ha⁻¹ resulted to decrease the plant height, branches per plant, days to flowering and maturity stage, siliqua per plant and seeds per siliqua due to crops differ markedly in their susceptibility to Zn toxicity. In case of Binasarisha-10 (V₁) × 6.0 kg Zn ha⁻¹ (T₅), Binasarisha-10 (V₁) × 7.5 kg Zn ha⁻¹ (T₆), BARI Sarisha-14 (V₂) × 6.0 kg Zn ha⁻¹ (T₅) and BARI Sarisha-14 (V₂) × 7.5 kg Zn ha⁻¹ (T₆) decreased the plant height, branches per plant, days to flowering and maturity stage, siliqua per plant and seeds per siliqua. Zn toxicity symptoms include reduced yields and stunted growth, Fe-deficiency-induced chlorosis through reductions in chlorophyll synthesis and chloroplast degradation, and interference with P (and Mg and Mn) uptake [16].

4.1 Plant Height

Different zinc doses had a substantial impact on yield and yield attributing factors of the two varieties under investigation. Plant height was significantly affected by different zinc dose and variety combinations. Both the mustard varieties were found to be responsive to Zn levels, but Binasarisha-10 showed more plant height than BARI Sarisha-14; this might be due to genetic

potentiality of the variety. Pal et al. [17] and Chaplot et al. [18] both found similar findings.

4.2 Number of Branches Plant⁻¹

The interaction of varieties and Zinc influenced significantly to the number of primary and secondary branches plant⁻¹ of mustard. Application of Zn recorded maximum number of primary and secondary branches plant⁻¹ over control (T₁). The sufficient production of photosynthates, which boost metabolic activities, faster cell division, form meristematic tissues; which finally increased the number of branches and this boost up was due to the availability of nutrients in sufficient amounts. Present results are consistent with the findings of Pal et al. [17], Mandal and Sinha [19]. Alike conclusions were also reported by Dubey et al. (2013). Both the mustard varieties were noticed to be Zn responsive; but better performance of Binasarisha-10 than BARI Sarisha-14 might be attributable to genetic constitution for better Zn utilization. Chaplot et al. [18] narrated similar results.

4.3 Number of Siliqua Plant⁻¹ and Seeds Siliqua⁻¹

The application of Zinc fertilizer caused a substantial rise in the number of siliqua plant⁻¹ and seeds per siliqua. Zinc plays a major role of metabolism in plants; thereby balancing source sink relationship [20]. According to Diepenbrock [21], the quantity of siliqua per plant is closely related to the seed output of individual plants. Dubey et al. [22] stated an escalation in the number of siliquae plant⁻¹ with Zinc application.

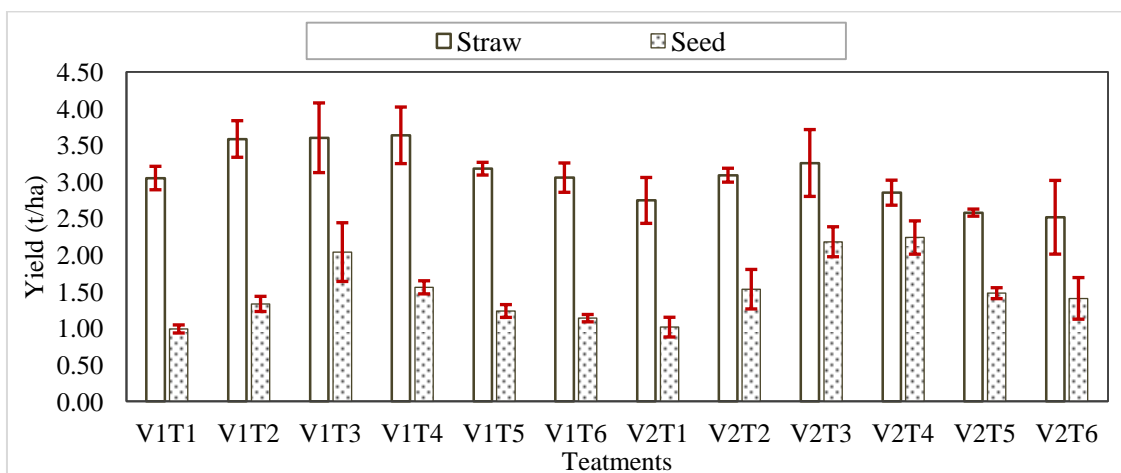


Fig. 3 Interaction effect of mustard varieties and Zinc doses on yield

4.4 Days to First Flower Initiation and Maturity

Days to 1st flowering and maturity of mustard varieties were influenced by combination of different mustard varieties and Zinc doses. Sahito et al. [23] uncovered that days to flowering of mustard varieties were influenced by variable levels of Zn usage. BARI [24] alluded mean duration of BARI Sarisha-14 was 86 days from evaluation plots. Contrary, BINA [25] reported an average duration of Binasarisha-10 with 82 days from multiple field demonstrations. Reasons for deviation of the current findings might be due to tillage practice, soil moisture, macro and micro nutrient variations. Differences in varietal characters might also be a cause for earliness and late duration. Kumar et al. [26] reported differences in mustard maturity days with various level of Zn fertilization.

4.5 Yield

Interaction effect of various levels of Zinc and varieties induced significantly on straw yield and seed yield of mustard varieties. Our investigation showed that employing Zn level above 4.5 kg ha⁻¹ resulted a declination in straw yield and seed yield. The fall in the yields were might be due to toxicity effect of Zn in the mustard varieties. In case of treatment combinations- Binasarisha-10 (V₁) × 6.0 kg Zn ha⁻¹ (T₅), Binasarisha-10 (V₁) × 7.5 kg Zn ha⁻¹ (T₆), BARI Sarisha-14 (V₂) × 6.0 kg Zn ha⁻¹ (T₅) and BARI Sarisha-14 (V₂) × 7.5 kg Zn ha⁻¹ (T₆); reduced straw and seed yield were observed. Excess Zn in soils can result in several alterations in plants like decrease growth, photosynthetic and respiratory rate, imbalanced mineral nutrition and reactive oxygen species production [27]. It was seen that, application of Zn level above 1.5 kg hectare⁻¹ and up to 4.5 kg hectare⁻¹ fostered straw and seed yield. According to some theories, NPKSB and Zn application, in conjunction with the transport of photosynthesis toward the reproductive structure, may have resulted in improved yield attributes. Researchers, Dubey et al. [22] and Choudhary et al. [28] obtained results that are similar to ours. Riley et al. [29] found that the application of Zn fertilizer significantly increased seed yield. Attainment of highest seed yield under T₃ (3.0 kg ha⁻¹) and T₄ (4.5 kg ha⁻¹) with recommended dose fertilizer supply might be ascribed, mainly due to the combined effect of nutrients. Increased number of siliquae per plant, increased number of seeds per siliqua, and increased seed weight were all observed as a result of improved

photosynthate translocation from source to sink. Combined use of N, P, K, S, Zn, and B stimulate siliquae setting, seed formation, and oil synthesis in mustard seeds; resulting more biological, seed, and stover yields of the plant. Considerable number of works have also reported related conclusions [30].

5. CONCLUSIONS

Zinc application controlled the yield and yield attributes of the mustard varieties (cv. Binasarisha-10 and BARI Sarisha-14), but their response varied. The seed yield of mustard improved markedly due to Zn application at the rate 3.0 kg ha⁻¹. Hence it can be inferred that, optimal seed yield of mustard can be acquired between the rate of 3 kg ha⁻¹ to 4.5 kg ha⁻¹ contingent on the type of mustard varieties under zero tillage. As this experiment covered a single unit of an area further or repeated trials are needed to validate the outcomes of these results.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. This research was funded by the authors affiliated institute but publication of the research findings was from the personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAOSTAT (Statistics Division, Food and Agriculture Organization of the United Nations). Crops-Rice; 2021. Available: <http://www.fao.org/faostat/en/#data/QC>, accessed on 29 May 2021.
2. Chowhan S, Ghosh SR, Hoque MI, Islam M, Nabi KME. Yield and profitability analysis of pulse and oil seed based cropping patterns against aman-boro-fallow cropping systems in Magura. *Agricultural Science Digest*. 2021;41(1):42-48. Available: <https://doi.org/10.18805/ag.D-261>
3. Sommer AL, Lipman CB. Evidence on indispensable nature of zinc and boron for higher green plants. *Plant Physiology*. 1926;1(3):231-249. Available: <https://doi.org/10.1104/pp.1.3.231>
4. Suganya A, Saravanan A, Manivannan N. Role of Zinc nutrition for increasing zinc availability, uptake, yield, and quality of maize (*Zea mays* L.) grains: An overview. *Communications in Soil Science and Plant Analysis*. 2020;51(15):2001-2021. Available: <https://doi.org/10.1080/00103624.2020.1820030>
5. Maqsood MA, Rahmatullah S, Kanwal T, Aziz, Ashraf M. Evaluation of Zn distribution among grain and straw of twelve indigenous wheat (*Triticum aestivum* L.) genotypes. *Pakistan Journal of Botany*. 2009;41(1):225-231. Available: [http://www.pakbs.org/pjbot/PDFs/41\(1\)/24.pdf](http://www.pakbs.org/pjbot/PDFs/41(1)/24.pdf) Accessed on 02 July 2021.
6. Mandal KG, Sinha AC. Nutrient management effects on light interception, photosynthesis, growth, dry-matter production and yield of Indian mustard (*Brassica juncea*). *Journal of Agronomy and Crop Science*. 2004;190(2):119-129. Available: <https://doi.org/10.1046/j.1439-037X.2003.00083.x>
7. Torun A, Gültekin I, Kalayci M, Yilmaz A, Eker S. Effects of zinc fertilization on grain yield and shoot concentrations of zinc, boron, and phosphorus of 25 wheat cultivars grown on a zinc-deficient and boron-toxic soil. *Journal of Plant Nutrition*. 2001;24(11):1817-1829. Available: <https://doi.org/10.1081/PLN-100107314>
8. Hacisalihoglu G. Zinc (Zn): The last nutrient in the alphabet and shedding light on Zn efficiency for the future of crop production under suboptimal Zn. *Plants*. 2020;9(11):1471. Available: <https://doi.org/10.3390/plants9111471>
9. Banglapedia. Soil fertility; 2021. Available: https://en.banglapedia.org/index.php?title=Soil_Fertility Accessed on 10 July 2021.
10. Sarker M, Moslehuddin A, Jahiruddin M, Islam M. Available status and changing trend of micronutrients in floodplain soils of Bangladesh. *SAARC Journal of Agriculture*. 2018;16(1):35-48. Available: <https://doi.org/10.3329/sja.v16i1.37421>
11. FRG. Fertilizer recommendation guide-2012. Dhaka: Bangladesh Agricultural Research Council. 2012;01-274. ISBN: 978-984-500-000-0
12. Ahmmed S, Jahiruddin M, Razia S, Begum RA, Biswas JC, Rahman ASMM, Ali MM, Islam KMS, Hossain MM, Gani MN, Hossain GMA, Satter MA. Fertilizer recommendation guide-2018. Dhaka: Bangladesh Agricultural Research Council. 2018;223. ISBN: 984-500-029-1
13. Statistix. Data analysis software for researchers (Version 10.0). Analytical Software, 2105 Miller Landing Rd, Tallahassee Florida 32312, USA, 2020; 2021. Available: <https://www.statistix.com/>
14. Russell DF. MSTAT-C computer package programme. Crop and Soil Sci Dept., Michigan State University., US; 1986.
15. PRC. Weather data of 2020-21. Pulses Research Center, Bangladesh agricultural research institute, Ishurdi, Pabna-6620, Bangladesh; 2021.
16. Chaney RL. Zinc phytotoxicity. In: Robson A.D. (eds) Zinc in Soils and Plants. *Developments in Plant and Soil Sciences*. Springer, Dordrecht. 1993;55:135-150. Available: https://doi.org/10.1007/978-94-011-0878-2_10
17. Pal AK, Nayak BK, Shukla AK. Zinc use and management of oilseed crops: An overall review. *Chemical Science Review and Letters*. 2021;10(37):69-80. Available: <https://doi.org/10.37273/chesci.CS205111272>
18. Chaplot PC, Amita V, Kumar R. Effect of balanced fertilization and agrochemicals on growth, yield attributes and yield of mustard varieties. 3rd International Agron., Con., Nov., 26-30, New Delhi. 2012;1110-1111.

19. Mandal KG, Sinha AC. Effect of integrated nutrient management on growth, yield, oil content and nutrient uptake of Indian mustard (*Brassica juncea* L.) in foothills soils at eastern India. *Indian Journal of Agronomy*. 2002;47(1):109-13. Available: <https://www.indianjournals.com/ijor.aspx?target=ijor:ija&volume=47&issue=1&article=021&type=pdf> Accessed on 01 July 2021
20. Marschner H. Mineral nutrition of higher plants. 2. ed. Newyork: Academic press. eBook; 1995. ISBN: 9780080571874
21. Diepenbrock W. Yield analysis of winter oilseed rape (*Brassica napus* L.): A review. *Field Crops Research*. 2000;67:35-49. Available: [https://doi.org/10.1016/S0378-4290\(00\)00082-4](https://doi.org/10.1016/S0378-4290(00)00082-4)
22. Dubey SK. Effect of sulphur and zinc levels on growth, yield and quality of mustard (*Brassica juncea* L. Czern & Coss). *Research & Reviews: Journal of Crop Science and Technology*. 2013;2(1):1-10. Available: <https://doi.org/10.37591/rrjocst.v2i1.2183>
23. Sahito HA, Solangi AW, Lanjar AG, Solangi AH, Khuhro SA. Effect of micronutrient (zinc) on growth and yield of mustard varieties. *Asian Journal of Agriculture and Biology*. 2014;2(2):105–113. Available: <http://www.asianjab.com/wp-content/uploads/2015/05/5-2-2-MS-No.-66.pdf> Accessed on 02 July 2021.
24. BARI. BARI (Bangladesh agricultural research institute) annual report 2019-20. 2020;49-57. Available: http://www.bari.gov.bd/sites/default/files/files/bari.portal.gov.bd/annual_reports/f301c91f_74ed_4cbe_a414_019cdac83dd8/2020-10-08-17-38-79c02e8bb05d060a94a4508e35a1389c.pdf Accessed on 03 July 2021.
25. BINA. Annual report 2019-20 of Bangladesh institute of nuclear agriculture. 2020;351-449. Available: http://bina.gov.bd/sites/default/files/files/bina.portal.gov.bd/annual_reports/afe8264c_844d_41bc_a50e_8004abe5db6b/2020-10-13-15-13-5d9efd7cbe0585ae985e1985d62e6d94.pdf Accessed on 03 July 2021
26. Kumar V, Kandpal BK, Dwivedi A, Sagar VK, Kumar V, Sharma DK. Effect of nitrogen and zinc fertilizer rates on growth, yield and quality of indian mustard (*Brassica juncea* L.). *International journal of agriculture sciences*. 2016;8(6):1031-1035. Available: https://bioinfopublication.org/files/articles/8_6_2_IJAS.pdf
27. Kaur H, Garg N. Interactive effects of Zinc-arbuscular mycorrhizal (AM) fungi on cadmium uptake, rubisco, osmolyte synthesis and yield in *Cajanus cajan* (L.) Millsp. *International Journal of Sustainable Agricultural Research*. 2021;8(1):17-42. Available: <https://doi.org/10.18488/journal.70.2021.81.17.42>
28. Choudhary P, Jhajharia A, Kumar R. Influence of sulphur and zinc fertilization on yield, yield components and quality traits of soybean (*Glycine max* L.). *The Bioscan*. 2014;9(1):137-142.
29. Riley TG, Zhao F, McGrath SP. Availability of different forms of sulphur fertilisers to wheat and oilseed rape. *Plant and Soil*. 2000;222:139–147. Available: <https://doi.org/10.1023/A:1004757503831>
30. Shankar B, Meena KC. Nutrient management for enhancing the productivity of Indian mustard (*Brassica juncea*). *Advances in Applied Research*. 2015;7(1):36–41. Available: <https://doi.org/10.5958/2349-2104.2015.00006.6>

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