# No tillage cultivation of mustard requires definite Boron dose for optimizing seed yield

Sushan Chowhan[11*], Majharul Islam[2], Kamrun Nahar[3], Md. Khan Jahan Ali[3] and Muhammad Maruf Husain[4]

[1]Adaptive Research and Extension Division, Bangladesh Institute of Nuclear Agriculture, Sub-station, Ishurdi, Pabna-6620, Bangladesh.
[2]Soil Science Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh
[3]Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture, Sub-station, Ishurdi, Pabna-6620, Bangladesh.
[3]Entomology Division, Bangladesh Institute of Nuclear Agriculture, Sub-station, Jamalpur-2000, Bangladesh

## Abstract

Boron (B) is an essential plant nutrient which plays a key role during plant seed formation and quality seed development. No tillage (NT) or zero tillage mustard (*Brassica* sp.) production has already received remarkable attention by the farmers mainly due to time, cost effectiveness and profitability. Vast growers only apply NPK fertilizers and avoid boron (B) or other micronutrient fertilizers; which imbalances nutrient translocation, mobilization, utilization in plants and ultimately affects seed quality, yield and maturity duration. Considering this drawback, the present investigation was done to ascertain the role of B in attaining desirable seed yield of mustard in no tillage condition. Experiment was set during winter season (*Rabi*) at BINA Sub-station farm, Ishurdi, Pabna. A factorial RCBD with three replications were followed for the trial. Two varieties ($V_1$: Binasarisha-9 and $V_2$: BARI Sarisha-17) and six B doses ($T_1$: 0 kg/ha, $T_2$: 1 kg/ha, $T_3$: 2 kg/ha, $T_4$: 3 kg/ha, $T_5$: 4 kg/ha, $T_6$: 5 kg/ha) were used as treatments. Data on yield and yield attributes were collected at different phenological stage and upon harvest. Findings depicted that, treatment combinations $V_1 \times T_4$ beared maximum siliqua length (8.43 cm), highest seed yield (2.34 t/ha), straw yield (3.01 t/ha), 100 grain weight (HGW) (0.32 g) and days to maturity (90.67 days). $V_1 \times T_3$ and $V_2 \times T_4$ treatment combinations gave the greatest number of siliqua/plant (82.55) and number of seeds per siliqua (36.33). Contrary, least seed yield (0.82 t/ha) and number of seeds per siliqua (22.89) was recorded with combination in $V_1 \times T_1$. Minimum number of siliquae per plant (21.37), straw yield (1.17 t/ha), days to harvest (82.00 days) and HGW (0.20 g) was found with combination in $V_2 \times T_1$. Results obtained suggest that, B doses between 2 kg/ha to 3 kg/ha might be accurate with B responsive mustard varieties for achieving higher seed yield of mustard under NT.

**Keywords:** no tillage, zero tillage, boron doses, yield, Pabna, Binasarisha-9, BARI Sarisha-17

### Author Contributions

Author SC planned, designed, executed and performed the statistical analysis of the experiment. MI wrote the first draft of the whole manuscript. Authors KN and MKJA collected the pertinent data and managed

[1*]Corresponding author: sushan04@yahoo.com

the literature searches. MMH did the field management of the trial and aided in data entry. All authors read and approved the final manuscript.

**1. Introduction**

Rapeseed-mustard, which belongs to the Cruciferae family under the genus Brassica commonly known as mustard in Bangladesh, is a cool season, thermo sensitive as well as photosensitive crop (Sharif et al. 2016). Brassica oil crop supplies substantial quality of edible oil in Bangladesh. It accounts for 59.4% of total oil seed production in the country (AIS 2010). At present, the local production of edible oil meets only 25% of the country requirement but our country is running a short 60-75% of the demand of edible oil (Chowdhury and Uddin, 1990; Mondal and Wahab, 2001; Miah and Mondal, 2017). Among the edible oil cultivation rapeseed and mustard occupies more than 65.91% and sesame occupies 9.23% of the total oilseed area being the largest and the second largest oilseed crop, respectively (Akbar 2011). During 2020, a total of 3,09,115 hectares of land was under cultivation of this crop which produced a yield of 3,58,249 tonnes (FAOSTAT, 2022). Mustard is the most common source of edible oil in this country which ranks top among the oil seed crops (Chowhan and Islam, 2021).

Water scarcity during the post-monsoon season, a lack of irrigation facilities, a short time lag after rice harvest for seed sowing, and a high incidence of pests and diseases in late-sown crops are all challenges in Bangladesh's high land region. As a result, farmers practice monocropping of rice and leave their land fallow. Mustard grows during rabi season (October-February) usually under rainfed and low inputs condition in this country (Ghosh and Chatterjee, 1988). Mustard, being a drought-tolerant crop, can grow in residual soil moisture without the use of additional water. Between the two primary rice crops, Aman rice (monsoon) and *boro* rice, mustard planting takes place (dry winter). If residual moisture exists in the field after the harvest of T. Aman rice, mustard cultivation may be feasible under zero tillage. Due to residual soil moisture after rice harvest, the growth and yield parameters in all rapeseed-mustard varieties were better in zero tillage than in conventional tillage because there was no rain throughout the crop period. In the relatively low and heavy-woven soils of Bangladesh, it is not possible to cultivate mustard as the soil moisture is high after harvesting *aman* paddy. Farmers can increase productivity, reduce cultivation costs, increase cropping intensity and earn an additional income with less effort by implementing no or zero tillage. No tillage also aids in timely sowing (October-November), conserves soil moisture and requires less water, reduces tillage costs and time, and protects the soil from erosion due to the retention of surface residues and the reduction of organic matter depletion. Therefore, under the water stress situation or excess moisture conditions no tillage rapeseed-mustard cultivation is increased and popularized during the rabi crop period of Bangladesh.

Balance fertilizers and resource use is crucial to maintain productivity of crops (Sultana et al. 2015; Hossain and Siddique, 2015). Fertilizers have effect on yield and yield attributes of crops (Sultana et al. 2019; Sultana et al. 2019a). Usually for mustard production farmers apply NPK fertilizers and do not give focus on other micro element as its necessity is unknown to them. Brassica sp. is sensitive to low B-supply and severe deficiency may result in floral abortion and significant drop in seed production (Mengel and Kirkby, 1982; Yang et al. 1989; Zaman et al. 1998). The number of siliquae and seed setting and seed yield of mustard plants is greatly influenced by boron particularly where soil is deficient in boron (Islam and Sarker, 1993). The uptake and requirement of boron varies upon plant development stages, soil, plant parts, among cultivars and species (Pommerrenig et al. 2018). Boron deficiency causes deformed and curled young mustard leaves. They are typically rough, thick, and leathery in texture. The growing points die, and axillary shoots emerge, becoming moribund and dying. Flower buds shed prematurely in severe cases, and the flowers that form are likely malformed. In less severe cases, the seed set is limited (Lei et al. 2009).

Boron deficiency is a major cause of lower mustard yield in Bangladesh. This element deficiency has occurred primarily as a result of continuous mining of soil nutrients for increased cropping intensity without adequate replenishment. Soils with high pH (greater than 7) and calcareous soils in Bangladesh are prone to B deficiency. Furthermore, soils, especially those subjected to constant waterlogging and irrigation, have been shown to respond to boron (B) applications (Banglapedia, 2021). Nowadays zero tillage mustard cultivation is increased in Bangladesh but due to a lack of information and the fact that most farmers do not follow the prescribed fertilizer dose, micronutrient application, particularly B, is uncommon. It is essential to find out the optimum rate of B application for better yield and quality seed production. The research work for the use of B under zero tillage mustard cultivation is also rare. Therefore, the present study was conducted to quantify the effect of boron on the yield and morpho-physical properties of mustard under zero tillage cultivation.

## 2. Materials and methods

### *2.1. Site of Experiment*

This experiment was conducted at Bangladesh Institute of Nulcear Agriculture, Sub-station farm, Ishurdi, Pabna falling under the Agro Ecological Zone (AEZ) 11 (Shil et al. 2016) of high Ganges river flood plain. The site was characterized by high and medium high lands and complex relief of broad and narrow ridges and basins. Soil type is generally calcareous dark grey to calcareous brown flood plain soils. Organic matter is deficit in brown ridge soils but enriched in the dark grey soils. Top soils are slightly acidic to slightly alkaline and sub soils are mostly slightly alkaline in reaction. Overall soil fertility is low with N, P, K, S and B while CEC is medium. K bearing minerals are medium to high but Zn level is low to medium (FRG, 2012).

### *2.2. Crop and Field Management*

This was a *Rabi* season i.e. winter season experiment. Residual soil moisture (after *aman* season) were utilized to sow the mustard seeds. Soil water remains limited in this area as it’s the dry season of the year occurring almost no rainfall. Trial plot including land preparation, plot size, seed rate, sowing method was followed as per the procedure described by Chowhan and Islam (2021). Seeds were sown on 18$^{th}$ November 2020 having replication to replication distance 1m and plot to plot distance 50 cm respectively. N, P, K, S and Zn were applied at the rate of 80 kg/ha, 24 kg/ha, 60 kg/ha, 18 kg/ha and 1.5 kg/ha respectively following medium soil fertility interpretation level (yield goal: 2.0 ± 0.2 t/ha). Full amount of P, K, S and Zn were applied as basal dose before sowing (Ahmmed et al. 2018). N was applied in two equal doses along with light irrigation after hand thinning (to keep the desired plant population of 70-80/m$^2$) at 20 DAS (days after sowing) and 35 DAS through broadcasting. The treatments of B (Bingo of Syngenta company) were applied individually in the unit plots as per the experimental design before sowing of seeds. An overview of the weather factors are given in Fig. 1

### *2.3. Experimental Design*

Randomized complete block design (RCBD) with 3 replicates was ensued for the experiment setup. Two mustard varieties were considered as factor A and six Boron doses were regarded as factor B. Details of the treatments are mentioned below—

Factor A: Variety (2)-

$V_1$ = Binasarisha-9, $V_2$ = BARI Sarisha-17

Factor B: Boron doses (6)-

$T_1$ = B@ 0 kg/ha, $T_2$ = B@ 1.0 kg/ha, $T_3$ = B@ 2.0 kg/ha
$T_4$ = B@ 3.0 kg/ha, $T_5$ = B@ 4.0 kg/ha, $T_6$ = B@ 5.0 kg/ha.

Thus, total number of treatment combinations were 36 so, altogether 36 unit plots were assigned.

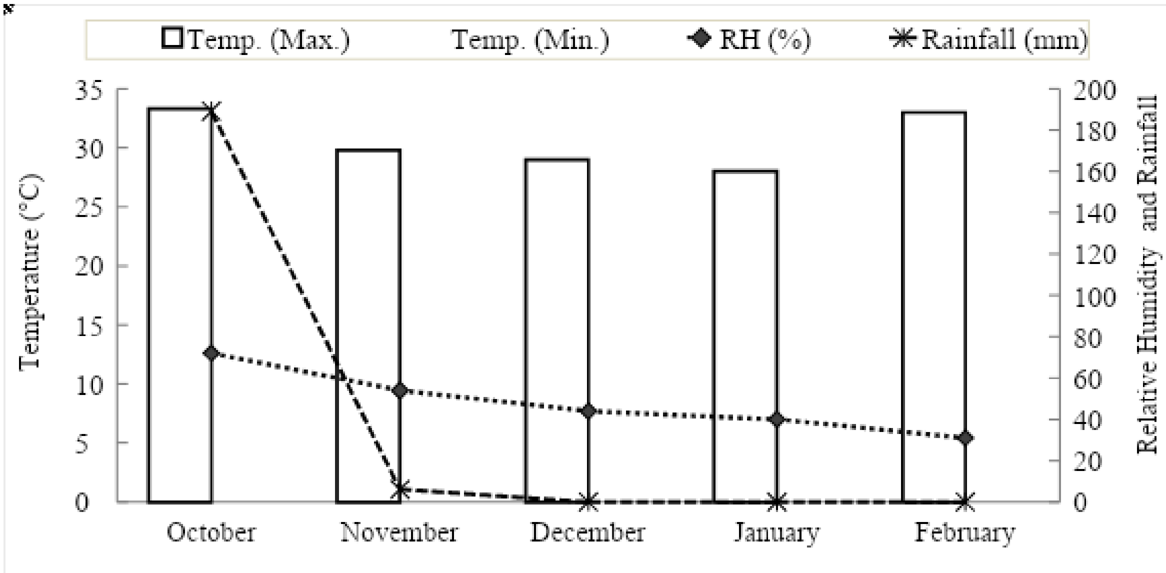


Figure 1. Weather data of the experimental site during October 2020 to February 2021. (Source: PRC, 2021)

***2.4. Data Collection and Analysis***

Mustards were harvested when 75% of the siliquae became golden colour. Randomly ten plants were selected from each plot and data were collected on plant height (cm), number of leaves per plant at 30 DAS, 45 DAS, 60 DAS, 75 DAS and during harvest, number of primary and secondary branches per plant at 45 DAS, 60 DAS, 75 DAS and at harvest, number of siliqua/plant, siliqua length (cm), number of seeds/siliqua, days of $1^{st}$, 50% and 90% flowering, hundred seed weight (g), seed yield (t/ha), straw yield (t/ha) and maturity duration (days). Seed yield was converted at 10% moisture basis and straw yield was calculated on sun dry basis. collected data were statistically separately analyzed with ANOVA (analysis of variance) technique through Statistix 10 software (Statistix, 2021). Significance of mean difference was compared by LSD (least significant difference) test (Russell, 1986, Gomez and Gomez, 1984) at 5% level of probability.

**3. Results**

***3.1 Number of siliquae per plant***

Total number of siliquae per plant was significantly influenced by variety, Boron doses and their interaction. Binasarisha-9 beared most siliquae than BARI Sarisha-17 (Table 1). Boron dose 2.0 kg/ha ($T_3$) carried maximum and without Boron application ($T_1$) resulted in minimum number of siliquae. In terms of interaction, treatment $V_1 \times T_3$ (Binasarisha-9 with 2.0 Kg Boron $ha^{-1}$) demonstrated highest and $V_2 \times T_2$ (BARI Sarisha-17 with 1.0 Kg Boron $ha^{-1}$) expressed lowest siliquae per plant.

***3.2 Siliqua length***

With varietal effect, BARI Sarisha-17 showed exhibited the lower siliqua length than Binasarisha-9 (Table 1). Boron doses $T_3$ (2.0 kg/ha) and $T_4$ (3.0 kg/ha) gave longest siliquae. Collative effects depicted that, $V_1 \times T_3$ (Binasarisha-9 with 2.0 Kg Boron $ha^{-1}$) and $V_1 \times T_4$ (Binasarisha-9 with 3.0 Kg Boron $ha^{-1}$) generated lengthiest and $V_2 \times T_6$ (BARI Sarisha-17 with 5.0 Kg Boron $ha^{-1}$) produced shortest siliquae length.

### *3.3 Number of seeds per siliqua*

The number of seeds per siliqua was more in BARI Sarisha-17 than Binasarisha-9 (Table 1). However, seeds per siliqua remained unaffected by the various boron doses. With the collective influence, treatment $V_2 \times T_4$ (BARI Sarisha-17 with 4.0 Kg Boron $ha^{-1}$) produced much and $V_1 \times T_1$ (Binasarisha-9 with none or 0.0 Kg Boron $ha^{-1}$ application) delivered fewest seeds per siliqua.

Table 1: Effect of variety, Boron doses and their interaction on the yield attributes of mustard.

| **Treatments** | **NOTSPP** | **SL (cm)** | **NOSPS** | **HGW (g)** | **Days to flowering** | | |
|---|---|---|---|---|---|---|---|
| **Variety** | | | | | **1st** | **50%** | **90%** |
| Binasarisha-9 ($V_1$) | 57.11 a | 6.98 a | 26.32 b | 0.27 a | 30.33 b | 37.00 b | 42.89 |
| BARI Sarisha-17 ($V_2$) | 43.57 b | 5.05 b | 31.52 a | 0.24 b | 31.44 a | 38.39 a | 43.61 |
| $LSD_{0.05}$ | 5.01 | 0.73 | 2.77 | 0.04 | 0.39 | 0.72 | 0.72 |
| LoS | * | * | * | * | * | * | NS |
| SEm | 2.42 | 0.35 | 1.34 | 0.002 | 0.19 | 0.35 | 0.35 |
| **Boron doses** | | | | | | | |
| $T_1$ (0 kg/ha) | 30.80 d | 5.26 b | 27.83 | 0.22 d | 31.50 a | 38.67 a | 43.83 ab |
| $T_2$ (1 kg/ha) | 46.70 c | 6.09 ab | 30.72 | 0.23 c | 31.17 ab | 38.50 ab | 44.00 a |
| $T_3$ (2 kg/ha) | 73.05 a | 7.11 a | 31.22 | 0.29 b | 31.00 a-c | 37.83 a-c | 43.50 a-c |
| $T_4$ (3 kg/ha) | 63.84 b | 7.27 a | 28.11 | 0.31 a | 30.83 a-c | 37.33 bc | 43.00 a-c |
| $T_5$ (4 kg/ha) | 47.26 c | 5.42 b | 28.06 | 0.24 c | 30.50 bc | 36.83 c | 42.67 bc |
| $T_6$ (5 kg/ha) | 40.41 c | 4.96 b | 27.56 | 0.24 c | 30.33 c | 37.00 c | 42.50 c |
| $LSD_{0.05}$ | 8.68 | 1.26 | 4.80 | 0.01 | 0.68 | 1.25 | 1.25 |
| LoS | * | * | NS | * | * | * | * |
| SEm | 4.18 | 0.61 | 2.31 | 0.004 | 0.33 | 0.60 | 0.61 |
| **Variety × Boron doses** | | | | | | | |
| $V_1 \times T_1$ | 40.22 f | 5.84 bc | 22.89 e | 0.23 e | 30.67 cd | 37.00 bc | 42.67 c |
| $V_1 \times T_2$ | 55.33 cd | 7.30 ab | 27.89 b-e | 0.24 d | 30.33 d | 36.67 c | 43.33 a-c |
| $V_1 \times T_3$ | 82.55 a | 8.08 a | 25.11 de | 0.31 a | 30.33 d | 37.00 bc | 43.00 bc |
| $V_1 \times T_4$ | 74.67 ab | 8.43 a | 30.45 a-d | 0.32 a | 30.33 d | 37.33 bc | 43.00 bc |
| $V_1 \times T_5$ | 49.11 d-f | 6.28 bc | 27.11 c-e | 0.27 c | 30.33 d | 37.00 bc | 42.67 c |
| $V_1 \times T_6$ | 40.78 ef | 5.96 bc | 24.44 de | 0.25 d | 30.00 d | 37.00 bc | 42.67 c |
| $V_2 \times T_1$ | 21.37 g | 4.56 cd | 25.78 c-e | 0.20 f | 32.33 a | 40.33 a | 45.00 a |
| $V_2 \times T_2$ | 38.07 f | 4.88 cd | 31.22 a-d | 0.22 e | 32.00 ab | 40.33 a | 44.67 ab |
| $V_2 \times T_3$ | 63.56 bc | 6.14 bc | 34.56 ab | 0.28 c | 31.67 ab | 38.67 ab | 44.00 a-c |
| $V_2 \times T_4$ | 53.00 c-e | 6.11 bc | 36.33 a | 0.30 b | 31.33 bc | 37.33 bc | 43.00 bc |
| $V_2 \times T_5$ | 45.40 d-f | 4.68 cd | 32.22 a-c | 0.21 f | 30.67 cd | 36.67 c | 42.67 c |
| $V_2 \times T_6$ | 40.04 f | 3.95 d | 29.00 b-e | 0.23 de | 30.67 cd | 37.00 bc | 42.33 c |
| $LSD_{0.05}$ | 12.27 | 1.78 | 6.79 | 0.01 | 0.93 | 1.76 | 1.77 |
| LoS | * | * | * | * | * | * | * |
| SEm | 5.92 | 0.86 | 3.27 | 0.005 | 0.46 | 0.85 | 0.86 |
| CV | 14.40% | 17.79% | 13.86% | 2.57% | 1.84% | 2.77% | 2.42% |

Figures in a column having different letter(s) differ significantly at 5% level of probability as per LSD, NS- Non significant, SEm- Standard Error mean, CV- Coefficient of Variation, NOTSPP- Number of total siliquae per plant, SL- Siliqua length, NOSPS-Number of seeds per siliqua, HGW- Hundred grain weight.

### *3.4 Hundred grain weight*

Heavier hundred grain weight was recorded with Binasarisha-9 than BARI Sarisha-17 (Table 1). Boron application at 3 kg/ha ($T_4$) had the heaviest and without applying Boron fertilizer ($T_1$) beared the lightest grains. Both $V_1 \times T_4$ (Binasarisha-9 with 3.0 Kg Boron $ha^{-1}$) and $V_1 \times T_3$ (Binasarisha-9 with 2.0 Kg Boron $ha^{-1}$) treatment combinations had the uppermost hundred grain weight; whereas the lowest was noted with combinations $V_2 \times T_1$ (BARI Sarisha-17 with no Boron use) and $V_2 \times T_5$ (BARI Sarisha-17 with 4.0 Kg Boron $ha^{-1}$).

### *3.5 Days to flowering*

First and fifty percent flowering was earlier in Binasarisha-9 compared to BARI Sarisha-17 (Table 1). No Boron usage ($T_1$) caused late flowering; inversely excess Boron application ($T_6$) led to earlier first, fifty and ninety percent flowering. Delayed ninety percent flowering was seen with treatment $T_2$ (application of 1.0 Kg Boron $ha^{-1}$). Interaction effect of variety and Boron doses showed that $V_2 \times T_1$ (BARI Sarisha-17 with no Boron use) treatment had the ultimate delayed flowering in all cases. While, rest combinations had more or less alike flower initiation durations.

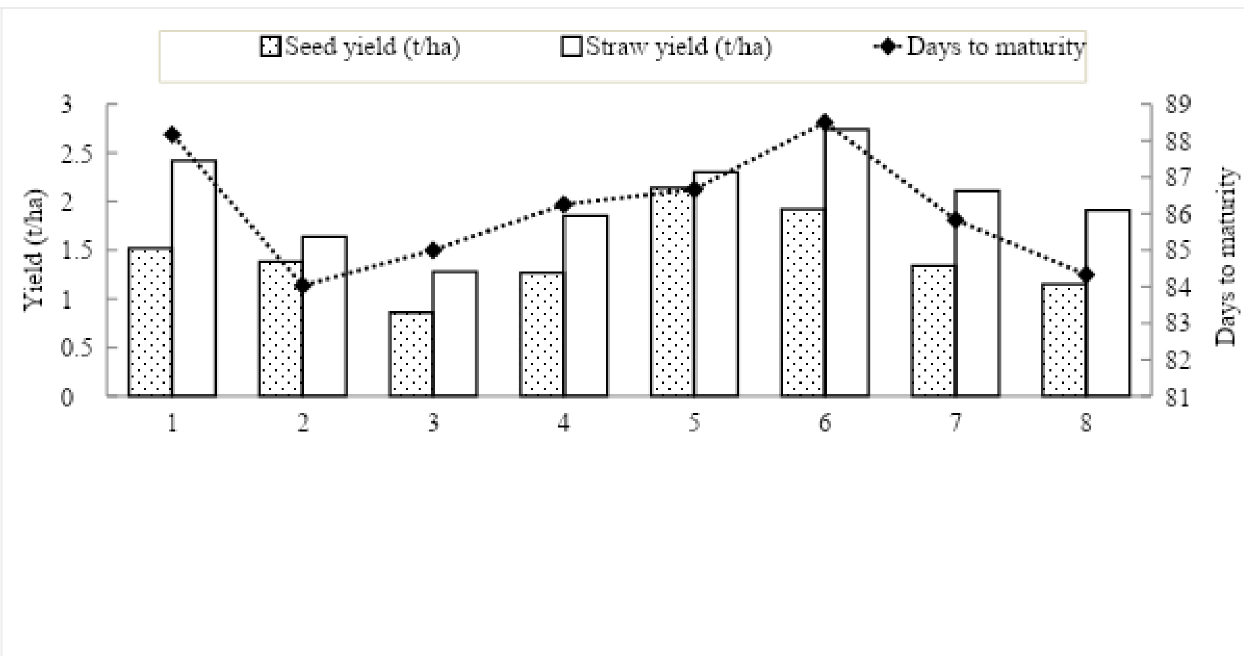


Figure 2. Effect of variety and Boron doses on yield and duration

### *3.6 Yield*

Yield was significantly influenced by the variety, Boron usage and their interaction (Figure 2). Both seed and straw yield was acquired higher in Binasarisha-9 over BARI Sarisha-17. Nevertheless, without Boron fertilizer seed and straw yield was least. Maximum seed and straw yield were found with the treatments $T_3$ (Boron 2.0 kg/ha) and $T_4$ (Boron 3.0 kg/ha).

Interaction effects indicated that, combination $V_1 \times T_1$ (Binasarisha-9 with no Boron use) and $V_2 \times T_6$ (BARI Sarisha-17 with 5.0 Kg Boron $ha^{-1}$) yielded the lowest seed; whereas, $V_2 \times T_1$ (BARI

Sarisha-17 with no Boron application) gave the least straw yield. In contrast, $V_1 \times T_4$ (Binasarisha-9 with 3.0 Kg Boron $ha^{-1}$) treatment produced highest seed and straw yield respectively (Figure 5).

Both seed and straw yield of mustard raised rapidly with increasing boron levels up to 3.0 kg/ha, but after that dose, seed yield decreased with a similar trend. The mean data revealed a positive but quadratic relationship between seed yield and boron levels (Figure 3, Figure 4). It meant that, above that level of B, there was a risk of yield loss.

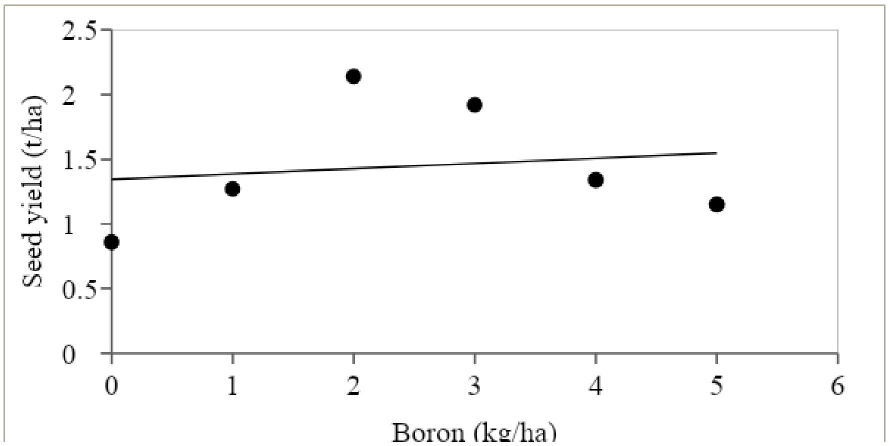


Figure 3. Response of boron on seed yield of mustard

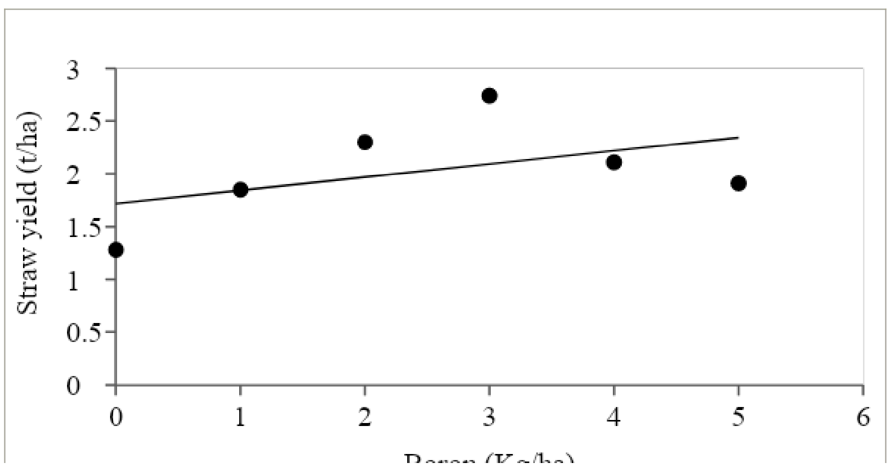


Figure 4. Trend of mustard straw yield with relation to boron applications

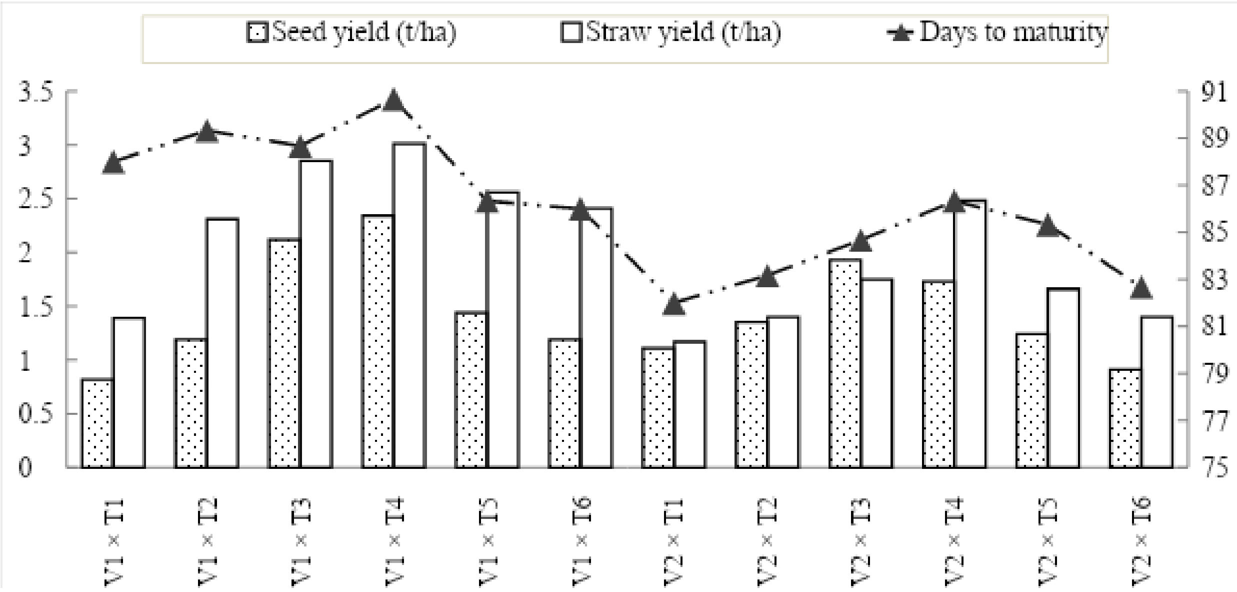

Figure 5. Influence of variety and Boron applications yield and maturity.

***3.7 Maturity duration***

BARI Sarisha-17 matured earlier than Binasarisha-9 (Figure 2). Against Boron doses, application of 3.0 kg/ha ($T_4$) Boron ensued longer duration; but using 5.0 Kg Boron $ha^{-1}$ ($T_6$) resulted shortest maturity period in the mustards.

Combined influences displayed, treatment $V_1 \times T_4$ (Binasarisha-9 with 3.0 Kg Boron $ha^{-1}$) took longest days to maturity; in contrast, $V_2 \times T_1$ (BARI Sarisha-17 with no Boron use) had the shortest life cycle among the treatments (Figure 5).

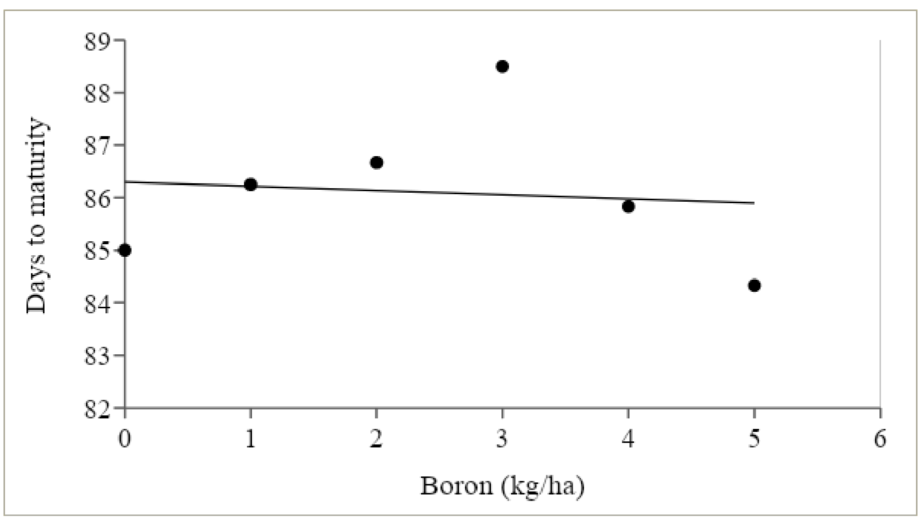

Figure 6. Life duration of mustard varieties under various boron rates.

The days to maturity increased rapidly with increasing boron levels up to 3.0 kg/ha, but after that dose, days to maturity decreased with a similar trend. The mean data revealed a positive but quadratic relationship between days to maturity and boron levels (Figure 6).

## 4. Discussion

### *4.1 Influence of variety, Boron and their interaction on yield attributes*

With varietal, boron dose and their interaction, number of total siliquae per plant, siliqua length, hundred grain weight differed significantly. Number of seeds per siliqua was also significant except boron rates. Value of the above attributes varied according to variety and applied boron rates. But it was remarkably reflected that boron dose between 2.0 kg/ha to 3.0 kg/ha was most responsive in both Binasarisha-9 and BARI Sarisha-17. The yield contributing characters such as number of siliquae per plant$^{-1}$, siliqua length, number of seeds per siliqua and thousand seed weight differed significantly between varieties and boron doses. These results were in agreement with Singh et al. (2017) and Halder et al. (2007). Different treatment combinations noticeably exerted significant influence on the yield features. The number of siliquae per plant of mustard was found to be higher in the presence of available boron in the soil (Chatterjee et al. 1985). Masum et al. (2019) also found significant effect of boron on number of siliquae per plant. While Islam and Sarker (1993) spotted number of seeds per siliqua boosted with the increasing rate of boron application. Yadav et al. (2016) narrated, effect of boron on rape seed formation was good and it significantly increased the seeds per siliqua. Hossain et al. (2012) stated, application of boron gave higher weight of 1000-seed over control.

### *4.2 Effect on yield and maturity*

Seed and straw yield was obtained satisfactory with the application of 3.0 Kg and 2.0 Kg Boron ha$^{-1}$; which was also similar in the collaborative effect with Binasarisha-9. Trend of yield was dependent mainly on amount of boron concentration application. Maturity duration was short for the control and less amount of boron application. But applying 3.0 Kg and 2.0 Kg Boron ha$^{-1}$ exhibited the potential duration of the mustard varieties. Actually, boron might have influenced the uptake and utilization of other macro nutrients thus led to the improved growth and yield which took the actual time; but those with deficit boron shortened the life cycle might be due to physiological factors. Sharma et al. (2020) commented that, application of recommended doses of fertilizers with optimum doses of boron and sulphur increased the growth and yield of mustard. Likewise, Shekhawat et al. (2012) reported seed yield in mustard increased significantly (16–47%) with boron usage. The same findings were also discerned by Bhogal (2017), Jaiswal et al. (2015) and Singh et al. (2017). AICRP-RM (2005a, 2005b) opined that yield increase of mustard was due to 27% and 10% increase in seeds/siliqua and 1000 seed weight respectively which indicated the role of boron in seed formation. Azam et al. (2020) found thousand seed weight (g) was closely related with days to 50% flowering and days to maturity, in addition the number of seeds per siliqua was positively correlated with length of siliqua. Seed yield of mustard was positively and significantly correlated with yield contributing characters *viz*. pods/plant, seeds/pod, and 1000-seed weight Hossain et al. (2012).

## 5. Conclusion

Boron usage had significant difference on yield and maturity duration of the studied varieties. It was ascertained that both over and under dose of boron affected the yield and maturity features of mustard under no tillage. Hence, to curtail the economic loss and apply judicial fertilizer, boron doses at the rate of 3.0 kg/ha to 2.0 kg/ha was found to have optimum yield in the state of no or zero tillage cultivation. Since this experiment covered a limited area and time; further validation trials are necessary to justify the outcomes of this investigation.

**Acknowledgements**

Authors would like to express heartfelt thanks to Abdus Sobhan, Farm Manager, Julekha Khatun, Field Man, all staffs specially, Isaq, Selim, Mamun, Arif and labors of BINA Sub-station, Ishurdi, Pabna for their helpful coordination during the entire experiment work. We also acknowledge the cooperation of Regional Agricultural Research Station (BARI), Ishurdi, Pabna for providing seeds of BARI variety to undertake the experimentation. Finally, we are sincerely grateful to the Bangladesh Institute of Nuclear Agriculture for providing necessary supports to conduct this research investigation.

**References**

Akbar, M. A. (2011). Adoption of modern rapeseed mustard and sesame varieties with production technology for yield gap reduction. Technical Bulletin, No. 16.

AIS (Agricultural Information Service) (2010). Krishi diary (in Bangla). Agricultural Information Service, Dhaka, 13-14.

Chowdhury, M. A. Z. and Uddin, M. J. (1990). Genetic parameters and character association in mustard, Ed. 5, p. 8.

Ghosh, R. K. and Chatterjee, B. N. (1988). Effect of dates of sowing on oil content and fatty acid profiles of Indian mustard. Indian Journal of Oilseed Research, 5, 144-149.

Hossain, M. A. and Siddique, M. N. A. (2015). Water-A limiting resource for sustainable agriculture in Bangladesh. EC Agriculture, 1(2), 124-137.

Islam, M. B. and Sarker, M. A. Z. (1993). Effect of different level of boron on the yield of mustard .Ed. Research Report 1992-1993. Bangladesh Agricultural Research Institute, On-farm Research Division, Agricultural Research Station, Rangpur.

Lei, S. H. I. Yun-Hua, W. Fu-Zhao, N. Jian-Wei, L. U. Jin-Ling, M. and Fang-Sen, X. U. (2009). Inheritance of boron efficiency in oilseed rape. Pedosphere, 19, 403-408. https://doi.org/10.1016/S1002-0160(09)60132-6

Mengel, K. and Kirkby, E. A. (1982). Principles of plant nutrition. International Potash Institute, Bern, Switzerland

Pommerrenig, B. Junker, A. Abreu, I. Bieber, A. Fuge, J. Willner, E. Bienert, M. D. Altmann, T. and Bienert, G. P. (2018). Identification of Rapeseed (Brassica napus) Cultivars with a High Tolerance to Boron-Deficient Conditions. Frontiers in Plant Science, 9. https://doi.org/10.3389/fpls.2018.01142

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, B. S., Mian, M. 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, 1-26

Sultana, B., Mian, M., Jahiruddin, M., Rahman, M. M., Siddique, M. N. A. and Sultana, J. (2019a). Liming and Soil Amendments for Acidity Regulation and Nutrients Uptake by Potato-Mung bean Rice

Cropping Pattern in the Old Himalayan Piedmont Plain. Asian Journal of Agricultural and Horticultural Research, 3(2), 1-15. https://doi.org/10.9734/ajahr/2019/v3i229994

Sharif, M. A. R. Haque, M. Z. Howlader, M. H. K. and Hossain, M. J. (2016). Effect of sowing time on growth and yield attributes of three mustard cultivars grown in Tidal Floodplain of Bangladesh. Journal of the Bangladesh Agricultural University, 14, 155-160. https://doi.org/10.3329/jbau.v14i2.32689

Miah, M., & Mondal, M. (2017). Oilseeds sector of Bangladesh: challenges and opportunities. SAARC Journal of Agriculture, 15(1), 161–172. https://doi.org/10.3329/sja.v15i1.33146

Mondal, M. R. I. and Wahab, M. A. (2001). Production technology of oilseeds. Oilseed Res. Centre, Bangladesh Agricultural Research Institute. Joydebpur, Gaziprur, 6-24

Yang, Y. A. Xu, H. K. Jie, Z. Q. and Wang, B. Y. (1989). Influences of B, N and K nutritional level on B uptake, quality and yield of rapeseed. Scientia Agricultura Sinica, 22, 44-45.

Zaman, N. W. Farid, A. T. M. Rahman, A. F. M. Talukder, M. Z. I. and Sarker, R. H. (1998). Yield and fertility of Brassica napus as affected by boron deficiency in soil. Thailand Journal of Agricultural Science.

Bhogal, N. S. (2017). Effect of boron on yield, quality and its uptake in Indian mustard ( Brassica Juncea L ) genotypes. 19(4), 394–397.

Singh, R., Kumar, Y. and Singh, S. (2017) Yield quality and nutrient uptake of Indian mustard (Brassica juncea) under sulphur and boron nutrition. Annals of Plant and Soil Research 19 (2): 227-231

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 Vindhyan red soil. Journal of the Indian Society of Soil Science 63 (3): 362-364. DOI: 10.5958/0974-0228.2015.00047.X

Yadav, S.N., Singh, S.K. and Kumar O. (2016) Effect of boron on yield attributes, seed yield and oil content of mustard (*Brassica juncea* L) on an Inceptisol. Journal of the Indian Society of Soil Science 64(3): 291-296. DOI: 10.5958/0974-0228.2016.00041.4

Halder, N. K ., Hossain M. A., Siddiky, M. A., Rafiuddin, M. and Ullah M.H. (2007) Performance of mustard varieties with boron fertilization in calcareous brown floodplain soil of Bangladesh. Journal of Agronomy 6 (1): 171-174.

Hossain, M. A. Jahiruddin, M. and Khatun, F. (2012). Response of mustard (*Brassica*) varieties to boron application. Bangladesh Journal of Agricultural Research, 37, 137-148. https://doi.org/10.3329/bjar.v37i1.11187

Masum, M. A., Miah, M. N. H., Islam, M. N., Hossain, M. S., Mandal, P., & Chowdhury, A. P. (2019). Effect of boron fertilization on yield and yield attributes of mustard var. BARI Sarisha-14. Journal of Bioscience and Agriculture Research, 20(2), 1717–1723. https://doi.org/10.18801/jbar.200219.209

Shil, N., Saleque, M., Islam, M., & Jahiruddin, M. (2016). Soil fertility status of some of the intensive crop growing areas under major agroecological zones of Bangladesh. Bangladesh Journal of Agricultural Research, 41(4), 735–757. https://doi.org/10.3329/bjar.v41i4.30705

FRG. Fertilizer recommendation guide-2012. Dhaka: Bangladesh Agricultural Research Council. 2012;01-274. ISBN: 978-984-500-000-0

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

Statistix. "Data analysis software for researchers (Version 10.0)". Analytical Software, 2105 Miller Landing Rd, Tallahassee Florida 32312, USA (2021).

Russell DF MSTAT-C computer package programme. Crop and Soil Sci Dept., Michigan State University, US (1986).

Gomez KA and Gomez AA. "Statistical producers for agricultural research. A Wiley Int. Sci. Pub. John Wiley and Sons, New York, Brisbane, Singapore (1984): 139-240.

Banglapedia. Soil fertility; 2021. Available at: https://en.banglapedia.org/index.php?title=Soil_Fertility

FAOSTAT. 2022. Crops and livestock products (Item-Rapeseed, Country-Bangladesh, Year-2020). https://www.fao.org/faostat/en/#data/QCL/visualize

Shekhawat, Kapila, S. S. Rathore, O. P. Premi, B. K. Kandpal, and J. S. Chauhan. 2012. Advances in Agronomic Management of Indian Mustard (*Brassica juncea* (L.) Czernj. Cosson): An Overview. International Journal of Agronomy. Volume 2012, Article ID 408284, 14 pages. DOI:10.1155/2012/408284

AICRP-RM, Annual Progress Report of All India Coordinated Research Project on Rapeseed-Mustard, pp. A1–28, 2005.

AICRP-RM, Annual Progress Report of National Research Centre on Rapeseed-mustard. 2004-05, pp. 9–11, 2005.

Sharma, Simta, Shikha Chaudhray and Rupinder Singh. 2020. Effect of boron and sulphur on growth, yield and nutrient uptake of mustard (*Brassica juncea* L.). International Journal of Chemical Studies (IJCS). 8(4): 1998-2001.

Chowhan, S., & Islam, M. (2021). Zinc Effects Yield of Mustard (*Brassica campestris* L.) Under Zero Tillage. Asian Journal of Soil Science and Plant Nutrition, 7(4), 83-91. https://doi.org/10.9734/ajsspn/2021/v8i130126

PRC. Weather data of 2020-21. Pulses Research Center, Bangladesh Agricultural Research Institute, Ishurdi, Pabna-6620, Bangladesh; 2021.

Chatterjee, B. N. Ghosh, R. K. and Chakraborty, P. K. (1985). Response of mustard to sulphur and micro-nutrients. Indian Journal of Agronomy, 30, 75-78.

Azam, M. G., Chowdhury, S. M. K. H., Hoque, M. M. U., Hasan, M. Z. and Jarin, N. J. (2020). Phenotyping of Mustard (*Brassica juncea*) under the agro ecological condition of Chattogram region. Asian Journal of Crop, Soil Science and Plant Nutrition, 03(01), 94-101. https://doi.org/10.18801/ajcsp.030120.13

## Appendix-1

Table I: Effect of variety, Boron doses and their interaction on yield and duration of mustard varieties.

| **Treatments** | **Straw yield (t/ha)** | **Seed yield (t/ha)** | **Days to maturity** |
|---|---|---|---|
| **Variety** | | | |
| BinaSarisha-9 ($V_1$) | 2.42 a | 1.52 a | 88.17 a |
| BARI Sarisha-17 ($V_2$) | 1.64 b | 1.38 b | 84.03 b |
| $LSD_{0.05}$ | 0.13 | 0.07 | 1.15 |
| Level of significance | * | * | * |
| SEm | 0.06 | 0.03 | 0.56 |
| Boron doses | | | |
| $T_1$ (0 kg/ha) | 1.28 e | 0.86 e | 85.00 bc |
| $T_2$ (1 kg/ha) | 1.85 d | 1.27 c | 86.25 bc |
| $T_3$ (2 kg/ha) | 2.30 b | 2.14 a | 86.67 ab |
| $T_4$ (3 kg/ha) | 2.74 a | 1.92 b | 88.50 a |
| $T_5$ (4 kg/ha) | 2.11 bc | 1.34 c | 85.83 bc |
| $T_6$ (5 kg/ha) | 1.91 cd | 1.15 d | 84.33 c |
| $LSD_{0.05}$ | 0.22 | 0.11 | 2.00 |
| Level of significance | * | * | * |
| Standard Error Mean (SEm) | 0.11 | 0.05 | 0.96 |
| Variety × Boron doses | | | |
| $V_1 \times T_1$ | 1.39 ef | 0.82 h | 88.00 abc |
| $V_1 \times T_2$ | 2.31 c | 1.19 fg | 89.33 a |
| $V_1 \times T_3$ | 2.85 ab | 2.12 b | 88.67 ab |
| $V_1 \times T_4$ | 3.01 a | 2.34 a | 90.67 a |
| $V_1 \times T_5$ | 2.56 bc | 1.44 e | 86.33 bcd |
| $V_1 \times T_6$ | 2.41 c | 1.19 g | 86.00 bcd |
| $V_2 \times T_1$ | 1.17 f | 1.11 g | 82.00 f |
| $V_2 \times T_2$ | 1.40 ef | 1.35 ef | 83.17 ef |
| $V_2 \times T_3$ | 1.75 d | 1.93 c | 84.67 def |
| $V_2 \times T_4$ | 2.48 c | 1.73 d | 86.33 bcd |
| $V_2 \times T_5$ | 1.66 de | 1.24 fg | 85.33 cde |
| $V_2 \times T_6$ | 1.40 ef | 0.91 h | 82.67 ef |
| $LSD_{0.05}$ | 0.31 | 0.16 | 2.83 |
| Level of significance | * | * | * |
| Standard Error Mean (SEm) | 0.15 | 0.08 | 1.36 |
| Coefficient of Variation | 9.12% | 6.55% | 1.94% |

Figures in a column having different letter (s) differ significantly at 5% level of probability according to LSD