# EFFECTS OF FOLIAR APPLICATION OF BORON ON GROWTH, YIELD AND NUTRIENTS CONTENT OF TOMATO

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# *CERTIFICATE*

*This is to certify that the thesis entitled "**EFFECTS OF FOLIAR APPLICATION OF BORON ON GROWTH, YIELD AND NUTRIENTS CONTENT OF TOMATO**" submitted to the Department of **Agricultural Chemistry**, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirement for the degree of **MASTERS OF SCIENCE (M.S.)** in **AGRICULTURAL CHEMISTRY**, embodies the result of a piece of bonafide research work carried out by **MD. MAHADI HASAN**, Registration No. **18-09281** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

*I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.*

**December, 2020**
**Dhaka, Bangladesh**

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# Dedicated to
# My
# Beloved Parents

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# EFFECTS OF FOLIAR APPLICATION OF BORON ON GROWTH, YIELD AND NUTRIENTS CONTENT OF TOMATO


## ABSTRACT

The experiment was conducted during October 2019 to March 2020 in the farm of Sher-e-Bangla Agricultural University. The experiment consisted of two factors: Factor A: two tomato varieties *viz*. $V_1$: BARI tomato-2 and $V_2$: BARI tomato-16 and Factor B: 5 levels of boron application *viz*. $B_0$: Control (0 kg B $ha^{-1}$), $B_1$: 0.5 kg B $ha^{-1}$, $B_2$: 1.0 kg B $ha^{-1}$, $B_3$: 1.5 kg B $ha^{-1}$ and $B_4$: 2.0 kg B $ha^{-1}$. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Different varieties of tomato and boron levels influenced significantly on most of the recorded parameters. In case of different tomato varieties, the highest results regarding growth, yield and yield contributing parameters were obtained from $V_2$ (BARI tomato-16) compared to $V_1$ (BARI tomato-2). Regarding boron treatment, $B_3$ (1.5 kg B $ha^{-1}$) showed best results on most of the yield and yield contributing parameters such as number of flower clusters $plant^{-1}$, number of fruits $cluster^{-1}$, number of fruits $plant^{-1}$, single fruit weigh,t fruit weight $plant^{-1}$ and yield $ha^{-1}$. In terms of treatment combination of variety and boron, the highest number of flower clusters $plant^{-1}$ (6.15), number of flowers $plant^{-1}$ (38.95), number of fruits $cluster^{-1}$ (5.79), fruit length (7.35 cm), fruit diameter (8.40 cm), number of fruits $plant^{-1}$ (34.72), fruit weight $plant^{-1}$ (1.99 kg) and yield (65.98 t $ha^{-1}$) were recorded from $V_2B_3$ (BARI tomato-16 with 1.5 kg B $ha^{-1}$) whereas the lowest was recorded from $V_1B_0$ (BARI tomato-2 with 0 kg B $ha^{-1}$). Regarding nutrient content of tomato fruits; N, P and K were not affected significantly by variety and boron and also their combination but boron content affected significantly. The highest B content (26.25 ppm) was found from $V_2B_3$ (BARI tomato-16 with 1.5 kg B $ha^{-1}$) whereas the lowest (14.25 ppm) was found from $V_2B_0$ (BARI tomato-16 with 0 kg B $ha^{-1}$). So, the treatment combination of $V_2B_3$ (BARI tomato-16 with boron @ 1.5 kg $ha^{-1}$) can be considered as best.

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## ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| BBS | = | Bangladesh Bureau of Statistics |
| BCSRI | = | Bangladesh Council of Scientific Research Institute |
| cm | = | Centimeter |
| CV % | = | Percent Coefficient of Variation |
| DAS | = | Days After Sowing |
| DMRT | = | Duncan’s Multiple Range Test |
| *et al.*, | = | And others |
| e.g. | = | exempli gratia (L), for example |
| etc. | = | Etcetera |
| FAO | = | Food and Agricultural Organization |
| g | = | Gram (s) |
| i.e. | = | id est (L), that is |
| Kg | = | Kilogram (s) |
| LSD | = | Least Significant Difference |
| $m^2$ | = | Meter squares |
| mL | = | Mili Litre |
| M.S. | = | Master of Science |
| No. | = | Number |
| SAU | = | Sher-e-Bangla Agricultural University |
| var. | = | Variety |
| $^oC$ | = | Degree Celceous |
| % | = | Percentage |
| NaOH | = | Sodium hydroxide |
| GM | = | Geometric mean |
| mg | = | Miligram |
| P | = | Phosphorus |
| K | = | Potassium |
| Ca | = | Calcium |
| L | = | Litre |
| µg | = | Microgram |
| USA | = | United States of America |
| WHO | = | World Health Organization |

# CHAPTER I

# INTRODUCTION

Tomato *(Solanum lycopersicum)* belonging to the family Solanaceae, is one of the important, popular and nutritious vegetables grown in Bangladesh during winter season and cultivated in all parts of the country (Haque *et al.*, 1999). It ranks third in the world's vegetable production, next to potato and sweet potato, placing itself first as processing crop among the vegetables. It is a cheap source of vitamin-C.

Tomato covers about 9.8% of the area under total winter vegetables in Bangladesh and its yield was 6.98 t/ha in the country during the year 2005-06 (BBS, 2007). Bangladesh produced 389000 thousand tons of tomato in 27530 hectares of land during the year 2016-2017 and the average yield being 14.13 t/ha (BBS, 2018) which is very low in comparison with that of other countries.

Various cultivars produce fruit that range in size from small marbles to giant grapefruits (Benton, 2008). Breeding over the past 50 years has substantially changed the tomato plant and its fruit characteristics. Varieties available today for use by both the commercial and home gardener have a wide range of plant characteristics. Cultivar selection is one of the critical decisions that the commercial grower must make each season. Variety selection is a dynamic process. Some varieties may remain favorable for many years while others might be supplanted by newer cultivars after a few seasons (McAvoy and Ozores-Hampton, 2010). By this time BARI released a good number of varieties.

Adequate supply of nutrient can increase the yield, fruit quality, fruit size, keeping quality, colour, and taste of tomato (Shukla and Naik, 1993). Micronutrients deficiencies are major limiting factors for crop production in Bangladesh (Ahmed *et al.*, 2007). Among the micronutrients, boron play an important role in improving the yield and quality of tomato in addition to checking various diseases and physiological disorders (Magalhaes *et al.*, 1980).

Boron is an essential micronutrient for normal growth of higher plants, when it absorbed in excess amounts, it can be toxic and induce a number of deleterious effects. Tomato is one of the crops which respond well to boron application. Demoranville and Deubert (1987) reported that fruit shape, yield, and shelf life of tomato were affected by boron deficiency.

Bubarai (2017) reviewed that boron (B) is an essential nutrient for normal growth of plants, and B availability in soil is an important determinant of agricultural production. To date, the function of B is undoubtedly its structural role in the cell wall; however, there is increasing evidence for a possible role of B in other processes such as the maintenance of plasma membrane function and several metabolic pathways. The aim of this review is to provide an update on recent findings related to these topics, which can contribute to a better understanding of the role of B in plants.

Boron is one of the micronutrient; the primary function of B is in plant cell wall structural integrity. Under B deficiency, normal cell wall expansion is disrupted (Havlin *et al*., 2006). Boron is needed by the crop plants for cell division, nucleic acid synthesis, uptake of calcium and transport of carbohydrates (Bose and Tripathi, 1996). Boron also plays an important role in flowering and fruit formation (Nonnecke, 1989). Boron deficiency affects the growing points of roots and youngest leaves. The leaves become wrinkled and curled with light green colour. Its deficiency affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins (Stanley *et al*., 1995). In spite of the obvious importance of boron, the mechanisms of boron tolerance and toxicity in plants are poorly understood (Cervilla *et al*., 2007 and Esim *et al*., 2012). Kaya *et al*. (2009) showed that high B reduced dry matter of tomato plants compared to control. Cervilla *et al*.

(2008) found that, born toxicity significantly decreased soluble proteins in tomato plants.

Therefore, it is important to evaluate the effect of foliar application of boron on growth, yield and nutrients content of tomato. However, the present study was undertaken with the following objectives:

1. To evaluate the effect of foliar application of boron on growth and yield of tomato
2. To determine nutrients content of tomato and
3. To find out best foliar dose of boron in tomato cultivation

# CHAPTER II

# REVIEW OF LITERATURE

Tomato is one of the most important vegetable crops grown under field and greenhouse condition, which received much attention of the researchers throughout the world. The response of tomato to different varieties and boron levels for its successful cultivation has been investigated by numerous investigators in various parts of the world. In Bangladesh, there have not enough studies on the influence of either variety or boron application or both in combination on the growth and yield of tomato. However, the available research findings in this connection over the world have been reviewed in this chapter under the following headings.

## 2.1 Effect of variety

Devkota (2018) conducted an experiment to evaluate hybrid genotypes of tomato for fruit yield and fruit quality in Horticulture Research Division, NARC, Khumaltar, Lalitpur, Nepal during March to August, 2014 in open field condition. Eleven hybrid genotypes developed from the crosses between HRA and HRD lines, selected as good performer under late blight condition and ‘Srijana’as a local check were taken for the evaluation. Design of experiment was single factorial RCBD with three replications. Observation on traits related to plant morphology, maturity and yield component were recorded to develop, evaluate, identify and recommend high yielding hybrids of tomato. The fruit yield per hectare ranged from 80.83 t/ha (HRA 14 × HRD 7) to 45.89 ton/ha (HRA 15 × HRD 6). Fruit yields of the genotypes HRA 14 × HRD 7, HRA 13 × HRD 7, HRA 20 × HRD 1, HRA 20 × HRD 2, HRA 20 × HRD 6 and HRA 16 × HRD 1 had 80.83 ton/ha, 78.50 ton/ha, 73.75 ton/ha, 70.44 ton/ha, 68.72 ton/ha, 64.64 ton/ha were higher than the yield of ‘Srijana’ (62.33 ton/ha). Based on overall performance, genotypes HRA 14 × HRD 7, HRA 13 × HRD 7, HRA 20 × HRD 1 and HRA 20 × HRD 6 were observed as good performer than Srijana (Check) and selected as high yielder with good fruit quality.

Mehraj *et al*. (2014) conducted an experiment at Horticultural farm of Sher-e-Bangla Agricultural University, Bangladesh for performance evaluation of twenty tomato cultivar coded from V1-V20 cultivated in summer. Maximum plant height (116 cm) and number of leaves (147) were found from cultivar Mini Anindyo Red (V8) and Hybrid Tomato US440 (V18) respectively. Maximum chlorophyll content, days to flower bud appearance and days to flowering were observed from cultivar BARI Tomato 6 (V19). Maximum number of flower bud/bunch (6.0) and fruit/bunch (1.2) were observed from cultivar BARI Tomato 11(V20) and Aran Chan Mini (V12) respectively. Maximum number of branch/plant (5.7), number of bunch/plant (15.3), number of flower bud/plant (129.7), number of flower/plant (108.3), number of flower/bunch (6.7), number of fruit/plant (6.7), fruit length (22.8 cm), fruit diameter (61.3 mm), fruit weight (100 gm), yield/plant (667.1 gm), yield/plot (6.7 kg) and calculated yield/ha (22.3) were found from cultivar Mini Chika (V10). Thus, cultivar Mini Chika (V10) was found to be suitable for cultivation in summer.

Biswas *et al*. (2015) conducted an experiment at Agronomy Farm of the Sher-e-Bangla Agricultural University, Dhaka to study growth and yield responses of tomato varieties. Experiment consisted of four varieties, viz. BARI Tomato-4 (V1), BARI Tomato-5 (V2), BARI Tomato-7 (V3) and BARI Tomato-9 (V4) using Randomized Complete Block Design with three replications. Tallest plant (101.3 cm), maximum number of leaves (114.1/plant) and maximum number of branches (10.0/plant) was found from BARI Tomato-7. While maximum number of flowers (6.1/cluster), number of fruits (5.0/cluster), number of clusters (17.9/plant) were found from BARI Tomato-9. However, maximum fruit diameter (20.1 cm), individual fruit weight (115.9 g) and yield (34.7 kg/plot and 95.9 t/ha) were also found from BARI Tomato-7. Virus infestation, fruit length and Total soluble solid (TSS) were statistically identical among the varieties.

Dunsin (2016) conducted a study to evaluate the performance of five different varieties of tomatoes under controlled environment (screen house). The results revealed that the Nemoneta variety, performed better compared to other varieties in terms of plant height (8.3cm) and also have the highest shelf life of 14 days followed by Delicious with 7 days, while the number of fruits per plant was highest in Small Cherry with an average of 8.733/plant, but Delicious variety gave the highest values in terms of marketable fruit weight (9.33kg) and highest pH values (4.07). In terms of fruit quality, Large Cherry variety contains the highest values for lycopene (1467.30mg/100g), vitamin A & B (56.7mg/100g & 0.62 mg/100g, respectively) and potassium (0.62%).

Benti and Degefa (2017) conducted a field experiment to evaluate tomato varieties under irrigation water and recommend high fruit yielding variety to the area. The results revealed that there was significant ($P \leq 0.05$) differences among varieties for plant height, days to flowering, fruits per cluster, clusters per plant, average fruit weight and fruit yield per hectare, except primary branches per plant. 'Melkashola' and 'Bishola' out yielded among the varieties; 30.86 t ha-1 and 26.96 t $ha^{-1}$, respectively over the two years. 'Melkashola' and 'Bishola' 'Melkashola' and 'Bishola' advanced fruit yield per hectare by about 40% and 35% over the 'Babile local', respectively. However, farmers preferred 'Melkashola' due to its fruit size and shape over 'Bishola' which is extreme in fruit size and was susceptible to sun scald. Therefore, 'Melkashola' was recommended to the area for its high fruit yield per hectare under irrigation during offseason cropping.

Isah and Amans (2014) conducted a field experiments in 2010-2011 and 2011-2012 dry seasons at the Research farm of the Institute for Agricultural Research, Samaru northern guinea savanna agro ecological zone of Nigeria to study growth rate and yield of tomato under green manure and NPK fertilizer rates. Treatment consisted of two tomato varieties (Roma VF and UC82B), four rates of NPK 15-15-15 fertilizer (0, 150, 300, and 450$kgha^{-1}$), and three rates of green manure (0, 5, and 10 t $ha^{-1}$), laid in a split-plot design with three replications. The variety and fertilizer constituted the main plot while green manure was allocated in subplot. Both varieties responded linearly in growth stages of 5 and 7 weeks after transplanting (WAT) on plant height, relative growth rate, and crop growth rate (CGR). However, UC82B proves superior over Roma VF on growth indices CGR at 5–7 WAT, net assimilation rate (NAR) at 7–9 WAT, and total fruit yield with 10.6% higher. Application of NPK fertilizer significantly increased growth such as plant height, crop dry weight, crop growth rate, and yield. Application between 250 and 280 kg $ha^{-1}$ NPK fertilizers was found efficient for total fruit yield.

Sidhu and Nandwani (2017) conducted a field research trials from April to October in 2015 and 2016 growing seasons at the Tennessee State University organic farm. Differences occurred in number of marketable fruit, fruit weight and total soluble solids. ‘Arbason F1’ (28.67 Mt·$ha^{-1}$), ‘Gold Nugget’ (26.08 Mt· ha-1), ‘Roma’ (25.65 Mt·$ha^{-1}$) were the high yielding and ‘Pink Bumblebee’ (2.61 Mt·$ha^{-1}$), ‘Hillbilly’ (3.10 Mt·$ha^{-1}$), ‘Cherokee Green’ (5.99 Mt·$ha^{-1}$) had the lowest marketable yield. ‘Mountain Prince’ (57.68%), ‘Pink Brandywine’ (52.32%) and ‘Black Prince’ (44.74%) had the most culls and ‘Pink Bumblebee’ (1.80%), ‘Rutgers VF’ (4.98%), and ‘Hillbilly’ (5.02%) had the fewest cull fruit. ‘Bing Cheery’ and ‘Cheery Sweetie’ ranked highest in taste among cherry types. All twenty six cultivars did set fruits during the growing seasons in local climatic conditions. Results suggest that ‘German Johnson’ and ‘Pink Brandywine’ (beefsteak type), ‘Gold Nugget’, (cherry type), and ‘Roma’, (plum type) were top performers in higher yields and brix.

Parmar and Thakur (2018) conducted an experiment to study the performance of different tomato cultivars under organic regimes, at the experimental farm of the Himachal Pradesh Agricultural University, Hill Agricultural Research and Extension Centre, Kullu, India. Among different cultivars, Sioux variety took maximum days (74) from transplanting to first harvest and Heem Sohna hybrid took minimum time of 67.2 days. The maximum plant height was observed in hybrid RK 123 (100.6 cm) followed by Best of all (100.3 cm). The minimum height was recorded for Sioux (83.9 cm). The Red gold hybrid recorded significantly highest number of fruits per plant (25.9) followed by RK 123 (20.0). The Red Gold hybrid had greater fruit size (29.0 $cm^2$) followed by RK 123 (26.4 $cm^2$), Heem Sohna (24.6 $cm^2$), Palam Pink (23.3 $cm^2$) and Mar Globe (22.9 $cm^2$), whereas the fruit size of Best of All (18.8 $cm^2$) and Naveen 2000 (19.2 $cm^2$) was minimum. Some of the entries of tomato namely RK 123, Manisha, Best of all Yash, Naveen 2000, Red Gold hybrid recorded highest but similar TSS content as compared to rest of the hybrids/varieties. All hybrids had highest but statistically similar acidity ranging from 0.54-0.58 g/100 ml of juice but varieties recorded significantly lower value of acidity (0.41-0.46 g/100 ml of juice). The ascorbic acid contents within hybrids and varieties were identical, though hybrids recorded higher ascorbic acid values (18.53-22.08 g/100 ml of juice) than varieties (11.53- 14.52 g/100ml of juice). The hybrids contained lower carotene and lycopene as compared to varieties. The hybrid Manisha recorded minimum carotene and lycopene content (5.25 mg/100 g of fruit and 3.90 mg/100 g of fruit) and highest was in Best of a variety (9.51 mg/100 g and 6.38 mg/100 g of fruit). Red Gold hybrid produced maximum tomato fruits (143.7 q/ha) and minimum fruit yield was recorded for Best of all (33.7 q/ha) and Marglobe (34.7 q/ha). Significantly higher profit and B: C was observed in case of Red Gold hybrid (rupees 259685/ha and 1.37) followed by RK 123 (rupees 186497/ha and 0.99), however, rest of the entries were found to be non-profitable.

Kena (2018) conducted a field experiment at Meti and Kombolcha sub sites of Kellem Wollega, and Inango of West Wollega zones in Western Ethiopia, during the 2016/2017 and 2017/2018 cropping season under supplementary irrigation. A total of 11 tomato varieties collected from Melkasa Agricultural Research Center (MARC) of the Ethiopian Institute of Agricultural Research (EIAR) and one local check variety were used as planting materials. The combined analysis of variance (ANOVA) for fruit yield and other agronomic traits of 12 tomato varieties grown at five locations in 2016/2017 and 2017/2018 revealed significant varietal difference for all considered traits except for unmarketable yield and number of branches per plant. In the present experiment, Melka shola, Melka salsa, Fetene and Miya varieties were found superior in terms of economic yield (marketable yield) and other parameters and thus they are recommended for popularization and wider production in test locations and similar agro-ecologies in the Western Oromia in particular and tomato producing regions of Ethiopia under supplementary irrigation in general.

Ali (2014) carried out a study and thirteen local and exotic hybrid tomato varieties viz. BARI $F_1$ Tomato-4, BARI $F_1$ Tomato-5, BARI $F_1$ Tomato-6, BARI $F_1$ Tomato-7, BARI $F_1$ Tomato-8, Lali, Abhilash, Nayak, Moon, Delta, Mintoo super, Mintoo, and Sucsess were evaluated to see their performances during the winter season of 2012-2013. All the characters showed significant differences among the varieties. The variety Nayak required maximum days for 50% flowering (77.00) while BARI $F_1$ tomato-4 and 8 required minimum days for 50% flowering (60.00). The highest plant height was found in Success variety (134.3cm) and the lowest was found in BARI F1 Tomato-7 (103.3). The maximum number of fruits/cluster (5.83) was recorded from BARI $F_1$ tomato-8 while minimum was recorded from Mintoo Super (4.40). BARI F1 tomato-4 variety produced the maximum number and weight of fruits/plant (87.6 and 2.30 kg) whereas BARI $F_1$ tomato-6 and Delta produced minimum number and weight of fruits per plant (49.33 and 1.62 kg). The average fruit weight was maximum in BARI $F_1$ tomato-5 (52.73 g) and minimum in Abhilash (41.97 g). The maximum fruit length and diameter (5.14 cm and 5.41 cm) were obtained from BARI tomato-7 and 5 whereas minimum fruit length and diameter (3.77 cm and 4.22 cm) were obtained from BARI F1 tomato-4 and Mintoo. The variety Nayak showed maximum thickness of pericarp (0.52cm) and BARI $F_1$ tomato-8 showed minimum thickness of pericarp

(0.34cm). The TSS percentage was found maximum (5.00) in BARI $F_1$ tomato-8 and Mintoo while minimum TSS percentage (4.00) was found in BARI $F_1$ tomato-8 and Mintoo Super. The shelf life of the fruits were maximum in Delta (18.00 days) and minimum in Abhilash (5.00 days). The variety Nayak required maximum days to 1st harvest (154.0) and BARI $F_1$ tomato-4 and 8 required minimum days to 1st harvest (138.0). Yellow leaf curl virus was found maximum in the variety Lali (10.41%) and minimum (2.08%) in BARI $F_1$ tomato-5 and Mintoo. No virus infected plants were found in the rest varieties. The yield ranged from 64.92 to 93.21 t/ha. The maximum yield (93.21t/ha) was obtained from BARI $F_1$ tomato-4 while minimum yield was obtained from Delta (64.92 t/ha). Considering the results it can be concluded that most of the local varieties showed better performance compared to the exotic varieties.

### 2.2 Effect of boron

Sturiao *et al*. (2020) found that boron deficiency is very harmful in tomato (*Solanum lycopersicum* L.) cultivation. Boron foliar sprays can be used as a mean of preventing plant stunting, that results in low growth, poor onset of flowers and fruits, fruit physiological disorders, and hence, low tomato productivity. Boron sources and polyol like surfactants can affect foliar sprays' effectiveness. This work had the objective of evaluating foliar sprays of boric acid, borax and B-ethanolamine, with or without, polyol surfactant. The experiment was carried out in a 3×2+2 factorial arranged in randomized blocks with four replications. Plants of tomato cultivar 'Tangerine' $F_1$ were fed with complete nutrient solution containing 5 μmol $L^{-1}$ of B. These plants were sprayed with the three sources of boron, with or without a polyol like surfactant at 14 days intervals until the production cycle was complete. The additional treatments were: a positive control ($C^+$), in which the plants received 20 μmol $L^{-1}$ B, and a negative control ($C^-$), in which the plants received 5 μmol $L^{-1}$ B via nutrient solution, both without supply of B via foliar sprays. They evaluated plant height, root volume, number of flowers and fruits; dry matter production;

nutrient contents and accumulation, in four phenological stages, and fresh and dry matter of fruits at the harvest. The data obtained were subjected to analysis of variance and the treatments compared by mean test. Leaf sprays improved the tomato growth and production compared to the ($C^-$) treatment, but the adequate B supply by roots ($C^+$) was the most efficient method for nutrition of tomato plants with boron. Among the boron sources, B-ethanolamine and boric acid were those which promoted the best results in tomato production, compared to the foliar application of borax. The use of the polyol like surfactant did not result in significant improvements on growth and production of the tomato plants.

Roy and Monir (2020) conducted an experiment 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 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 study suggested cultivating BARI Tomato-15, but other two exotic lines adapted well and showed good performance in terms of yield and quality parameters.

Sanjida *et al*. (2020) conducted a study to investigate the effects of varieties and boron (B) levels on growth and yield of summer tomato (*Lycopersicon* *escuientum* Mill.) during the period from May, 2018 to September, 2018. Fifteen treatments were comprising (i) three summer tomato varieties (BARI hybrid tomato 4, 8 and 10) and (ii) five levels of boron as boric acid (0,1,2, 3 and 5 kg B $ha^{-1}$) in all combinations. Randomized complete block design with three replications was used in the earthen pot (0.79 $ft^3$) experimentation. The effects of varieties and boron levels showed significant variations ($p < 0.05$) on growth and yield of summer tomato at different days after transplanting. Among the varieties at final count $plant^{-1}$, delayed flowering (32.6 days), the highest plant height (93.8 cm), number of leaves (99.93), number of branches (26.27), number of flower clusters (18.53), number of flowers (82.73), number of fruits (51.87), longest fruit length (41.87 mm) and maximum fruit width (48.0 mm), weight of individual fruit (55.71 g) and total weight of fruits (2892.88 g) were observed in BARI hybrid tomato 8. In contrast, the lowest plant height (87.3 cm), number of leaves (86.47), number of branches (24.06), number of flower clusters (15.87), number of flowers (66.07), number of fruits (37.33), weight of individual fruit (43.60 g) and total weight of fruits (1630.57g) were found in BARI hybrid tomato 4; and early flowering (31.93 days), shortest fruit length (33.07 mm) and maximum fruit width (34.60 mm) were noticed in BARI hybrid tomato 10. Among the boron levels at final count $plant^{-1}$, early flowering (29.67 days), the maximum number of flower clusters (18.44), number of flowers (89.11), number of fruits (46.22) and total weight of fruits (2364.29 g) were recorded in 2 kg B $ha^{-1}$ treatment; the maximum plant height (96.50 cm), number of leaves (102.89), number of branches (28.11), longest fruit length (42.89 mm) and maximum fruit width (46.78 mm) and weight of individual fruit (51.74 g) were obtained in 3 kg B $ha^{-1}$ treatment. Conversely, delayed flowering (34.67 days), minimum plant height (83.50 cm), number of leaves (87.56), number of branches (21.78), number of flower clusters (15.89), number of flowers (63.56), number of fruits (40.33), shortest fruit length (31.78 mm) and minimum fruit width (34.67 mm), weight of individual fruit (47.47 g) and total weight of fruits (1936.00 g) were recorded in control (0 kg B $ha^{-1}$) treatment. Our results suggest that the inclusion of B (2-3 kg $ha^{-1}$) with the current fertilization practice will enhance the growth and yield of summer tomato grown at AEZ (agro-ecological zone) 13 while BARI hybrid tomato 8 could be recommended as one of the promising varieties.

Osman (2019) conducted an experiment to investigate the effect of boron and zinc on the growth and yield of tomato. Three levels of boron (viz., 0, 1 and 2kg $H_3BO_3$ $ha^{-1}$) and zinc (viz., 0, 1 and 2kg $ZnSO_4$ $ha^{-1}$) were applied for each experiment. Results revealed that boron had significant effect on all yield attributes and yield of tomato. Application of 2kg $H_3BO_3$/ha produced the highest tomato yield (79.2 ton $ha^{-1}$) through increasing plant height, number of leaves per plant, number of branches per plant, number of flower clusters per plant, number fruits per plant, weight of fruits per plant, fruit weight, individual fruit length, fruit diameter and yield $ha^{-1}$ of fruits. On the other hand, maximum yield of tomato was obtained from 2kg $ZnSO_4$ $ha^{-1}$. A combination of 2kg $H_3B0_3$ and 2kg $ZnS0_4$ $ha^{-1}$ gave the highest yield of Tomato (83.50 ton $ha^{-1}$). So, application of 2kg $H_3B0_3$ along with 2kg $ZnSO_4$ $ha^{-1}$ was the best for growth and yield of tomato.

Application of boron to tomato was found to be significant on most of the parameters observed as reported by many researchers (Jyolsna and Usher, 2008; Dipti *et al., 2008* and Kumuthini, 2015)

Gazala *et al.* (2016) carried out an experiment on boron its importance in crop production status in Indian soils and crop responses to its application and summarizes their result by saying that “application of boron at different rates in different crop have shown a positive influence on yield and other agronomic parameters of different crops reflecting the significant of boron in enhancing the yield of different crops”.

Naz *et al.* (2012) conducted an experiment to study the effect of Boron (B) on the growth and yield of Rio Grande and Rio Figue cultivar of tomato. Different doses of B (0, 0.5, 1.0, 2.0, 3.0 and 5.0kg $ha^{-1}$) with constant doses of nitrogen, phosphorus and potash was incorporated at the rate of 150, 100, 60 kg $ha^{-1}$. The outcome of the experiment was positive with Rio Grande cultivar of tomato showing significant respond on all parameters. They concluded that 2 kg B $ha^{-1}$ significantly affected flowering and fruiting of Rio Grande cultivar.

Maria and Ladislav (2014) performed an experiment at the Research - Breeding Station - Pstrusa to investigate the effect of increasing doses of boron on oil production of oilseed rape. Doses of nitrogen and sulfur (183 kg N.$ha^{-1}$, 46.5 kg S.$ha^{-1}$) and different doses of boron (200 g B $ha^{-1}$, 400 g B $ha^{-1}$, 800 g B $ha^{-1}$) were applied. The result shows that the boron nutrition positively influences the oil content in seeds of oilseed rape *(Brassica napusL.).*

Moura *et al.* (2013) conducted an experiment with the objective to evaluate the effect of boron on the nutritional status of the cocoanut palm trees and its productivity when artificially applied to the culture soil. The treatments consisted of five levels of boron dosages: zero, 1, 2, 4, and 6 kg $ha^{-1}$. Boron (borax) dosages were applied in equal halves directly into the soil. The outcome of the research shows that ninety five percent of palm trees maximum production was obtained with the use of boron dosage at 2.1kg $ha^{-1}$.

Syed *et al.* (2012) carried out an experiment to investigate the effect of different levels of boron (0.5, 1.0, 1.5 and 2.0 kg $ha^{-1}$) on growth, yield and ionic concentration of rice directly sown on raised beds under saline sodic soils. The crop was harvested at maturity. Data on tillering, plant height, spike length, number of grains $spike^{-1}$, 1000-grain weight, straw and paddy yields were recorded. Na, K, Ca and B concentration in grain and straw were estimated. The result obtained was significant; it shows that B concentration in grain increased with boron application. Positive correlation was found between B contents in grain and paddy grain yield.

Hellal *et al.* (2009) investigated the application of nitrogen and boron rates on root yield and nutrient contents of sugar beet *(Beta vulgaris* L.) *cv.* pamela grown in calcareous soil conditions. The obtained results showed that increasing N level up to 80 mg N $kg^{-1}$ significantly increased root and shoot yield and P, K and Fe. Application of 50 ppm Boron significantly improved the parameters of the yield of roots and above ground growth and nutrient contents and balance ratio of sugar beet. The combined application of N-B treatments at the rate of 100 mg N kg-1 + 50 ppm B gave the maximum shoot and root yield and nutrient balance whereas increasing the B application until 100 ppm appeared to have a toxic effect on plant growth. The results concluded that B found also to interact positively with nitrogen to affect yield components of sugar beet. The interaction from the applied N and B increased N, K and Fe distribution between root and shoot. The yield of sugar beet was highly and positively correlated with N, K and B content in root and shoot.

Hossain *et al.* (2011) carried out a research to find out the optimum rate of B application for maximizing nutrient uptake and yield of mustard in calcareous soil, boron was applied at 0, 1, and 2 kg/ha. Effect of B was evaluated in terms of yield and mineral nutrients (N, P, K, S, Zn, and B) uptake. The mustard crop responded significantly to B application. Boron and N concentrations of grain and stover were significantly increased with increased rate of B application indicating that B had positive role on protein synthesis. In case of P, S, and Zn, the concentrations were significantly increased but in case of K, it remained unchanged in stover. The grain B concentration increased from 19.96 pg/g in B control to 45.99 pg/g and 51.29 pg/g due to application of 1 kg and 2 kg B/ha, respectively. Concerning the effect of B on the nutrient uptake, six elements followed the order K> N> S> P> B> Zn and these were significantly influenced by B application.

Soomro *et al*. (2011) conducted a field experiment to compare the effect of foliar and soil applied boron on the different growth stages and fodder yield of maize (Zea *mays* L.) variety Akbar. Experimental results revealed that the foliar application of 0.5% boron as a boric acid at early, mid and late whorl stages resulted in significant increase in all parameters recorded. Soil and applied boron at 2 kg $ha^{-1}$ did not remain effective for growth and yield of maize crop as compared to foliarly applied boron. There was significant effect of boron on its concentration in straw and its uptake when applied on foliage. It can be concluded from the study that application of B (0.5%) as foliar spray at early, mid and late whorl stage along with recommended dose of NPK fertilizers may be considered for getting higher fodder yield of maize.

Riaz and Muhammad (2011) conducted an experiment to evaluate the response of wheat, rice and cotton to B application. Boron was applied at 1 kg $ha^{-1}$ as Borax decahydrate (11.3% B) at different times along with recommended doses of N, P and K. The results revealed that B application at sowing time to wheat increased significantly the number of tillers plant (15%), number of grains spike (11%), 1000-grain weight (7%) and grain yield (10%) over control. Among the treatments, B application at sowing time showed best results followed by B application at 1st irrigation and at booting stage. In rice (coarse), B application before transplanting substantially increased number of tillers $hill^{-1}$ (21%), plant height (3%), panicle length (10%), and number of paddy grains $panicle^{-1}$ (17%), 1000-grain weight (11%) and paddy yield (31%) over control. Response of fine rice to the B application was similar for all yield parameters as in coarse rice. In cotton, B application considerably increased plant height (3%), number of mature bolls $plant^{-1}$ (12%), seed weight $boll^{-1}$ (8%) and seed cotton yield (9%) over control..

In a trial conducted by Mubshar *et al.* (2012) they reported that application of boron at different stages in rice field significantly improved the growth and yield of the crop. They recommended soil application of boron to rice field for maximum yield production

Yadav *et al.* (2006) evaluated the effects of boron (0.0, 0.10, 0.15, 0.20, 0.25, 0.30 or 0.35%), applied to foliage after transplanting, on the yield of tomato cv. DVRT-1 in Allahabad, Uttar Pradesh, India, during 2003-04. The highest number of fruits per plant (44.0), number of fruits per plot (704.0), yield per plant (0.79 kg), yield per plot (12.78 kg) and yield/ha (319.50 quintal) were obtained with 0.20% boron, whereas the greatest fruit weight (27.27 g) was recorded for 0.10% boron.

Bhatt and Srivastava (2005) investigated the effects of the foliar application of boron (boric acid), zinc (zinc sulfate), molybdenum (ammonium molybdate), copper (copper sulfate), iron (ferrous sulfate), manganese (manganese sulfate), mixture of these nutrients, and Multiplex (a commercial micronutrient formulation) on the nutrient uptake and yield of tomato (Pusa hybrid-1) in Pantnagar, Uttaranchal, India, during the summer of 2002 and 2003. Zinc, iron, copper, boron and manganese were applied at 1000 ppm each, whereas molybdenum was applied at 50 ppm. Foliar spraying was conducted at 40, 50 and 60 days after transplanting. All treatments significantly enhanced dry matter yield, fruit yield and nutrient uptake over the control. The mixture of the micronutrients was superior in terms of dry matter yield of shoot (53.25 g/ha); dry matter content of shoot (27.25%); nitrogen (152.38 kg/ha), phosphorus (47.49 kg/ha), potassium (157.48 kg/ha), sulfur (64.87 kg/ha), zinc (123.70 g/ha), iron (940.36 g/ha), copper (72.70 g/ha), manganese (359.17 g/ha) and boron (206.58 g/ha) uptake by shoots; total fruit yield (266.60 kg/ha); dry matter yield of fruit (16.98 kg/ha); and nitrogen (78.78 kg/ha), phosphorus (8.51 kg/ha), potassium (34.31 kg/ha), sulfur (16.14 kg/ha), iron (141.81 g/ha), copper (23.13 g/ha), zinc (63.06 g/ha), manganese (34.08 g/ha) and boron (95.23 g/ha) uptake by fruits.

Shoba *et al.* (2005) conducted a field experiment in Tamil Nadu, India, during the 2002 rabi season, to investigate the effects of calcium (Ca) and boron (B) fertilizer and ethrel [ethephon] applications and 45x45 and 65x45 spacings against fruit cracking in the tomato genotypes LCR 1 and LCR 1 x H 24. Between the 2 genotypes, the fruit cracking percentage was low in LCR 1 x H 24. Among the 2 spacings, closer spacing showed less fruit cracking and among the different nutrient treatments, the spraying of B with Ca was effective in controlling fruit cracking.

Oyinlola (2004) conducted a field trial in the Sudan savanna ecological zone in Nigeria to identify the effects of 0, 1, 2, 3, 4, and 5 kg B/ha on the growth, dry matter yield and nutrient concentration of tomato cultivars Roma VF and Dandino. Application of boron significantly ($P<0.05$) increased the number of leaves and dry matter yield of the crop. Nutrient concentrations of potassium and phosphorus in the plant tissue fell within the deficiency range established for tomato plants, while calcium, magnesium, boron, zinc, manganese and copper concentrations fell within and iron concentrations above the sufficient nutrient range. Significant correlation existed between growth, yield parameters and nutrient concentrations and also among the nutrient concentrations. Plants supplied with 2 kg B/ha recorded the highest number of leaves and dry matter yield in both years. Cultivar Dandino recorded higher number of leaves and dry matter yield than cv. Roma VF.

Oyinlola and Chude (2004) studied the effects of 0, 1, 2, 3, 4 and 5 kg B/ha on the yield and biochemical properties of tomato cultivars Roma VF and Dandino. Matured ripe fruits were analysed for biochemical properties such as ascorbic acid, reducing sugar and total soluble solid content and titratable acidity. Boron rates significantly ($P<0.01$) increased the yield and yield attributes of the crop such as number of fruits and average weight of fruits, as well improved the biochemical properties of the fruits. In both years, the highest fruit yield and best fruit quality were obtained at 2 kg B/ha. Fruit yield increased by 121 and 72% relative to the control in 1992/93 and 1993/94, respectively. Cultivar Dandino recorded higher ascorbic acid, total soluble solids, titratable acidity, reducing sugars and yield compared to cv. Roma VF, whereas cv. Roma VF flowered earlier than Dandino. Fruit yield correlated with all the yield attributes and biochemical properties determined for both years.

Amarchandra and Verma (2003) conducted an experiment during the rabi seasons of 1998 and 1999 at Jabalpur, Madhya Pradesh, India, to evaluate the effects of boron and calcium on the growth and yield of tomato cv. Jawahar Tomato 99. Boron (1, 2, and 3 kg/ha, calcium carbonate), along with phosphorus (60 kg/ha) and potassium (40 kg/ha), were applied before transplanting, whereas nitrogen (100 kg/ha) was applied in split doses at 25 and 50 days after transplanting. Data were recorded for plant height, number of branches per plant, fruit yield and seed yield. Application of 2 kg B/ha + 2 kg Ca/ha recorded the highest yield.

Davis *et al.* (2003) carried out an experiment to compare the effects of foliar and soil applied B on plant growth, fruit yield, fruit quality, and tissue nutrient levels. Regardless of the application method, B was associated with increased tomato growth and the concentration of K, Ca, and B in plant tissue. Boron application was associated with increased N uptake by tomato in field culture, but not under hydroponic culture. In field culture, foliar- and/or soil-applied B similarly increased fresh-market tomato plant and root dry weight, uptake, and tissue concentrations of N, Ca, K, and B, and improved fruit set, total yields, marketable yields, fruit shelf life, and fruit firmness. The similar growth and yield responses of tomato to foliar and root B application suggests that B is translocated in the phloem in tomatoes. Fruits from plants receiving foliar- or root-applied B contained more B, and K than fruits from plants not receiving B, indicating that B was translocated from leaves to fruits and is an important factor in the management of K nutrition in tomato.

Naresh (2002) carried out an investigation in Nagaland, India during 1998-2000 to determine the effects of foliar application of boron (50, 100, 150, 200, 250 and 300 ppm) on the growth, yield and quality of tomato cv. Pusa Ruby. Boron improved the yield and quality of the crop. The highest yield (327.18 and 334.58 q/ha) was obtained when the plant was drenched with 250 ppm aqueous solution of boron. B also had positive effects on plant height, number of branches, flowers and number of fruit set per plant, resulting in an increase in the number of fruits per plant and total yield. At lower rates, B improved the chemical composition of tomato fruits and at higher rates increased the total soluble solids, reducing sugar and ascorbic acid contents of the fruits. Acidity of fruits showed a marked increase with increasing levels of B up to 250 ppm. However, the significant effects of B were recorded in the second year only.

Smit and Combrink (2004) observed that insufficient fruit set of tomatoes owing to poor pollination in low cost greenhouses is a problem in South Africa, as bumblebee pollinators may not be imported. Since sub-optimum boron (B) levels may also contribute to fruit set problems, this aspect was investigated. Four nutrient solutions with only B at different levels (0.02; 0.16; 0.32 and 0.64 mg $L^{-1}$) were used. Leaf analyses indicated that the uptake of Ca, Mg, Na, Zn and B increased with higher B levels. At the low B level, leaves were brittle and appeared pale-green and very high flower abscission percentages were found. At the 0.16 mg $kg^{-1}$ B-level, fruit set, fruit development, colour, total soluble solids, firmness and shelf life seemed to be close to optimum. The highest B-level had no detrimental effect on any of the yield and quality related parameters.

Ben and Shani (2003) stated that Boron is essential to growth at low concentrations and limits growth and yield when in excess. The influences of B and water supply on tomatoes *(Lycopersicon esculentum* Mill.) were investigated in lysimeters. Boron levels in irrigation water were 0.02, 0.37, and 0.74 m mol. Conditions of excess boron and of water deficits were found to decrease yield and transpiration of tomatoes. Both irrigation water quantity and boron concentration influenced water use of the plants in the same manner as they influenced yield.

Alpaslan and Gunes (2001) investigated a greenhouse study to determine interactive effects of NaCl salinity and B on the growth, sodium (Na), chloride (Cl), boron (B), potassium (K) concentrations and membrane permeability of salt- resistant tomato *(Lycopersicon esculentum* cv. Lale F1) and salt-sensitive cucumber *(Cucumis sativus* cv. Santana F1) plants. Plants were grown in a factorial combination of NaCl (0 and 30 mM for cucumber and 0 and 40 mM for tomato) and B (0, 5, 10 and 20 mg $kg^{-1}$ soil). Boron toxicity symptoms appeared at 5 mg $kg^{-1}$ B treatments in both plants. Salinity caused an increase in leaf injury due to B toxicity, but it was more severe in cucumber. Dry weights of the plants decreased with the increasing levels of applied B in nonsaline conditions, but the decrease in dry weights due to B toxicity was more pronounced in saline conditions especially in cucumber. Salinity x B interaction on the concentration of B in both plants was found significant. However, increase in B concentrations of tomato decreased under saline conditions when compared to nonsaline conditions. Contrary to this, B concentration of cucumber increased as a result of increasing levels of applied B and salinity. Salinity increased Na and Cl concentrations of both plants. Potassium concentration of tomato was not affected by salinity and B treatments, but K concentration of cucumber was decreased by salinity. Membrane permeability of the plants was increased by salinity while toxic levels of B had no effect on membrane permeability in nonsaline conditions. Membrane permeability was significantly increased in the presence of salinity by the increasing levels of applied B.

Cardozo *et al.* (2001) concluded the effects of Ca and B fertilizers on the productivity of tomato cv. Debora Max were investigated in Espirito Santo do Pinhal, Sao Paulo, Brazil from April to July 2000. Aminobor at 300 ml/100 litres gave the highest value for fruit weight, while Ca at 60 g/100 litres and B at 150 g/100 litres recorded the highest number of fruits.

Chude and Oyinlola (2001) concluded that plant responses to soil and applied boron varies widely among species and among genotypes within a species. This assertion was verified by comparing the differential responses of Roma VF and Dandino tomato cultivars to a range of boron levels in field trials at

Kadawa (11°39´N, 8°2´E) and Samara (11°12´, 7°37´ E) in Sudan and northern Guinea savanna, respectively, in Nigeria. Boron levels were 0, 0.5, 1.0, 1.50, 2.0 and 2.5 kg/ha replicated three times in a randomized complete block design. Treatment effects were evaluated on fruit yield and nutritional qualities of the two tomato cultivars at harvest. There was a highly significant (P=0.01) interaction between B rates and cultivars, with Dandino producing higher yields than Roma VF in both years and locations. Total soluble solids, titratable acidity and reducing sugar contents of the two cultivars differed significantly (P=0.05). Generally, Dandino contained higher amounts of these indexes than Roma VF. This cultivar seems to be more B efficient than Roma VF even at low external B level.

Yadav *et al.* (2001) designed a study during 1990 and 1991, in Hisar, Haryana, India, to evaluate the effect of different concentrations of zinc and boron on the vegetative growth, flowering and fruiting of tomato. The treatments comprised five levels of zinc (0, 2.5, 5.0, 7.5, and 10.0 ppm) and four levels of boron (0, 0.50, 0.75, and 1.0 ppm) as soil application, as well as 0.5% zinc and 0.3% boron as foliar application. The highest fruit length, fruit breadth and fruit number were obtained with the application of 7.5 ppm zinc and 1.0 ppm boron.

A greenhouse experiment involving 4 rates of B (0, 5, 10 and 20 mg B/kg) and 3 rates of Zn (0, 10 and 20 mg Zn/kg) was conducted by Gunes *et al.* (2000) in tomato plants (cv. Lale). B toxicity symptoms occurred at B rates of 10 and 20 mg/kg. These symptoms were lower in plants grown with applied Zn. Fresh and dry weights of the plants clearly decreased with applied B. Zn treatments partially depressed the inhibitory effect of B on growth. Increased rates of B increased the concentrations of B in plant tissues; higher concentrations were observed in the absence of applied Zn. Zn + B treatments increased the concentration of Zn in plants.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from October 2019 to March 2020 to study the effect of foliar application of boron on growth, yield and nutrient contents of tomato. The details of the materials and methods have been presented below:

## 3.1 Experimental location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´E longitude and 23°77´N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

## 3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. The details of morphological and chemical properties of initial soil of the experiment plot were presented in Appendix III.

## 3.3 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix II.

### 3.4 Test crop and its characteristics

Seeds of BARI tomato-2 and BARI tomato-16 were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur and were used as plant materials for the present study.

### 3.5 Experimental details

#### 3.5.1 Treatments of the experiment

**Factor A: Variety – two**

1. $V_1$ = BARI tomato-2
2. $V_2$ = BARI tomato-16

**Factor B: Boron doses – five**

1. $B_0$ = Control (0 kg B $ha^{-1}$)
2. $B_1$ = 0.5 kg B $ha^{-1}$
3. $B_2$ = 1.0 kg B $ha^{-1}$
4. $B_3$ = 1.5 kg B $ha^{-1}$
5. $B_4$ = 2.0 kg B $ha^{-1}$

**Treatment combinations –** Ten (2×5=10) which are as

$V_1B_0$, $V_1B_1$, $V_1B_2$, $V_1B_3$, $V_1B_4$, $V_2B_0$, $V_2B_1$, $V_2B_2$, $V_2B_3$ and $V_2B_4$.

#### 3.5.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The layout of the experiment was prepared for distributing the combinations of varieties and doses of boron (B). The 10 treatment combinations of the experiment were assigned at random into 40 plots. The size of each unit plot was 1.87 m × 1.45 m. The distance between block to block and plot to plot were 0.5 m and 0.25 m respectively. The layout of the experiment field is presented in Appendix VII.

### 3.5.3 Variety used and seed collection

BARI tomato-2 and BARI tomato-16, high yielding varieties of tomato (*Solanum lycopersicum* L.) developed by Bangladesh Agricultural Research Institute (BARI), Gazipur were used as test crop. Seeds were collected from BARI, Joydebpur, Gazipur.

## 3.6 Raising of seedlings

The land selected for nursery beds were well drained and were sandy loam type soil. The area was well prepared and converted into loose friable and dried mass to obtain fine tilth. All weeds and dead roots were removed and the soil was mixed with well rotten cowdung at the rate of 5 kg/bed. Seed bed size was 3m × 1m raised above the ground level maintaining a spacing of 50 cm between the beds. Ten (10) grams of seeds were sown in each seed bed on 20 October, 2019. After sowing, the seeds were covered with light soil. Complete germination of the seeds took place with 5 days after seed sowing. Necessary shading was made by bamboo mat (chatai) from scorching sunshine or rain. No chemical fertilizer was used in the seed bed.

## 3.7 Preparation of the main field

The plot selected for the experiment was opened in the last week of October, 2019 with a power tiller, and was exposed to the sun for a few days, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for transplanting. The land operation was completed on 14 November 2019. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

### 3.8 Fertilizers and manure application

The N, P, K, S, Zn and B nutrients were applied through urea, Triple super phosphate (TSP), Muriate of potash (MoP) Gypsum, $ZnSO_4$ and Boric acid, respectively. Boron (B) was applied as per treatment where rest of the nutrients was applied according to Krishi Projukti Hat Boi, 2016. Name and doses of nutrients were as follows:

| Plant nutrients | Manure and fertilizer | Doses $ha^{-1}$ |
|---|---|---|
| -- | Cowdung | 10 t |
| N | Urea | 220 kg |
| P | TSP | 175 kg |
| K | MoP | 200 kg |
| S | Gypsum | 10 kg |
| Zn | $ZnSO_4$ | 4 kg |
| B | Boric acid | As per treatment |

One third (1/3) of whole amount of Urea and full amount of TSP, MoP and Gypsum $ZnSO_4$ were applied at the time of final land preparation. The remaining Urea was top dressed in two equal installments- at 20 days after transplanting (DAT) and 50 DAT respectively.

### 3.9 Transplanting of seedlings

Healthy and uniform sized 25 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field on 15 November, 2019 maintaining a spacing of 60 cm × 60 cm. The seed bed was watered before uprooting the seedlings so as to minimize the damage of the roots. This operation was carried out during late hours in the evening. The seedlings were watered after transplanting. Shading was provided by piece of banana leaf sheath for three days to protect the seedlings from the direct sun. A strip of the same crop was established around the experimental field as border crop to do gap filling and to check the border effect.

### 3.10 Intercultural operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the tomato.

#### 3.10.1 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gap fillings were done by healthy plants from the border whenever it was required. Weeds of different types were controlled manually as and when necessary.

#### 3.10.2 Irrigation

Irrigation was done at three times. The first irrigation was given in the field at 25 days after transplanting (DAT) through irrigation channel. The second irrigation was given at the stage of maximum vegetative growth stage (40 DAT). The final irrigation was given at the stage of fruit formation (60 DAT).

#### 3.10.3 Plant protection

The crop was infested with cutworm, leaf hopper and others. The insects were controlled successfully by spraying Malathion 57 EC @ 2ml /L water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting. During foggy weather precautionary measures against disease infestation specially late blight of tomato was taken by spraying Dithane M-45 fortnightly @ 2 g/L.

### 3.11 Harvesting

Fruits were harvested at 5 days intervals during maturity to ripening stage. The maturity of the crop was determined on the basis of red colouring of fruits. Harvesting was started from 2 February, 2020 and completed by 18 March, 2020.

### 3.12 Data Collection and Recording

Five plants were selected randomly from each unit plot for recording data on crop parameters and the yield of grain and straw were taken plot wise. The following parameters were recorded during the study:

#### 3.12.1 Growth parameters

1. Plant height (cm)
2. Number of branches plant$^{-1}$

#### 3.12.2 Yield contributing parameters

1. Number of flower clusters plant$^{-1}$
2. Number of flowers plant$^{-1}$
3. Number of fruits cluster$^{-1}$
4. Fruit length (cm)
5. Fruit diameter (cm)

#### 3.12.3 Yield parameters

1. Number of fruits plant$^{-1}$

1. Single fruit weight (g)
2. Fruit weight plant$^{-1}$ (kg)
3. Fruit yield ha$^{-1}$ (t)

#### 3.12.4 Chemical analysis

1. N, P, K, and B content in fruit

### 3.13 Procedure of recording data

#### 3.13.1 Plant height

The height (cm) of plant was recorded in centimeter (cm) at the time of harvest. Data were recorded as the average of 5 plants of each plot. The height was measured from the ground level to the tip of the leaves.

### 3.13.2 Number of branches plant$^{-1}$

The total number of branches was counted from 5 plants of each plot. The average branches number was calculated which is termed as number of branches plant$^{-1}$.

### 3.13.3 Number of flower clusters plant$^{-1}$

The number of flower clusters was counted from 5 plants of each plot and the average number of clusters produced per plant was calculated.

### 3.13.4 Number of flowers plant$^{-1}$

Total number of flowers was recorded from the five sample plants, and the average number of flowers plant$^{-1}$ was calculated by the following procedure

$$\text{Number of flowers plant}^{-1} = \frac{\text{Total number of flowers}}{\text{Number of plants}}$$

### 3.13.5 Number of fruits cluster$^{-1}$

The number of fruits and clusters from first harvest to last harvest was recorded from the five plants, and the average number of fruits cluster$^{-1}$ was recorded by the following calculation

$$\text{Number of fruits cluster}^{-1} = \frac{\text{Total number of fruits from 5 plants}}{\text{Total number of clusters from 5 plants}}$$

### 3.13.6 Fruit length

The length (cm) of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 10 selected marketable fruits from each plot and their average was calculated in centimeter.

### 3.13.7 Fruit diameter (cm)

Diameter of fruit (cm) was measured at the middle portion of 10 selected marketable fruits from each plot with a slide calipers and their average was calculated in centimeter.

### 3.13.8 Number of fruits plant$^{-1}$

The total number of fruits was counted at first harvest to last harvest from 5 plants of each plot and then averaged to obtain number of fruits plant$^{-1}$.

### 3.13.9 Number of fruits plot$^{-1}$

Number of fruits was recorded at each harvest from 5 plants of each plot. Totaling of fruit was calculated till final harvest and expressed as number of fruits plot$^{-1}$.

### 3.13.10 Single fruit weight

Randomly 10 fruits were selected from sample plants regarding each treatment and then average single fruit weight (g) was calculated by the following formula:

$$\text{Single fruit weight (g)} = \frac{\text{Weight of randomly selected ten fruits (g)}}{\text{Number of sample fruits}}$$

### 3.13.11 Fruit weight plant$^{-1}$

At first the total weight (kg) of fruit was taken from the 5 selected plants harvested at different dates using an electric balance and then weight plant$^{-1}$ (kg) was calculated by following formula:

$$\text{Yield plant}^{-1}\text{ (kg)} = \frac{\text{Total weight of fruits from selected 5 plants (kg)}}{\text{Number of sample plants}}$$

### 3.13.12 Fruit yield $ha^{-1}$

After collection of per plot yield, it was converted to ton per hectare by the following formula:

$$\text{Fruit yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg)} \times 10000\ m^2}{\text{Plot size } (m^2) \times 1\,000\ \text{kg}}$$

### 3.15.10 Analysis of different chemical constituents of tomato fruits

Chemical analysis was done in the Agro-Environmental Chemistry Laboratory following the procedure of nutrient content measurement in fruit regarding nitrogen (N), phosphorus (P), potassium (K) and boron (B).

### 3.15.10.1 Determination of nitrogen (%)

Oven dried of plant samples were grined in a Mill passed through 40 mesh screen, mixed well and stored in plastic vials.

For the determination of N an amount of 1 g oven dry grined sample were taken in a micro Kjeldahl flask. One gram catalyst mixture ($K_2SO_4$; $CuSO_4.5H_2O$ in the ratio of 100:10:1) and 10 mL conc. $H_2SO_4$ were added. The flasks were heated at 160°C and added 2 mL $H_2O_2$ than heating was continued at 360°C until digests become clear and colorless.

After cooling the content was taken into a 100 mL volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner.

Nitrogen in the digest was estimated by distilling with 10N NaOH followed by titration of the distillate trapped in $H_3BO_3$ indicator solution with 0.01N $H_2SO_4$.

The amount of nitrogen was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100/S$$

Where,

$T$ = Sample titration (mL) value of standard $H_2SO_4$

$B$ = Blank titration (mL) value of standard $H_2SO_4$

$N$ = Strength of $H_2SO_4$

$S$ = Sample weight (g)

### 3.15.10.2 Determination of phosphorus and potassium (%)

Oven dried of plant samples were grined in a Mill passed through 40 mesh screen, mixed well and stored in plastic vials.

Exactly 1 g of grined fruit sample was taken in a 250 mL conical flask. 20 mL Di-acid mixture was added (previously prepared by adding 60% $HNO_3$ and $HClO_4$ in 2:1 ration through wet oxidation method) to the fruit sample.

Flask was stirred to moisten the entire mass of tissue and was placed on an electric hot plate. The content was heated at 180-200°C until white fume was evolved. 5 mL Di-acid mixture was added to the flask if the contents become dry before the end of the digestion. The flask was removed from the hot plant and was allowed to cool. Than 20-30 mL distilled water was added and shaken and after that the solution was filtered with Whatman Filter Paper No.1 in 100 mL volumetric flask. The conical flask was washed several times to ensure that all the minerals are transferred to the volumetric flask. The volume was made upto the mark with distilled water.

The contents of phosphorus (P) was measured by Spectophotometer HALO DB-20S at 660 nm and potassium (K) was measured by flame photometer JENWAY PFP7.

### 3.15.10.3 Determination of boron (ppm)

Oven dried of plant samples were grined in a Mill passed through 40 mesh screen, mixed well and stored in plastic vials.

Exactly 0.5 g of grined fruit sample was taken in a 250 mL conical flask. 5 mL Di-acid mixture was added (previously prepared by adding $HNO_3$ and $HClO_4$ in 5:1 ration through wet oxidation method) to the fruit sample. Flask was stirred to moisten the entire mass of tissue and was placed on an electric hot plate.

The content was heated at 150-200°C for 2-2.5 hours and was cooled. The solution was filtered with Whatman Filter Paper No.1 in 25 mL volumetric flask for stock solution.

2 mL of stock solution was taken and added 4 mL buffer solution (250 g Ammonium acetate + 15 g Na EDTA + 400 mL distilled water + 400 mL acetic acid and final volume is 1000 mL) and 4 mL Azomethen-H (0.20 g Azomethen-H + 0.50 g ascorbic acid and final volume 100 mL) and wait till 30 minutes.

The contents of boron (B) was measured by Spectophotometer at 420 ηm.

### 3.14 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

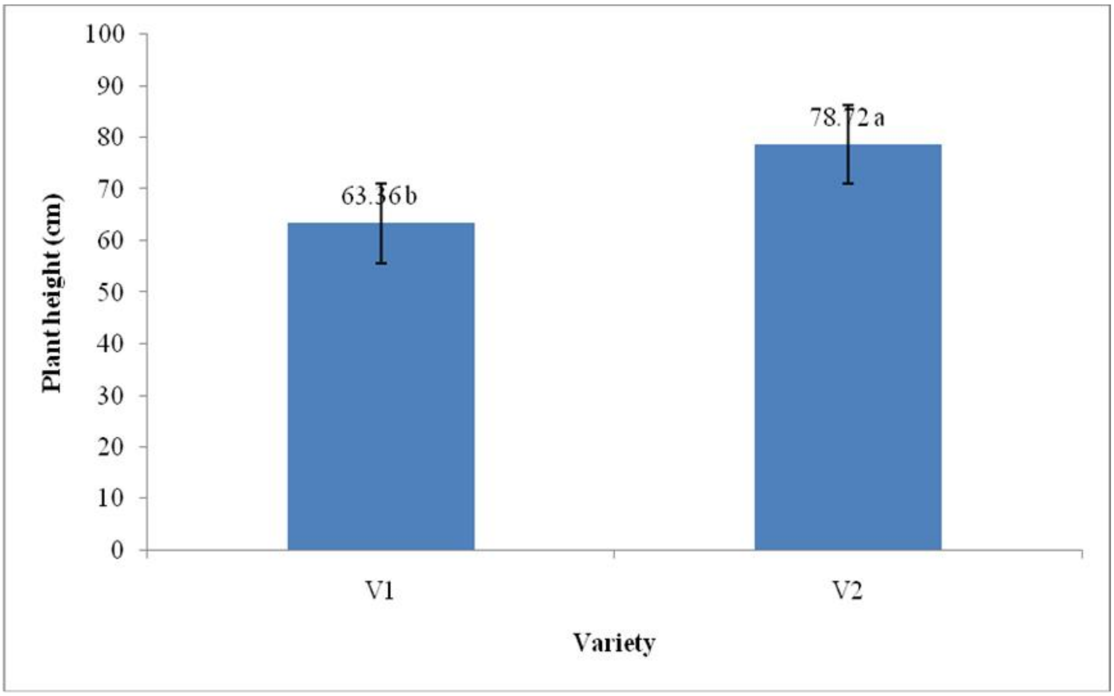
The study was conducted to find out effect of foliar application of boron on growth, yield and nutrient contents of tomato. Analyses of variance (ANOVA) of the data on different growth, yield parameters, yield and nutrient content of tomato are presented in Appendix IV-IX. The results have been presented and discussed through different tables and graphs and possible interpretations have been given under the following headings:

## 4.1 Growth parameters

### 4.1.1 Plant height

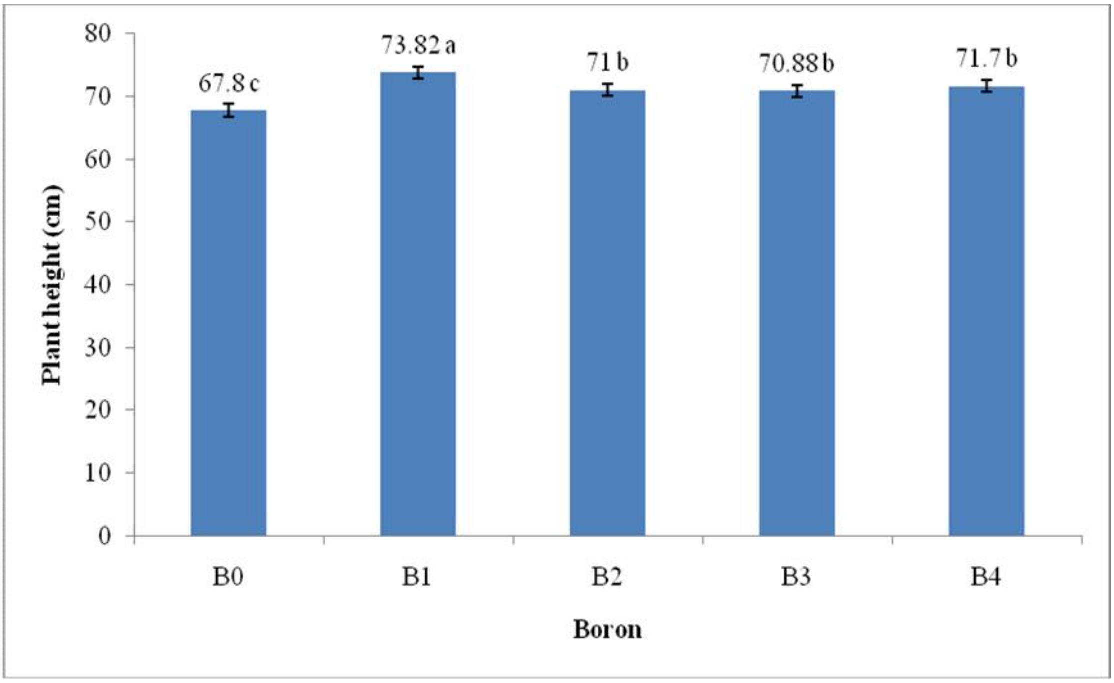
Plant height (cm) of tomato was significantly influenced of different tomato varieties (Figure 1 and Appendix V). Results showed that the variety $V_2$ (BARI tomato-16) gave the highest plant height (78.72 cm) whereas the variety $V_1$ (BARI tomato-2) showed lowest plant height (63.36 cm). These results are in agreements with the findings of Sanjida *et al*. (2020), Benti and Degefa (2017), Dunsin (2016) and Mehraj *et al*. (2014) who observed significant variation on plant height due to varietal difference.

There was positive and significant difference among the different levels of boron in respect to plant height (cm) (Figure 2 and Appendix V). The highest plant height (73.82 cm) was recorded from the boron treatment $B_1$ (0.5 kg B $ha^{-1}$) followed by $B_2$ (1.0 kg B $ha^{-1}$), $B_3$ (1.5 kg B $ha^{-1}$) and $B_4$ (2.0 kg B $ha^{-1}$) whereas the lowest plant height (67.80 cm) was recorded from the control treatment $B_0$ (0 kg B $ha^{-1}$). The result was similar with the findings of Sanjida *et al*. (2020) and Osman (2019) who found variation in plant height of tomato due to different boron doses.




$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

Figure 1. Plant height of tomato as influenced by variety




$B_0$ = Control (0 kg B $ha^{-1}$), $B_1$ = 0.5 kg B $ha^{-1}$, $B_2$ = 1.0 kg B $ha^{-1}$, $B_3$ = 1.5 kg B $ha^{-1}$, $B_4$ = 2.0 kg B $ha^{-1}$

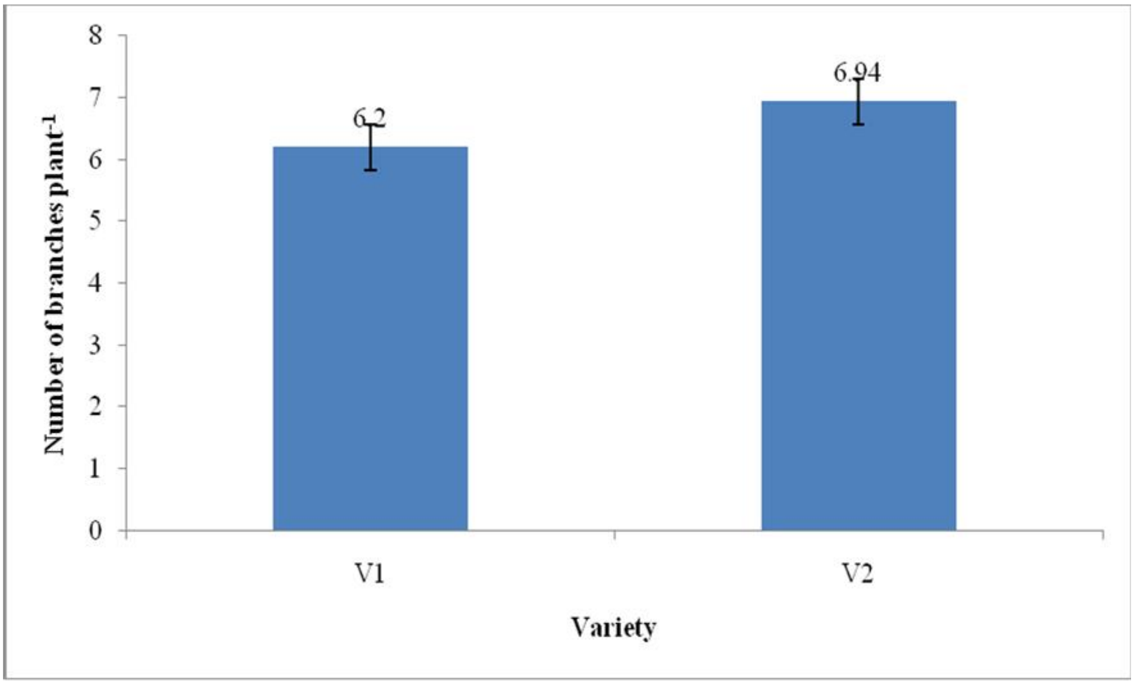
Figure 2. Plant height of tomato as influenced by boron application

The treatment combinations of variety and boron had significant effect on plant height (cm) of tomato (Table 1). The treatment combination of $V_2B_1$ (BARI tomato-16 and 0.5 kg B $ha^{-1}$) showed the highest plant height (80.45 cm) which was statistically identical with the treatment combination of $V_2B_2$ (BARI tomato-16 and 1.0 kg B $ha^{-1}$) and $V_2B_3$ (BARI tomato-16 and 1.5 kg B $ha^{-1}$). The lowest plant height (59.25 cm) was recorded from the treatment combination of $V_1B_0$ which was statistically similar with the treatment combination of $V_1B_3$ (BARI tomato-2 and 1.5 kg B $ha^{-1}$).

### 4.1.2 Number of branches plant$^{-1}$

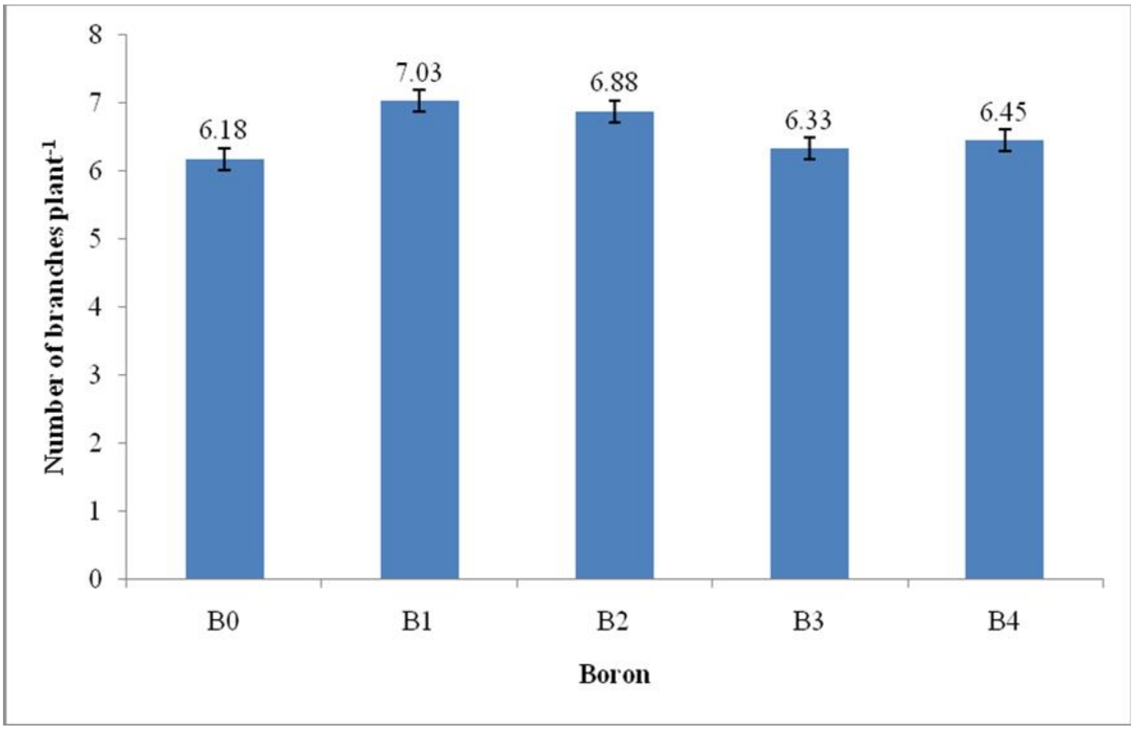
There was a non-significant variation on number of branches $plant^{-1}$ influenced by different tomato varieties (Figure 3 and Appendix V). However, the variety $V_2$ (BARI tomato-16) gave the highest number of branches $plant^{-1}$ (6.94) whereas the lowest number of branches $plant^{-1}$ (6.20) was recorded from the variety $V_1$ (BARI tomato-2). Similar result was also observed by Mehraj *et al*. (2014) and Biswas, *et al*. (2015).

Non-significant variation was observed on number of branches $plant^{-1}$ influenced by different levels of boron (Figure 4 and Appendix V). However, it was found that the boron treatment $B_1$ (0.5 kg B $ha^{-1}$) gave the highest number of branches $plant^{-1}$ (7.03) whereas the lowest number of branches $plant^{-1}$ (6.18) was recorded from the control treatment $B_0$ (0 kg B $ha^{-1}$). Osman (2019) and Sanjida *et al*. (2020) also found similar result with the present study.




$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

Figure 3. Number of branches plant$^{-1}$ of tomato as influenced by variety




$B_0$ = Control (0 kg B ha$^{-1}$), $B_1$ = 0.5 kg B ha$^{-1}$, $B_2$ = 1.0 kg B ha$^{-1}$, $B_3$ = 1.5 kg B ha$^{-1}$, $B_4$ = 2.0 kg B ha$^{-1}$

Figure 4. Number of branches plant$^{-1}$ of tomato as influenced by boron application

Significant influence was found on number of branches plant$^{-1}$ affected by treatment combinations of variety and boron (Table 1). The highest number of branches plant$^{-1}$ (7.05) was recorded from the treatment combination of $V_2B_1$ (BARI tomato-16 and 0.5 kg B ha$^{-1}$) which was statistically similar with the treatment combination of $V_1B_1$, $V_1B_2$, $V_2B_0$, $V_2B_3$ and $V_2B_4$. The lowest number of branches plant$^{-1}$ (5.35) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B ha$^{-1}$) which was significantly different from all other treatment combinations.

Table 1. Growth parameters of tomato as influenced by variety and boron application

| Treatments | | Growth parameters | |
|---|---|---|---|
| Variety | Boron doses (kg ha$^{-1}$) | Plant height (cm) | Number of branches plant$^{-1}$ |
| $V_1$ (BARI tomato-2) | 0 | 59.25 e | 5.35 e |
| | 0.5 | 67.65 c | 7.00 a |
| | 1.0 | 62.05 d | 7.00 a |
| | 1.5 | 61.30 de | 5.70 d |
| | 2.0 | 66.55 c | 5.95 c |
| $V_2$ (BARI tomato-16) | 0 | 76.35 b | 7.00 a |
| | 0.5 | 80.45 a | 7.05 a |
| | 1.0 | 79.95 a | 6.75 b |
| | 1.5 | 80.00 a | 6.95 ab |
| | 2.0 | 76.85 b | 6.95 ab |
| $LSD_{0.05}$ | | 2.653 | 0.238 |
| Significant level | | * | ** |
| CV(%) | | 5.86 | 12.25 |

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

$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B ha$^{-1}$), $B_1$ = 0.5 kg B ha$^{-1}$, $B_2$ = 1.0 kg B ha$^{-1}$, $B_3$ = 1.5 kg B ha$^{-1}$, $B_4$ = 2.0 kg B ha$^{-1}$

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

## 4.2 Yield contributing parameters

### 4.2.1 Number of flower clusters plant$^{-1}$

The effect of variety on number of flower clusters plant$^{-1}$ was not influenced significantly (Table 2). However, the highest number of flower clusters plant$^{-1}$

(5.41) was recorded from the variety $V_2$ (BARI tomato-16) whereas the lowest number of flower clusters plant$^{-1}$ (5.31) was recorded from the variety $V_1$ (BARI tomato-2). Mehraj *et al*. (2014) and Biswas *et al*. (2015) found variation on number of flower clusters plant$^{-1}$ which was not similar with the present study.

Boron fertilizer had significant effect on number of flower clusters plant$^{-1}$ (Table 2). The highest number of flower clusters plant$^{-1}$ (6.10) was recorded from the boron treatment $B_3$ (1.5 kg B ha$^{-1}$) which was significantly different from other treatments followed by $B_2$ (1.0 kg B ha$^{-1}$). The lowest number of flower clusters plant$^{-1}$ (4.76) was recorded from the control treatment $B_0$ (0 kg B ha$^{-1}$) which was statistically similar with $B_1$ (0.5 kg B ha$^{-1}$). Sanjida *et al*. (2020) also found similar results with the present study and observed that B had significant influence on flower clusters plant$^{-1}$. Similar result was also observed by Naz *et al.* (2012).

Combined effect of variety and B on the number of flower clusters plant$^{-1}$ was found significant (Table 2). The highest number of flower clusters plant$^{-1}$ (6.15) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B ha$^{-1}$) which was statistically similar with the treatment combination of $V_1B_3$ and $V_2B_2$. The lowest number of flower clusters plant$^{-1}$ (4.70) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B ha$^{-1}$) which was statistically similar with the treatment combination of $V_1B_1$, $V_2B_0$ and $V_2B_1$.

### 4.2.2 Number of flowers plant$^{-1}$

Number of flowers plant$^{-1}$ of tomato was not significantly influenced by different tomato varieties (Table 2). However, the highest number of flowers plant$^{-1}$ (35.95) was recorded from the variety $V_2$ (BARI tomato-16) and the lowest number of flowers plant$^{-1}$ (34.95) was recorded from the variety $V_1$ (BARI tomato-2). Benti and Degefa (2017) also found similar result with the present study.

There was positive and significant difference among the different levels of boron in respect of number of flowers plant$^{-1}$ (Table 2). The highest number of flowers plant$^{-1}$ (38.45) was recorded from the boron treatment $B_3$ (1.5 kg B ha$^{-1}$) which was statistically similar with $B_2$ (1.0 kg B ha$^{-1}$). The lowest number of flowers plant$^{-1}$ (31.12) was recorded from the control treatment $B_0$ (0 kg B ha$^{-1}$) which was significantly different from other treatments. Osman (2019) and Sanjida *et al*. (2020) also found similar result with the present study.

The treatment combinations of variety and boron had significant effect on number of flowers plant$^{-1}$ of tomato (Table 2). The highest number of flowers plant$^{-1}$ (38.95) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B ha$^{-1}$) which was statistically similar with the treatment combination of $V_1B_3$. The lowest number of flowers plant$^{-1}$ (29.43) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B ha$^{-1}$) which was significantly different from other treatment combinations.

### 4.2.3 Number of fruits cluster$^{-1}$

There was a non-significant variation on number of fruits cluster$^{-1}$ influenced by different tomato varieties (Table 2). However, the highest number of fruits cluster$^{-1}$ (5.19) was recorded from the variety $V_2$ (BARI tomato-16) and the lowest number of fruits cluster$^{-1}$ (5.16) was recorded from the variety $V_1$ (BARI tomato-2). Similar result was also observed by Biswas, *et al*. (2015).

Table 2. Yield contributing parameters of tomato as influenced by variety and boron application

| Treatments | | Yield contributing parameters | | |
|---|---|---|---|---|
| | | Number of flower clusters plant$^{-1}$ | Number of flowers plant$^{-1}$ | Number of fruits cluster$^{-1}$ |
| Effect of variety | | | | |
| $V_1$ (BARI tomato-2) | | 5.31 | 34.95 | 5.16 |
| $V_2$ (BARI tomato-16) | | 5.41 | 35.95 | 5.19 |
| $LSD_{0.05}$ | | 0.432 | 1.344 | 0.248 |
| Significant level | | NS | NS | NS |
| CV(%) | | 6.55 | 8.91 | 8.49 |
| Effect of boron | | | | |
| $B_0$ (0.0) | | 4.76 d | 31.12 d | 4.46 c |
| $B_1$(0.5) | | 4.99 cd | 34.52 c | 5.15 b |
| $B_2$(1.0) | | 5.68 b | 37.17 ab | 5.22 b |
| $B_3$(1.5) | | 6.10 a | 38.45 a | 5.56 a |
| $B_4$(2.0) | | 5.26 c | 36.00 b | 5.51 a |
| $LSD_{0.05}$ | | 0.340 | 1.432 | 0.107 |
| Significant level | | * | * | ** |
| CV(%) | | 6.55 | 8.91 | 8.49 |
| Combined effect of variety and boron | | | | |
| $V_1$ (BARI tomato-2) | 0 | 4.70 e | 29.43 h | 4.29 f |
| | 0.5 | 4.95 de | 34.16 f | 5.56 b |
| | 1.0 | 5.53 bc | 36.95 bc | 5.31 c |
| | 1.5 | 6.05 a | 37.95 ab | 5.33 c |
| | 2.0 | 5.30 cd | 36.26 cd | 5.48 bc |
| $V_2$ (BARI tomato-16) | 0 | 4.83 de | 32.80 g | 4.62 e |
| | 0.5 | 5.03 cde | 34.88 ef | 4.75 e |
| | 1.0 | 5.83 ab | 37.40 b | 5.12 d |
| | 1.5 | 6.15 a | 38.95 a | 5.79 a |
| | 2.0 | 5.23 cd | 35.74 de | 5.54 b |
| $LSD_{0.05}$ | | 0.509 | 1.111 | 0.189 |
| Significant level | | ** | * | ** |
| CV(%) | | 6.55 | 8.91 | 8.49 |

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

$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B ha$^{-1}$), $B_1$ = 0.5 kg B ha$^{-1}$, $B_2$ = 1.0 kg B ha$^{-1}$, $B_3$ = 1.5 kg B ha$^{-1}$, $B_4$ = 2.0 kg B ha$^{-1}$

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

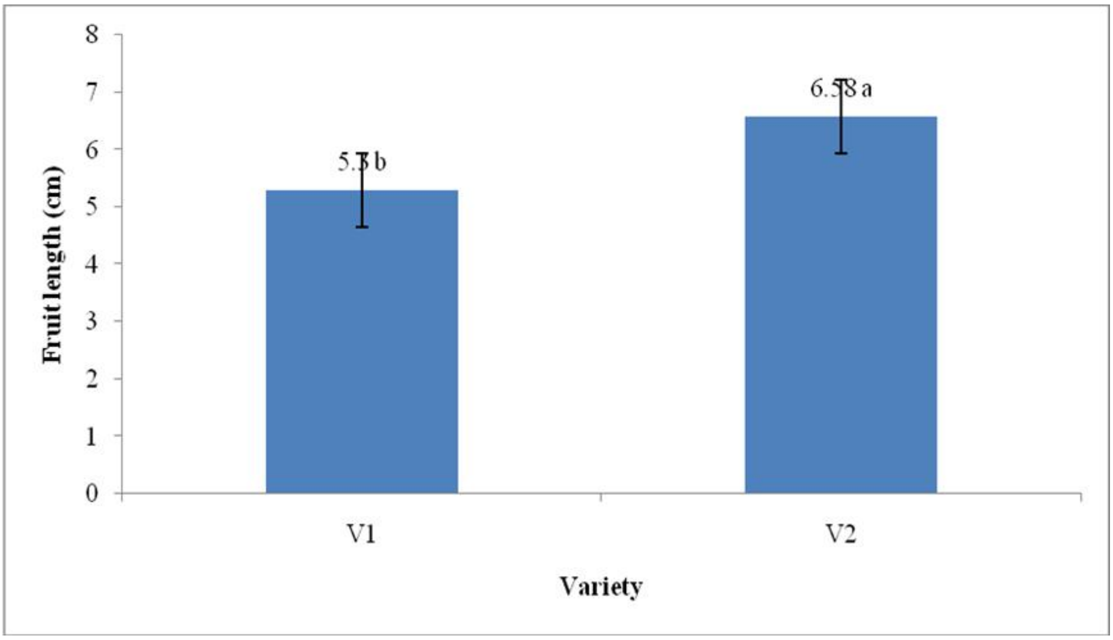
Significant variation was observed on number of fruits cluster$^{-1}$ influenced by different levels of boron (Table 2). The highest number of fruits cluster$^{-1}$ (5.56) was recorded from the boron treatment $B_3$ (1.5 kg B ha$^{-1}$) which was statistically identical with $B_4$ (2.0 kg B ha$^{-1}$) whereas the lowest number of fruits cluster$^{-1}$ (4.46) was recorded from the control treatment $B_0$ (0 kg B ha$^{-1}$). These results are in agreements with the findings of Sanjida *et al*. (2020) and Osman (2019).

Significant influence was found on number of fruits cluster$^{-1}$ affected by treatment combinations of variety and boron (Table 2). The highest number of fruits cluster$^{-1}$ (5.79) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B ha$^{-1}$) followed by $V_2B_2$ and $V_1B_4$. The lowest number of fruits cluster$^{-1}$ (4.29) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B ha$^{-1}$) which was significantly different from other treatment combinations.

### 4.2.4 Fruit length

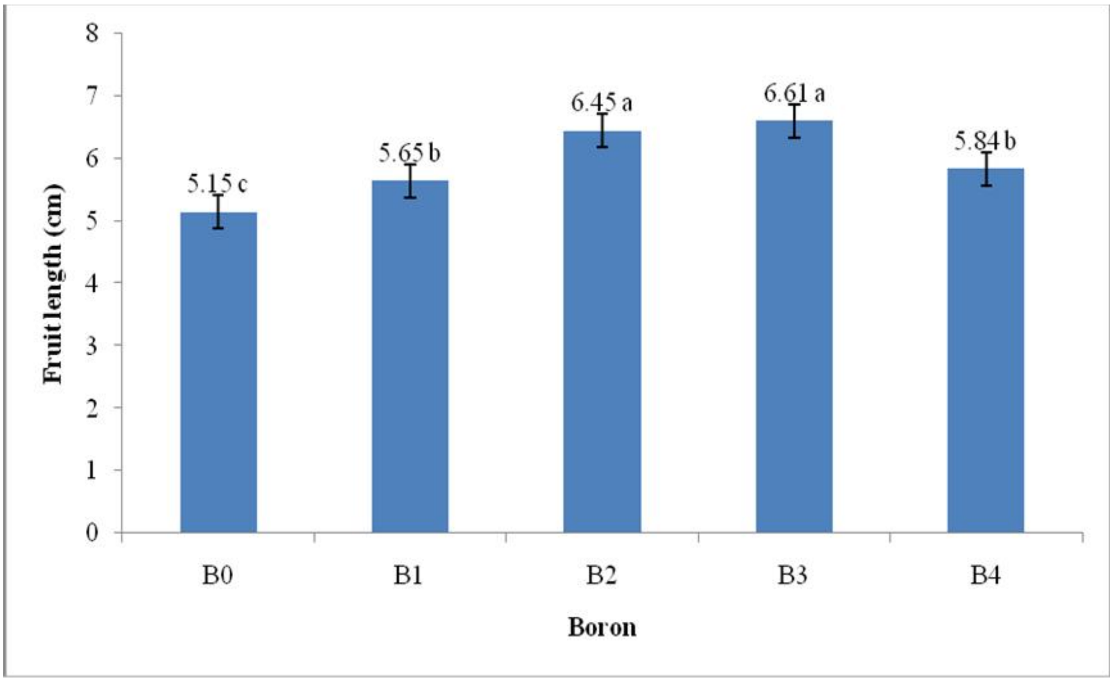
The effect of variety on fruit length (cm) of tomato was influenced significantly (Figure 5 and Appendix VI). The highest fruit length (6.58 cm) was recorded from the variety $V_2$ (BARI tomato-16) whereas the lowest fruit length (5.30 cm) was recorded from the variety $V_1$ (BARI tomato-2). Similar result was also observed by Ali (2014), Mehraj *et al*. (2014) and Biswas *et al*. (2015).

Boron fertilizer had significant effect on fruit length (cm) of tomato (Figure 6 and Appendix VI). The highest fruit length (6.61 cm) was recorded from the boron treatment $B_3$ (1.5 kg B ha$^{-1}$) which was statistically identical with $B_2$ (1.0 kg B ha$^{-1}$) whereas the lowest fruit length (5.15 cm) was recorded from the control treatment $B_0$ (0 kg B ha$^{-1}$). Osman (2019) found similar result with the present study.




$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

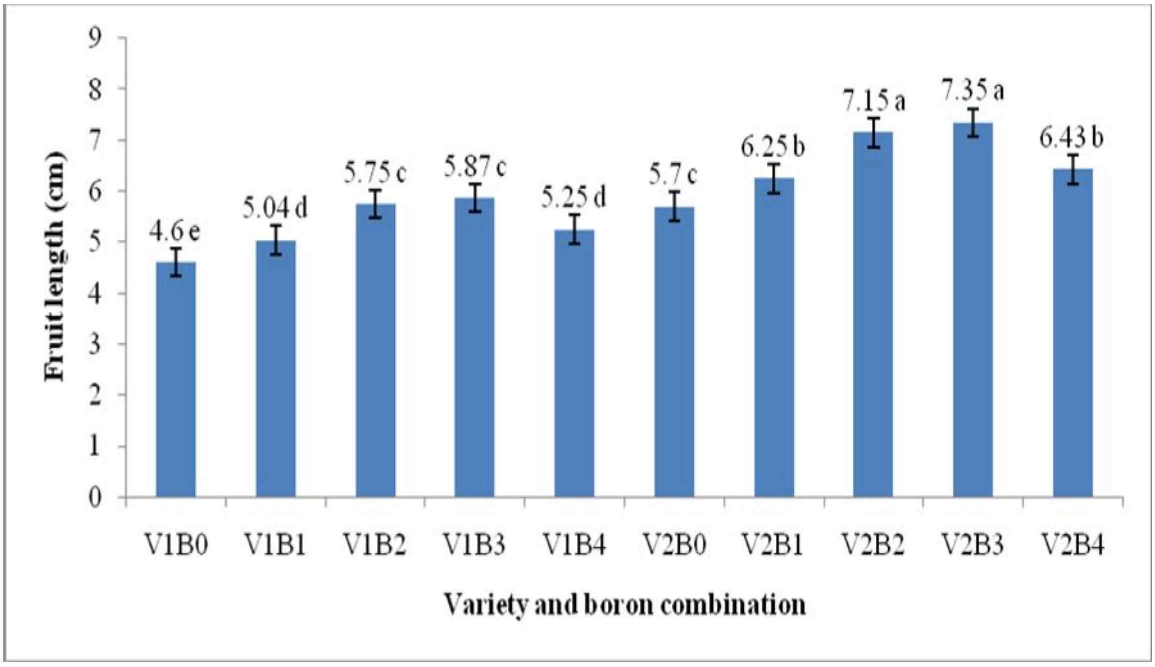
Figure 5. Fruit length of tomato as influenced by variety




$B_0$ = Control (0 kg B ha$^{-1}$), $B_1$ = 0.5 kg B ha$^{-1}$, $B_2$ = 1.0 kg B ha$^{-1}$, $B_3$ = 1.5 kg B ha$^{-1}$, $B_4$ = 2.0 kg B ha$^{-1}$

Figure 6. Fruit length of tomato as influenced by boron application

Combined effect of variety and boron on the fruit length (cm) of tomato was found significant (Figure 7 and Appendix VI). The highest fruit length (7.35 cm) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B $ha^{-1}$) which was statistically identical with the treatment combination of $V_2B_2$. The lowest fruit length (4.60 cm) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B $ha^{-1}$) which was significantly different from other treatment combinations.



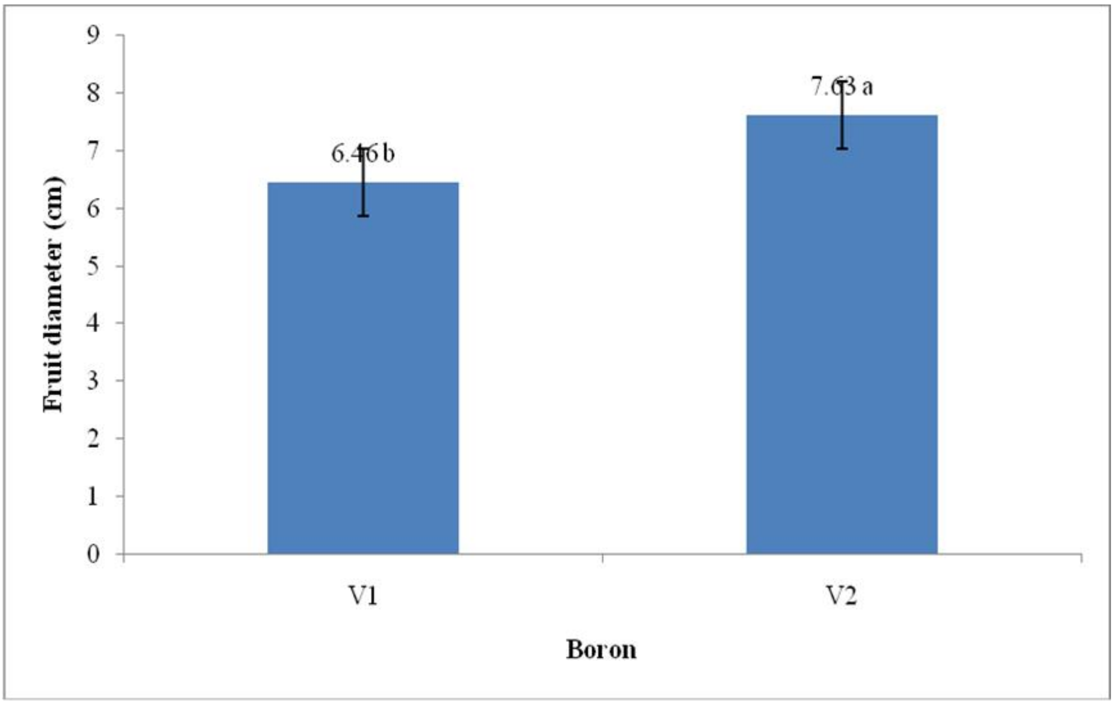

$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B $ha^{-1}$), $B_1$ = 0.5 kg B $ha^{-1}$, $B_2$ = 1.0 kg B $ha^{-1}$, $B_3$ = 1.5 kg B $ha^{-1}$, $B_4$ = 2.0 kg B $ha^{-1}$

Figure 7. Fruit length of tomato as influenced by combined effect of variety and boron application

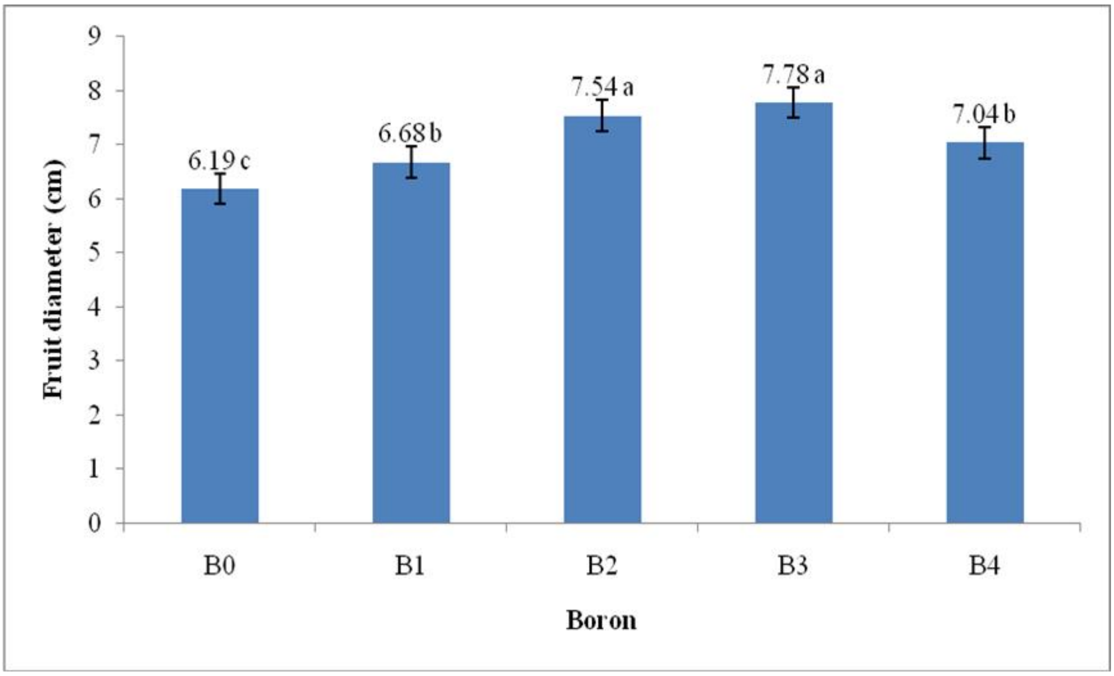
### 4.2.5 Fruit diameter

Fruit diameter (cm) of tomato was significantly influenced by different tomato varieties (Figure 8 and Appendix VI). The highest fruit diameter (7.63 cm) was recorded from the variety $V_2$ (BARI tomato-16) whereas the lowest fruit diameter (6.46 cm) was recorded from the variety $V_1$ (BARI tomato-2). The results obtained from the present study was similar with the findings of Mehraj *et al*. (2014) and Ali (2014) who observed varied fruit diameter due to varietal difference.




$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

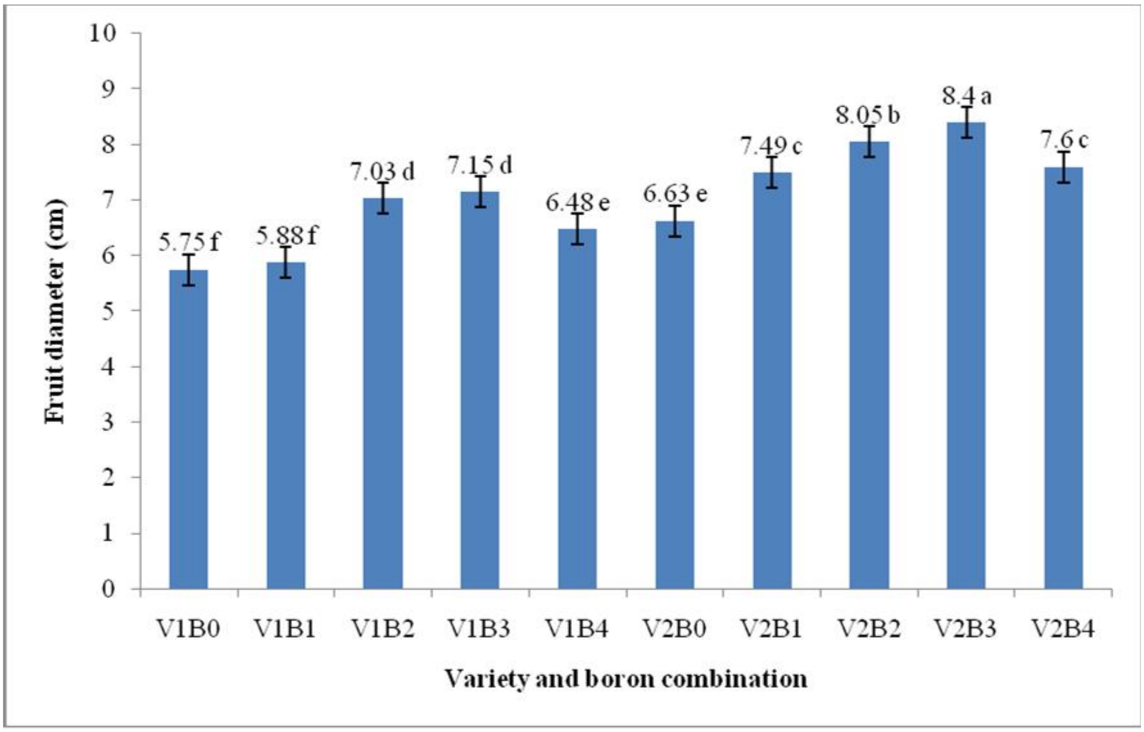
Figure 8. Fruit diameter of tomato as influenced by variety




$B_0$ = Control (0 kg B ha$^{-1}$), $B_1$ = 0.5 kg B ha$^{-1}$, $B_2$ = 1.0 kg B ha$^{-1}$, $B_3$ = 1.5 kg B ha$^{-1}$, $B_4$ = 2.0 kg B ha$^{-1}$

Figure 9. Fruit diameter of tomato as influenced by boron application

There was positive and significant difference among the different levels of boron in respect of fruit diameter (cm) (Figure 9 and Appendix VI). The boron treatment $B_3$ (1.5 kg B $ha^{-1}$) showed the highest fruit diameter (7.78 cm) which was statistically identical with $B_2$ (1.0 kg B $ha^{-1}$) whereas the lowest fruit diameter (6.19 cm) was recorded from the control treatment $B_0$ (0 kg B $ha^{-1}$). Sanjida *et al.* (2020) and Osman (2019) found similar result with the present study.




$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B $ha^{-1}$), $B_1$ = 0.5 kg B $ha^{-1}$, $B_2$ = 1.0 kg B $ha^{-1}$, $B_3$ = 1.5 kg B $ha^{-1}$, $B_4$ = 2.0 kg B $ha^{-1}$

Figure 10. Fruit diameter of tomato as influenced by combined effect of variety and boron application

The treatment combinations of variety and boron had significant effect on fruit diameter of tomato (cm) (Figure 10 and Appendix VI). The highest fruit diameter (8.40 cm) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B $ha^{-1}$) followed by $V_2B_2$ whereas the lowest fruit diameter (5.75 cm) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B $ha^{-1}$) which was statistically identical with the treatment combination of $V_1B_1$.

### 4.3 Yield parameters

### 4.3.1 Number of fruits plant$^{-1}$

There was non-significant variation on number of fruits plant$^{-1}$ influenced by different tomato varieties (Table 3). The highest number of fruits plant$^{-1}$ (27.89) was recorded from the variety $V_2$ (BARI tomato-16) whereas the lowest number of fruits plant$^{-1}$ (27.65) was recorded from the variety $V_1$ (BARI tomato-2). These results are in agreements with the findings of Mehraj *et al*. (2014), Biswas *et al*. (2015) and Dunsin (2016) who found significant variation on fruits per plant among the varieties.

Significant variation was observed on number of fruits plant$^{-1}$ influenced by different levels of boron (Table 3). The highest number of fruits plant$^{-1}$ (33.49) was recorded from the boron treatment $B_3$ (1.5 kg B ha$^{-1}$) which was significantly different from other treatments followed by $B_2$ (1.0 kg B ha$^{-1}$) and $B_4$ (2.0 kg B ha$^{-1}$). The lowest number of fruits plant$^{-1}$ (21.26) was recorded from the control treatment $B_0$ (0 kg B ha$^{-1}$). Naz *et al.*, (2012), Osman (2019) and Sanjida *et al*. (2020) also found similar result with the present study.

Significant influence was found on number of fruits plant$^{-1}$ affected by treatment combinations of variety and boron (Table 3). The highest number of fruits plant$^{-1}$ (34.72) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B ha$^{-1}$) which was significantly different from other treatment combinations followed by $V_1B_3$. The lowest number of fruits plant$^{-1}$ (20.18) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B ha$^{-1}$) which was significantly different from other treatment combinations.

### 4.3.2 Single fruit weight

The effect of variety on single fruit weight (g) was not influenced significantly (Table 3). However, the highest single fruit weight (59.27 g) was recorded from the variety $V_2$ (BARI tomato-16) and the lowest single fruit weight (57.51

g) was recorded from the variety $V_1$ (BARI tomato-2). Biswas *et al*. (2015) also found similar result with the present study.

Boron fertilizer had significant effect on single fruit weight (g) (Table 3). The highest single fruit weight (60.94 g) was recorded from the boron treatment $B_1$ (0.5 kg B $ha^{-1}$) which was statistically similar with control treatment $B_0$. The lowest single fruit weight (55.83 g) was recorded from the boron treatment $B_4$ (2.0 kg B $ha^{-1}$) which was statistically identical with $B_2$ (1.0 kg B $ha^{-1}$). The result found from the present study was similar with the findings of Sanjida *et al*. (2020) and Osman (2019).

Combined effect of variety and B on the single fruit weight (g) was found significant (Table 3). The highest single fruit weight (65.56 g) was recorded from the treatment combination of $V_2B_1$ (BARI tomato-16 and 0.5 kg B $ha^{-1}$) followed by $V_2B_0$. The lowest single fruit weight (55.68 g) was recorded from the treatment combination of $V_1B_4$ (BARI tomato-2 and 2.0 kg B $ha^{-1}$) which was statistically similar with the treatment combination of $V_1B_1$, $V_1B_2$, $V_2B_2$ and $V_2B_3$.

### 4.3.3 Fruit weight plant$^{-1}$

Fruit weight plant$^{-1}$ (kg) of tomato was significantly influenced by different tomato varieties (Table 3). The highest fruit weight plant$^{-1}$ (1.64 kg) was recorded from the variety $V_2$ (BARI tomato-16) whereas the lowest fruit weight plant$^{-1}$ (1.59 kg) was recorded from the variety $V_1$ (BARI tomato-2). The result found from the present study was similar with the findings of Mehraj *et al*. (2014), Ali (2014) and Biswas *et al*. (2015).

Table 3. Yield parameters of tomato as influenced by variety and boron application

| Treatments | | Yield parameters | | |
|---|---|---|---|---|
| | | Number of fruits plant$^{-1}$ | Single fruit weight (g) | Fruit weight plant$^{-1}$ (kg) |
| Effect of variety | | | | |
| $V_1$ (BARI tomato-2) | | 27.65 | 57.51 | 1.59 b |
| $V_2$ (BARI tomato-16) | | 27.89 | 59.27 | 1.64 a |
| $LSD_{0.05}$ | | 0.457 | 2.466 | 0.012 |
| Significant level | | NS | NS | ** |
| CV(%) | | 6.31 | 4.02 | 5.20 |
| Effect of boron | | | | |
| $B_0$ (0.0) | | 21.26 d | 59.79 ab | 1.27 c |
| $B_1$(0.5) | | 25.65 c | 60.94 a | 1.55 b |
| $B_2$(1.0) | | 29.43 b | 56.84 c | 1.67 b |
| $B_3$(1.5) | | 33.49 a | 58.54 b | 1.95 a |
| $B_4$(2.0) | | 28.99 b | 55.83 c | 1.62 b |
| $LSD_{0.05}$ | | 1.366 | 1.455 | 0.140 |
| Significant level | | * | * | ** |
| CV(%) | | 6.31 | 4.02 | 5.20 |
| Combined effect of variety and boron | | | | |
| $V_1$ (BARI tomato-2) | 0 | 20.18 f | 59.32 bc | 1.20 e |
| | 0.5 | 27.44 d | 56.32 d | 1.54 c |
| | 1.0 | 29.26 c | 56.49 d | 1.65 b |
| | 1.5 | 32.26 b | 59.74 bc | 1.92 a |
| | 2.0 | 29.08 cd | 55.68 d | 1.62 bc |
| $V_2$ (BARI tomato-16) | 0 | 22.34 e | 60.26 b | 1.35 d |
| | 0.5 | 23.86 e | 65.56 a | 1.56 c |
| | 1.0 | 29.60 c | 57.19 cd | 1.69 b |
| | 1.5 | 34.72 a | 57.34 cd | 1.99 a |
| | 2.0 | 28.91 cd | 55.99 d | 1.62 bc |
| $LSD_{0.05}$ | | 1.780 | 2.723 | 0.092 |
| Significant level | | * | * | ** |
| CV(%) | | 6.31 | 4.02 | 5.20 |

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

$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B ha$^{-1}$), $B_1$ = 0.5 kg B ha$^{-1}$, $B_2$ = 1.0 kg B ha$^{-1}$, $B_3$ = 1.5 kg B ha$^{-1}$, $B_4$ = 2.0 kg B ha$^{-1}$

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

There was positive and significant difference among the different levels of boron in respect of fruit weight plant$^{-1}$ (kg) (Table 3). The highest fruit weight plant$^{-1}$ (1.95 kg) was recorded from the boron treatment $B_3$ (1.5 kg B ha$^{-1}$) followed by $B_1$ (0.5 kg B ha$^{-1}$), $B_2$ (1.0 kg B ha$^{-1}$) and $B_4$ (2.0 kg B ha$^{-1}$) whereas the lowest fruit weight plant$^{-1}$ (1.27 kg) was recorded from the control treatment $B_0$ (0 kg B ha$^{-1}$). The result found from the present study was similar with the findings of Yadav *et al.* (2006), Osman (2019) and Sanjida *et al*. (2020).

The treatment combinations of variety and boron had significant effect on fruit weight plant$^{-1}$ (kg) of tomato (Table 3). The highest fruit weight plant$^{-1}$ (1.99 kg) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B ha$^{-1}$) which was statistically identical with the treatment combination of $V_1B_3$. The lowest fruit weight plant$^{-1}$ (1.20 kg) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B ha$^{-1}$) which was significantly different from other treatment combinations.

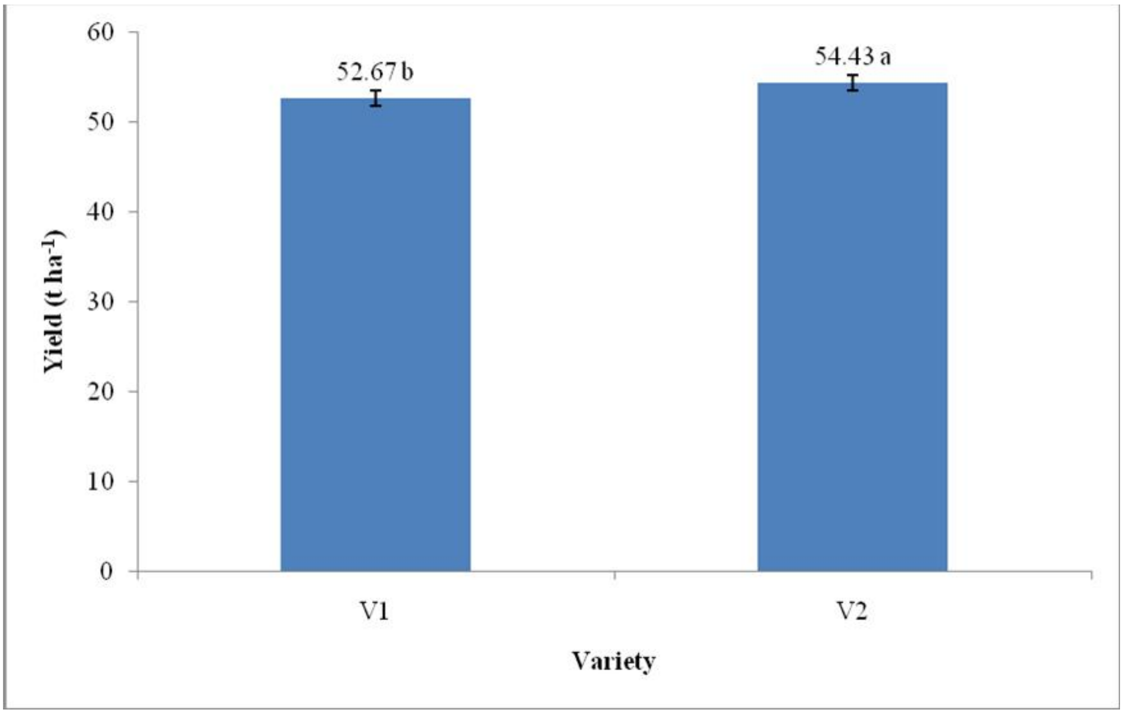
### 4.3.4 Yield ha$^{-1}$

There was a significant variation on yield of tomato (t ha$^{-1}$) influenced by different tomato varieties (Figure 11 and Appendix VII). Results showed that the variety $V_2$ (BARI tomato-16) gave the highest yield (54.53 t ha$^{-1}$) whereas the variety $V_1$ (BARI tomato-2) gave the lowest yield (52.67 t ha$^{-1}$) of tomato. These results are in agreements with the findings of Benti and Degefa (2017), Biswas *et al*. (2015), Ali (2014) and Mehraj *et al*. (2014) who found fruit yield varied significantly due to varietal difference

Significant variation was observed on yield of tomato (t ha$^{-1}$) as influenced by different levels of boron (Figure 12 and Appendix VII). The highest yield (64.90 t ha$^{-1}$) was recorded from the boron treatment $B_3$ (1.5 kg B ha$^{-1}$) followed by $B_2$ (1.0 kg B ha$^{-1}$) and $B_4$ (2.0 kg B ha$^{-1}$) whereas the lowest yield (42.18 t ha$^{-1}$) was recorded from the control treatment $B_0$ (0 kg B ha$^{-1}$). These results are in agreements with the findings of Sanjida *et al*. (2020), Osman

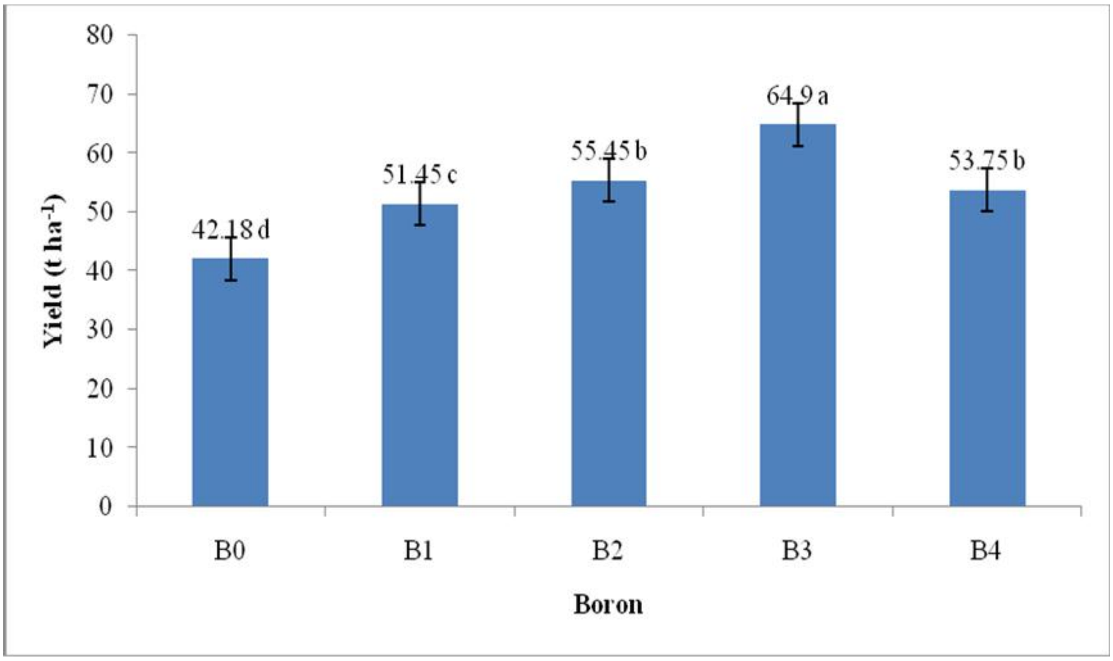
(2019) and Yadav *et al*. (2006) who found significant variation on tomato yield $ha^{-1}$ due to different boron doses.

Significant influence was found on yield of tomato (t $ha^{-1}$) affected by treatment combinations of variety and boron (Figure 13 and Appendix VII). Results exhibited that the highest yield (65.98 t $ha^{-1}$) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B $ha^{-1}$) which was significantly different from other treatment combinations followed by $V_1B_3$. The lowest yield (39.73 t $ha^{-1}$) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B $ha^{-1}$) which was significantly different from other treatment combinations.



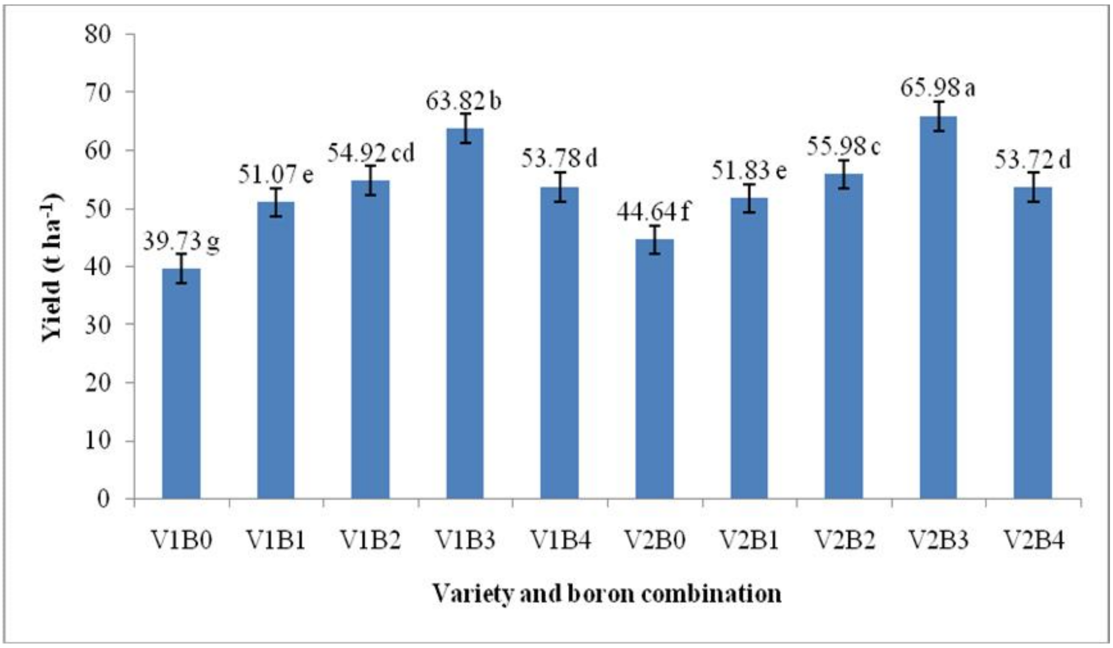

$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

Figure 11. Yield $ha^{-1}$ of tomato as influenced by variety




$B_0$ = Control (0 kg B ha$^{-1}$), $B_1$ = 0.5 kg B ha$^{-1}$, $B_2$ = 1.0 kg B ha$^{-1}$, $B_3$ = 1.5 kg B ha$^{-1}$, $B_4$ = 2.0 kg B ha$^{-1}$

Figure 12. Yield ha$^{-1}$ of tomato as influenced by boron application




$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B ha$^{-1}$), $B_1$ = 0.5 kg B ha$^{-1}$, $B_2$ = 1.0 kg B ha$^{-1}$, $B_3$ = 1.5 kg B ha$^{-1}$, $B_4$ = 2.0 kg B ha$^{-1}$

Figure 13. Yield ha$^{-1}$ of tomato as influenced by combined effect of variety and boron application

## 4.4 Nutrient contents

### 4.4.1 Nitrogen (N)

There was insignificant variation on nitrogen content (%) of tomato influenced by different varieties (Table 4). However, the highest nitrogen content (0.166%) was recorded from the variety $V_2$ (BARI tomato-16) whereas the lowest nitrogen content (0.162%) was recorded from the variety $V_1$ (BARI tomato-2).

Non-significant variation was observed on nitrogen content (%) of tomato influenced by different levels of boron (Table 4). However, the highest nitrogen content (0.169%) was recorded from the boron treatment $B_2$ (1.0 kg B $ha^{-1}$) and the lowest nitrogen content (0.158%) was recorded from the control treatment $B_0$ (0 kg B $ha^{-1}$). Similar result was also observed by Jeanine *et al*. (2003) and they found that foliar and/or soil applied B increased fresh-market tomato plant and root dry weight, uptake, and tissue concentration of N.

Significant influence was found on nitrogen content (%) of tomato affected by treatment combinations of variety and boron (Table 4). Results exhibited that the highest nitrogen content (0.172%) was recorded from the treatment combination of $V_2B_2$ (BARI tomato-16 and 1.0 kg B $ha^{-1}$) which was statistically similar with the treatment combination of $V_1B_2$ and $V_2B_3$. The lowest nitrogen content (0.155%) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B $ha^{-1}$) which was statistically similar with the treatment combination of $V_1B_1$.

### 4.4.2 Phosphorus (P)

Phosphorus content (%) of tomato was not significantly influenced by different varieties (Table 4). However, the highest phosphorus content (0.135%) was recorded from the variety $V_2$ (BARI tomato-16) and the lowest phosphorus content (0.114%) was recorded from the variety $V_1$ (BARI tomato-2)

There was non-significant difference among the different levels of boron in respect of phosphorus content (%) of tomato (Table 4). But the results showed that the highest phosphorus content (0.144%) was recorded from the boron treatment $B_3$ (1.5 kg B $ha^{-1}$) and the lowest phosphorus content (0.099%) was recorded from the control treatment $B_0$ (0 kg B $ha^{-1}$).

The treatment combinations of variety and boron had insignificant effect on phosphorus content (%) of tomato (Table 4). But it was found that the highest phosphorus content (0.163%) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B $ha^{-1}$) and the lowest phosphorus content (0.075%) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B $ha^{-1}$).

**4.4.3 Potassium (K)**

The effect of variety on potassium content (%) of tomato was not influenced significantly (Table 4). However, the highest potassium content (0.470%) was recorded from the variety $V_2$ (BARI tomato-16) whereas the lowest potassium content (0.440%) was recorded from the variety $V_1$ (BARI tomato-2).

Boron fertilizer had no significant effect on potassium content (%) of tomato (Table 4). But the highest potassium content (0.471%) was recorded from the boron treatment $B_3$ (1.5 kg B $ha^{-1}$) and the lowest potassium content (0.438%) was recorded from the control treatment $B_0$ (0 kg B $ha^{-1}$). The result obtained from the present study was similar with the findings of Jeanine *et al*. (2003) who observed foliar and/or soil applied B increased fresh-market tomato plant and tissue concentration of K.

Combined effect of variety and B on the potassium content (%) of tomato was found insignificant (Table 4). But the highest potassium content (0.490%) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B $ha^{-1}$) and the lowest potassium content (0.431%) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B $ha^{-1}$).

Table 4. Nutrient contents of tomato as influenced by variety and boron application

| Treatments | | Nutrient contents | | | |
|---|---|---|---|---|---|
| | | Nitrogen (N) (%) | Phosphorus (P) (%) | Potassium (K) (%) | Boron (B) (ppm) |
| Effect of variety | | | | | |
| $V_1$ (BARI tomato-2) | | 0.162 | 0.114 | 0.440 | 18.75 b |
| $V_2$ (BARI tomato-16) | | 0.166 | 0.135 | 0.470 | 20.00 a |
| $LSD_{0.05}$ | | 0.014 | 0.207 | 0.466 | 0.572 |
| Significant level | | NS | NS | NS | * |
| CV(%) | | 9.25 | 6.30 | 8.50 | 8.23 |
| Effect of boron | | | | | |
| $B_0$ (0.0) | | 0.158 | 0.099 | 0.438 | 14.38 d |
| $B_1$ (0.5) | | 0.166 | 0.109 | 0.451 | 17.00 c |
| $B_2$ (1.0) | | 0.169 | 0.133 | 0.466 | 21.25 b |
| $B_3$(1.5) | | 0.165 | 0.144 | 0.471 | 25.38 a |
| $B_4$ (2.0) | | 0.162 | 0.138 | 0.453 | 18.88 c |
| $LSD_{0.05}$ | | 0.020 | 0.064 | 0.096 | 1.913 |
| Significant level | | NS | NS | NS | * |
| CV(%) | | 9.25 | 6.30 | 8.50 | 8.23 |
| Combined effect of variety and boron | | | | | |
| $V_1$ (BARI tomato-2) | 0 | 0.155 | 0.075 | 0.413 | 14.25 f |
| | 0.5 | 0.1.59 | 0.130 | 0.438 | 16.50 e |
| | 1.0 | 0.171 | 0.115 | 0.453 | 19.75 c |
| | 1.5 | 0162 | 0.125 | 0.453 | 24.50 ab |
| | 2.0 | 0162 | 0.125 | 0.448 | 18.75 cd |
| $V_2$ (BARI tomato-16) | 0 | 0161 | 0.123 | 0.463 | 14.50 f |
| | 0.5 | 0166 | 0.088 | 0.465 | 17.50 de |
| | 1.0 | 0172 | 0.150 | 0.480 | 22.75 b |
| | 1.5 | 0168 | 0.163 | 0.490 | 26.25 a |
| | 2.0 | 0162 | 0.150 | 0.458 | 19.00 cd |
| $LSD_{0.05}$ | | 0.027 | 0.165 | 0.159 | 1.803 |
| Significant level | | NS | NS | NS | ** |
| CV(%) | | 9.25 | 6.30 | 8.50 | 8.23 |

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

$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B $ha^{-1}$), $B_1$ = 0.5 kg B $ha^{-1}$, $B_2$ = 1.0 kg B $ha^{-1}$, $B_3$ = 1.5 kg B $ha^{-1}$, $B_4$ = 2.0 kg B $ha^{-1}$

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

### 4.4.4 Boron (B)

The effect of variety on boron content (ppm) of tomato was influenced significantly (Table 4). The highest boron content (20.00 ppm) was recorded from the variety $V_2$ (BARI tomato-16) whereas the lowest boron content (18.75 ppm) was recorded from the variety $V_1$ (BARI tomato-2).

Boron fertilizer had significant effect on boron content (ppm) of tomato (Table 4). The highest boron content (25.83 ppm) was recorded from the boron treatment $B_3$ (1.5 kg B $ha^{-1}$) which was significantly different from all other treatments followed by $B_2$ (1.0 kg B $ha^{-1}$). The lowest boron content (14.38 ppm) was recorded from the control treatment $B_0$ (0 kg B $ha^{-1}$). Jeanine *et al*. (2003) found that foliar and/or soil applied B increased fresh-market tomato plant and root dry weight, uptake, and tissue concentration of B, so, the present investigation was supported by this finding.

Combined effect of variety and B on the boron content (ppm) of tomato showed significant variation (Table 4). The highest boron content (26.25 ppm) was recorded from the treatment combination of $V_2B_3$ (BARI tomato-16 and 1.5 kg B $ha^{-1}$) which was statistically similar with the treatment combination of $V_1B_3$. The lowest boron content (14.25 ppm) was recorded from the treatment combination of $V_1B_0$ (BARI tomato-2 and 0 kg B $ha^{-1}$) which was statistically identical with the treatment combination of $V_2B_0$.

# CHAPTER V

# SUMMARY AND CONCLUSION

The experiment was carried out during the period of October 2019 to March 2020 at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 to find out the effect of foliar application of boron on growth, yield and nutrient contents of tomato. The experiment consisted of two factors: Factor A: variety (two) *viz*. $V_1$ = BARI tomato-2 and $V_2$ = BARI tomato-16 and Factor B: Boron application (5 levels) *viz*. $B_0$ = control (0 kg B $ha^{-1}$), $B_1$ = 0.5 kg B $ha^{-1}$, $B_2$ = 1.0 kg B $ha^{-1}$, $B_3$ = 1.5 kg B $ha^{-1}$ and $B_4$ = 2.0 kg B $ha^{-1}$. The experiment was laid out in randomized complete block design (RCBD) with three replications. Data on different growth, yield contributing parameters, yield and nutrient content of tomato were recorded and analyzed statistically. Variety and boron application at different levels individually influenced plant characters.

Results showed that the variety $V_2$ (BARI tomato-16) gave best performance in case of different growth, yield and yield contributing parameter and also nutrient in tomato. BARI tomato-16 ($V_2$) showed the highest plant height (78.72 cm), number of branches $plant^{-1}$ (6.94), number of flower clusters $plant^{-1}$ (5.41), number of flowers $plant^{-1}$ (35.95), number of fruits $cluster^{-1}$ (5.19), fruit length (6.58 cm), fruit diameter (7.63 cm), number of fruits $plant^{-1}$ (27.89), single fruit weight (59.27 g), fruit weight $plant^{-1}$ (1.64 kg) and highest yield (54.53 t $ha^{-1}$) whereas the lowest plant height (63.36 cm), number of branches $plant^{-1}$ (6.20), number of flower clusters $plant^{-1}$ (5.31), number of flowers $plant^{-1}$ (34.95), number of fruits $cluster^{-1}$ (5.16), fruit length (5.30 cm), fruit diameter (6.46 cm), number of fruits $plant^{-1}$ (27.65), single fruit weight (57.51 g), fruit weight $plant^{-1}$ (1.59 kg) and yield (52.67 t $ha^{-1}$) were recorded from $V_1$ (BARI tomato-2). In case of nutrient content (N, P and K), non-significant variation was found among the varieties, however, the highest N (0.166%), P (0.135%), K (0.470%) and B (20.00 ppm) content were recorded from $V_2$ (BARI tomato-

16) whereas the lowest (0.162%, 0.114%, 0.440% and 18.75 ppm, respectively) were recorded from $V_1$ (BARI tomato-2).

In case of boron effect, the highest plant height (73.82 cm) and number of branches plant$^{-1}$ (7.03) were recorded from $B_1$ (0.5 kg B ha$^{-1}$).

Similarly, the highest number of flower clusters plant$^{-1}$ (6.10), number of flowers plant$^{-1}$ (38.45), number of fruits cluster$^{-1}$ (5.56), fruit length (6.61 cm), fruit diameter (7.78 cm), number of fruits plant$^{-1}$ (33.49), fruit weight plant$^{-1}$ (1.95 kg) and yield (64.90 t ha$^{-1}$) were recorded from $B_3$ (1.5 kg B ha$^{-1}$) but the highest single fruit weight (60.94 g) was recorded from $B_1$ (0.5 kg B ha$^{-1}$). The lowest plant height (67.80 cm), number of branches plant$^{-1}$ (6.18), number of flower clusters plant$^{-1}$ (4.76), number of flowers plant$^{-1}$ (31.12), number of fruits cluster$^{-1}$ (4.46), fruit length (5.15 cm), fruit diameter (6.19 cm), number of fruits plant$^{-1}$ (21.26), fruit weight plant$^{-1}$ (1.27 kg) and yield (42.18 t ha$^{-1}$) were recorded from the control treatment $B_0$ (0 kg B ha$^{-1}$) but the lowest single fruit weight (55.83 g) was recorded from $B_4$ (2.0 kg B ha$^{-1}$). The highest P (0.144%), K (0.471%) and B (25.83 ppm) content were recorded from $B_3$ (1.5 kg B ha$^{-1}$) but the highest N content (0.169%) was recorded from $B_2$ (1.0 kg B ha$^{-1}$) whereas the lowest N (0.158%), P (0.099%), K (0.438%) and B (14.38 ppm) content were recorded from the control treatment $B_0$ (0 kg B ha$^{-1}$).

Regarding treatment combination of variety and boron, the highest plant height (80.45 cm) and number of branches plant$^{-1}$ (7.05) were recorded from $V_2B_1$ whereas the lowest (59.25 cm and 5.35, respectively) were recorded from $V_1B_0$.

Similarly, the highest number of flower clusters plant$^{-1}$ (6.15), number of flowers plant$^{-1}$ (38.95), number of fruits cluster$^{-1}$ (5.79), fruit length (7.35 cm), fruit diameter (8.40 cm), number of fruits plant$^{-1}$ (34.72), fruit weight plant$^{-1}$ (1.99 kg) and yield (65.98 t ha$^{-1}$) were recorded from $V_2B_3$. The lowest number of flower clusters plant$^{-1}$ (4.70), number of flowers plant$^{-1}$ (29.43), number of fruits cluster$^{-1}$ (4.29), fruit length (4.60 cm), fruit diameter (5.75 cm), number of fruits plant$^{-1}$ (20.18), fruit weight plant$^{-1}$ (1.20 kg) and yield (39.73 t ha$^{-1}$) were recorded from $V_1B_0$.

Likewise, the highest P (0.163%), K (0.490%) and B (26.25 ppm) content were recorded from the treatment combination of $V_2B_3$ but the highest N content (0.172%) was recorded from $V_2B_2$ whereas the lowest N (0.155%), P (0.075%), K (0.431%) and B (14.25 ppm) content were recorded from $V_1B_0$.

From the present study, the following conclusion may be drawn –

1. Individual effect of variety and boron on growth and yield of tomato was found significant for most of the parameters except number branches plant$^{-1}$, number of flowers plant$^{-1}$, number of fruits plant$^{-1}$ and single fruit weight.
2. The combined effect of variety and boron enhanced growth, yield and yield attributes of tomato.
3. BARI tomato-16 was the suitable variety which gave the highest yield of tomato compared to BARI tomato-2.
4. Application of boron @ 1.5 kg B ha$^{-1}$ was most suitable regarding highest yield of tomato compared to other doses including control and BARI tomato-16 performed better.

Further research works at different regions of the country are needed to be carried out for the confirmation of the present findings.

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**APPENDICES**

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

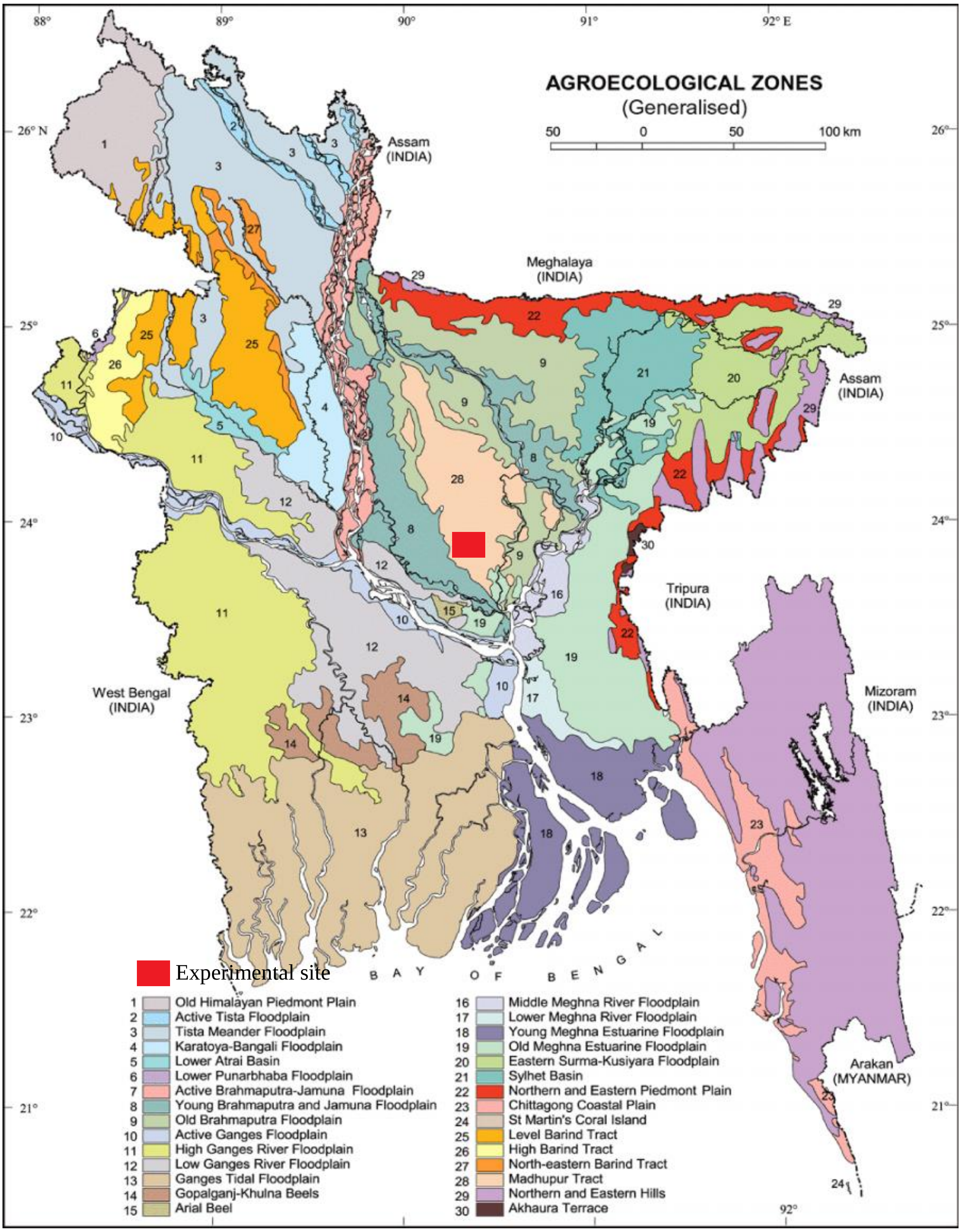


Figure 14. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from October 2019 to February 2020.

| Year | Month | Air temperature (°C) | | | Relative humidity (%) | Rainfall (mm) |
|---|---|---|---|---|---|---|
| | | *Max* | *Min* | *Mean* | | |
| 2019 | October | 30.42 | 16.24 | 23.33 | 68.48 | 52.60 |
| 2019 | November | 28.60 | 8.52 | 18.56 | 56.75 | 14.40 |
| 2019 | December | 25.50 | 6.70 | 16.10 | 54.80 | 0.0 |
| 2020 | January | 23.80 | 11.70 | 17.75 | 46.20 | 0.0 |
| 2020 | February | 22.75 | 14.26 | 18.51 | 37.90 | 0.0 |
| 2020 | March | 35.20 | 21.00 | 28.10 | 52.44 | 20.4 |

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

| **Morphological features** | **Characteristics** |
|---|---|
| Location | Agronomy Farm, SAU, Dhaka |
| *AEZ* | Modhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |
| Cropping pattern | Not Applicable |

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

| **Characteristics** | **Value** |
|---|---|
| Partical size analysis % Sand | 27 |
| %Silt | 43 |
| % Clay | 30 |
| Textural class | Silty Clay Loam (ISSS) |
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20 |
| Exchangeable K ( me/100 g soil) | 0.1 |
| Available S (ppm) | 45 |

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Growth parameters of tomato as influenced by variety and boron application

| Treatments | Growth parameters | |
|---|---|---|
| | Plant height (cm) | Number of branches plant$^{-1}$ |
| Effect of variety | | |
| $V_1$ | 63.36 b | 6.20 |
| $V_2$ | 78.72 a | 6.94 |
| $LSD_{0.05}$ | 3.246 | 1.06 |
| Significant level | * | NS |
| CV(%) | 5.86 | 12.25 |
| Effect of boron | | |
| $B_0$ | 67.80 c | 6.18 |
| $B_1$ | 73.82 a | 7.03 |
| $B_2$ | 71.00 b | 6.88 |
| $B_3$ | 70.88 b | 6.33 |
| $B_4$ | 71.70 b | 6.45 |
| $LSD_{0.05}$ | 1.168 | 1.24 |
| Significant level | * | NS |
| CV(%) | 5.86 | 12.25 |

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

$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B ha$^{-1}$), $B_1$ = 0.5 kg B ha$^{-1}$, $B_2$ = 1.0 kg B ha$^{-1}$, $B_3$ = 1.5 kg B ha$^{-1}$, $B_4$ = 2.0 kg B ha$^{-1}$

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Yield contributing parameters of tomato as influenced by variety and boron application

| Treatments | Yield contributing parameters | |
|---|---|---|
| | Fruit length (cm) | Fruit diameter (cm) |
| Effect of variety | | |
| $V_1$ | 5.30 b | 6.46 b |
| $V_2$ | 6.58 a | 7.63 a |
| $LSD_{0.05}$ | 0.115 | 0.107 |
| Significant level | * | * |
| CV(%) | 7.95 | 5.86 |
| Effect of boron | | |
| $B_0$ | 5.15 c | 6.19 c |
| $B_1$ | 5.65 b | 6.68 b |
| $B_2$ | 6.45 a | 7.54 a |
| $B_3$ | 6.61 a | 7.78 a |
| $B_4$ | 5.84 b | 7.04 b |
| $LSD_{0.05}$ | 0.352 | 0.436 |
| Significant level | * | * |
| CV(%) | 7.95 | 5.86 |

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

$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B $ha^{-1}$), $B_1$ = 0.5 kg B $ha^{-1}$, $B_2$ = 1.0 kg B $ha^{-1}$, $B_3$ = 1.5 kg B $ha^{-1}$, $B_4$ = 2.0 kg B $ha^{-1}$

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Yield of tomato as influenced by variety and boron application

| Treatments | Yield (t $ha^{-1}$) |
|---|---|
| Effect of variety | |
| $V_1$ | 52.67 b |
| $V_2$ | 54.43 a |
| $LSD_{0.05}$ | 0.146 |
| Significant level | * |
| CV(%) | 5.20 |
| Effect of boron | |
| $B_0$ | 42.18 d |
| $B_1$ | 51.45 c |
| $B_2$ | 55.45 b |
| $B_3$ | 64.90 a |
| $B_4$ | 53.75 b |
| $LSD_{0.05}$ | 1.795 |
| Significant level | * |
| CV(%) | 5.20 |

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

$V_1$ = BARI tomato-2, $V_2$ = BARI tomato-16

$B_0$ = Control (0 kg B $ha^{-1}$), $B_1$ = 0.5 kg B $ha^{-1}$, $B_2$ = 1.0 kg B $ha^{-1}$, $B_3$ = 1.5 kg B $ha^{-1}$, $B_4$ = 2.0 kg B $ha^{-1}$

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Layout of the experiment field

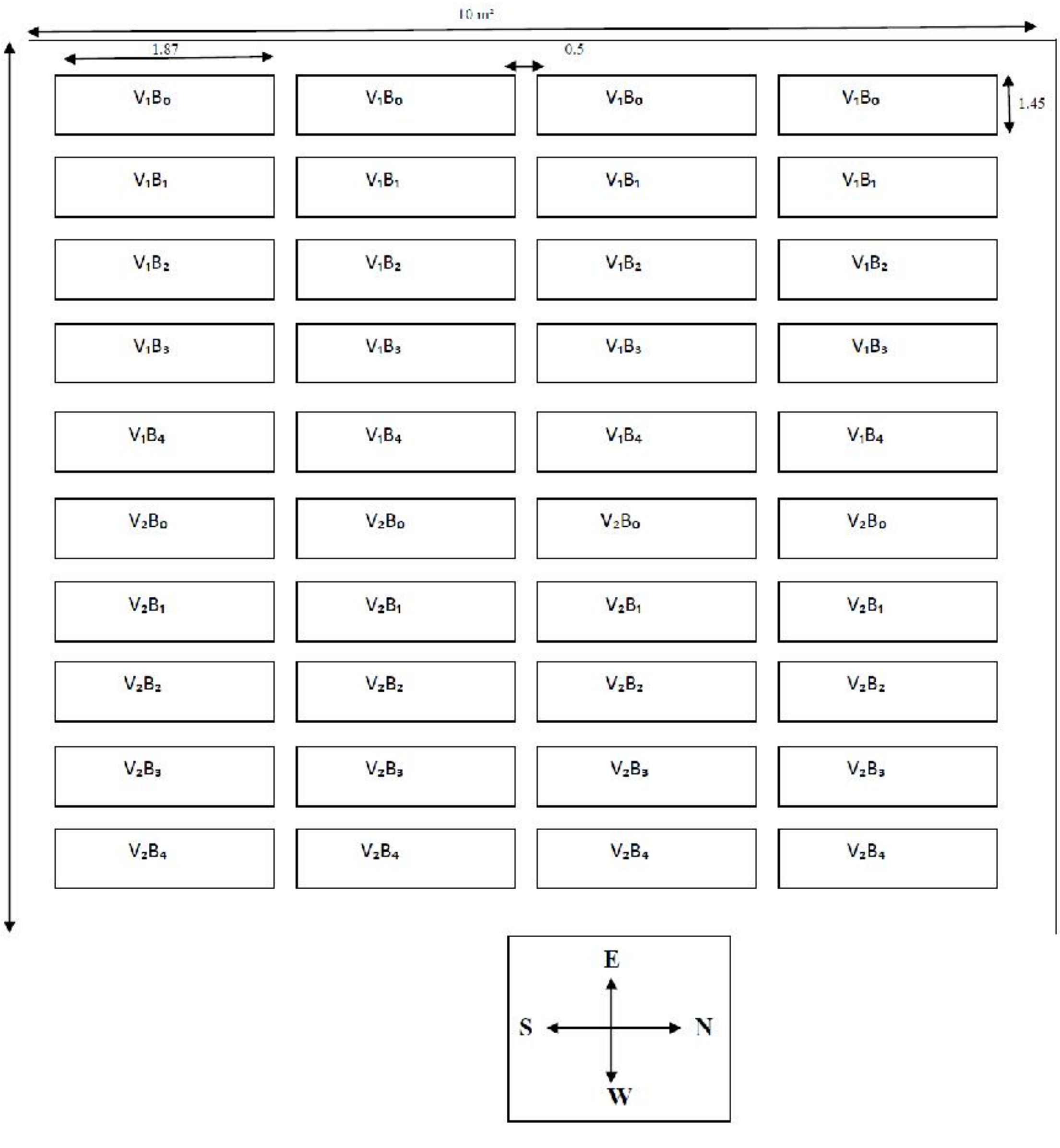


Figure 15. Layout of the experimental plot