



Effect of Foliar Spray of Boron on the Growth and Quality of Exotic Tomato (*Lycopersicon esculentum* Mill) in Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2016 to April 2017. The experiment was conducted to assess the effect of two factors, for example; I, two levels of foliar spray of boron as: 100 ppm boric acid (B1) and 200 ppm boric acid (B2) in relation to a control and II, three different tomato cultivars/lines as: L1: Exotic Tomato Line-1, L2: Exotic Tomato Line-2, L3: BARI Tomato-15. The two factorial experiments were laid out in Randomized Complete Block Design with three replications. Fruit setting (56.73%), yield (64.89 t/ha) and total soluble solid (TSS) (4.3%) were considerably higher in B1 and low in B2. Whereas, significantly higher yield (79.87 t/ha) was recorded in L3 in comparison to L1. Considering quality parameters, Vitamin C (20 mg) was the highest in L3 whereas TSS (4.58%) was the highest in L1. In interaction effect, the highest yield (85 t/ha) was obtained from B1L3 and the lowest (31.23 t/ha) in B2L1. The present study suggest to cultivate BARI Tomato-15, but other two exotic lines adapted well and showed good performance in terms of yield and quality parameters.

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1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill family *Solanaceae*) is one of the most popular and widely cultivated nourishing vegetable crops used over the world. The fruits are have valuable nutrients viz. vitamins C (22%); K (6%) and molybdenum. It is a good source of macro and micronutrients, dietary fiber (4%), vitamin A and E. The fruits can be consumed in many ways like raw, cooked and processed such as canned tomato, sauce, juice, ketchup, puree, stews and soup. Tomatoes have an outstanding antioxidant property and many health benefits. Tomato contains lycopene pigment which is a vital antioxidant that helps to fight against cancerous cells [1]. The significance of tomato as a beneficial crop is very apparent. The potential for production of tomato is high. In Bangladesh two crops are produced, one is the summer crop and the other is the winter crop. The area under tomato cultivation in Bangladesh is very low as compared to that in many other countries. Applications of micronutrients using boron have been reported in increasing seed yield in tomato [2]. Micronutrients such as B is essential for pollen germination and development of the pollen tube, increased amount of fertilized ovules and more seeds per fruit whereas Zn is responsible for the metabolism of RNA, stimulation of carbohydrates, proteins and DNA formation, higher seed yield, fruit set, number of fruits/plant, fruit length and fruit diameter, dry weight of fruits, number of seeds/fruit and seed yield/plant [3]. Foliar application of micronutrients is the most efficient way to utilize the nutrients by plants. Varietal tomato line or cultivar shows significant response to yield and quality characters on tomato due to variability in genetic makeup. The types of antioxidants present in tomato are also used to differentiate tomato cultivars [4]. The overall antioxidant activity of tomatoes varies considerably according to the genetic variety, ripening stage and growing conditions [5]. There appears to be a relationship between high vitamin C levels and relatively poor yield. Better yield and quality could be achieved through selection of genotypes with better keeping quality when harvested at optimum fertilization of micronutrient like boron. This aims to assess the effect of two levels of foliar application of boron on three tomato cultivars/lines in Bangladesh in relation to control.

2. MATERIALS AND METHODS

2.1 Experimental Design

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

2.2 SPADE Value

Leaf chlorophyll content was measured using a hand-held chlorophyll content SPAD-502Plus (KONKA MINOLLTA). At each evaluation the content was measured 5 times from five leaves at different positions per plant and the average was used for analysis.

2.3 Fruit Set Percentage

Fruit set percentage (%) was counted by following formula:

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set}}{\text{Number of flower set}} \times 100$$

2.4 Measurement of Total Soluble Solids (TSS)

Brix refractometer (Model RHB 32 ATC) was used to measure TSS. One tomato sample was collected from each of the treatment. Tomato sample was cut with a sharp knife and inside was squeeze with the needle for sample juice. A drop of juice was placed on the transparent glass and it was covered by the upper glass. Brix refractometer directly showed the value of TSS as percentage.

2.5 Measurement of P^H

Two tomato samples were collected from each of the treatment which was fully ripened. Each sample was blended in liquid form. All the samples were poured in clean and transparent plastic pots. Electric P^H meter (model H 12211 P^H/OPR meter of Hanna Company) was adjusted in buffer solution of P^H 7.0; later on it was adjusted in buffer solution containing P^H 4.0. Finally, Electric P^H meter was inserted in first sample and data were recorded.

2.6 Measurement of Vitamin-C

Vitamin-C was measured by Oxidation Reduction Titration Method. Single fruit was blend and

tomato extract was filtrated with Whatman No.1 filter paper. It was then mixed with 3% metaphosphoric acid solution. The titration was conducted in presence of glacial acetic acid and metaphosphoric acid to inhibit aerobic oxidation with dye solution (2, 6-dichlorophenol indophenol). The solution was titrated with dye.

2.7 Statistical Analysis

All the data collected were subjected to analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height is an important character of a plant, which is closely related to proper growth and development and finally produced higher yield. Plant height of tomato varied significantly at 65 days after transplanting due to foliar spray of different levels of boron. At 65 DAT, the longest plant (102.9 cm) was produced from B₁ followed by (96.93 cm) produced from B₀ treatment and the shortest (90.64 cm) was found from B₃ treatment (Table 1). Boric acid generated higher plant height due to the improvement of vegetative growth of tomato plant through better uptake of boron but excess amount may be toxic to the plant. The increased height may be due to the influence of foliar application of boron. The author [6,7] also reported that boron increase plant height of tomato. Plant height of tomato varied significantly at 65 days after transplanting due to effect of tomato lines. At 65 DAT, the tallest plant (127.8 cm) was produced from L₁. The shortest plant (74.16 cm) was produced in L₃ treatment at 65 DAT (Table 2). Similar results were also found by [8]. The variations in plant height at 65 days after transplanting due to interaction effect of boron and tomato line were found to be statistically significant. The tallest plant (135.40 cm) was observed from the treatment combination of B₁L₁ and the shortest plant (68.89 cm) was found from the treatment combination of B₂L₃ (Table 3).

3.2 Number of Leaves per Plant

Number of leaves per plant of tomato varied significantly at 65 days after transplanting due to two levels of boron application. At 65 DAT, the highest number of leaves per plant (48.34) was obtained from B₁ and the lowest (39.13) from B₂

application (Table 1). The author [9] reported that application of boron significantly increased the number of leaves on tomato plants compared to control. Number of leaves per plant of tomato varied significantly at 65 days after transplanting (DAT) due to effect of tomato lines. At 65 DAT, the highest number of leaves (51.16) per plant was obtained from L₁ and the lowest (33.69) from L₂ (Table 2). Interaction effect of different levels of boron and tomato lines were found to be statistically significant. The maximum number of leaves per plant (58.41) was recorded by the treatment combination of B₁L₁ and minimum number of leaves per plant (30.17) was found by treatment combination of B₂L₂ (Table 3).

3.3 SPAD Value

There was insignificant effect of different levels of boron on chlorophyll content in terms of SPAD value at vegetative stage. Maximum Chlorophyll content (49.76) was found in B₁ and the minimum Chlorophyll content (46.21) was found in B₂ at vegetative stage (Table 1). Lines of tomato also showed insignificant effect on Chlorophyll content at vegetative stage. The highest Chlorophyll content at vegetative state (49.86) and the lowest Chlorophyll content at vegetative stage (45.39) of tomato was found from L₃ (Table 2). Effect of different levels of boron and tomato lines on the Chlorophyll content was insignificant at vegetative stage. Maximum Chlorophyll content at vegetative stage (51.43) was obtained from B₁L₂ while the minimum Chlorophyll content (44.10) was obtained from B₂L₃ (Table 3).

3.4 Number of Flower Clusters per Plant

Number of flower clusters per plant varied significantly due to application of boron. The highest number (21.25) of flower clusters per plant of tomato was obtained in B₁ and the lowest number (17.93) was observed in B₂ treatment (Table 1). The author [10,11] observed that boron treated tomato plants showed higher flower clusters per plant than untreated control. Number of flower clusters per plant varied significantly due to effect of tomato lines. The highest number (21.82) of flower clusters per plant of tomato was found in L₃ and the lowest number (18.24) was observed in L₁ (Table 2), which was the same with the findings of [12]. There were significant variations among the different levels of boron and tomato lines in respect of flower clusters per plant. The Maximum number of flower clusters per plant (23.97) was found in B₁L₃ and the minimum (17.03) was found in B₂L₃ (Table 3).

Table 1. Effect of different levels of boron on tomato growth, flowering and yield contributing parameters

Treatments	Plant height (cm)	No.of leaves/plant	SPAD value	No. flower cluster/plant	Fruit set (%)	Fruit yield (t/h)	TSS value	pH value	Vitamin C
B ₀	96.93 ab	44.15 b	46.56	18.24 b	53.01a	59.61 b	4.02 a	4.55 b	16.27 b
B ₁	102.9 a	48.34 a	49.76	18.87 b	56.73a	64.89 a	4.31 a	5.02 a	16.96 b
B ₂	90.64 b	39.13 c	46.21	21.82 a	47.36b	54.05 c	3.66 b	4.23 b	19.42 a
CV%	7.99	8.29	10.12	6.58	7.92	7.69	9.04	8.93	10.24

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per as 0.05 (%) level of probability

Table 2. Effect of tomato lines on tomato growth, flowering and yield contributing parameters

Treatments	Plant height (cm)	No.of leaves/plant	SPAD value	Number of flower cluster per plant	Fruit set (%)	Fruit yield(t/ha)	TSS value	pH value	Vitamin C
L ₁	127.8 a	51.16 a	47.28	18.24 b	55.32a	36.74 c	4.58 a	4.31 b	14.91 c
L ₂	88.48 b	33.69 c	49.86	18.87 b	48.65a	61.94 b	3.88 b	4.43 b	17.73 b
L ₃	74.16 c	46.76 b	45.39	21.82 a	53.13b	79.87 a	3.53 b	5.06 a	20.00 a
CV%	7.99	8.29	10.12	6.58	7.92	7.69	9.04	8.93	10.24

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per as 0.05 (%) level of probability

Table 3. Interaction effect of different levels of boron and tomato line, growth, flowering and yield contributing parameters

Treatment combinations	Plant height	No of leaves/plant	SPAD value	No. of flowers cluster/plant	Fruit set (%)	Fruit yield (t/ha)	TSS value	pH value	Vitamin C
B ₀ L ₁	128.90 ab	50.31 b	46.17	18.19 c-e	55.32 abc	4.97 b	4.60 ab	4.39 b-d	13.37 e
B ₀ L ₂	88.44 c	34.50 e	49.47	18.94 c-e	49.05 cd	1.98 cd	4.00 bc	4.17 cd	15.04 de
B ₀ L ₃	73.43 de	47.63 bc	44.03	22.11 ab	54.66 abc	2.05 cd	3.47 cd	5.09 ab	20.39 ab
B ₁ L ₁	135.40 a	58.41 a	49.80	19.50 cd	61.83 a	5.58 a	4.73 a	4.81 a-c	13.59 e
B ₁ L ₂	93.11 c	36.39 de	51.43	20.28 bc	52.12 bc	2.37 c	4.47 ab	5.05 ab	16.79 cd
B ₁ L ₃	80.17 c-e	50.22 b	48.03	23.97 a	56.26 ab	2.14 cd	3.73 cd	5.20 a	20.51 ab
B ₂ L ₁	119.20 b	44.78 bc	45.87	17.03 e	48.81 cd	4.57 b	4.40 ab	3.72 d	17.78 b-d
B ₂ L ₂	83.88 cd	30.17 e	48.67	17.39 de	44.80 d	1.74 d	3.17 d	4.07 d	21.35 a
B ₂ L ₃	68.89 e	42.44 cd	44.10	19.38 cd	48.47 cd	1.73 d	3.40 cd	4.90 ab	19.12 a-c
LSD _(0.05)	13.39	6.29	NS	2.24	7.18	0.43	0.63	0.71	3.11
CV (%)	7.99	8.29	10.12	6.58	7.92	8.19	9.04	8.93	10.24

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per as 0.05 (%) level of probability

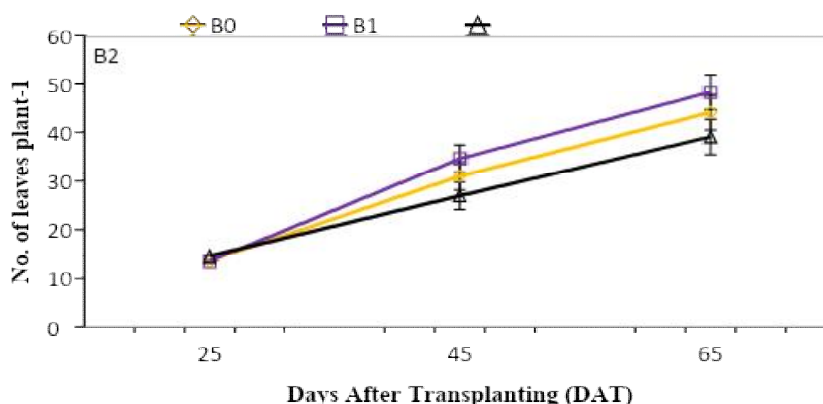


Fig. 1. Effect of different levels of boron on the no. of leaves plant⁻¹ of tomato at different days after transplanting (LSD_(0.05) = 3.63 at 65 DAT showing vertical error bar, respectively) (Here, B₀ = control, B₁ = 100 ppm boric acid and B₂ = 200 ppm boric acid)

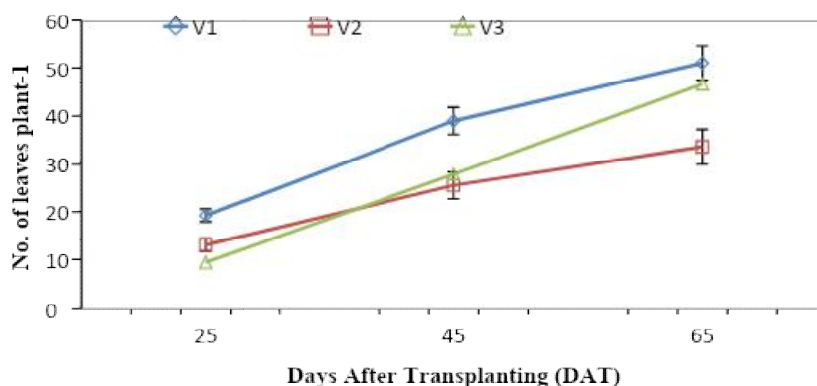


Fig. 2. Effect of tomato line on the no. of leaves plant⁻¹ of tomato at different days after transplanting (LSD_(0.05) = 1.34, 2.84 and 3.63 at 25, 45 and 65 DAT, showing vertical error bar, respectively) (Here, L₁ = exotic tomato line-1, L₂ = exotic tomato line-2 and L₃ = BARI Tomato-15)

3.5 Fruit Set Percentage

The effect of different levels of boron on the fruit set percentage was positive and significant. The highest number of fruit set percentage (56.73%) was obtained with the foliar application of B₁ and the lowest number of fruit set percentage (47.36%) was found in B₂ (Table 1). The results proved that boron plays a vital role in fruit setting of tomato plants. The maximum fruit set percentage might be due to optimum foliar application of boron. Similar result was also reported by [13]. The effect of tomato lines on the fruit set percentage of tomato was found positive and significant. The highest number of fruit set percentage (55.32%) was obtained in L₁ and the lowest number of fruit set percentage (48.65%) was found in L₂ (Table 2). Interaction effect of different levels of boron with tomato lines on

fruits set percentage of tomato was found significant. The maximum number of fruits set percentage (61.83%) was obtained in B₁L₁ and the minimum number of fruit set percentage (44.80%) was recorded in B₂L₃ (Table 3).

3.6 Fruit Yield per Hectare

The fruit yield of tomato per hectare was also significantly influenced by different levels of boron. The highest yield (64.89 t/ha) was obtained from B₁ followed by B₀ (59.61t/ha), while the lowest yield (54.05 t/ha) was obtained in B₂ (Table 1) [14,15]. Effect of tomato lines also significantly influenced the yield of fruit per hectare. The highest yield (79.87 t/ha) was produced in L₃ and the lowest yield (36.74 t/ha) was produced in L₁ (Table 2). The treatment combination of B₁L₃ gave the maximum yield (85

t/ha) and the minimum yield (31.23 t/ha) was obtained in the treatment combination of B₂L₁ (Table 3).

3.7 Total Soluble Solids (TSS) Percentage

The research work exhibited distinct variations in total soluble solids (TSS) percentage of tomato by the effect of boron. The maximum TSS percentage in tomato (4.31%) was observed in B₁, while the minimum (4.02%) was obtained in B₀ (Table 1). This is in line with the findings [16,17,18]. Total soluble solids (TSS) percentage in tomato varied significantly due to effect of tomato lines. The maximum TSS (4.58%) was found in L₁ treated plants, whereas the minimum TSS percentage (3.53%) was found in L₃ (Table 2). The author [19] also found similar result. Interaction effect of foliar application of boron and tomato lines had significant effect on TSS percentage of tomato. It was observed that maximum TSS percentage (4.73%) was obtained in B₁L₁ treated plants, which was statistically similar with B₀L₁ (4.60%) and B₂L₁ (4.40%), whereas the minimum (3.17%) was recorded in B₂L₂ which was statistically identical with B₀L₃, B₁L₃ and B₂L₃ (Table 3).

3.8 Tomato P^H

Distinct variation in pH was exhibited in this research work on tomato by the levels of boron. The maximum pH in tomato (5.02) was found in B₁ while the minimum (4.23) was obtained in Table 1. Similar results were obtained by [20,2,21] in tomato. pH in tomato varied significantly with the effect of tomato lines. The maximum pH (5.06) was found from L₃ plants, whereas the minimum pH (4.31) was found from L₁ (Table 2). Similar results were reported by [22]. Interaction effect of foliar application of boron and tomato lines was significant on pH of tomato. It was observed that maximum (5.20) was obtained from B₁L₃ treated plants, which was statistically similar with B₂L₃ (4.90), B₁L₂ (5.05) and B₀L₃ (5.09), whereas the minimum (3.72) was recorded for B₂L₁ which was statistically identical (4.07) B₂L₂ (Table 3).

3.9 Vitamin-C Content

This research work showed that distinct variation existed in vitamin-C content of tomato which was as a result of foliar application of different levels of boron. The maximum vitamin-C content (19.42 mg per 100 g of tomato) was found in B₂ while the minimum content of Vitamin-C (16.27 mg)

was obtained in B₀ (Table 1). The results obtained are in conformity with the findings of [23,24] in tomato. Vitamin-C content in tomato varied significantly with the effect of tomato lines. The maximum vitamin-C content (20.00) was obtained from L₃ plants, whereas the minimum content of vitamin-C (14.91 mg) was recorded from L₁. [25] investigated Vitamin-C content of different tomato lines and obtained similar results. Interaction effect of different levels of boron and tomato lines varied significantly for the content of vitamin-C of tomato. The maximum amount of vitamin-C content (21.35 mg) was obtained from B₂L₂ which was statistically similar to B₀L₃ (20.39 mg) and B₃L₁ (20.51 mg) while the minimum amount of vitamin-C content (13.37 mg) was recorded from B₀L₁ which was statistically similar to B₁L₁ (13.59 mg) and B₀L₂ (15.04 mg) (Table 3).

4. CONCLUSION

Considering the above discussion it may be concluded that among the boron concentrations, B₁ treated plant showed best performance in plant height, number of leaves, fruit setting percentage, TSS percentage and pH value. In case of tomato lines, L₃ showed best performance in yield/ha and vitamin-C content, but in TSS percentage and fruit setting percentage was the best in L₁. It is concluded that foliar spray of 100 ppm boric acid for boron treatment and BARI Tomato-15 cultivars/lines were the best for growth, flowering, yield and quality of tomato. Considering the result of the present experiment, further studies will be useful to get the best combination for the performance tomato.

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. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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