



No Tillage Cultivation of Mustard Requires Definite Boron Dose for Optimizing Seed Yield

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Authors' contributions

This work was carried out in collaboration among all authors. Author SC planned, designed, executed and performed the statistical analysis of the experiment. Author MI wrote the first draft of the whole manuscript. Authors KN and MKJA collected the pertinent data and managed the literature searches. Author MMH did the field management of the trial and aided in data entry. All authors read and approved the final manuscript.

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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,

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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.

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 [1]. *Brassica* oil crop supplies substantial quality of edible oil in Bangladesh. It accounts for 59.4% of total oil seed production in the country [2]. 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 [3-5]. 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 [6]. 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 [7]. Mustard is the most common source of edible oil in this country which ranks top among the oil seed crops [8].

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 [9]. 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, requires less water, reduces tillage costs and time, 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.

Balanced fertilizers and resource use is crucial to maintain productivity of crops [10,11]. Fertilizers have effect on yield and yield attributes of crops [12,13]. 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 [14-16]. The number of siliquae, seed setting and seed yield of mustard plants is greatly influenced by boron particularly where soil is deficient in boron [17]. The uptake and requirement of boron varies upon plant development stages, soil, plant parts, among cultivars and species [18]. 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 [19].

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 [20]. 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 Nuclear Agriculture, Sub-station farm, Ishurdi, Pabna falling under the Agro Ecological Zone (AEZ) 11 [21] 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 [22].

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 [8]. Seeds were sown on 18th 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 [23]. 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 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)-

V₁ = Binasarisha-9,
V₂ = BARI Sarisha-17

Factor B: Boron doses (6)-

T₁ = B@ 0 kg/ha,
T₂ = B@ 1.0 kg/ha,
T₃ = B@ 2.0 kg/ha
T₄ = B@ 3.0 kg/ha,
T₅ = B@ 4.0 kg/ha,
T₆ = B@ 5.0 kg/ha.

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

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 1st, 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 [24]. Significance of mean difference was compared by LSD (least significant difference) test [25,26] 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.

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}).

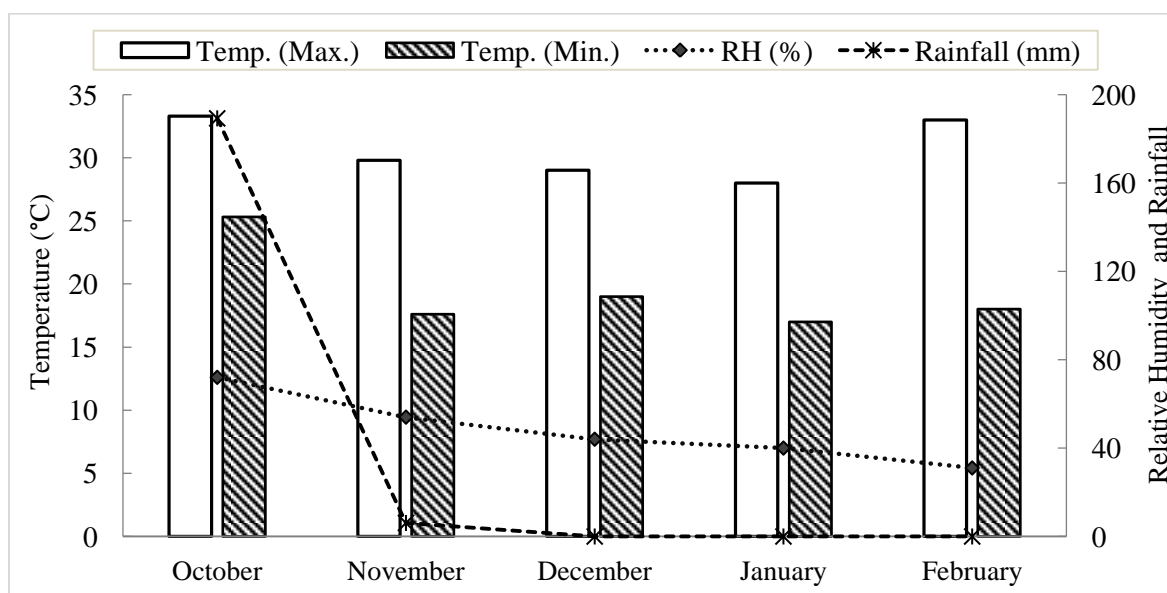


Fig. 1. Weather status during October 2020 to February 2021

(Source: Chowhan and Islam [8])

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		
					1 st	50%	90%
Variety							
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 × 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 × 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 × 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 × 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 × 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 × 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 × 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 × 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 × 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 × 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 × 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 × 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, LoS- Level of Significance SEm- Standard Error mean, CV- Coefficient of Variation, NOTSPP- Number of total siliqua per plant, SL- Siliqua length, NOSPS-Number of seeds per siliqua, HGW- Hundred grain weight.

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 (T₁) caused late flowering; inversely excess Boron application (T₆) led to earlier first, fifty and ninety percent flowering. Delayed ninety percent flowering was seen with treatment T₂ (application of 1.0 Kg Boron ha⁻¹). Interaction effect of variety and Boron doses showed that V₂ × T₁ (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.

3.6 Yield

Yield was significantly influenced by the variety, Boron usage and their interaction (Fig. 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 T₃ (Boron 2.0 kg/ha) and T₄ (Boron 3.0 kg/ha).

Interaction effects indicated that, combination V₁ × T₁ (Binasarisha-9 with no Boron use) and V₂ × T₆ (BARI Sarisha-17 with 5.0 Kg Boron ha⁻¹) yielded the lowest seed; whereas, V₂ × T₁ (BARI Sarisha-17 with no Boron application) gave the least straw yield. In contrast, V₁ × T₄ (Binasarisha-9 with 3.0 Kg Boron ha⁻¹) treatment produced highest seed and straw yield respectively (Fig. 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 (Figs. 3, Figure 4). It meant that, above that level of B, there was a risk of yield loss.

3.7 Maturity Duration

BARI Sarisha-17 matured earlier than Binasarisha-9 (Fig. 2). Against Boron doses, application of 3.0 kg/ha (T₄) Boron ensued longer duration; but using 5.0 Kg Boron ha⁻¹ (T₆) resulted shortest maturity period in the mustards.

Combined influences displayed, treatment V₁ × T₄ (Binasarisha-9 with 3.0 Kg Boron ha⁻¹) took longest days to maturity; in contrast, V₂ × T₁ (BARI Sarisha-17 with no Boron use) had the shortest life cycle among the treatments (Fig. 5).

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 (Fig. 6).

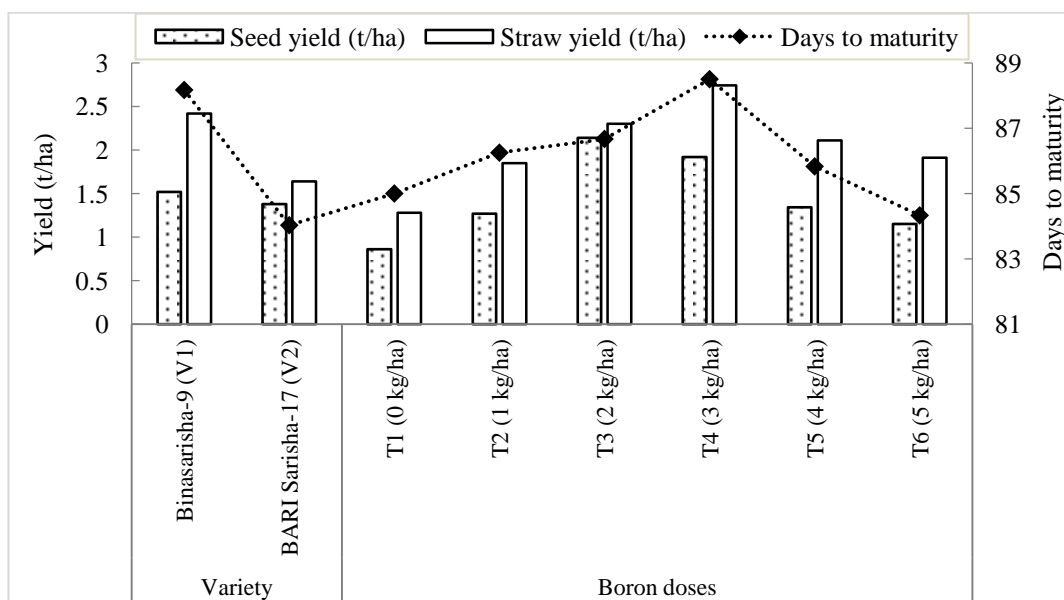


Fig. 2. Effect of variety and Boron doses on yield and duration

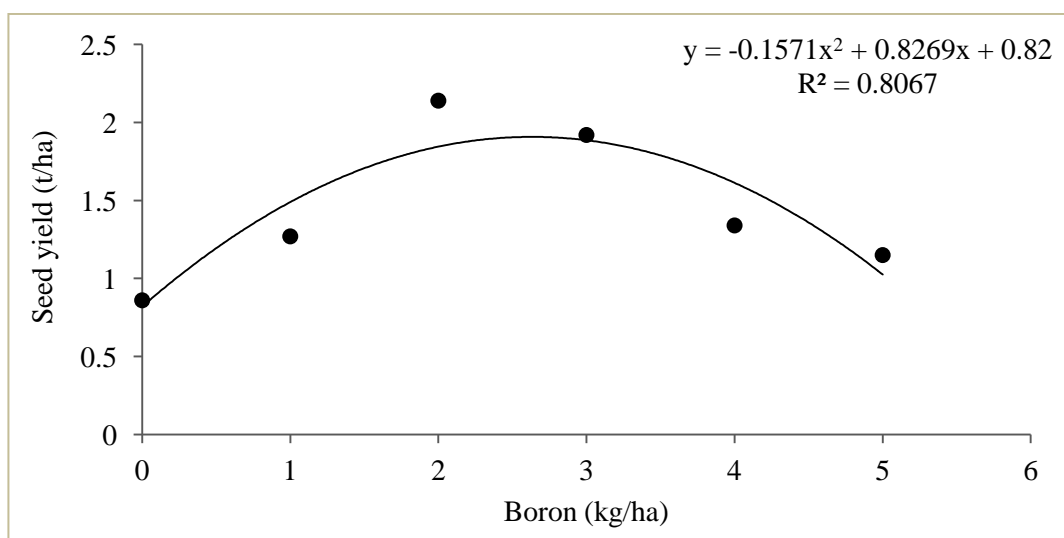


Fig. 3. Response of boron on seed yield of mustard

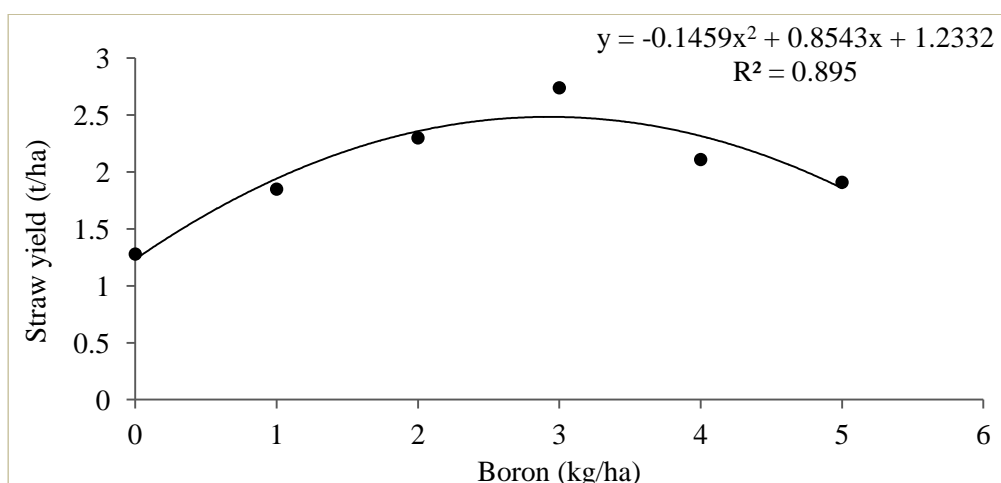


Fig. 4. Trend of mustard straw yield with relation to boron applications

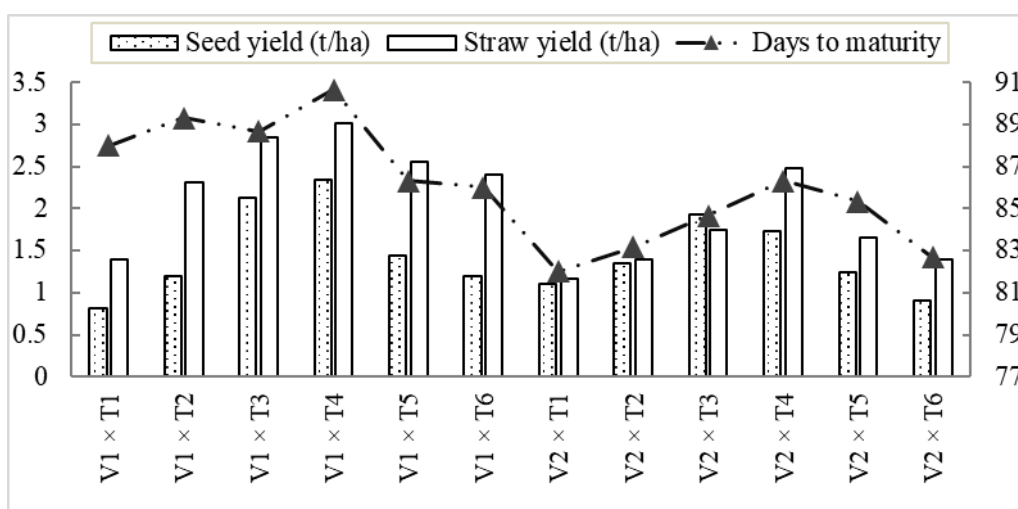


Fig. 5. Influence of variety and boron applications yield and maturity

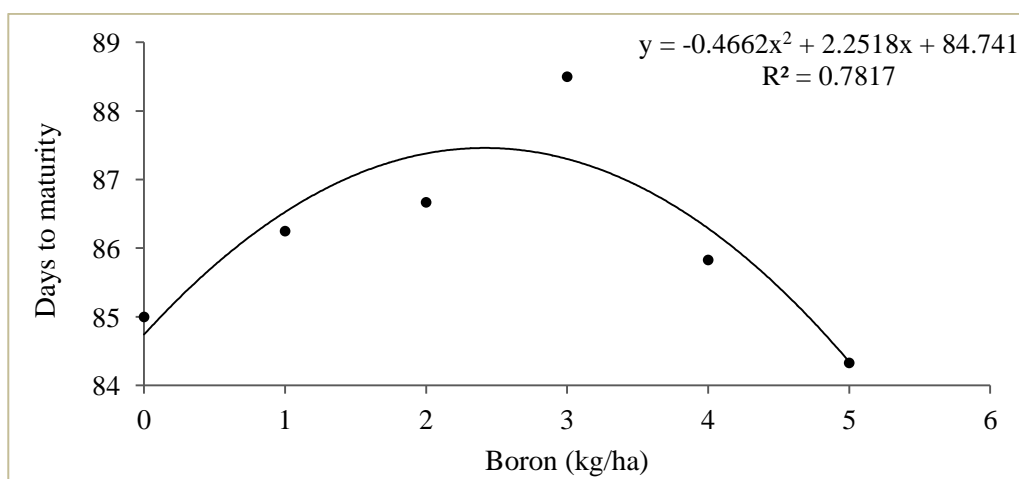


Fig. 6. Life duration of mustard varieties under various boron rates

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. [27] and Halder et al. [28]. 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 [29]. Masum et al. [30] also found significant effect of boron on number of siliquae per plant. While Islam and Sarker [17] spotted number of seeds per siliqua boosted with the increasing rate of boron application. Yadav et al. [31] narrated, effect of boron on rape seed formation was good and it significantly increased the seeds per siliqua. Hossain et al. [32] 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. [33] 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. [34] reported seed yield in mustard increased

significantly (16–47%) with boron usage. The same findings were also discerned by Bhogal [35], Jaiswal et al. [36] and Singh et al. [27]. AICRP-RM [37,38] 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. [39] 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. [32].

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 judicious fertilizer, boron doses at the rate of 2.0 kg/ha to 3.0 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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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