EFFECT OF BORON ON THE GROWTH, YIELD AND QUALITY OF EXOTIC TOMATO LINES

ARJUN CHANDRA ROY

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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BY

ARJUN CHANDRA ROY

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Approved by

Prof. Dr. Mohammad Humayun Kabir Department of Horticulture SAU, Dhaka **Supervisor**	**Dr. Khaleda Khatun** Associate Professor Department of Horticulture SAU, Dhaka **Co-Supervisor**

Prof. Dr. Mohammad Humayun Kabir
Chairman
Examination Committee

Department of Horticulture

Sher-e-Bangla Agricultural University
Sher-e -Bangla Nagar, Dhaka-1207

Memo. No.: Date:

CERTIFICATE

This is to certify that the thesis entitled **“EFFECT OF BORON ON THE GROWTH, YIELD AND QUALITY OF EXOTIC TOMATO LINES”** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of *bona fide* research work carried out by **ARJUN CHANDRA ROY,** Registration No. **11-04404** 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.

Dated: June, 2017
Dhaka, Bangladesh

Prof. Dr. Mohammad Humayun Kabir
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

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ABSTRACT

The experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2016 to April 2017. The experiment consisted of two factors namely Factor A: Three levels of foliar spray of boron as- B_0: 0 ppm (Control), B_1: 100 ppm boric acid and B_2: 200 ppm boric acid; Factor B: Three different tomato line as- L_1: Exotic Tomato Line-1, L_2: Exotic Tomato Line-2, L_3: BARI Tomato-15. The two factorial experiments were laid out in Randomized Complete Block Design with three replications. Among boron concentrations, maximum fruit setting (56.73 %), yield (64.89 t/ha) and TSS (4.3 %) was found in B_1 whereas these were minimum in B_2. For tomato lines, maximum yield (79.87 t/ha) was found in L_3 while the minimum in L_1. Considering quality parameters, Vitamin C (20 mg) was the highest in L_3 whereas TSS (4.58%) was the highest in L_1. In interaction effect, the highest yield (85 t/ha) was obtained from B_1L_3 and the lowest (31.23 t/ha) in B_2L_1. Although the present study suggest to cultivate BARI Tomato-15, but other two exotic lines were adopted well and showed good performance in terms of yield and quality parameters.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF PLATES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

SAU	: Sher-e-Bangla Agricultural University
TSS	: Total Soluble Solid
BARI	: Bangladesh Agricultural Research Institute
L	: Tomato Line
g	: Gram unit
B	: Boron
Vit-C	: Vitamin C
cm	: Centimeter
p^H	: Potential hydrogen
ppm	: Parts per million
DAT	: Days after transplanting
LSD	: Least Significant Difference
AEZ	: Agro-Ecological Zone
ANOVA	: Analysis of Variance
df	: Degrees of freedom
CV%	: Percentage of Coefficient of Variation
BBS	: Bangladesh Bureau of Statistics
Kg	: Kilogram
%	: Percentage
AVRDC	: Asian Vegetable Research And Development Centre

CHAPTER I

INTRODUCTION

Tomato *(Lycopersicon esculentum* Mill*)* belongs to the family *Solanaceae* and is one of the most popular, important and widely used vegetable crops. It is also one of the nourishing vegetables cultivated all over the world. It endows with several uses to human. The fruits are having a wide array of valuable nutrients viz. vitamin B (biotin, B_6, folate and niacin); C (22%); K (6%) and molybdenum. It is a good source of macro (phosphorus, potassium) and micronutrients (copper, manganese), dietary fiber (4%), vitamin A and E. The fruits can be consumed in many ways i.e. as raw or cooked vegetable or processed into various products such as canned tomato, sauce, juice, ketchup, puree, stews and soup.

Tomatoes have an outstanding antioxidant property. Health benefits of tomatoes are; it lowers the danger of cancer (especially prostate cancer), cardiovascular diseases 2,3 and total cholesterol, LDL cholesterol, and triglycerides. Tomato contains lycopene pigment which is a vital anti-oxidant that helps to fight against cancerous cell formation as well as other kind of health complications and diseases (Kumavat and Chaudhari, 2013). A single tomato can provide 40% of the daily requirement of Vitamin-C which is a natural anti-oxidant.

Tomatoes are rich with Vitamin-K which plays a major role in blood clotting. The main antioxidants in tomatoes are ascorbic acid, carotenoids and phenolic compounds (Giovanelli *et al.* 1999). The significance of tomato as a beneficial crop is very apparent. The potential for production of tomato is high. In Bangladesh two crops are produced, one is the summer crop and the other is the winter crop. The area under tomato cultivation in Bangladesh was 76000 acre with a total production of 414000 metric tons with the average yield of 5471 kg per acre which is very low as compared to that in many other countries (BBS, 2015). The average tomato yield in Bangladesh is 50-90 tons/ha (Anon., 2010).

Varietal line or cultivar shows significant response to yield and quality characters on tomato due to variability in genetic makeup. The types of antioxidants present in tomato are also used to differentiate tomato cultivars (Langlois *et al.*, 1996). The overall antioxidant activity of tomatoes varies considerably according to the genetic variety, ripening stage and growing conditions (Leonardi *et al.* 2000). There is large variation in Vitamin C levels among tomato cultivars. There appears to be a relationship between high vitamin C levels and relatively poor yield (Taylor, 1986). Young *et al.* (1993) found that both total solids and total soluble solid decreased as color increased in a typical cultivar. Postharvest product quality develops during growing of the product and that could be maintained, but not improved by postharvest technologies. This could be achieved through selection of genotypes with better keeping quality when harvested at optimum maturity (Ramakrishnan *et al.*, 2010). Moreover, Tan (2006) indicated that available genetic material allows discrimination of external and internal quality attributes that must satisfy consumer requirements and indulgences.

Micronutrients are vital to the growth of plants, acting as catalyst in promoting various organic reactions taking place within the plant. Tomato being a heavy feeder and exhaustive crop removes substantial amount of micronutrients from soil. Applications of micronutrients using boron have been reported in increasing seed yield in tomato (Sivaiah *et al.*, 2013). Micronutrients such as B is essential for pollen germination and development of the pollen tube, increased amount of fertilized ovules and more seeds per fruit set, number of fruits/plant, fruit length and fruit diameter, dry weight of fruits, number of seeds/ fruit and seed yield/plant (Harris and Mathuma, 2015). Foliar application of micronutrients is the most efficient way to utilize the nutrients by plants. Tomato plant height responses by foliar application of different micronutrients were also determined by Singh and Tiwari (2013). Micronutrients are required by plants in very small quantities, yet they are very effective regulating plant growth due to enzymatic action (Sathya *et al.*, 2009). Applications of micronutrients i.e. zinc and boron have been reported in increasing growth and fruit yield in tomato (Naga *et al*., 2013).

Boron plays an important role in flowering and fruit formation. Boron has role on accumulation of photosynthates that has correlation with fruit weight (Shukha, 2011). Simultaneous intake of 200mg/l of nitrogen and 1mg/l of boron were recommended to achieve the highest fruit yield in hydroponic environments (Farzaneh *et al*., 2011). Boron (B) is an essential nutrient for normal growth of higher plants and its availability in soil and irrigation water is an important determinant of agricultural production (Saleem *et al*., 2011). Boron is mobile and readily leached in sandy soils and regular additions are necessary for many vegetables, but only in small amounts (Johnson, 2015). Application of B increased fruit firmness which increased shelf life of tomato by Rab and Haq (2010). Similarly boron also play important role in tomato production, and deficiency of this element usually occur due to undersupply, thus decreasing in growth, yield and quality of tomato.

It was therefore considered appropriate to make a comparative study of local as well as exotic cultivars of tomatoes for screening high yielding tomato lines suitable to our agro-climatic conditions**.**

However, considering the above circumstances, the present study was undertaken with the following objectives:

Objectives

1) To determine the effect of boron on the growth, flowering, yield and quality of tomatoes;
2) To evaluate the performance of exotic tomato lines; and
3) To find out the suitable combination of boron and exotic tomato ensuring higher yield and quality of tomato

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the popular and widely cultivated vegetables in Bangladesh as well as many countries of the world. Limited research has been conducted to find out the effective level of boron on exotic tomato line through foliar spray. An attempt has been made in this chapter to present relevant review of literature on the research works performed till to date in Bangladesh and other part of the world in relation to the effects of boron on growth, yield and quality of tomato.

2.1 Influence of Boron

Acharya *et al.* (2015) reported the effect of boron and zinc application on seeding transplanting multiplier onion at different levels of both foliar and basal application. Results were found to be significant in most of the parameters of like plant height, number of leaves per plant, leaf girth, fresh leaf weight, fresh bulb weight, total dry matter production, bulb yield per plot and bulb yield per hectare.

Ali *et al.* (2015) studied the effect of foliar application of zinc and boron in tomato. Maximum plant height, number of leaves, leaf area, number of branches, number of clusters, were found from foliar application of 12.5-ppm $ZnSO_4$ + 12.5-ppm H_3BO_3 while minimum from control. Foliar application of Zinc and boron was more effective than the individual application of zinc or boron on growth and yield for summer season tomato (BARI hybrid tomato 4).

Mashayekhi *et al*. (2015). conducted an experiment to evaluate the influence of plants foliar spray by sucrose and Boron on some characteristics of the fruit and leaves of tomato v. Super-A. Most of the brix, acidity, dry matter, sucrose, glucose, fruit and lycopene related to the interaction of 0.2% of Boron by five percent sucrose. In an aggregation of the best treatment for the purposes of processing and conversion, fresh salad, and drug, treatment 0.2% Boron with a 5% sucrose in order to increase in the amount of brix, acidity, dry weight, glucose and sucrose in fruit lycopene and appropriate values anthocyanins and fresh fruit is recommended.

Meena *et al*. (2015) designed a research to find out the response of zinc and boron on improvement of growth, yield and quality of tomato. It was found that the vegetative growth in terms of plant height and number of branches, leaf area, stem girth and flowering at various stages was greatly influenced by the application of micronutrients Zn and B.

Oliveira *et al.* (2015) conducted the study to evaluate the effect of the application of boron (B) by foliar spraying for the yield of beet and tomato crops. The highest yield of the tuberous root and the total plant dry matter of beet occurred with B foliar concentration of 0.065 g L^{-1} and it was associated with the B foliar content of 26 mg kg^{-1}. The highest yield of fruit and total plant dry matter of tomato occurred with the B foliar spraying of 0.340 g L^{-1} and it was associated with the B foliar content of 72 mg kg^{-1}.

Suganiya and Kumuthini (2015) studied the effect of boron on flower and fruit setting and yield of ratoon crop of brinjal (*Solanum melongina* L.) in the Eastern Region of Sri Lanka. The results showed that foliar application of boron (H_3BO_3) at 150 ppm increased the number of flower buds/plant flowers/cluster, flower clusters/plant, total flowers/plant, percentage of flower set, percentage of fruit set, fruits/plant and fresh weight of fruits/plant than that of control. It was, therefore, concluded that foliar application of H_3BO_3 at 150 ppm (at flowering stage) could increase the percentage of flowering, fruit set and fruit yield per plant of ratoon crop of brinjal.

Saravaiya *et al.* (2013) conducted an experiment to study the effect of foliar application of micronutrients in tomato (*Lycopersicon esculentum* Mill.) cv. Gujarat Tomato-2. The result clearly showed that the yield obtained with treatment T_7 (NPK+boron) had significantly maximum fresh weight of plants, number of fruits $plant^{-1}$, fruit length, fruit diameter, fruit volume, single fruit weight, fruit weight per plant and marketable fruit yield/ha.

Kazemi (2014) studied the effects of foliar application of humic acid and calcium chloride on vegetative and reproductive growth, yield and quality of tomato plants. Results showed that humic acid (30 ppm) and calcium chloride (15mM) spray either alone or in combination (30 ppm HA+15 mM Ca) affected on vegetative and reproductive growth and chlorophyll content, significantly. Foliar application of Ca (15 mM) + HA (30 ppm) resulted in the maximum TSS, vitamin C, nitrate reductase activity, yield, fruit firmness, fruit vitamin-c content.

Singh and Tiwari (2013) studied the impact of micronutrient spray on growth, yield and quality of tomato. Interaction application of micro- nutrient increased the number of flowers per plant which might be due to the fact that boron may serve as anti fruit drop agent, which helps in high fruit setting. The research concluded that foliar spray of boric acid + zinc sulphate + copper sulphate @250 ppm each was found superior over other treatments for growth, flowering, yield and quality of tomato.

Devi *et al*. (2013) conducted an experiment on chilli having ten treatments *viz.*, Zinc sulphate (0.25%, 0.5%, 0.75%), boric acid (0.2%, 0.4%, 0.6%), Copper sulphate (0.1%, 0.2%, 0.4%) and control (water). The result showed that treatment T_6 was found best for most of the characters viz. number of fruits per plant (194.7), fruit weight per plant (481.3 g), fruit diameter (1.2 cm), yield per plot (8.67 kg/plot), and yield per hectare (192.53 q/ha).

Roosta and Hamidpour (2013) was conducted an experiment to evaluate the effects of foliar applications of some micro nutrients on mineral nutrient content of tomato leaves and fruits. Eight treatments were used, untreated control and foliar application at the rate of 250 mL $Plant^{-1}$ with 0.5 g L^{-1} potassium sulfate, magnesium sulfate, ferrous (Fe)- ethylenediamine-N, N'-bis (EDDHA), manganese sulfate, boric acid (H_3BO_3), zinc chloride, and copper sulfate. These findings indicated that foliar application of some elements can effectively alleviate nutrient deficiencies in the leaves of tomatoes grown on aquaponics.

Desai *et al*. (2012) conducted an experiment to find out the effect of different plant growth regulators and micronutrient on fruit quality and micronutrient content of tomato. The fruit quality and micronutrient content parameters in plant were significantly differed due to different plant growth regulators and micronutrient on tomato. The maximum acidity per cent and ascorbic acid, reducing sugars, non-reducing sugars, total sugars and TSS were found in treatment boron content T_8 (Boric acid 75 ppm).

El-Feky *et al.* (2012) carried out an experiment to assess the role of elevated concentrations of boron in barley (*Hordeum vulgare* L. cv. Giza 123) growth and yield. The inhibitory effects of boron on barley growth started at concentrations above 3.0 mg $L^{-1,}$ causing decrease in all the measured parameters. The five tested growth modulators alleviated boron toxicity at 3.0 mg L^{-1} at the following sequence: salicylic acid (1 mM), calcium chloride 5 mM ≥, ascorbic acid (2 mM) ≥, glycine (1 mM) and glutamic acid (3 mM).

Kavvadias *et al* (2012) stated that the foliar application of Boron concentration in fruits of that treatment was increased in both cultivation years compared to most of the applied treatments. Foliar application of B at flowering, fruit set, and fruit growth, primarily in combination with foliar calcium (Ca) application, showed fruits to be less affected by cracking over all treatments.

Kumari (2012) conducted an experiment to assess the effects of micronutrients viz boron, zinc, molybdenum, copper, iron, manganese, mixture of all and multiplex through foliar application on quality of fruit and seed in tomato. Three sprays of each at 100 ppm were applied at 10 days interval starting from 30 days after transplanting; Variation in total soluble solids was significant. Maximum total soluble solids (4.52 B) were observed with the treatment of copper. Maximum increase in vitamin C content of tomato fruits (25.27

mg/100g) was recorded with the application of zinc which accounted for an increase of 36.89 per cent as compared to 18.46 mg/100 g in control.

Naz *et al*. (2012) observe the effect of Boron on physiological growth on tomato. Like other nutrients, Boron plays an important role in production of any crop in terms of yield, quality and control of some diseases. Boron plays an essential role in the development and growth of new cells in the meristem, proper pollination and fruit or seed set, translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins, regulation of carbohydrate metabolism and stabilize the oxidative system in plants.

Raj *et al*. (2012) carried out an experiment to study the effect of foliar application of secondary and micro nutrients on yield and quality of tomato. The result indicated that shelf life of tomato increased with foliar spray and amendment applications compared to major nutrients alone. The fruits from plots receiving all the three combinations recorded significantly higher TSS, acidity and ascorbic acid content. The quality parameters like TSS, ascorbic acid and acidity of tomato fruits increased with micronutrient like boron.

Sakamoto (2012) conducted a study to demonstrate the only role of B in plants as the structural maintenance of cell wall. The author stated that soil B, as boric acid, is acquired through roots and then distributed around the 14 plant via the passive and active transport pathway. In agriculture, both deficient and excess levels of soil B impair plant growth, resulting in the reduction of quantity and quality of crops. The major causes of B toxicity in plants contain oxidative stress, metabolism alteration and deoxyribonucleic acid damage.

Ullah *et al.* (2012) carried out an experiment to study the growth and yield of tomato (*Lycopersicon esculentum* L.) cv ‘Rio Grand as influenced by different levels of zinc and boron as foliar application. Four levels of zinc (0, 0.2, 0.4 and 0.6%) and four levels of boron (0, 0.05, 0.10 and 0.15%) were applied as foliar spray. Boron also significantly affected growth and yield components. Among different levels of boron 0.15% showed significant increased in number of flowers cluster per plant (27.55), number of fruits per cluster (4.40) and yield 23.33 (t/ha). Based on the above results it can be recommended that Zn @ 0.4% and B @ 0.15% should be combinely applied to tomato for better growth and yield under the agro climatic conditions of Peshawar.

Ejaz *et al.* (2011) conducted a study to investigate the efficacy of micronutrient of foliar application on tomato. After the statistical analysis it was found that individual application of nutrient provide better results as compared to control but their interaction effect (Zn = 6%, B = 5%, N = 2%) provided substantial results in plant heights, no. of leaves, no of flowers, no of fruits, average fruit weight and yield per plant. It is confirmed from the results that combination of macronutrients and micro-nutrients as foliar application has the ability to enhance the growth and yield of tomato positively.

Farzaneh *et al*. (2011) conducted an experiment to study the effect of nitrogen and boron on yield, shoot and root dry weights and leaf concentration of nutrient elements in hydroponically grown tomato in greenhouse. The results showed that the simple and interaction effect of nitrogen and boron on yield and tomato shoot and root dry weights were significant. In contrast, by increasing B of nutrient solution are recommended to obtain higher yield and better quality for tomato in hydroponic culture.

Saleem *et al.,* (2011) investigated Boron is unique, not only in its chemical properties, but also in its roles in biology. Normal healthy plant growth requires a continuous supply of B, once it is taken up and used in the plant; it is not translocated from old to new tissue. That is why, deficiency symptoms starts with the youngest growing tissues. Therefore, adequate B supply is necessary for obtaining high yields and good quality y of agriculture crops.

Sahin *et al.* (2011) studied to investigate the effects of calcium and boron on the growth of indeterminate tomato. Calcium and boron was applied in two doses. Sedir F_1 line was used as the plant material of the experiments. The Ca and B content of plant leaves were significantly affected by calcium and boron doses, but vitamin C, pH, titratable acidity (TA) and soluble solid dry matter (SSDM) were not significantly affected by treatment doses. The highest Ca and B contents were observed in 60 and 90 kg ha^{-1} Ca and 3000 gr ha^{-1} B doses.

Swati *et al.* (2011) conducted an experiment to study the response of foliar application of micronutrients on tomato line Rashmi and reported that the maximum fruit yield (1.18 kg/ plant and 375.94 q/ha) was obtained with application of BA + $ZnSO_4$ +$CuSO_4$).

Nada *et al.* (2010) conducted a study to clarify a critical concentration of excess boron (B) in nutrient solution for hydroponically cultured tomato. The study also investigated the influences of excess B on growth, photosynthesis and fruit maturity. However, fruit size and Brix were reduced in the second truss. Based on these results, the authors suggest that the critical concentration of B in nutrient solution is 4 ppm for long-term hydroponic cultivation of tomatoes.

Patil *et al.* (2010) was conducted an experiment to evaluate the effect of foliar application of micronutrients on flowering and fruit-set of tomato. They have showed the flowering parameters like days required for initiation and 50 percent flowering, number of clusters, number of flowers, total number of flowers and fruit setting percentage per plant were influenced significantly due to different treatments. Maximum number of flowers per cluster and percent fruit setting (47.76%) was recorded with Boron 50 ppm + Iron 100 ppm + Zinc 100 ppm, while minimum was recorded in control.

Sathya *et al.* (2010) investigated the effect of application of boron on growth, quality and fruit yield of PKM 1 tomato. The biometric characters such as plant height and number branches were significantly influenced by soil and foliar application of boron. It was observed that among the various levels of foliar application of boron, 0.25 per cent borax spray produced taller plants with more no. of branches. The results also revealed that the highest fruit yield of 33 tonnes per hectare was recorded in treatment that received borax @ 20 kg ha^{-1} recording 33.6 per cent increase over control and was found to be significantly superior to rest of the treatments.

Salam *et al*. (2010) investigated the effects of boron and zinc in presence of different levels of NPK fertilizers on quality of tomato. The highest pulp weight (88.14%), dry matter content (5.34%), TSS (4.50%), acidity (0.47%), ascorbic acid (10.95 mg/100g), marketable fruits at 30 days after storage (67.48%) and shelf life (16 days) were recorded with the combination of 2.5 kg B+ 6 kg Zn/ha and recommended dose of NPK fertilizers (N= 253, P= 90, and K= 125 kg/ha).

Singh and sing (2012) conducted an experiment with three zinc levels and three boron levels (0, 30 and 60 (ppm) and three Molybdenum levels with the objective to see the effect on yield and economics of okra. Application of zinc, boron and molybdenum improved growth, yield attributes and yield. The application of zinc, boron individually increased significantly green pod yield of 93.70, 88.35 and 86.57 q/ha followed by 30 ppm and control.

Theunissen *et al.* (2010) stated that Plant nutrients including K, Zn and B, the uptake of which has a positive effect on plant nutrition, photosynthesis, chlorophyll content of the leaves and improves nutrient content of the different plant components of carrot (roots, shoots and leaf).

Jyolsna and Mathew (2008) conducted a pot culture experiment, to study the effects of 0, 0.5, 1.0, and 1.5 kg B ha^{-1} with recommended doses of chemical fertilizer and RDF + farmyard manure (FYM; 25 tons ha^{-1}) on growth, yield and quality of tomato. Boron significantly increased plant height and number of primary branches. It also reduced the days to flowering and increased fruit set both with and without FYM. Quality parameters like reducing sugars, total sugars, vitamin C and lycopene content also improved by B application.

Taber and Henry (2008) reported Fresh market tomato production has a high demand for potassium (K) and may be responsive to the micronutrient boron (B). An excellent Iowa yield of 1,000 cwt/acre will remove 240 lb of K_20/acre in the fruit alone. Thus, growers apply high rates of K_20 fertilizer to achieve top yields and quality. Iowa research and soil surveys over the years have shown no need for B additions for corn, soybean, and alfalfa production. However, our vegetable K research trials have shown low B leaf levels early in the growing season, 27 to 42 ppm. Tomato leaf sufficiency ranges vary from 20 to 75 ppm, depending on the region where the research was conducted at the time of sampling.

Smitha and Ukkund (2008) studied the effect of foliar application of micronutrients on growth and yield of tomato. The results with nine different treatments, the application of boric acid @ of 100 ppm resulted in maximum yield per plant (2.07 kg) and fruit yield (30.50 t/ha). Followed by best treatment was the mixture of micronutrients (Bo, Zn, Mn and Fe@ 100ppm and Mo@ 50 ppm) recording fruit yield of 27.98 t/ha and differed significantly from the control as well as other treatments. The maximum benefit ratio of 1.80 was obtained with application of boron recording net returns followed by mixture of micronutrients recording net returns compared to control.

Basavarajeshwari *et al*. (2006) studied the effect of foliar application of micronutrients on growth and yield of tomato. The results based on two years mean revealed that out of nine different treatments, the application of boric acid @ of 100 ppm resulted in maximum number yield per plant (2.07 kg) and fruit yield (30.50 t/ha). Followed by best treatment was the mixture of micronutrients (Bo, Zn, Mn and Fe@ 100 ppm and Mo @ 50 ppm) recording fruit yield of 27.98 t/ha and differed significantly from the control as well as other treatment.

2.2 Influence of tomato line

Ali *et al.* (2014) investigated performance of thirteen local and exotic hybrid tomato varieties were evaluated to see their performances during the winter season. All the characters showed significant differences among the varieties. The average fruit weight was maximum in BARI F_1 tomato-5 and minimum in Abhilash. The maximum yield (93.21 t/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.

Aoun *et al.* (2013) reported that physicochemical, nutritional, agronomic and sensorial parameters, which define fruit quality of tomato, were evaluated in 13 traditional varieties collected from several localities, using three commercial varieties as controls. Several varieties were identified as better score for total solid, soluble solid, sugars/acid ratio and vitamin C concentration than the commercial varieties.

Islam *et al.* (2013) investigated performance Nine traits of 11 cherry tomato var. cerasiforme (Dunal)) inbred lines exhibited a wide range of genetic variability. Resuslt of the investigation indicates that improvement of high yield through selection is difficult, rather hybridization can be effective for improving the fruit yield/plant.

Naga *et al.* (2013) investigated the influence of micronutrients application on growth and seed yield in tomato in two varieties of tomato viz Utkal Kumari and Utkal Raja. The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese, mixture of all and control. Tomato cv. Utkal Raja, maximum increase in branches per plant was observed with the application of manganese followed by micronutrient combination. In both the varieties, interaction application of micronutrients produced the maximum fruit yield followed by application of boron and zinc.

Akteruzzaman (2012) conducted a pot experiment in the net house to study the effect of boron on the growth, yield, size, shape and nutrient contents of three varieties of tomato *viz.* BINA Tomato-6 (BT-6), BINA Tomato-7 (BT-7) and BARI Tomato-14 (BT-14). Boron (B) significantly influenced the growth, yield, size, shape and nutrient contents of three varieties of tomato. Growth parameters like plant height, number of bloomed flower plant^{-1}, number of fruits plant^{-1}, fruit size (fruit diameter), number of deformed fruit plant^{-1}, yield plant^{-1}, total soluble solids and vitamin C were significantly influenced due to the addition of B.

Gurmani *et al*. (2012) designed a glasshouse pot experiment, with two tomato cultivars VCT-1 and Riogrande, to assess the effects of four levels of soil application of B (0, 0.5, 1.0 and 1.5 mg kg^{-1}) in the form of borax on plant growth and fruit yield. Application of 0.5 mg B kg^{-1} had lower dry matter production as well as fruit yield when compared with B 1.0 and 1.5 mg kg^{-1}. Foliar application of boron in both cultivars at 1.0 and 1.5 mg kg^{-1} significantly increased chlorophyll, sugar and protein content. The study results showed that foliar application of 1.0 mg B kg^{-1} have positive effect on plant growth, yield and biochemical component of both cultivars.

Luis *et al*. (2012) conducted a study to evaluate the effect of boron on two tomato lines. The objective of this research was to study the how B toxicity affects the time course of different indicators of abiotic stress in leaves of two tomato genotypes having different sensitivity to B toxicity (cv. Kosaco and cv. Josefina). These results were more pronounced in the cv. Josefina, indicating greater sensitivity than in cv. Kosaco with respect to excessive B in the environment. Their results indicate that these parameters could be used to evaluate the stress level as well as to develop models that could help to prevent the damage inflicted by B toxicity in tomato plants.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October 2016 to April 2017. The materials and methods those were used and followed for conducting the experiment have been presented below:

3.1 **Experimental site**

This study was conducted at the Horticulture Farm showed in Plate-1(A & B), Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. The location of the experimental site is 23°74′N latitude and 90°35′E longitude with the altitude of 8.6 meter above the sea level, which have been shown in the Appendix I.

3.2 Soil of the experimental field

The soil of the experimental area belongs to the Modhupur Tract under AEZ No. 28. The characteristics of the soil under the experiment were analyzed in the Laboratory of Soil science Department, SAU, Dhaka and details of soil characteristics have been presented in Appendix I(a).

3.3 Climatic Condition of the experimental site

The experimental site is situated in the sub-tropical monsoon climatic zone, which is characterized by heavy rainfall during the months from April to September (Kharif season) and scanty of rainfall during the rest of the month of the year (Rabi season). Plenty of sunshine and moderately low temperature prevail during October to March (Rabi season), which are suitable for growing of tomato in Bangladesh. The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season October 2016 to April 2017 have been presented in Appendix I(b).

3.4 Planting materials

Seedlings of 30 days of two tomato lines Exotic tomato line-1 and Exotic tomato line-2 from AVRDC and a local variety were used. The seedlings of tomato were grown at the nursery of Horticulture Farm in Sher-e-Bangla Agricultural University, Dhaka-1207. BARI Tomato-15, a high yielding tomato variety, developed by the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, used as check variety for comparison. Its total duration is about 95-110 days after transplanting. Other two lines are exotic and collected from Horticultural Biotechnology and Stress Management Lab, SAU, Dhaka-1207.

3.5 Treatments of the experiment

The experiment consisted of two factors:

Factor A: Different levels of Boron/Boric acid

B_0 = Foliar Spray with Water (Control)
B_1 = Foliar Spray with 100 ppm boron
B_2 = Foliar Spray with 200 ppm boron

Factor (B): Tomato Lines

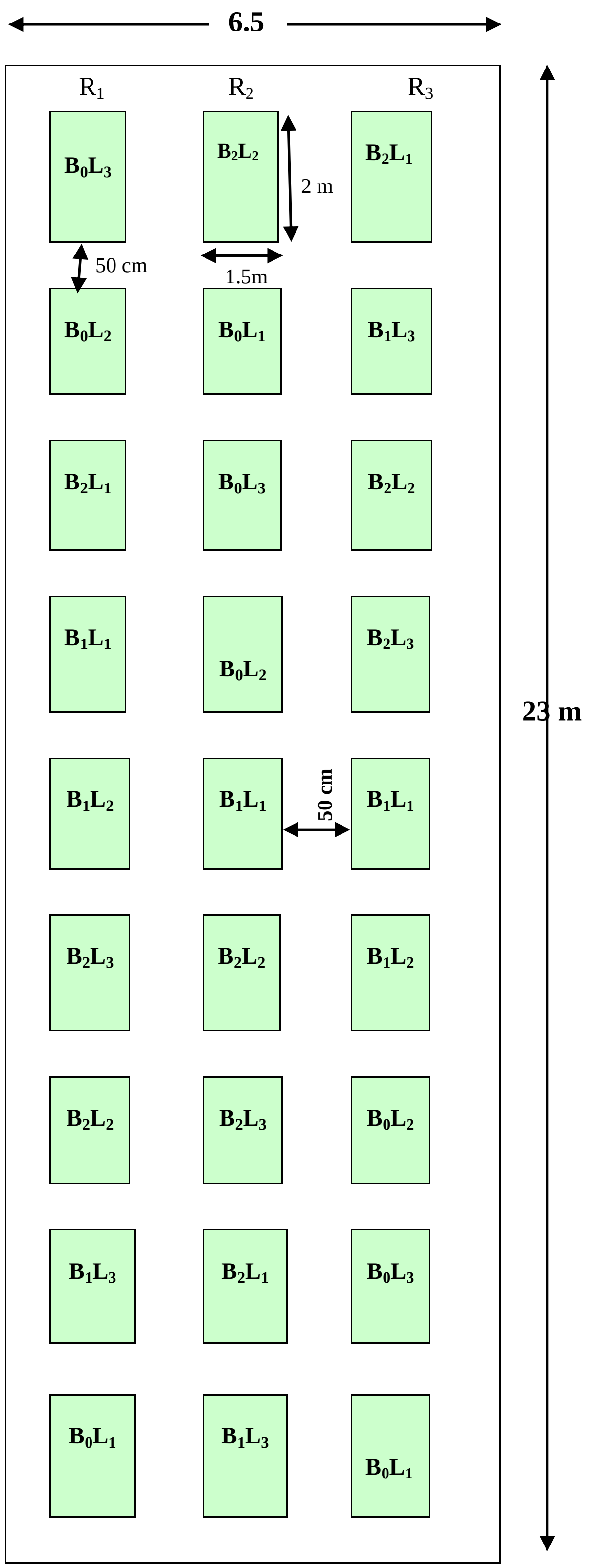
L_1= Exotic Tomato Line-1
L_2 = Exotic Tomato Line-2
L_3 = BARI Tomato-15 (Check variety)

Total 9 treatment combinations are as follows:

B_0L_1, B_0L_2, B_0L_3, B_1L_1, B_1L_2, B_1L_3, B_2L_1, B_2L_2, B_2L_3.

3.6 Design and layout of the experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three levels of Boron and three tomato lines. Three replications were maintained in this experiment.



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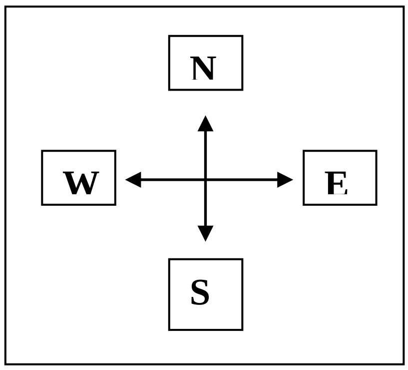

Treatments:

Factor A: Boron level as boric acid

B_0 = 0 ppm

B_1 = 100 ppm

B_2 = 200 ppm

Factor B: Exotic Tomato Lines

L_1 = Exotic Tomato Line-1

L_2 = Exotic Tomato Line-2

L_3 = BARI Tomato-15

Experiment layout:

Plant spacing = 50 cm × 50 cm

Replication to replication distances = 50 cm

Row to Row distance= 50 cm

Replication = 3

Total plot area = 23m × 6m= 138m^2

Figure-1: Design and layout of the research

Each replication containing 9 plots of 1.5 m x 2 m size, giving 27 unit plots. The space was kept 0.5 m between replications. Row to row and plant to plant distance were 50 cm and 50 cm, respectively. The layout of the experiment is shown in Figure 1.

3.7 Raising of seedlings

A common procedure was followed in raising of seedlings in the seedbed. Tomato seedlings were raised in one seedbed on a relatively high land at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the seedbed was (3 m × 1 m). The soil was well prepared with spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed from the seedbed and 5 kg well rotten cowdung was applied during seedbed preparation. The seeds were sown in the seedbed at 19 October, 2016 to get 30 days old seedlings. Germination was visible 4 days after sowing of seeds. After sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg ha^{-1} around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place within 5 to 6 days after sowing. Necessary shading by banana leaves was provided over the seedbed to protect the young seedlings from scorching sun or heavy rain. Weeding, mulching and irrigation were done from time to time as and when required to provide seedlings of a good condition for growth and no chemical fertilizer was used in this seedbed.

3.8 Field preparation

The experimental field was thoroughly ploughed and cross ploughed and cleaned prior to seed sowing and application of fertilizers and manure (Appendix-I.c) were done in the field. The experimental field was prepared by through ploughing followed by laddering to have until good tilth. Finally the land was properly leveled before transplanting then the plots were prepared as per the design.

3.9 Uprooting and transplanting of seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seedbed and were transplanted in the experimental plots in 19 November, 2016 maintaining required seedlings in each plot. The seedbed was watered before uprooting the seedlings from the seedbed to minimize damage to the roots with ensuring maximum retention of roots. Transplanting was done in the afternoon. The seedlings were watered after transplanting. Shading was provided using banana leaf sheath for three days to protect the seedlings from the scorching sun and removed after seedlings were established.

3.10 Application of the treatments

Tomato plants were treated with 0, 100 ppm and 200 ppm of boric acid with foliar application method by hand sprayer. Foliar application of different concentrations of boron were applied at 10 days interval after 20 days of transplanting up to fruit setting.

3.11 Intercultural operations

3.11.1 Irrigation

Light watering was provided with water cane immediately after transplanting the seedlings and this technique of irrigation was used as every day at early morning and sometimes also in evening throughout the growing period. But the frequency of irrigation became less in harvesting stage. The amount of irrigation water was limited up to that quantity which does not leached out through the bottom.

3.11.2 Staking

When the plants were well established, staking was given to each plant by bamboo sticks for support to keep them erect (Plate-2).

3.11.3 Gap filling

Very few seedlings were damaged after transplanting and these were replaced by the new seedlings from the same stock.

3.11.4 Weeding

Weeding was done whenever it was necessary, mostly in vegetative stage.

3.11.4 Plant protection measures

Malathion 57 EC was applied @ 2 ml L^{-1} of water against the insect pests like cutworm, leaf hopper, fruit borer and others. The insecticide application was stopped before second week of first harvest. During foggy weather precautionary measure against disease attack of tomato was taken by spraying Diathane M-45 fortnightly @ 2 g/l of water at the early vegetative stage. Ridomil gold was also applied @ 2 g/l of water against blight disease of tomato.

3.12 Harvesting

Fruits were harvested at 2-3 days interval during early ripening stage (Plate 3) when they developed red color slightly. Harvesting was started from 18 February, 2017 and was continued up to last week of March, 2017.

3.13 Recording of data

Experimental data were recorded from 25 days after transplanting and continued until harvest in field. In laboratory, quality analysis data also recorded based on parameters. Data were collected from six plants of each plot.

3.14 Detailed procedures of recording data

A brief outline of the data recording procedure followed during the study is given below:

3.14. 1. Plant height

Plant height was measured at 25, 45 and 65 DAT. The height of the plant was determined in centimeter by measuring the distance from the soil surface to the tip of the highest leaf.

3.14. 2. Number of leaf per plant

Leaf number was counted at 25, 45 and 65 DAT. The number of leaves per plant was counted from each plant.

3.14. 3. Foliage coverage

Foliar coverage was measured with a meter scale. It was estimated at the point where the plant was highly covered the area by the expansion of leaves. It was done five times during experimentation. It was measured at 25, 45 and 65 days after seedling transplant.

3.14. 4. Leaf area

Leaf area was measured at 25, 45 and 65 DAT by non-destructive method using CL-202 Leaf Area Meter, (USA). Mature leaves were measured all the time and were expressed in cm^2.

3.14. 5. Length of internode:

Plants were selected to determine internode length of plants. A scale was used to measure the distances of two consequence node of a plant.

3.14. 6. Stem diameter

Stem diameter was recorded from six plants of each plot. Stem diameter was measured at the 5 cm above the ground. The average value was recorded as stem girth in cm.

3.14. 7. Number of branches per plant

The total number of branches per plant was counted from each plant at 25, 45 and 65 DAT. There estimated an average value from collected value from six plants was maintained per plot.

3.14. 8. Chlorophyll content

Leaf chlorophyll content was measured using a hand-held chlorophyll content SPAD-502 Plus (KONKA MINOLLTA). At each evaluation the content was measure 5 times from five leaves at different positions per plant and the average was used for analysis. The data was recorded at 3 stages of plants, i.e. vegetative, flowering and fruiting stage.

3.14. 9. Number of flower clusters per plant

The total number of flower was counted from six sample plants periodically at different days after transplanting. The average number of flower produced per plant was recorded and calculated.

3.14. 10. Days of first flower initiation

The number of days from the date of transplanting to the date of first flower blooming was recorded.

3.14. 11. Number of flowers per cluster

The number of fruit cluster was recorded from the six sample plants at different days after transplanting, and the average number of fruit clusters produced per plant was recorded.

3.14. 12. Number of flowers per plant

The number of flower per plant was counted and recorded.

3.14. 13. Number of fruit per cluster

The number of fruits per cluster was taken from sample plants was calculated as follow:

$$\text{Number of fruit per cluster} = \frac{\text{Total number of fruit in sample plants}}{\text{Total number of fruit cluster in sample plants.}}$$

3.14. 14. Total number of fruits per plant

The total number of fruit was recorded from six sample plants at different days after transplanting and the average number of fruit produced per plant was recorded.

3.14. 15. Fruit set percentage

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

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

3.14. 16. Weight of individual fruit

Among the total number of fruits during the period from first to final harvest, fruit was considered for determining the individual fruit weight by the following formula:

$$\text{Weight of individual fruit (g)} = \frac{\text{Total weight of fruits}}{\text{Total number of fruits}}$$

3.14.17. Length of fruit

Fruit length was measured from the neck of fruit to the bottom of the same by using slide calipers of five fruits randomly selected from each of the pot.

3.14. 18. Diameter of fruit

Fruit diameter was measured along the equatorial part of the same five represented fruit by distal slide calipers and their average was taken.

3.14. 19. Fruit yield per hectare

Yield per hectare of tomato was calculated from the six plants from the each plot and was expressed in tonne.

3.14.20. Measurement of total soluble solids (TSS)

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

3.14.21. Measurement of tomato p^H

Two tomato samples were collected from each of the treatment which was fully ripened. Each sample was blended and it was made in liquid form. All the samples were taken in clean and transparent plastic pots. Electric p^H meter (Model H 12211 p^H/OPR meter of Hanna Company) was adjusted in buffer solution of p^H 7.0; later on again it was adjusted in buffer solution containing p^H 4.0. Finally, Electric p^H meter was inserted in first sample and data was recorded. Again, p^H meter was inserted in buffer solution containing p^H 4.0 to adjust the p^H meter and again it was inserted in second sample of tomatoes and data was recorded. The same procedure was followed to measure p^H of all other samples.

3.14.22 Measurement of Vitamin-C

Vitamin-C was measured by Oxidation Reduction Titration Method (Plate 4). Single fruit was blend and tomato extract was filtrated by Whatman No.1 filter paper. It was then mixed with 3% metaphosphoric acid solution. The titration was conducted in presence of glacial acetic acid and metaphosphoric acid to inhibit aerobic oxidation with dye solution (2, 6-dichlorophenol indophenol). The solution was titrated with dye. The observations mean will give, the amount of dye required to oxidize definite amount of L-ascorbic acid solution of unknown concentration, using L-ascorbic acid as known sample. It was measured in Genetics and Plant Breeding Lab, Sher-e-Bangla Agriculture University, Dhaka.

3.15. Statistical Analysis

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

Plate 1: **Experimental field**

Transplanted seedling

1st flowering

Vegetative growth

Flowering plants in plot

Plate 2: **Growth and flowering stages of tomato plant**

Plate 3: Fruits of different tomato lines on plant

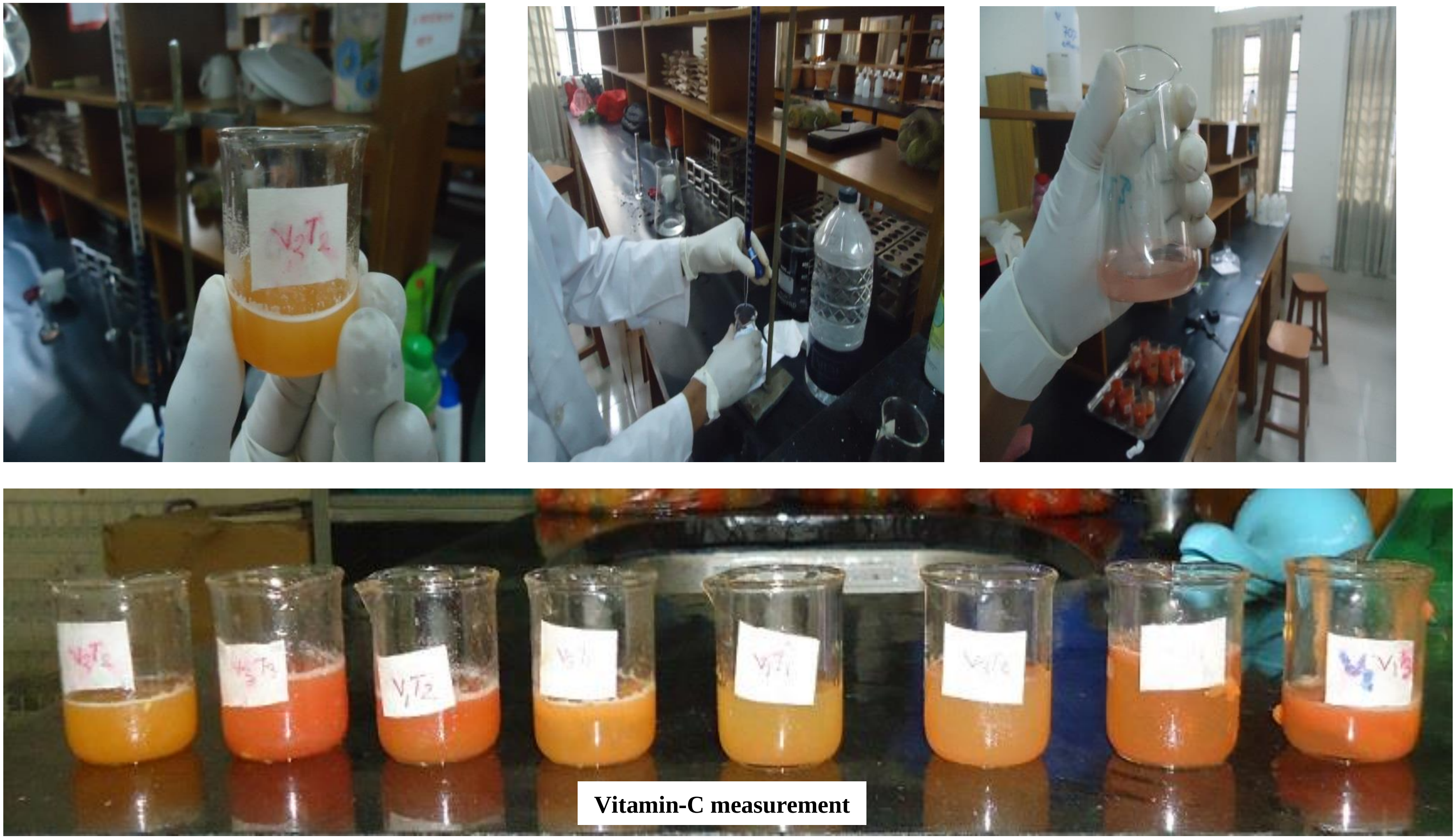

Plate 4: Quality analysis of tomato in laboratory

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the effect of boron on the growth, yield and quality of exotic tomato line. The effects due to different levels of boron, tomato line and their interaction on the growth, yield and quality contributing characters have been presented in figure and table. Results of the different parameters studied in the experiment have been presented and discussed under the following headings:

4.1 Plant height

Plant height is an important character of a plant, which is closely related to proper growth and development and finally produced higher yield. Plant height of tomato varied significantly at 45 and 65 days after transplanting (DAT) due to foliar spray of different levels of boron except 25 DAT (Appendix II). At 65 DAT, the longest plant (102.9 cm) was produced from B_1 (foliar spray with 100 ppm boric acid) followed by (96.93 cm) produced from B_0 (control) treatment and the shortest (90.64 cm) was found from B_3 (foliar spray with 200 ppm boric acid) treatment (Fig. 2). Boric acid generated higher plant height due to the improvement of vegetative growth of tomato plant through better uptake of boron but excess amount may toxic to the plant. The increased height may be due to the influence of foliar application of boron. Sivaiah *et al.* (2012), Weerasinghe *et al* (2014) and Meena *et al*. (2015) also said that boron increase plant height of tomato.

Plant height of tomato varied significantly at different days after transplanting (DAT) due to effect of tomato line (Appendix II). At 65 DAT, the tallest plant (127.8 cm) was produced from L_1 (Exotic Tomato Line-1). The shortest plant (74.16 cm) was produced in L_3 (BARI Tomato -15) treatment (Fig. 3) at 65 DAT. Similar results were also found by Naga *et al.* (2013).

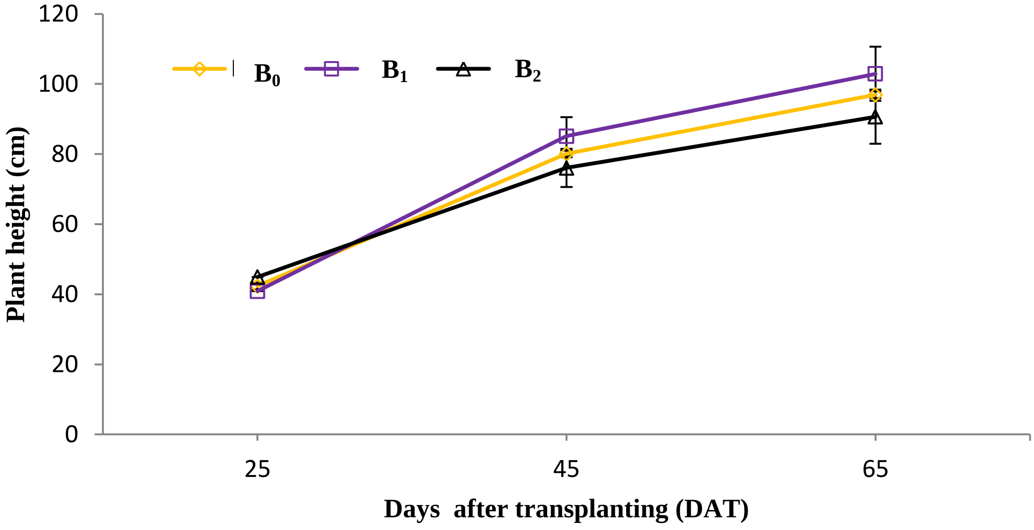

Fig. 2. Effect of different levels of boron on the plant height of tomato at different days after transplanting (LSD $_{(0.05)}$ = NS, 5.41 and 7.73 at 25, 45 and 65 DAT, showing vertical error bar respectively)

(Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

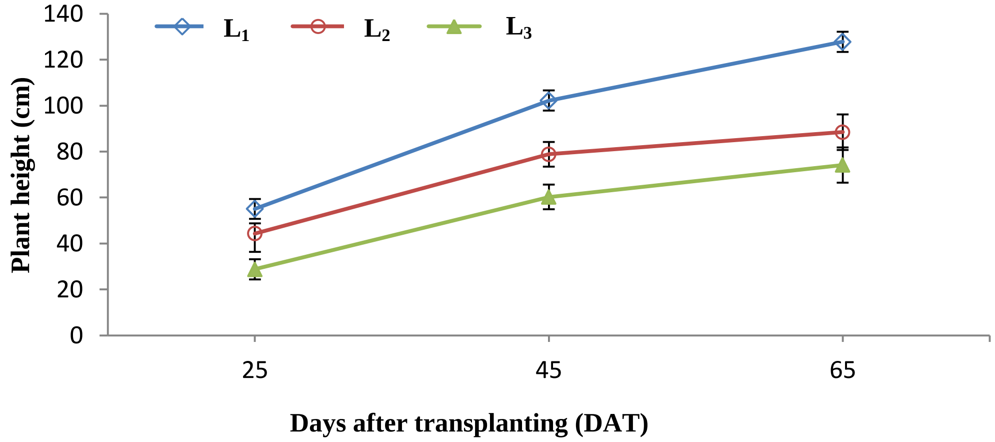

Fig. 3. Effect of tomato line on the plant height of tomato at different days after transplanting (LSD $_{(0.05)}$ = 4.38, 5.41 and 7.73 at 25, 45 and 65 DAT, showing vertical error bar respectively)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

The variations in plant height at different days after transplanting due to interaction effect of boron and tomato line were found to be statistically significant at 25, 45 and 65 DAT (Appendix II). The plant height at 65 DAT ranged from 68.89 cm to 135.40 cm. The tallest plant (135.40 cm) was observed from the treatment combination of B_1L_1 (foliar spray with 100 ppm boric acid) statistically similar to B_0L_1 and the shortest plant (68.89 cm) was found from the treatment combination of B_2L_3 (foliar spray with 200 ppm boric acid + BARI Tomato-15) which was statistically similar to B_0L_3 and B_1L_3 (Table 1).

Table 1. Interaction effect of different levels of boron and tomato line on the plant height of tomato at different days after transplanting

Treatment combinations	Plant height (cm) at different days after transplanting (DAT)		
	25	**45**	**65**
B_0L_1	55.55 a	103.5 ab	128.90 ab
B_0L_2	43.50 bc	78.61 c	88.44 c
B_0L_3	27.93 d	58.11 d	73.43 de
B_1L_1	53.66 a	108.6 a	135.40 a
B_1L_2	39.64 c	82.32 c	93.11 c
B_1L_3	29.39 d	64.49 d	80.17 c-e
B_2L_1	55.93 a	94.39 b	119.20 b
B_2L_2	49.83 ab	75.61 c	83.88 cd
B_2L_3	29.06 d	58.17 d	68.89 e
LSD $_{(0.05)}$	7.59	9.36	13.39
CV (%)	10.26	6.73	7.99

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

Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1=Exotic Tomato Line-1, L_2 =Exotic Tomato Line-2 and L_3 = BARI Tomato-15

4.2 Number of leaves per plant

Number of leaves per plant of tomato varied significantly at 45 and 65 days after transplanting (DAT) due to different boron levels except at 25 DAT (Appendix III). At 65 DAT, the highest number of leaves per plant (48.34) was obtained from B_1 (foliar spray with 100 ppm boric acid) and the lowest (39.13) from B_2 (200 ppm boric acid) application (Fig. 4). Chude and Oyinlola (2004) reported that application of boron significantly increased the number of leaves on tomato plant compared to control.

Number of leaves per plant is an important parameter of crop plant because of its physiological role in photosynthetic activities. Number of leaves is directly related to the tomato yield. Number of leaves per plant of tomato varied significantly at 25, 45 and 65 days after transplanting (DAT) due to effect of tomato line (Appendix III). At 65 DAT, the highest number of leaves (51.16) per plant was obtained from L_1 (Exotic Tomato Line-1) and the lowest (33.69) from L_2 (Fig. 5).

Interaction effect of different levels boron and tomato line were found to be statistically significant (Appendix III). Number of leaves per plant was gradually increased with the age of plant up to final harvest. It was ranged from 30.17 to 58.41 at 65 DAT. The maximum number of leaves per plant (58.41) was recorded by the treatment combination of B_1L_1 (100 ppm boric acid +Exotic Tomato Line-1). The minimum number of leaves per plant (30.17) was found by treatment combination of B_2L_2 (200 ppm boric acid+ BARI Tomato-15) which was statistically identical to (34.50) and (36.39) interaction of B_0L_2 and B_1L_2 (Table 2).

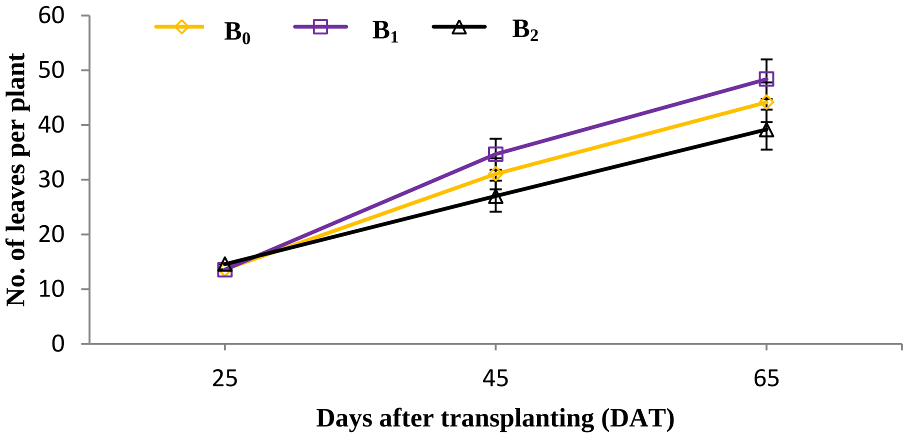

Fig. 4. Effect of different levels of boron on the no. of leaves per plant of tomato at different days after transplanting (LSD $_{(0.05)}$ = NS, 2.84 and 3.63 at 25, 45 and 65 DAT, showing vertical error bar respectively)

(Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

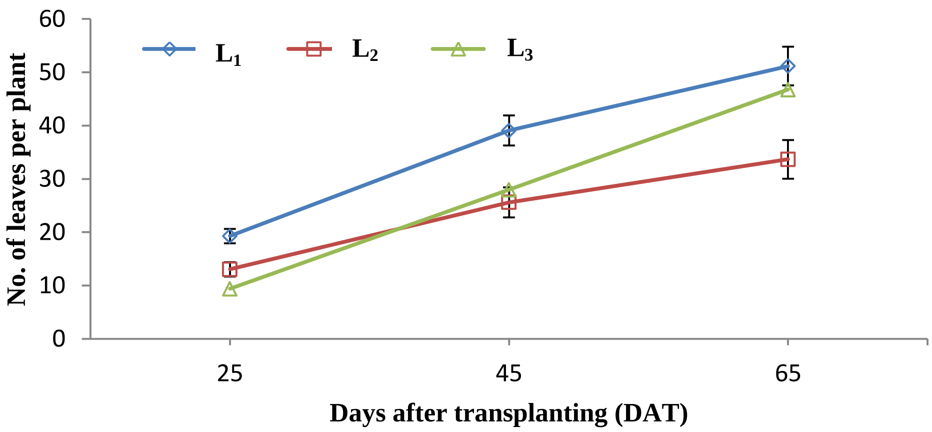

Fig. 5. Effect of tomato line on the no. of leaves per plant of tomato at different days after transplanting (LSD $_{(0.05)}$ = 1.34, 2.84 and 3.63 at 25, 45 and 65 DAT, showing vertical error bar respectively)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

Table 2. Interaction effect of different levels of boron and tomato line on the no. of leaves per plant at different days after transplanting

Treatment combinations	No. of leaves per plant at different days after transplanting (DAT)		
	25	**45**	**65**
B_0L_1	17.98 b	39.89 a	50.31 b
B_0L_2	13.11 c	26.00 cd	34.50 e
B_0L_3	9.72 d	27.22 cd	47.63 bc
B_1L_1	19.17 ab	42.55 a	58.41 a
B_1L_2	12.16 c	28.18 c	36.39 de
B_1L_3	9.28 d	33.22 b	50.22 b
B_2L_1	20.68 a	34.83 b	44.78 bc
B_2L_2	13.83 c	22.63 d	30.17 e
B_2L_3	9.17 d	23.48 cd	42.44 cd
$LSD_{(0.05)}$	2.31	4.91	6.29
CV (%)	9.62	9.19	8.29

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

Here, B_0 = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1= Exotic Tomato Line-1, L_2 = Exotic Tomato Line-2 and L_3 = BARI Tomato-15

4.3 Foliage coverage

The results of foliage coverage showed significant variation on plant of tomato for different levels of boron at different days after transplanting except 25 DAT (Appendix IV). The highest foliage coverage (64.30 cm) was recorded from B_1 (foliar spray with 100 ppm boric acid) and the lowest foliage coverage (55.93 cm) was recorded from B_2 (foliar spray with 200 ppm boric acid), (Fig. 6) at 65 DAT respectively. This result might be due to cause of proper boron level and similar result was found by El-Feky *et al.* (2012).

Effect of tomato line on foliage coverage of tomato showed the significant variation (appendix IV). Foliage coverage of tomato varied significantly at 25, 45 and 65 days after transplanting (DAT) due to different tomato line effect (Appendix IV). At 65 DAT, the highest foliage coverage (61.39 cm) was obtained from L_2 (Exotic Tomato Line -2) and the lowest (58.51 cm) from L_3 ((Fig. 7). The results were similar with Ali *et al.* (2014).

Interaction effect of different levels boron and tomato line were found to be statistically significant (Appendix IV). Foliage coverage of plant was gradually increased with the age of plant up to final harvest. It was ranged from 55.69 cm to 65.92 cm at 65 DAT. The minimum foliage coverage (55.69 cm) was found by treatment combination of B_2L_1 (200 ppm boric acid + Exotic Tomato Line -1) which was statistically identical to (55.74 cm), (56.06 cm) and (56.36 cm) interaction of B_2L_3, B_0L_3 and B_1L_2. The maximum (65.92 cm) was recorded by the treatment combination of B_1L_2 (Table 3).

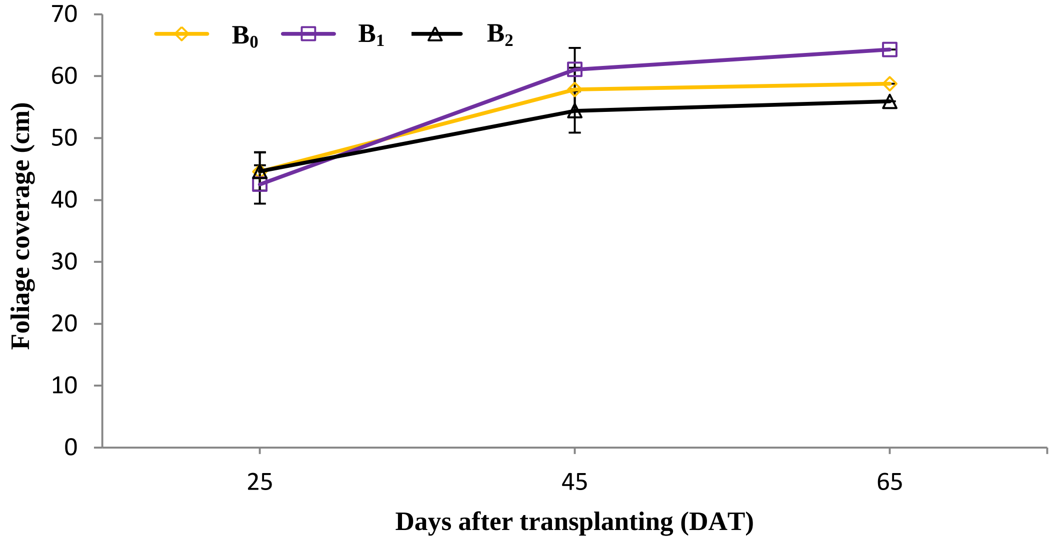

Fig. 6. Effect of different levels of boron on the foliage coverage of tomato at different days after transplanting (LSD $_{(0.05)}$ = NS, 3.52 and 5.42 at 25, 45 and 65 DAT, showing vertical error bar respectively)

(Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

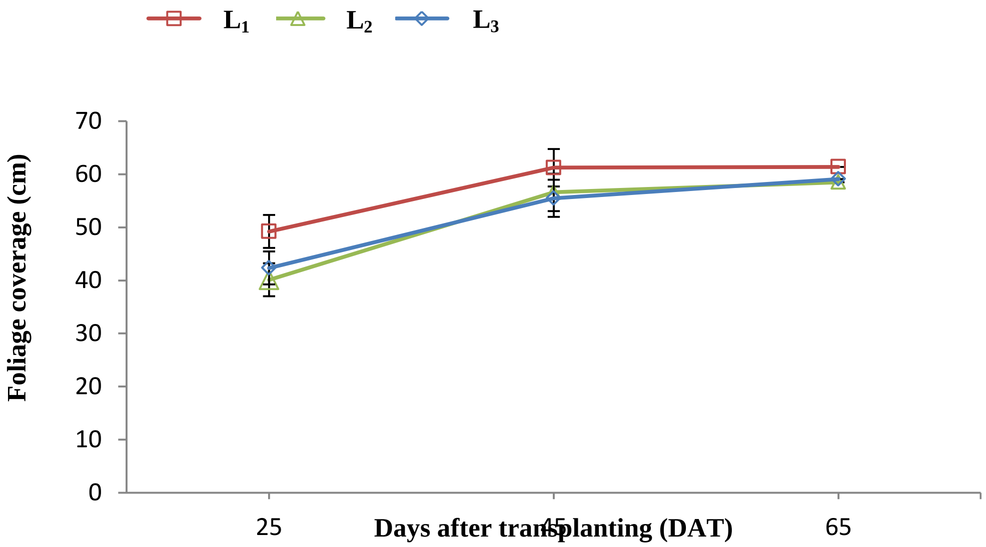

Fig. 7. Effect of tomato line on the foliage coverage of tomato at different days after transplanting (LSD $_{(0.05)}$ = 3.09, 3.52 and NS at 25, 45 and 65 DAT, showing vertical error bar respectively)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3= BARI Tomato-15)

Table 3. Interaction effect of different levels of boron and tomato line on the foliage coverage of tomato at different days after transplanting

Treatment combinations	Foliage coverage (cm) at different days after transplanting (DAT)		
	25	**45**	**65**
B_0L_1	42.78 bc	54.94 c-e	58.36 ab
B_0L_2	51.00 a	61.37 ab	61.89 ab
B_0L_3	39.89 c	57.24 b-e	56.06 b
B_1L_1	41.33 c	60.06 a-c	63.25 ab
B_1L_2	48.04 ab	64.00 a	65.92 a
B_1L_3	38.17 c	59.15 a-d	63.72 ab
B_2L_1	42.94 bc	51.44 e	55.69 b
B_2L_2	48.61 a	58.36 a-d	56.36 b
B_2L_3	42.31 c	53.38 de	55.74 b
LSD $_{(0.05)}$	5.35	6.09	9.39
CV (%)	7.03	6.09	9.09

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

Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1= Exotic Tomato Line-1, L_2 = Exotic Tomato Line-2 and L_3 = BARI Tomato-15

4.4 Length of internode

Significant variation was found on length of internode (cm) of tomato for different levels of boron at 45 and 65 DAT but not at 25 DAT (Appendix V). The highest length of internodes (5.08 cm) was recorded from B_1 (foliar spray with 100 ppm boric acid) which was statistically similar with (4.91 cm) B_0 (control) while the lowest length of internodes (4.46 cm) at 65 DAT was recorded from B_2 (Fig. 8). Davis *et al* (2003) also have found similar result.

Significant variation was found due to the effect of tomato line on length of internode of tomato (Appendix V). It was observed at 65 days, the highest internodal length was found (5.89 cm) from L_1 (Exotic Tomato Line-1) where the lowest intermodal length (3.88 cm) was obtained from L_3 (Fig. 9).

Significant variation was found due to the interaction effect of different levels of boron and tomato line on length of internode of tomato at 25, 45 and 65 DAT (Appendix V). The highest length of internodes (6.25 cm) at 65 DAT was recorded from B_1L_1 (100 ppm boric acid + Exotic Tomato Line-1) followed by B_0L_1. The lowest length of internodes (3.56 cm) at 65 DAT was recorded from B_2L_3 (Table 4).

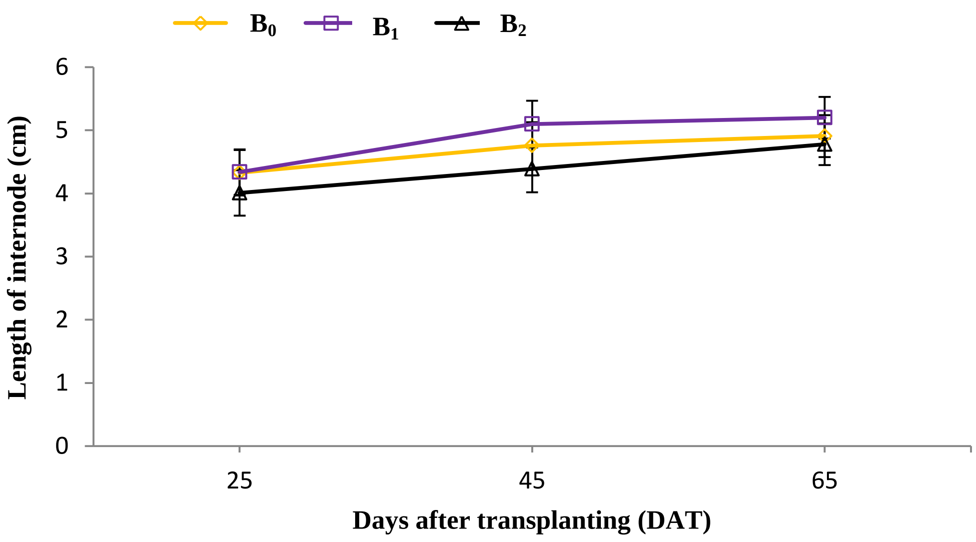

Fig. 8. Effect of different levels of boron on the length of internode at different days after transplanting (LSD $_{(0.05)}$ = NS, 0.36 and 0.33 at 25, 45 and 65 DAT, showing vertical error bar respectively)

(Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

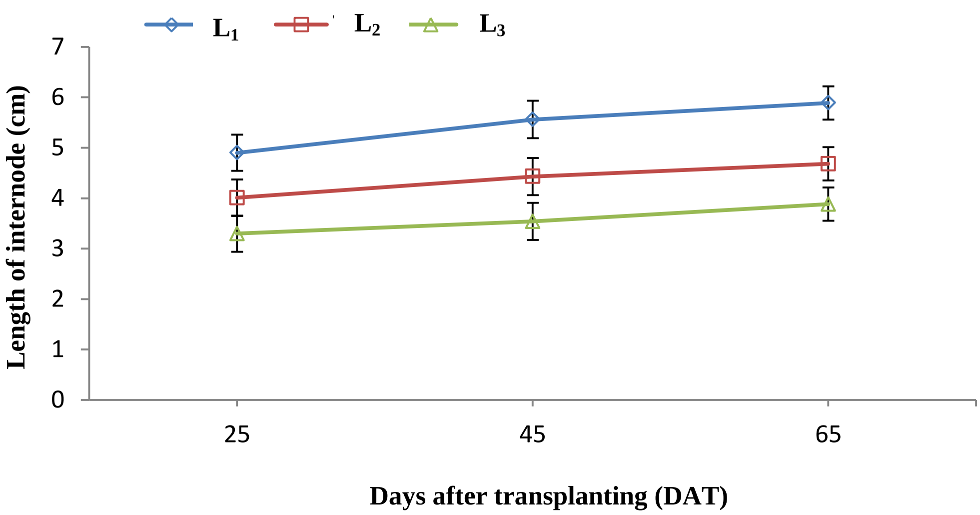

Fig. 9. Effect of tomato line on the length of internode of tomato at different days after transplanting (LSD $_{(0.05)}$ = 0.35, 0.36 and 0.33 at 25, 45 and 65 DAT, showing vertical error barrespectively)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3 = BARI Tomato-15)

Table 4. Interaction effect of different levels of boron and tomato line on the length of internode of tomato at different days after transplanting

Treatment combinations	Length of inter node (cm) at different days after transplanting (DAT)		
	25	45	65
B_0L_1	5.04 a-c	5.19 ab	5.96 ab
B_0L_2	4.58 cd	4.92 ab	4.79 d
B_0L_3	3.36 e	4.17 cd	3.97 ef
B_1L_1	5.43 ab	5.28 a	6.25 a
B_1L_2	4.20 d	5.15 ab	4.89 cd
B_1L_3	3.39 e	4.72 abc	4.11 ef
B_2L_1	5.59 a	5.07 ab	5.46 bc
B_2L_2	4.92 bc	4.61 bc	4.36 de
B_2L_3	3.14 e	3.97 d	3.56 f
$LSD_{(0.05)}$	0.60	0.63	0.58
CV (%)	7.88	7.61	6.93

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

Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1= Exotic Tomato Line-1, L_2 = Exotic Tomato Line-2 and L_3 = BARI Tomato-15

4.5 Stem Diameter

The results of stem diameter showed significant variation on plant of tomato for different levels of boron (Appendix VI). The highest stem diameter (1.6 cm) was recorded from B_1 (foliar spray with 100 ppm boric acid) and the lowest stem diameter (0.93 cm) was recorded from B_2 (foliar spray with 200 ppm boric acid) at 65 DAT respectively (Fig. 10). Application of boron might increase the uptake of plant nutrients and enhance the various mechanisms (photosynthesis, cell division) consequently improve plant growth. These results are in conformity with Siddique *et al.* (2009).

Effect of line on stem diameter of tomato showed the significant variation (Figure 5). Stem diameter of tomato varied significantly at 25, 45 and 65 days after transplanting (DAT) due to different tomato line effect (Appendix VI). At 65 DAT, the highest stem diameter (1.50 cm) was obtained from L_3 (BARI Tomato-15) and the lowest (1.03 cm) from L_2 (Exotic Tomato Line -2), (Fig. 11).

Interaction effect of different levels of boron and tomato line were found to be statistically significant (Appendix VI). Stem diameter of tomato plant was gradually increased with the age of plant up to final harvest. It was ranged from 0.89 to 2.3 cm at 65 DAT. The maximum stem diameter (2.3 cm) was recorded by the treatment combination of B_1L_3 (100 ppm boric acid + BARI Tomato-15). The minimum stem diameter (0.89 cm) was found by treatment combination of B_2L_1 (200 ppm boric acid + Exotic Tomato Line-1) which was statistically identical to (0.97 cm), (1.00 cm) and (1.02 cm) interaction of B_2L_3, B_0L_1 and B_0L_2 respectively (Table 5).

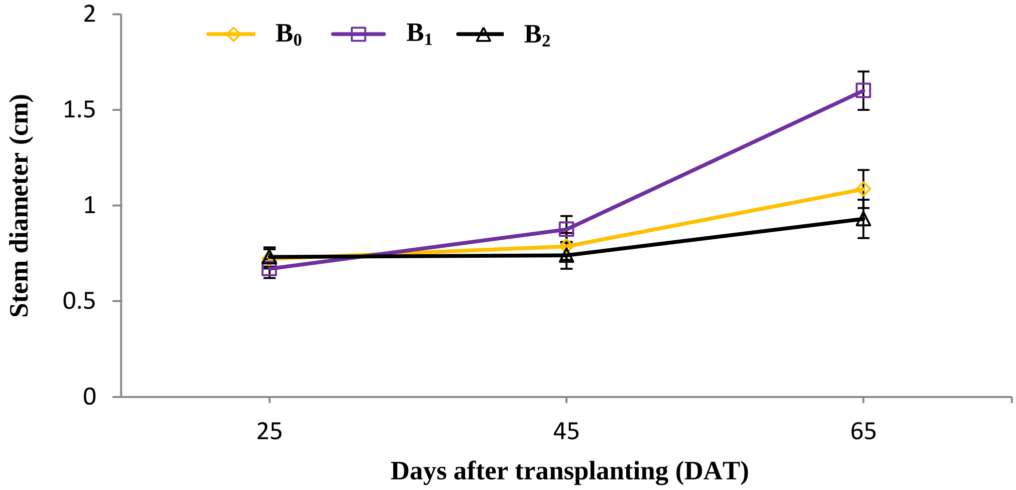

Fig. 10. Effect of different levels of boron on the stem diameter of tomato at different days after transplanting (LSD $_{(0.05)}$ = 0.05, 0.07 and 0.10 at 25, 45 and 65 DAT, showing vertical error bar respectively)

(Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

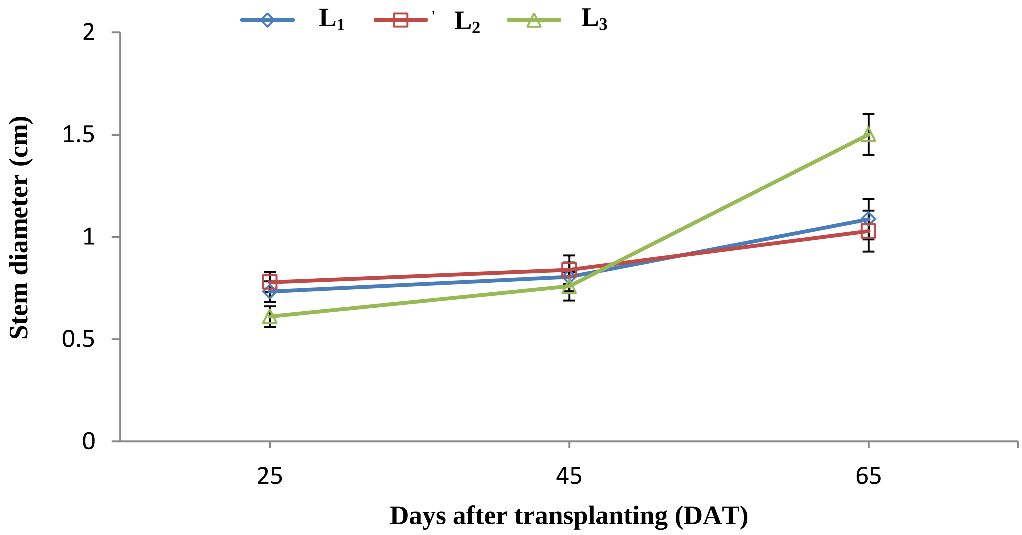

Fig. 11. Effect of line on the stem diameter of tomato at different days after transplanting (LSD $_{(0.05)}$ = 0.05, 0.07 and 0.10 at 25, 45 and 65 DAT, showing vertical error bar respectively)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

Table 5. Interaction effect of different levels of boron and tomato line on the stem diameter at different days after transplanting

Treatment combinations	Stem diameter (cm) at different days after transplanting (DAT)		
	25	45	65
B_0L_1	0.76 ab	0.79 a-d	1.01 de
B_0L_2	0.78 a	0.84 a-c	1.02 de
B_0L_3	0.62 c	0.72 cd	1.23 bc
B_1L_1	0.72 a-c	0.87 ab	1.36 b
B_1L_2	0.77 ab	0.91 a	1.14 cd
B_1L_3	0.52 d	0.85 ab	2.30 a
B_2L_1	0.72 ab	0.75 b-d	0.89 e
B_2L_2	0.78 a	0.76 b-d	0.93 e
B_2L_3	0.69 bc	0.70 d	0.97 de
LSD $_{(0.05)}$	0.09	0.12	0.18
CV (%)	8.2	9.11	8.53

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

Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1=Exotic Tomato Line-1, L_2 =Exotic Tomato Line-2 and L_3 = BARI Tomato-15

4.6 Number of branches per plant

Number of branches per plant was exposed significant with the different levels of boron at different days after transplanting (Appendix VII). Maximum number of branches per plant (3.73) was observed from B_1 (foliar spray with 100 ppm boric acid) whereas the minimum number of branches per plant (3.08) was found from B_2 (200 ppm boric acid) at 65 DAT which has notified in figure 12. Akteruzzaman (2012), Amarchandra and Verma (2003) finds similar result and stated that boron increase number of branch per plant.

Effect of tomato line significantly influenced the number of branches per plant (Appendix VII). L_3 (BARI Tomato-15) plants produced the maximum number of effective branches per plant (4.05) while the minimum number of branches per plant (2.64) was obtained from L_2 (Exotic Tomato Line-2) at 65 DAT (Fig. 13).

Interaction effect of different foliar application of different levels of boron and tomato line showed statistically significant in terms of number of branches per plant at 65 DAT (Appendix VII). Maximum number of branches per plant (4.48) was recorded from B_1L_3 (100 ppm boric acid+ BARI Tomato-15) which was statistically similar with B_0L_3 (4.05) while the minimum number of branches per plant (2.5) was recorded from B_2L_2 (200 ppm boric acid + Exotic Tomato Line-2) which was statistically similar with B_0L_2 treatment combination (Table 6).

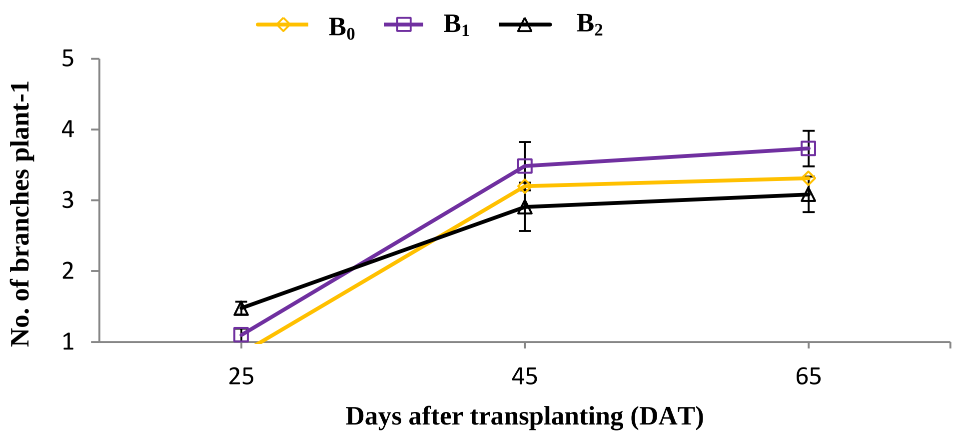

Fig. 12. Effect of different levels of boron on the no. of branches per plant of tomato at different days after transplanting (LSD $_{(0.05)}$ = 0.09, 0.34 and 0.25 at 25, 45 and 65 DAT, showing vertical error bar respectively)
(Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

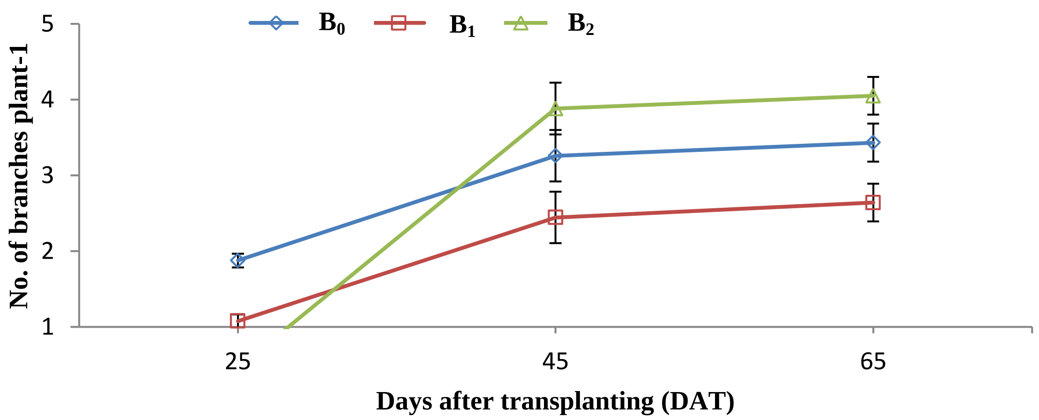

Fig. 13. Effect of tomato line on the no. of branches per plant at different days after transplanting (LSD $_{(0.05)}$ = 0.09, 0.34 and 0.25 at 25, 45 and 65 DAT, showing vertical error bar respectively)
(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

Table 6. Interaction effect of different levels of boron and tomato line on the no. of branches per plant at different days after transplanting

Treatment combinations	No. of branches per plant at different days after transplanting (DAT)		
	25	**45**	**65**
B_0L_1	0.79 d	3.33 bc	3.26 de
B_0L_2	1.11 c	2.45 de	2.61 g
B_0L_3	0.61 e	3.82 ab	4.07 ab
B_1L_1	2.20 b	3.56 b	3.90 bc
B_1L_2	0.88 d	2.67 de	2.82 fg
B_1L_3	0.22 f	4.22 a	4.48 a
B_2L_1	2.64 a	2.89 cd	3.14 ef
B_2L_2	1.24 c	2.22 e	2.50 g
B_2L_3	0.54 e	3.61 b	3.61 cd
$LSD_{(0.05)}$	0.16	0.59	0.44
CV (%)	8.42	10.61	7.5

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

Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1=Exotic Tomato Line-1, L_2 =Exotic Tomato Line-2 and L_3 = BARI Tomato-15

4.7 Leaf area

Leaf area per plant was significantly affected by different levels of boron (Appendix VIII). The highest value of leaf area (307.9 cm^2) was found in B_1 (foliar spray with 100 ppm boric acid) and lowest leaf area (212.0 cm^2) observed from B_2 (foliar spray with 100 ppm boric acid)at 65 DAT (Fig. 14). Similar result was also reported by Salam (2004), stated that boron increased the leaf area of tomato plants.

Effect of tomato line on leaf area of tomato showed significant result (Appendix VIII). The highest leaf area (352.9 cm^2) was found from L_3 (BARI Tomato-15). The lowest leaf area (224.9 cm^2) was found from L_2 at 65 DAT (Fig. 15).

The interaction effect different levels of boron and tomato line had significant effect on the leaf area of tomato (Appendix VIII). Maximum value of leaf area (400.4 cm^2) was obtained from B_1L_3 (100ppm boric acid + BARI Tomato-15) where minimum leaf area value (182.0 cm^2) was obtained from B_2L_1 (Table 7).

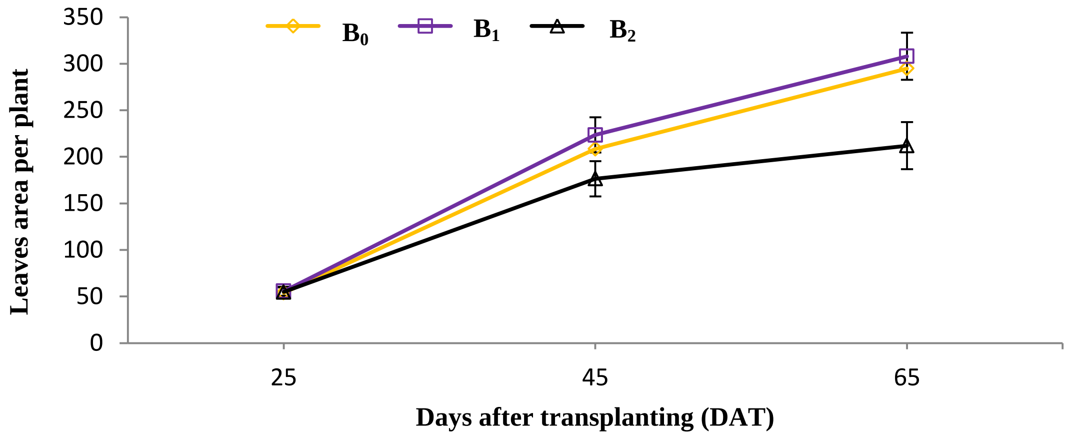

Fig. 14. Effect of different levels of boron on the leaf area per plant of tomato at different days after transplanting (LSD $_{(0.05)}$ = 4.82, 18.18 and 25.31 at 25, 45 and 65 DAT, respectively)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

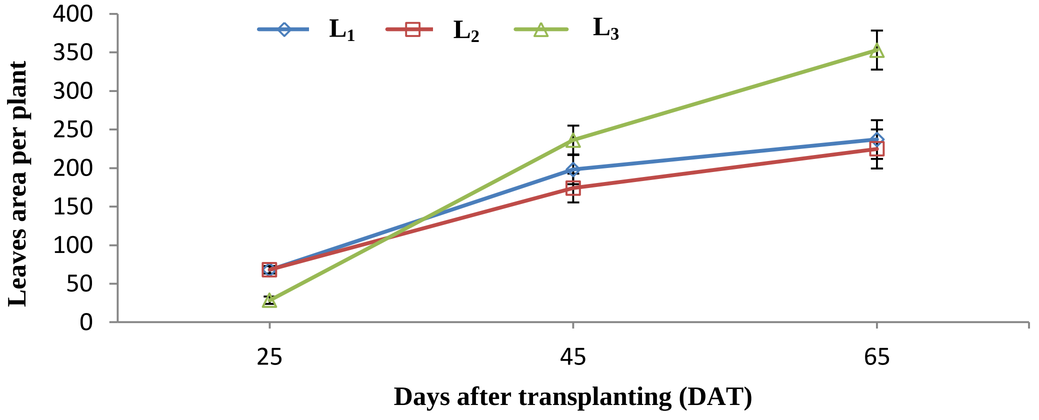

Fig. 15. Effect of tomato line on the leaf area per plant at different days after transplanting (LSD $_{(0.05)}$ = 4.82, 18.18 and 25.31 at 25, 45 and 65 DAT, respectively)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

Table 7. Interaction effect of different levels of boron and tomato line on the leaf area per plant of tomato at different days after transplanting

Treatment combinations	Leaf area per plant (cm^2) at different days after transplanting (DAT)		
	25	**45**	**65**
B_oL_1	63.06 c	210.3 cd	253.0 b
B_0L_2	67.83 bc	173.0 e	235.3 bc
B_0L_3	31.18 d	242.0 ab	396.3 a
B_1L_1	79.01 a	226.2 bc	276.1 b
B_1L_2	62.73 c	186.7 de	247.3 b
B_1L_3	25.34 d	257.7 a	400.4 a
B_2L_1	61.65 c	157.5 e	182.0 d
B_2L_2	73.79 ab	162.6 e	192.0 cd
B_2L_3	29.03 d	209.1 cd	261.9 b
$LSD_{(0.05)}$	8.35	31.49	43.84
CV (%)	8.79	8.97	9.33

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

Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1= Exotic Tomato Line-1, L_2 = Exotic Tomato Line-2 and L_3 = BARI Tomato-15

4.8 Chlorophyll Content

There was significant effect of different levels of boron on chlorophyll content at flowering stage but insignificant at vegetative and fruiting stage (Appendix IX). Maximum chlorophyll content (49.76), (49.58) and (49.33) was found in B_1 at vegetative, flowering and fruiting stage respectively. The minimum chlorophyll content (46.21), (42.75) and (46.02) was found at vegetative, flowering stage in B_2 and at fruiting stage from B_0 (control), (Fig. 16).

Tomato line showed significant effect on Chlorophyll content at flowering stage but insignificant at vegetative and fruiting stage (Appendix IX). The highest chlorophyll content at vegetative, flowering and fruiting stage (49.86), (49.90) and (50.64) was found from L_2 (Exotic Tomato Line-2), L_1 (Exotic Tomato Line-1) and L_2 respectively. The lowest chlorophyll content at vegetative, fruiting stage and flowering (45.39), (46.32) and (43.69) of tomato was found from L_3 (BARI Tomato-15) and L_2 (Exotic Tomato Line-2) respectively (Figure 17).

Interaction effect of different levels of boron and tomato line on the chlorophyll content at flowering and fruiting stage was significant but insignificant at vegetative stage (Appendix IX). Maximum chlorophyll content at vegetative stage (51.43) was obtained from B_1L_2 (100 ppm boric acid + Exotic Tomato Line-2) where minimum chlorophyll content (44.10) was obtained from B_2L_3 (200 ppm boric acid + BARI Tomato-15), (Table 8). At flowering stage, maximum chlorophyll content was found (52.20) from B_1L_2 (100 ppm boric acid + Exotic Tomato Line-2) where minimum chlorophyll content (36.96) was obtained from B_2L_3 (200 ppm boric acid + BARI Tomato-15). At fruiting stage, maximum was found (51.23) from B_2L_2 (200 ppm boric acid + Exotic Tomato Line-2) which is statistically similar with (50.30) and (50.40) from B_1L_2 and B_2L_2 where minimum was (42.07) obtained from B_0L_1 (Table 8).

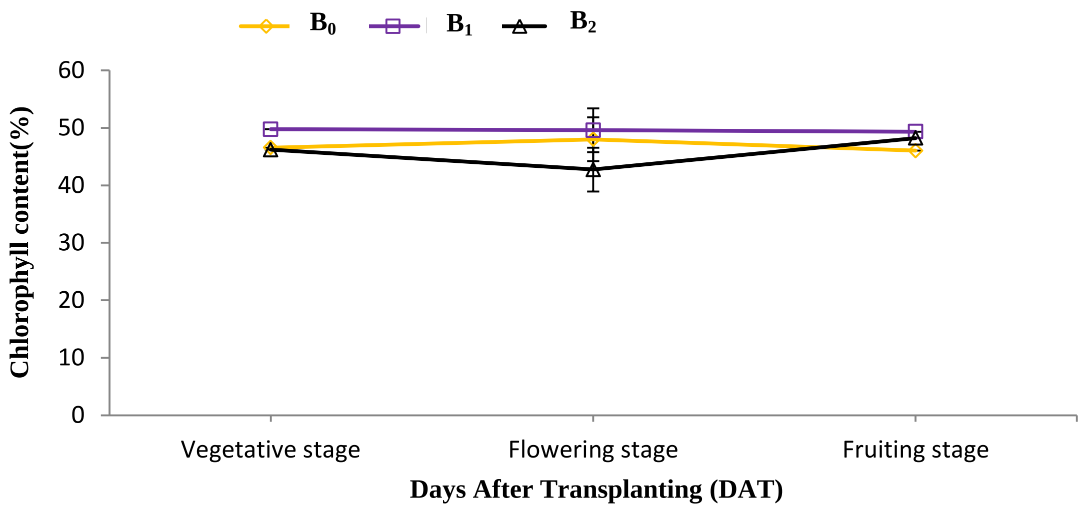

Fig. 16. Effect of different levels of boron on the Chlorophyll content of tomato at different growth stages (LSD $_{(0.05)}$ = NS, 3.76 and NS at vegetative, flowering and fruiting stages, respectively)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

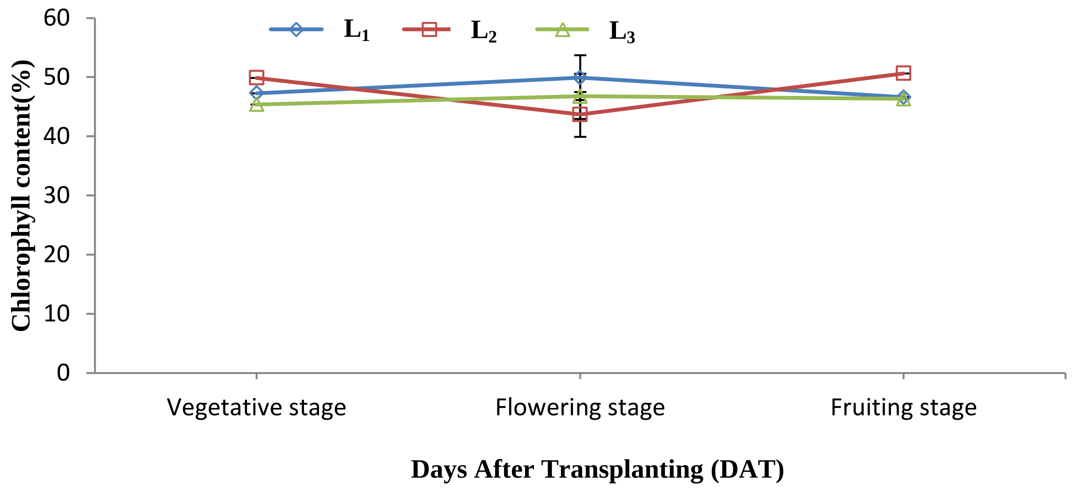

Fig. 17. Effect of tomato line on the Chlorophyll content of tomato at different growth stages (LSD $_{(0.05)}$ = NS, 3.76 and NS at vegetative, flowering and fruiting stages, respectively)

(Here, L_1=Exotic Tomato Line-1, L_2 =Exotic Tomato Line-2 and L_3=BARI Tomato-1

Table 8. Interaction effect of different levels of boron and tomato line on the chlorophyll content of tomato at different growth stages

Treatment combinations	Chlorophyll content at different growth stages		
	Vegetative	Flowering	Fruiting
B_0L_1	46.17	50.23 ab	42.07 b
B_0L_2	49.47	46.27 ab	50.40 a
B_0L_3	44.03	47.53 ab	45.60 ab
B_1L_1	49.80	52.20 a	50.10 ab
B_1L_2	51.43	47.83 ab	50.30 a
B_1L_3	48.03	48.70 ab	47.58 ab
B_2L_1	45.87	47.27 ab	47.67 ab
B_2L_2	48.67	36.96 c	51.23 a
B_2L_3	44.10	44.02 b	45.77 ab
LSD $_{(0.05)}$	NS	6.51	8.05
CV (%)	10.12	8.04	9.72

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

Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1= Exotic Tomato Line-1, L_2 = Exotic Tomato Line-2 and L_3 = BARI Tomato-15)

4.9 Number of flower clusters per plant

Number of flower clusters per plant varied significantly due to foliar application of boron (Appendix X). The highest number of (21.25) flower clusters per plant of tomato was found from B_1. The lowest number (17.93) of flower clusters per plant of tomato was observed in B_2 treatment (Fig.18). The results clearly showed that the number of flower clusters per plant was increased with B_1 levels of boron except the highest dose. Naz *et al*. (2012) observed that boron treated tomato plant showed higher flower cluster per plant than untreated control.

Number of flower cluster per plant varied significantly due to effect of tomato line (Appendix X). The highest number of (21.82) flower cluster per plant of tomato was found from L_3. The lowest number (18.24) of flower cluster per plant of tomato was observed in L_1 (Fig. 19). Yadav (2006), also found the same result.

There were significant variations among the different levels of boron and tomato line in respect of flower clusters per plant (Appendix X). The Maximum number of flower clusters per plant (23.97) was found at B_1L_3 (100 ppm boric acid + BARI Tomato-15) and the minimum (17.03) was found from the B_2L_1 (Table 9).

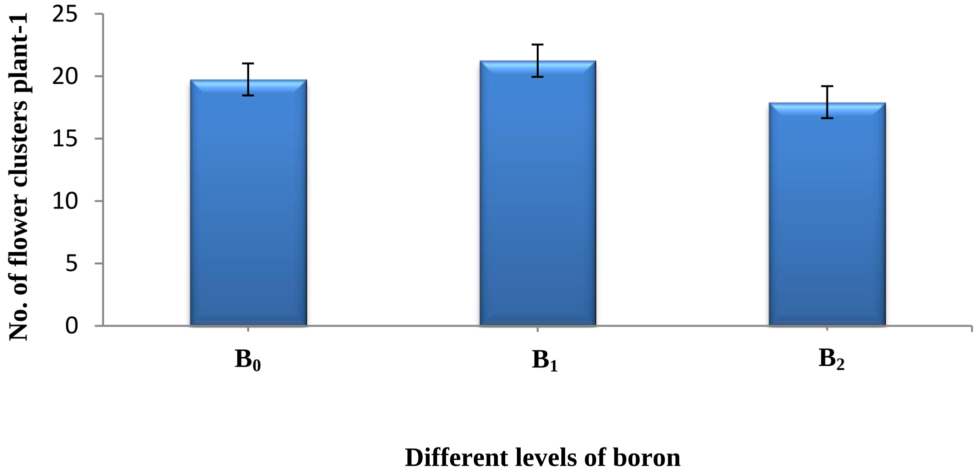

Fig.18. Effect of different levels of boron on the no. of flower clusters per Plant (LSD$_{(0.05)}$ = 1.29 showing vertical error bar)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

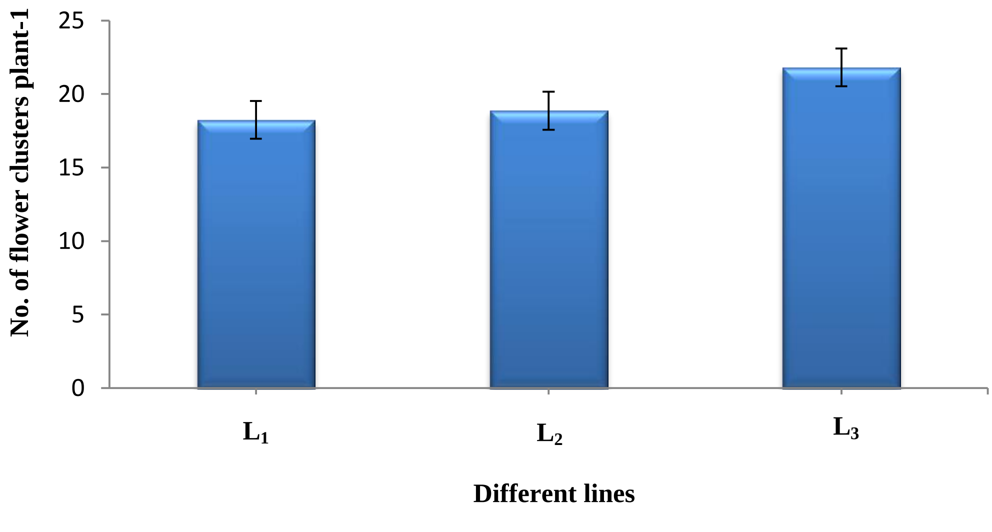

Fig. 19. Effect of tomato line on the no. of flower clusters per plant (LSD $_{(0.05)}$ = 1.29 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-1)

4.10 Days to first flowering

Days to 1st flowering of tomato varied significantly due to different levels of foliar boron application (Appendix X). The earliest flowering (29.44 days) was found from B_1 and late flowering (32.11 days) was found in B_2 (Figure 20).This result is similar to Khosa (2011), who said that days to first flower emergence increased with increasing boron level compared to control and began to turn down when boron level exceed beyond the above.

Days to 1st flowering of tomato varied significantly due to effect of tomato line (Appendix X). The earliest flowering (27.89 days) occurred in L_1(and the delayed flowering (32.56 days) was found in L_2 (Figure 21). Jeanine *et al.* (2003) reported the similar findings.

There was significant interaction effect among the different levels of boron and tomato line on days to first flowering of tomato (Appendix X). The days to first flowering ranged from 26.67 days to 34 days. The plants with treatment combination of B_1L_1 produced early flowering (26.67 days) and treatment combination of B_2L_2 produced delayed flowering (34 days) which is statistiaclly identical to B_0L_1 (Table 9).

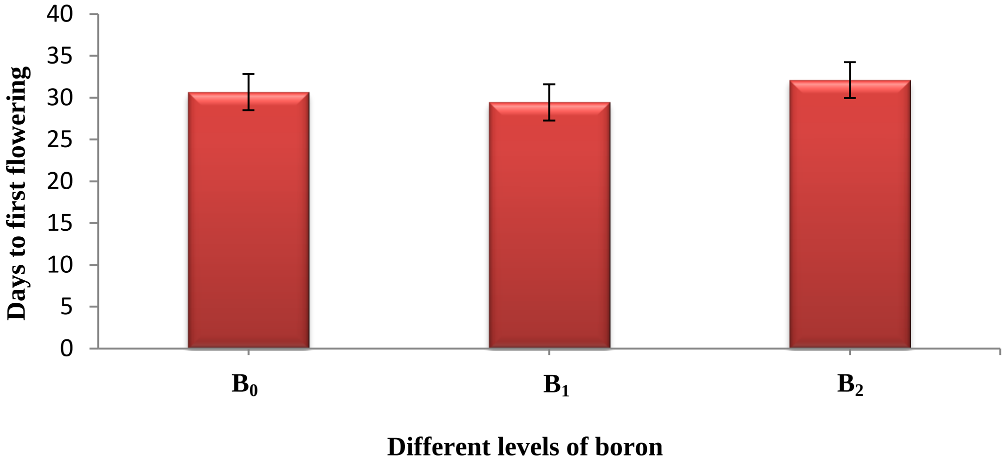

Figure 20. Effect of different levels of boron on the days to 1st flowering of tomato(LSD $_{(0.05)}$ = 2.15 showing vertical error bar)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

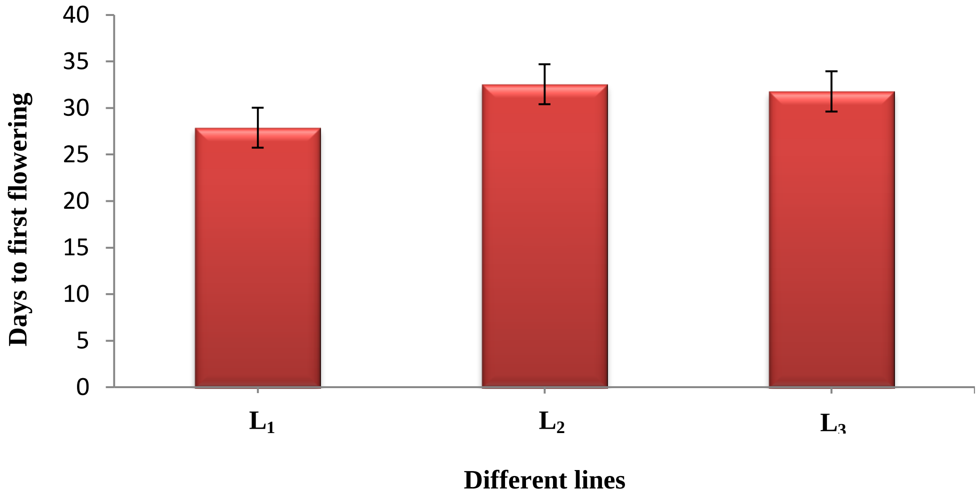

Figure 21. Effect of tomato line on the days to 1st flowering of tomato (LSD $_{(0.05)}$ =2.15 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

4.11. Number of flowers per cluster

Number of flowers per cluster of tomato showed significant variation due to the application of different levels of boron (Appendix X). The highest number of flowers per cluster (4.23) was observed in B_1 while the lowest number (3.53) was counted from B_2 (Fig. 22). Suganiya and Kumuthini (2015) reported that boron increased the number of flowers per cluster than control treatment in brinjal plant.

Number of flowers per cluster of tomato also showed significant differences due to the effect of tomato line (Appendix X). The highest number (4.19) of flowers per cluster was recorded from L_1 whereas the lowest number (3.50) was found in L_2 (Fig. 23).

Interaction effect of different levels of boron and tomato line showed significant differences on number of flowers per cluster of tomato (Appendix X). The highest number (4.57) of flowers per cluster was recorded from B_1L_1 which is statistically similar with B_0L_1, B_1L_2 and $B_1L_{3.}$ The lowest number (3.07) was recorded from B_2L_2 which is statistically similar with B_0L_2 (Table 9).

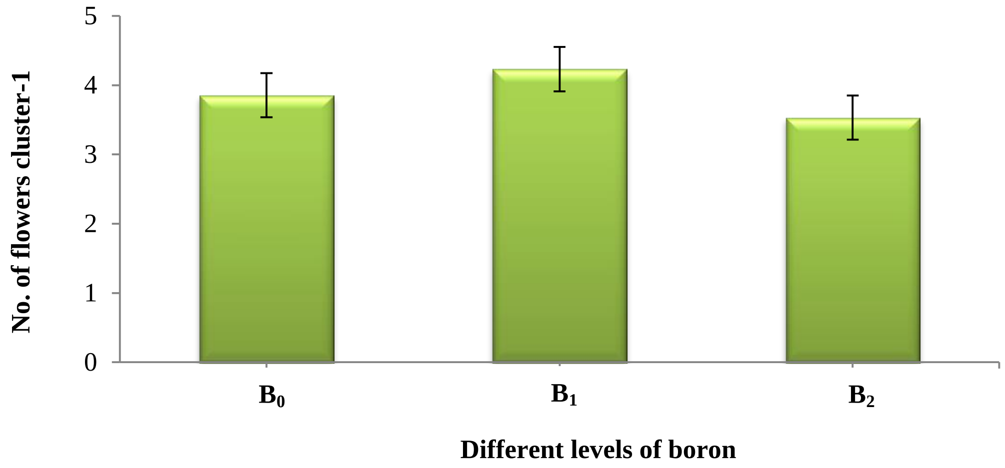

Fig. 22. Effect of different levels of boron on the no. of flowers per cluster of tomato (LSD $_{(0.05)}$= 0.32 showing vertical error bar)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

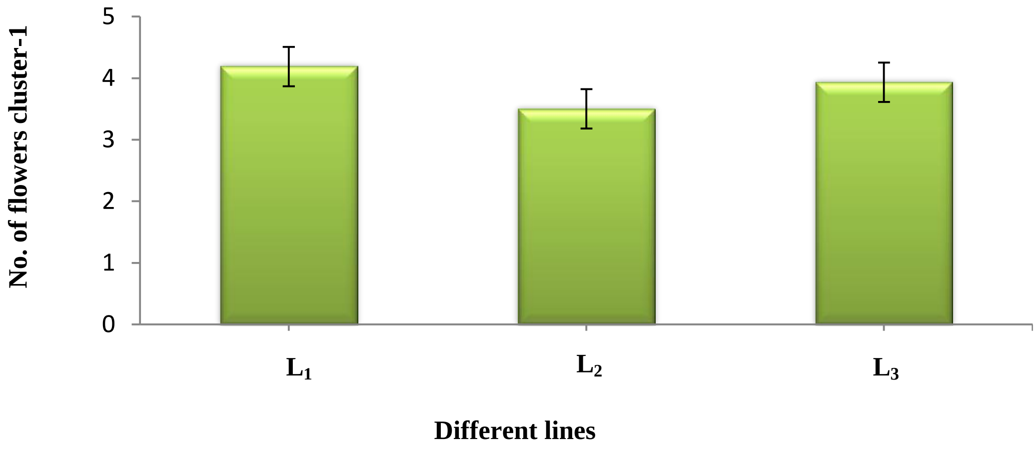

Fig. 23. Effect of tomato line on the no. of flowers per cluster of tomato (LSD $_{(0.05)}$=0.32 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

4. 12. Number of flowers per plant

Total number of flowers per plant of tomato showed significant differences with different levels of boron (Appendix X). The highest number of flowers per plant (119.1) was observed from B_1 which statistically similar with B_2, where the lowest number (105.1) was recorded from B_3 (Fig. 24). The similar result also mentioned by Naresh (2002).

Number of flower cluster per plant of tomato varied significantly due to effect of tomato line (Appendix X). The highest number of (182) flower per plant of tomato was found from L_1. The lowest number (71.76) of flower per plant of tomato was observed in, (Fig. 25).

There was significant effect of different levels of boron and tomato line on the number of flowers per plant (Appendix X). Maximum number of flowers per plant (192.1) was obtained from B_1L_1 (100 ppm boric acid + Exotic Tomato Line-1) while minimum flowers per plant (65.77) was obtained from B_2L_2 (200 ppm boric acid + Exotic Tomato Line-2) which is statistically identical with B_0L_2 and B_1L_2 (Table 9).

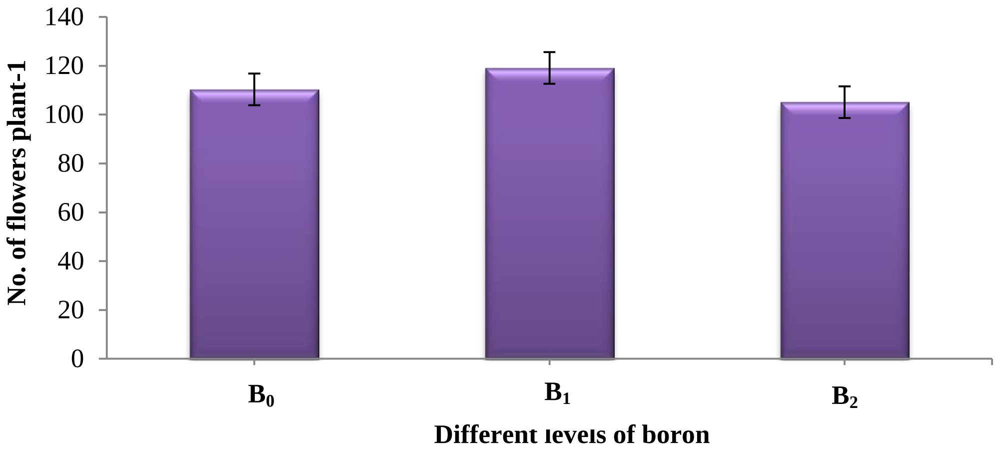

Fig. 24. Effect of different levels of boron on the no. of flowers per plant of tomato (LSD $_{(0.05)}$ =6.51 showing vertical error bar)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

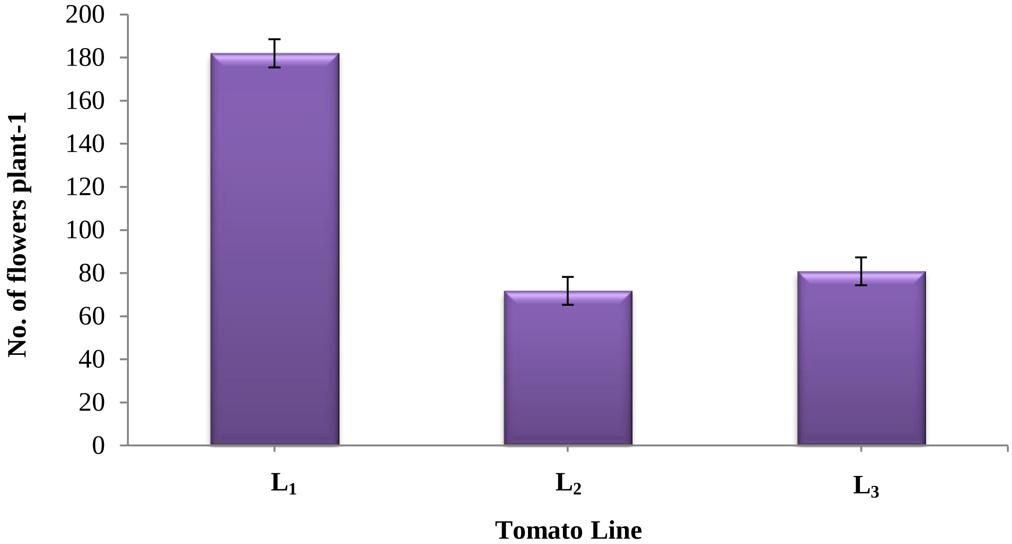

Fig. 25. Effect of tomato line on the no. of flowers per plant of tomato (LSD$_{(0.05)}$ =6.51 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2 =Exotic Tomato Line-2 and L_3 = BARI Tomato-15)

4.13 Number of fruits per cluster

Different levels of boron showed significant effect on number of fruits per cluster of tomato (Appendix X). Results indicated that the highest number of fruits per cluster (3.36) was found from B_1 (foliar spray of 100 ppm boric acid) where the lowest number of fruits per cluster (2.68) was achieved from B_2 (foliar spray of 200 ppm boric acid), (Fig. 26).

Number of fruits per cluster varied significantly due to effect of tomato line (Appendix X). The highest number fruits per cluster (5.04) of tomato was found from L_1 (Exotic tomato Line-1).The lowest number fruits per cluster (1.97) of tomato was observed in L_3 (BARI Tomato-15), (Fig. 27).

There was significant effect of different levels of boron and tomato line on the number of fruits per cluster (Appendix X). Maximum number fruits per cluster (5.58) was obtained from B_1L_1 (100 ppm boric acid + Exotic Tomato Line-1) while minimum number fruits per cluster (1.73) was obtained from B_2L_3 (100 ppm boric acid + BARI Tomato-15) which is statistically identical with B_0L_2, B_2L_2, B_0L_3 and B_1L_3 (Table 9).

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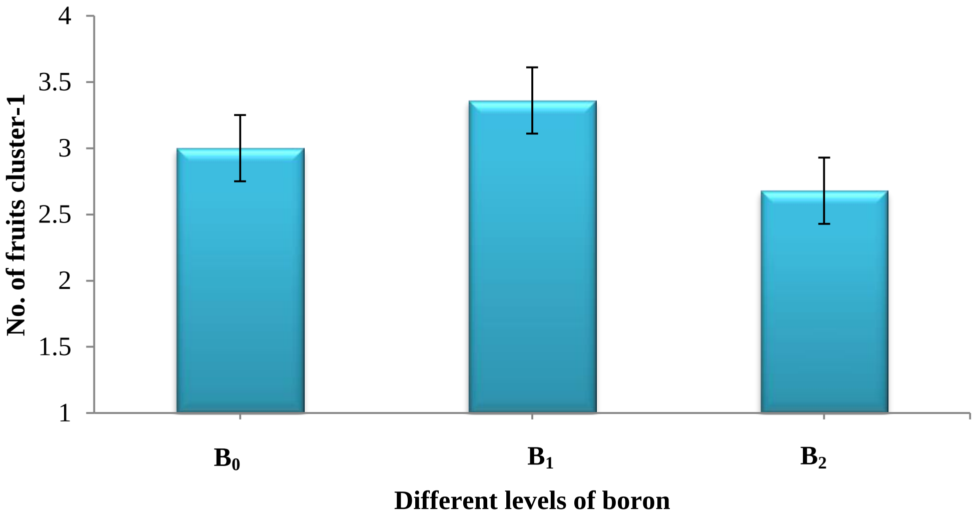

Fig. 26. Effect of different levels of boron on the no. of fruits per cluster of tomato(LSD $_{(0.05)}$ = 0.25 showing vertical error bar)
(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

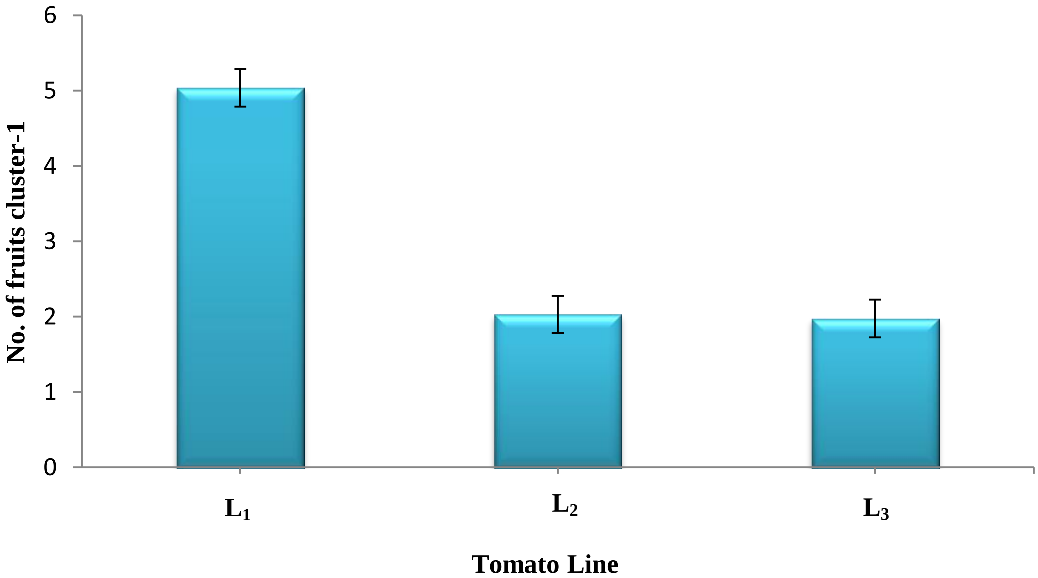

Fig. 27. Effect of tomato line on the no. of fruits per cluster of tomato (LSD $_{(0.05)}$ = 0.25 showing vertical error bar)
(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

Table 9. Interaction effect of different levels of boron and tomato line on the yield contributing characters of tomato

Treatment combinations	No. of flower clusters plant^{-1}	Days to 1st flowering	No. of flowers cluster^{-1}	No. of flowers plant^{-1}	No. of fruits cluster^{-1}
B_0L_1	18.19 c-e	27.67 cd	4.20 ab	180.0 b	4.97 b
B_0L_2	18.94 c-e	32.33 ab	3.40 cd	73.12 de	1.98 cd
B_0L_3	22.11 ab	32.00 ab	3.97 b	77.83 cd	2.05 cd
B_1L_1	19.50 cd	26.67 d	4.57 a	192.4 a	5.58 a
B_1L_2	20.28 bc	31.33 a-c	4.03 ab	76.38 de	2.37 c
B_1L_3	23.97 a	30.33 a-d	4.10 ab	88.63 c	2.14 cd
B_2L_1	17.03 e	29.33 b-d	3.80 bc	173.7 b	4.57 b
B_2L_2	17.39 de	34.00 a	3.07 d	65.77 e	1.74 d
B_2L_3	19.38 cd	33.00 ab	3.73 bc	75.94 de	1.73 d
$LSD_{(0.05)}$	2.24	3.73	0.56	11.27	0.43
CV (%)	6.58	7	8.31	5.84	8.19

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

Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1=Exotic Tomato Line-1, L_2 =Exotic Tomato Line-2 and L_3 = BARI Tomato-15

4. 14 Number of fruits per plant

The effect of different levels of boron on the number of fruits per plant was found positive and significant (Appendix X). The highest number of fruits per plant 69.33) was obtained with the foliar application of 100 ppm boric acid. The lowest number of fruits per plant (50.11) was found in B_2 (foliar application of 200 ppm boric acid) treatment (Fig. 28). The increased in number of fruits might be due to favorable environment under these treatments which provides congenial conditions for better growth and development of the fruit. Singh *et al.* (2006), Hamid *et al* (2012) also had found the same result.

Effect of tomato line on the number of fruits per plant was found positive and significant (Appendix X). Number of fruits per plant gradually increased with foliar application of boron at present trial. The highest number of fruits per plant (101.1) was obtained from L_1 (Exotic Tomato Line-1) and the lowest number of fruits per plant (38.22) was found in L_2 (Exotic Tomato Line-2), (Fig. 29).

Interaction effect of different levels of boron with tomato line was found significant (Appendix X). The maximum number of fruits (119.0) per plant was obtained from B_1L_1 (100 ppm boric acid + Exotic Tomato Line-1) and the minimum number of fruits per plant (31.67) was recorded from B_2L_2 (Table 10).

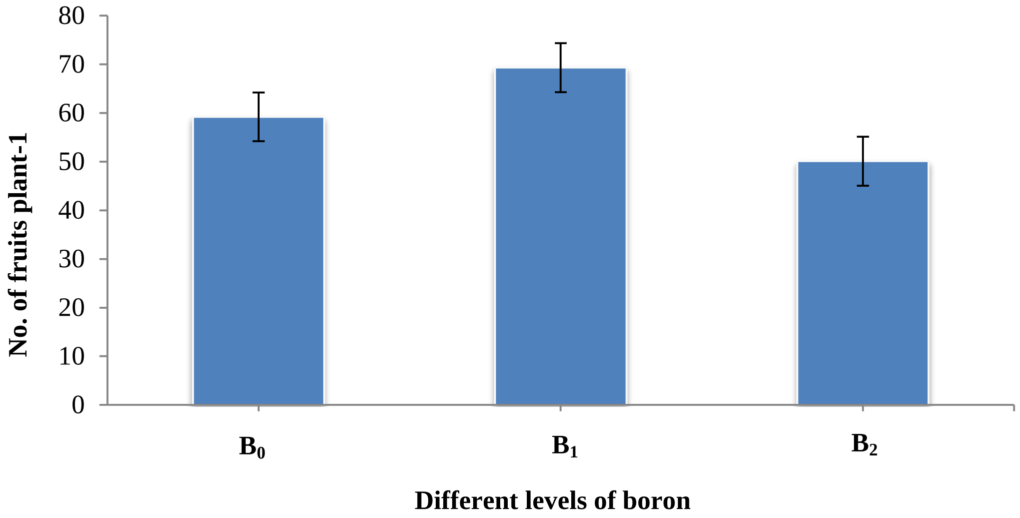

Fig. 28. Effect of different levels of boron on the no. of fruits per plant of tomato (LSD $_{(0.05)}$ = 5.03 showing vertical error bar)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

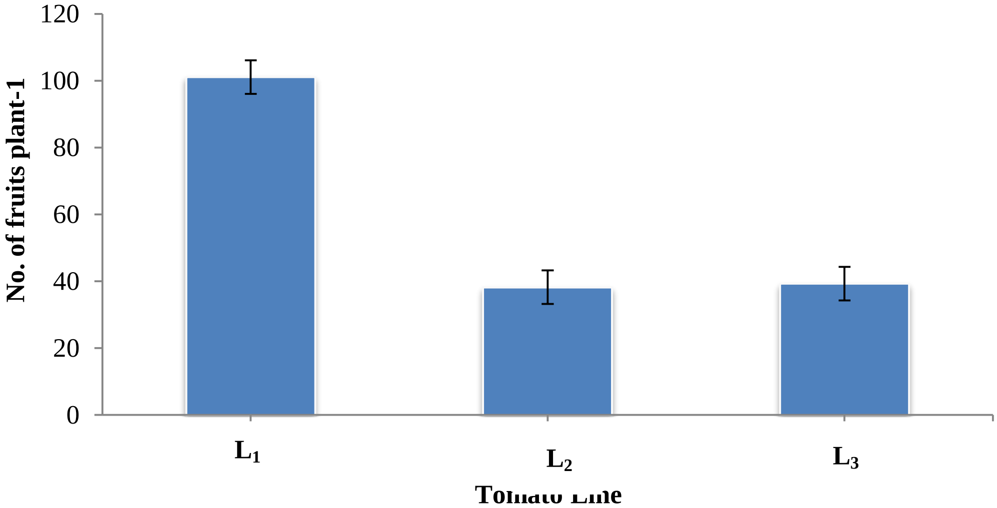

Fig. 29. Effect of tomato line on the no. of fruits per plant of tomato (LSD $_{(0.05)}$ =5.03 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

4. 15 Fruit set percentage

The effect of different levels of boron on the fruit set percentage was found positive and significant (Appendix X). The highest number of fruit set percentage (56.73 %) was obtained with the foliar application of B_1 (100 ppm boric acid). The lowest number of fruit set percentage (47.36 %) was found in B_2 (Fig. 30). The results proved that boron plays a vital role in fruit setting of tomato plants. The maximum fruit setting percentage might be due to optimum foliar application of boron. Similar result was also found by Naz *et al.* (2012), Patil *et al*. (2010).

The effect of tomato line on the fruit set percentage of tomato was found positive and significant (Appendix X). The number of fruit set percentage (55.32 %) was obtained from L_1 (Exotic Tomato Line-1) and the lowest number of fruit set percentage (48.65 %) was found in L_2 (Figure31).

Interaction effect of different levels of boron with tomato line on fruit set percentage of tomato was found significant (Appendix X). The maximum number of fruits set percentage (61.83%) was obtained from B_1L_1 (100 ppm boric acid + Exotic Tomato Line-1) and the minimum number of fruit set percentage (44.80 %) was recorded from B_2L_3 (Table 10).

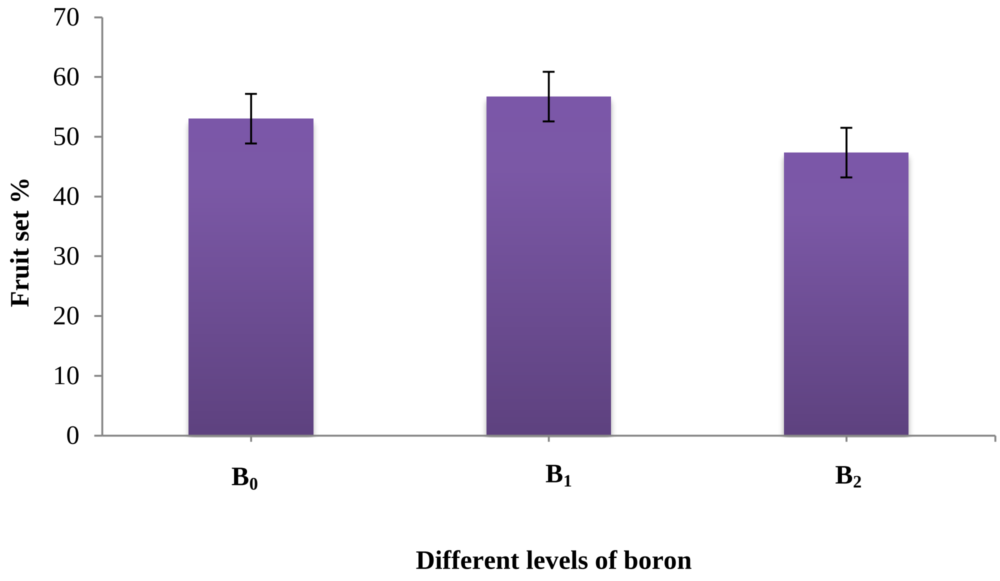

Fig. 30. Effect of different levels of boron on the fruit set percentage of tomato (LSD $_{(0.05)}$ =4.15 showing vertical error bar)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

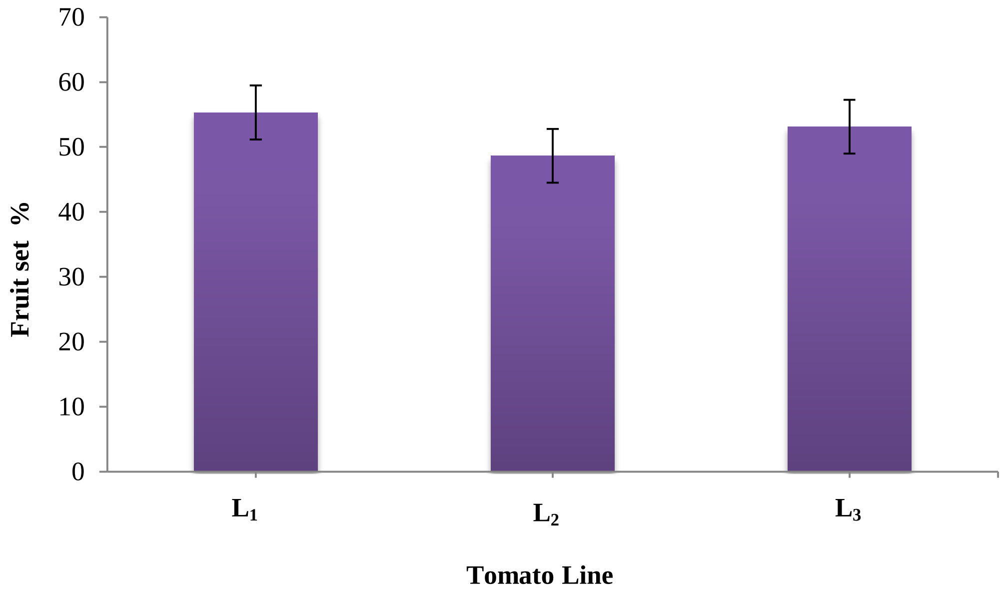

Fig. 31. Effect of tomato line on the fruit set percentage of tomato (LSD $_{(0.05)}$=4.15 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

4. 16 Individual fruit weight

Individual fruit weight of tomato varied significantly increased due to influence of different levels of boron (Appendix XI).The highest individual fruit weight (59.78 g) was found from B_1 (foliar spray of 100 ppm boric acid) and the lowest weight (44.56 g) was obtained from B_2 (Fig. 32). The results of present investigation are in accordance with the finding of Hatwar *et al.* (2003), Raghav and Sharma (2003), Rafique *et al*. (2004) and Bhatt *et al*. (2006).

Effects of tomato line showed statistically significant differences for the weight of individual fruit of tomato (Appendix XI).The highest individual fruit weight (71.33 gm) was recorded from L_3 (BARI Tomato-15) and the lowest value (23.89 g) was obtained from L_1 (Fig. 33).

Interaction effect of different levels of boron and tomato line was significant on the weight of individual fruit at harvest (Appendix XI). Individual fruit fresh weight at different treatment combinations varied from 19 g to 83 g. The maximum fruit fresh weight (83 g) was obtained from the treatment combination of B_1L_3 (100 ppm boric acid + BARI Tomato-15) whereas the minimum (19 g) was obtained from the treatment combination of B_2L_1 (200 ppm boric acid + Exotic Tomato Line-1) which is statistically similar with B_0L_1 (Table 10).

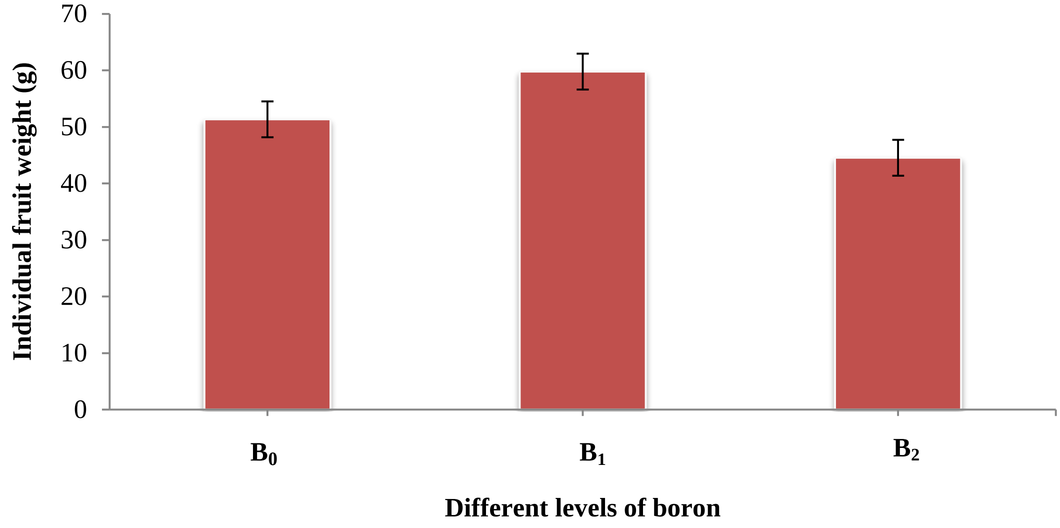

Fig. 32. Effect of different levels of boron on the individual fruit weight of tomato (LSD $_{(0.05)}$ = 0.39 showing vertical error bar)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

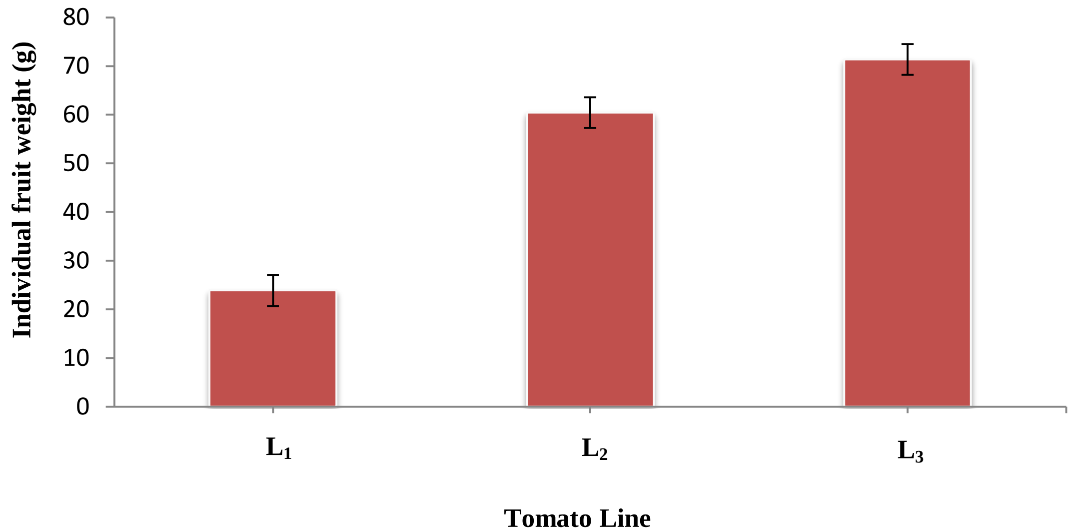

Fig. 33. Effect of tomato line on the individual fruit weight of tomato (LSD $_{(0.05)}$ = 0.39 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

4. 17 Fruit length

Fruit length showed significant differences with different levels of boron (Appendix XI). The maximum fruit length (4.52 cm) was observed from B_1 (foliar spray of 100 ppm boric acid) where the lowest number (3.95 cm) was recorded from B_2 (Fig. 34). Similar results also mentionde by Ejaz et al. (2011), Yildirim (2007).

Significant variation was found in fruit length due to effect of tomato line (Appendix XI). The longest fruit (4.93 cm) was produced from L_3 (BARI Tomato-15) and the shortest fruit (3.19 cm) was produced in L_1 (Fig. 35).

The analysis of variance given in (Appendix XI), revealed that the interaction effect of different levels of boron and tomato line on the fruit length was found to be statistically significant. Fruit length varied from 3.05 cm to 5.47 cm (Table 10). The highest fruit length (5.47 cm) was observed from the treatment combination of B_1L_3 (100 ppm boric acid +BARI Tomato-15). Whereas the lowest (3.05 cm) was measured from the treatment combination of B_2L_1(200 ppm boric acid + exotic tomato-1) which was statistical identical to B_0L_1 and B_1L_1 treatment combination.

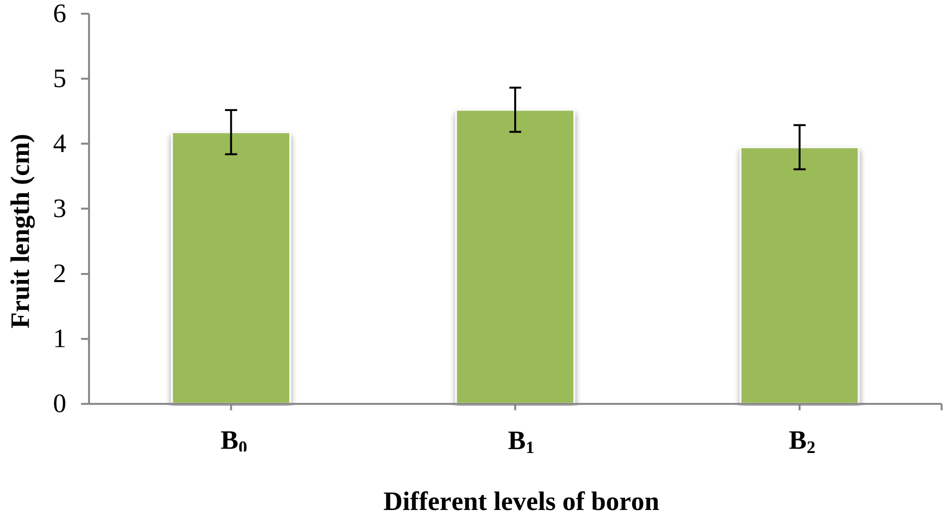

Fig. 34. Effect of different levels of boron on the fruit length of tomato

(LSD $_{(0.05)}$ = 0.34 showing vertical error bar)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

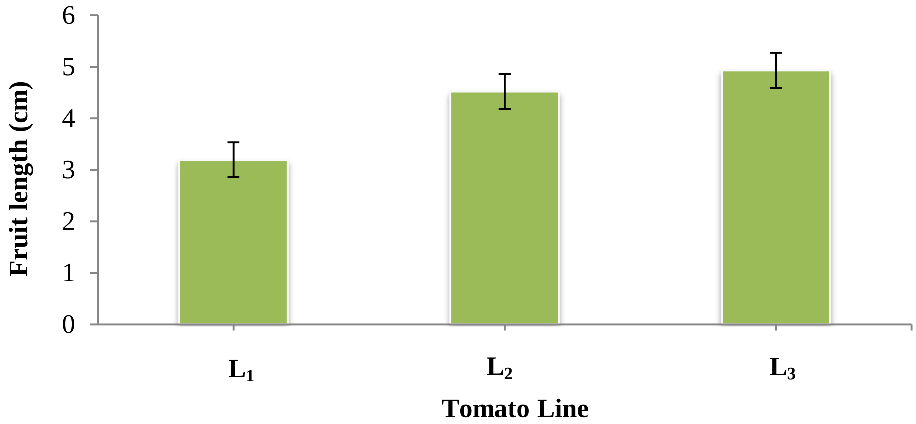

Figure 35. Effect of tomato line on the fruit length of tomato (LSD $_{(0.05)}$ = 0.34 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

4. 18 Fruit diameter

Diameter of tomato fruit showed significant differences with different levels of boron (Appendix XI) .Highest fruit diameter (4.86 cm) was observed from B_1 (foliar spray of 100 ppm boric acid) where the lowest fruit diameter (3.94 cm) was recorded from B_2 (Fig.36). Acharya *et al*. (2015) also found the similar result where foliar application increase diameter of fruits per plant . These results were also supported by Salam *et al*. (2010), and Devi *et al*. (2013).

Significant variation was found in fruit diameter due to effect of tomato line (Appendix XI). The highest number of (5.03 cm) flower fruit diameter of tomato was found from L_3 (BARI Tomato -15). The lowest number (3.28 cm) of fruit diameter of tomato was observed in L_1 (Fig. 37). Ali *et al.*(2014) have found similar result.

Interaction effect of different levels of boron and tomato line on fruit diameter was statistically significant (Appendix XI). However, the highest fruit diameter (5.63 cm) was found from the treatment combination of B_1L_3 (100 ppm boric acid +BARI Tomato-15) which was statistically similar with B_1L_2 (5.27 cm) treatment combination and the lowest (3.03 cm) was obtained from the treatment combination B_2L_1 (200 ppm boric acid + Exotic Tomato Line-1) which was identical to B_0L_1 and B_1L_1 treatment combination (Table 10).

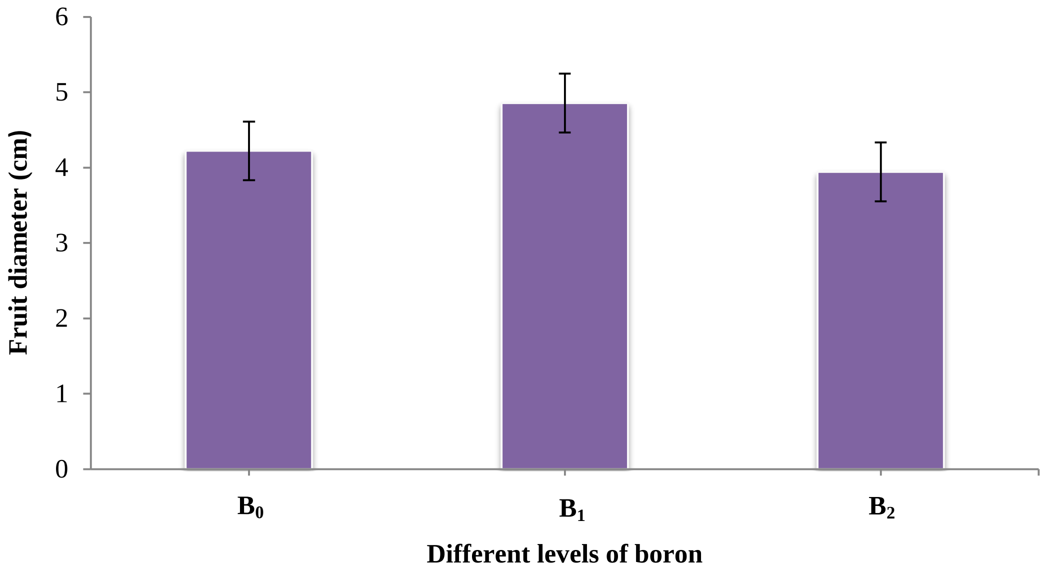

Figure 36. Effect of different levels of boron on the fruit diameter of tomato ($LSD_{(0.05)}$ = 3.17 showing vertical error bar)
(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

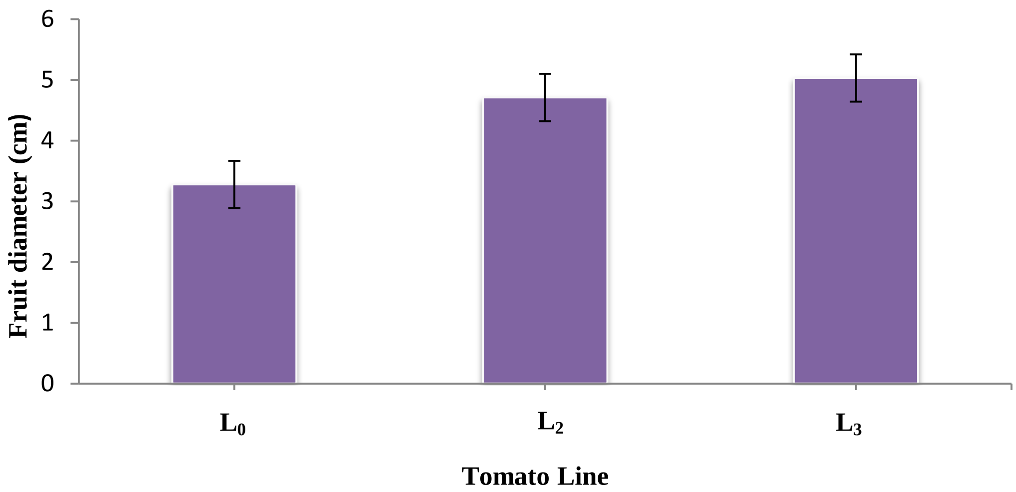

Figure 37. Effect of tomato line on the fruit diameter of tomato ($LSD_{(0.05)}$ = 3.17 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

4.19 Fruit yield per hectare

The fruit yield of tomato per hectare was also significantly influenced by different levels of boron (Appendix XI). The highest yield (64.89 t/ha) was obtained from B_1 (foliar spray of 100 ppm boron) followed by B_0 (59.61 t/ha) while the lowest yield (54.05 t/ha) was obtained from B_2 (foliar spray of 200 ppm boron), (Fig. 38). Rahman *et al.*,(2013) reported that 6-10 kg boron fertilizer per hectare is needed to fulfill the demand of boron in tomato plant for higher yield. Ullah *et al.*(2015) also showed that application of boron gave higher yield per hectare than untreated control in tomato.

Effect of tomato line also significantly influenced on the yield of fruit per hectare (Appendix XI). The highest yield (79.87 t/ha) was produced from L_3 (BARI Tomato -15). On the other hand, the lowest yield (36.74ton/ha) was produced from L_1 (Exotic Tomato Line-1), (Fig. 39). Considering plant height, number of leaves, number of flower, number of fruits per cluster, fruit size, fruit weight and other chraracteristics it can be assumed that the L_1 (Exotic Tomato Line-1) is a cherry tomato cultivar. So average yield of L_1 found lowest compare to other tomato lines. According to Islam *et al.,* (2013), cherry tomato yield ranges from 32.2 to 54.3 ton/ha obtained from different areas in Bangladesh. Similar yield has been obtained from BINA tomato -10 (cherry tomato) released by Bangladesh Institute of Nuclear Agriculture, Mymensingh.

Due to interaction effect of different levels of boron and tomato line performed significant effect on yield per hectare (Appendix XI). The treatment combination of B_1L_3 (100 ppm boric acid + BARI Tomato-15) gave the maximum yield (85 t/ha) of tomato followed by the treatment combination of (80 t/ha). On the other hand, the minimum yield (31.23 t/ha) was found from the treatment combination of B_2L_1 (Table 10).

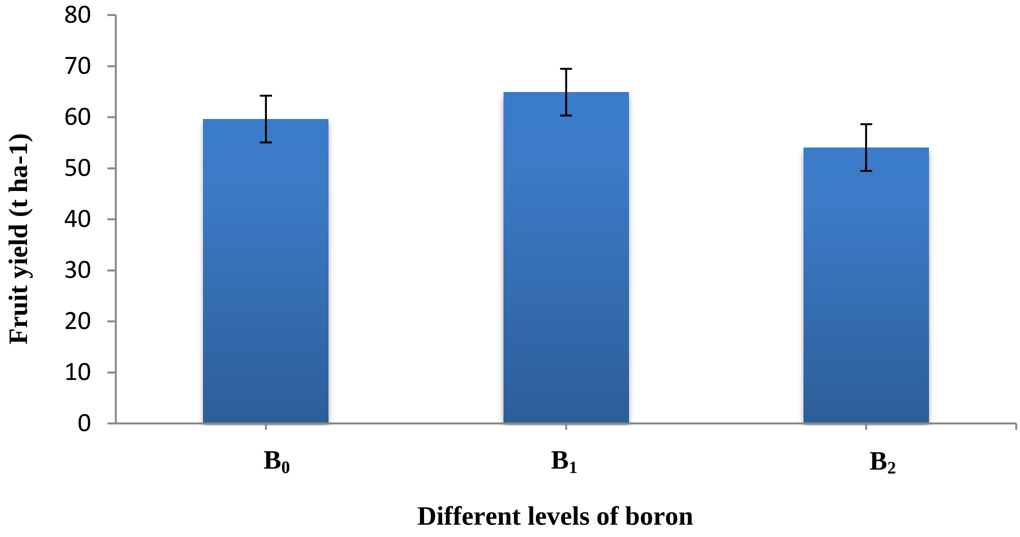

Fig. 38. Effect of different levels of boron on the fruit yield of tomato (LSD $_{(0.05)}$ = 4.58 showing vertical error bar)

(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

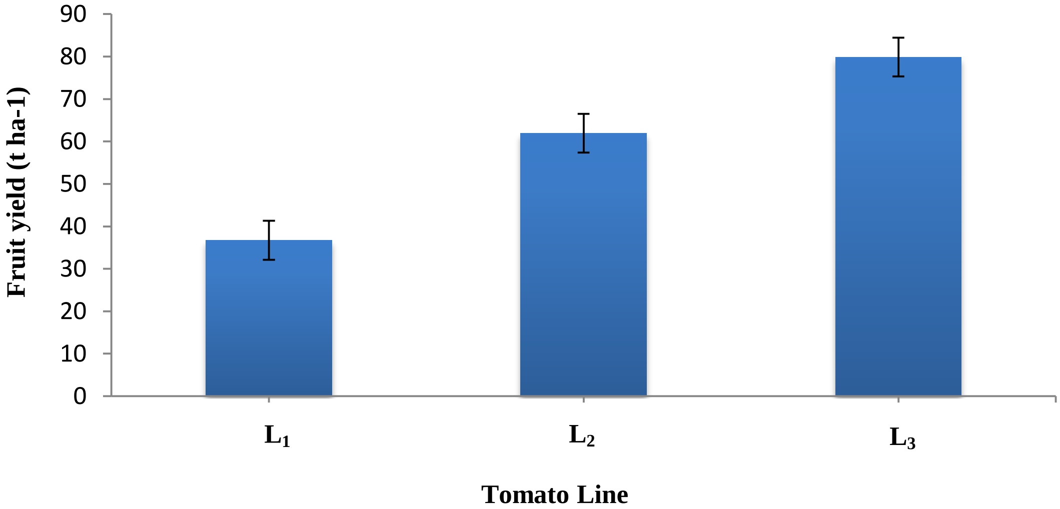

Fig. 39. Effect of tomato line on the fruit yield of tomato (LSD $_{(0.05)}$ = 4.58 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

Table 10. Interaction effect of different levels of boron and tomato line on the yield and yield contributing characters of tomato

Treatment combinations	No. of fruits plant^{-1}	Fruit set %	Individual fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield (t ha^{-1})
B_0L_1	99.67 b	55.32 abc	22.67 f	3.17 c	3.13 e	36.67 fg
B_0L_2	40.00 de	49.05 cd	61.67 c	4.57 b	4.60 bc	62.18 de
B_0L_3	38.00 de	54.66 abc	69.67 b	4.80 b	4.93 bc	80.00 ab
B_1L_1	119.0 a	61.83 a	30.00 e	3.37 c	3.67 de	42.33 f
B_1L_2	43.00 d	52.12 bc	66.33 bc	4.73 b	5.27 ab	67.33 cd
B_1L_3	46.00 d	56.26 ab	83.00 a	5.47 a	5.63 a	85.00 a
B_2L_1	84.67 c	48.81 cd	19.00 f	3.05 c	3.03 e	31.23 g
B_2L_2	31.67 e	44.80 d	53.33 d	4.27 b	4.27 cd	56.32 e
B_2L_3	34.00 e	48.47 cd	61.33 c	4.53 b	4.53 c	74.60 bc
LSD $_{(0.05)}$	8.72	7.18	5.50	0.59	0.68	7.93
CV (%)	8.46	7.92	6.12	8.16	9.02	7.69

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

Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1=Exotic Tomato Line-1, L_2 =Exotic Tomato Line-2 and L_3 = BARI Tomato-15

4.20 Total soluble solids (%)

This research work exhibited distinct variations in total soluble solid (TSS) percentage of tomato by the effect of boron (Appendix XI). The maximum TSS percentage in tomato (4.31 %) was found from B_1, while the minimum was (4.02 %) obtained from B_0 (Figure 40). This is similar with the findings of Fageria *et al.* (2002), Chaurasia *et al.* (2006) and Raj *et al.* (2012).

Total soluble solids (TSS) percentage in tomato varied significantly due to effect of tomato line (Appendix XI). The maximum TSS (4.58 %) was found from L_1 (Exotic Tomato Line-1) treated plants, whereas the minimum TSS percentage (3.53 %) was found from L_3 (Fig. 41). Aoun *et al.* (2013) reported same findings on commercial varieties of tomato. Emery and Munger (1970) also found similar result.

Interaction effect of foliar application of boron and tomato line significantly on TSS percentage of tomato (Appendix XI). It was observed that maximum TSS percentage (4.73 %) was obtained from B_1L_1(100 ppm boric acid + Exotic Tomato Line-1) treated plants, which was statistically similar with B_0L_1 (4.60 %) and B_2L_1 (4.40 %), whereas the minimum (3.17 %) was recorded from B_2L_2 (200 ppm boric acid + Exotic Tomato Line-2) which was statistically identical with B_0L_3, B_1L_3 and B_2L_3 (Fig. 39).

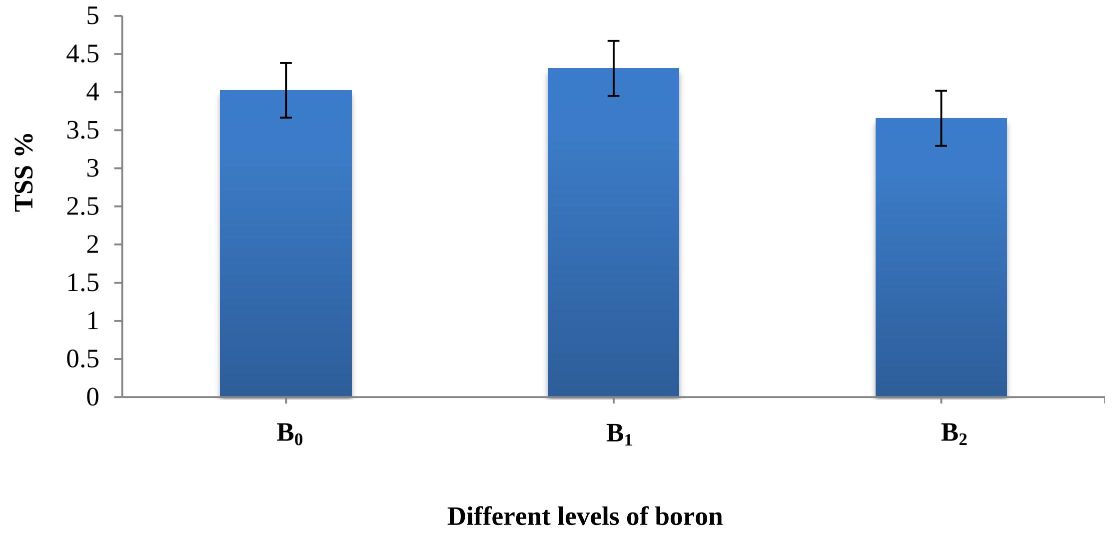

Fig. 40. Effect of different levels of boron on the TSS % of tomato ($LSD_{0.05)}$ = 0.36 showing vertical error bar)

(Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

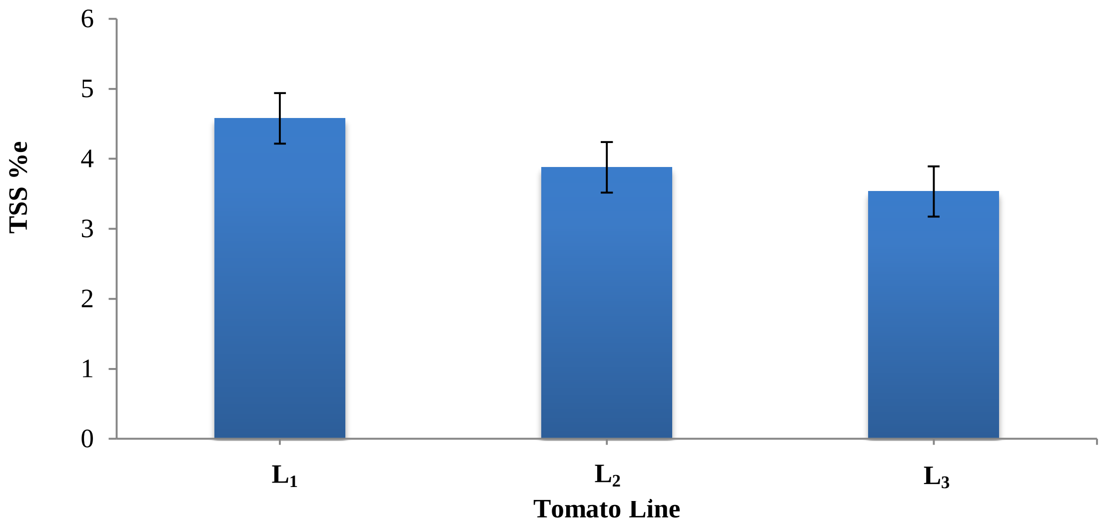

Fig. 41. Effect of tomato line on the TSS % of tomato ($LSD_{(0.05)}$ = 0.36 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

4.21 Tomato p^H

This research work exhibited distinct variations in p^H of tomato by the effect different levels of boron (Appendix XI). The maximum p^H in tomato (5.02) was found from B_1 (foliar spray with 100 ppm boric acid) while the minimum was (4.23) obtained from B_2 (Fig. 42). Similar results were obtained by Dube *et al.* (2003) and Harris and Lavanya (2016) in tomato.

p^H in tomato varied significantly with the effect of tomato line (Appendix XI). The maximum p^H (5.06) was found from L_3 (BARI Tomato-15) plants, whereas the minimum p^H (4.31) was found from L_1 (Fig. 43). Similar results were reported by Mohammed *et al.* (1999).

Interaction effect of foliar application of boron and tomato line significantly on p^H of tomato (Appendix XI). It was observed that maximum p^H (5.20) was obtained from B_1L_3 (100 ppm boric acid+ BARI Tomato-15) treated plants, which was statistically similar with B_2L_3 (4.90), B_1L_2 (5.05) and B_0L_3 (5.09), whereas the minimum p^H (3.72) was recorded from B_2L_1 which was statistically identical found (4.07) from B_2L_2 (Table 11).

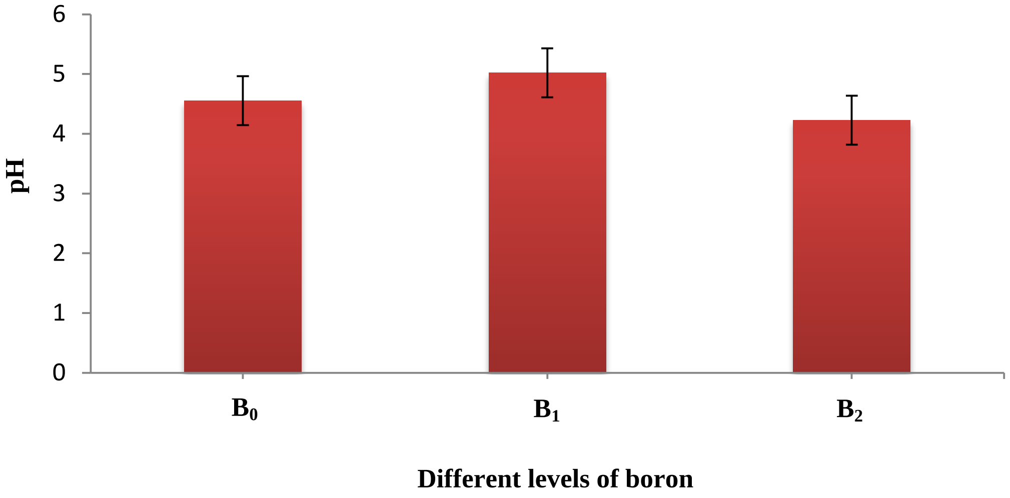

Fig. 42. Effect of different levels of boron on the tomato pH (LSD $_{(0.05)}$ = 0.41 showing vertical error bar)

(Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

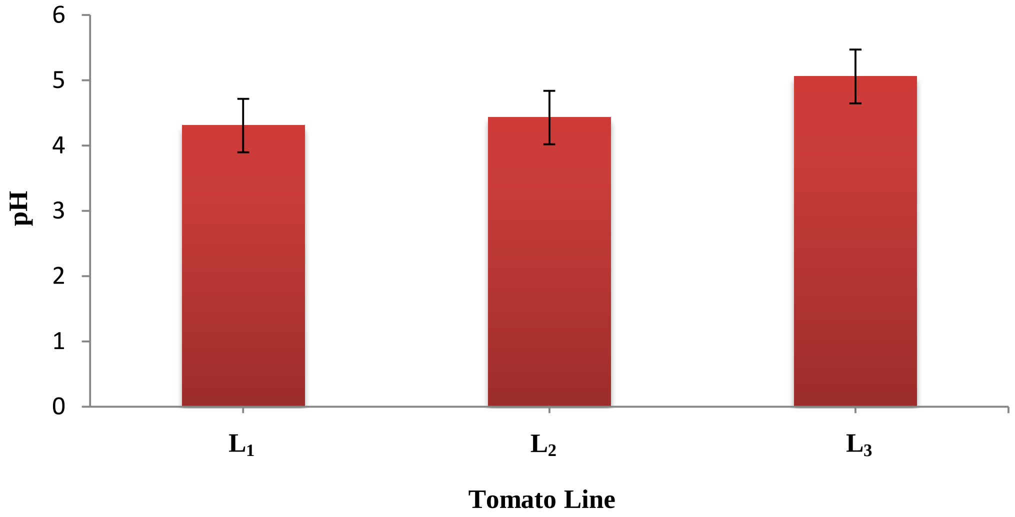

Fig. 43. Effect of tomato line on the tomato pH (LSD $_{(0.05)}$ = 0.41 showing vertical error bar)

(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

4.22 Vitamin C content

This research work exhibited distinct variation in terms of content of Vitamin C of tomato which has greatly affected by the foliar application of different levels of boron (Appendix XI). The maximum Vitamin C content (19.42 mg per 100 g of tomato) was found from B_2 (foliar spray with 100 ppm boric acid) while the minimum content of Vitamin C (16.27 mg) was obtained from B_0 (Control), (Fig. 44). The results obtained are in conformity with the findings of Tamilselvi *et al.*(2002) and Kumari (2012) in tomato.

Vitamin C content in tomato varied significantly with the effect of tomato line (Appendix XI). The maximum Vitamin C content (20 mg) was obtained from L_3 (BARI Tomato-15) plants, whereas the minimum content of Vitamin C (14.91 mg) was recorded from L_1 (Fig. 45). Toor and Savage (2006) investigated Vitamin C content of different tomato lines and have found similar result.

Interaction effect of different levels of boron and tomato line varied significantly for the content of Vitamin C of tomato (Appendix XI). The maximum amount of Vitamin C content (21.35 mg) was obtained from B_2L_2 which was statistically similar to B_0L_3 (20.39 mg) and B_3L_1 (20.51 mg) while the minimum amount of Vitamin C content (13.37 mg) was recorded from B_0L_1 which was statistically similar to B_1L_1 (13.59 mg) and B_0L_2 (15.04 mg), (Table 11).

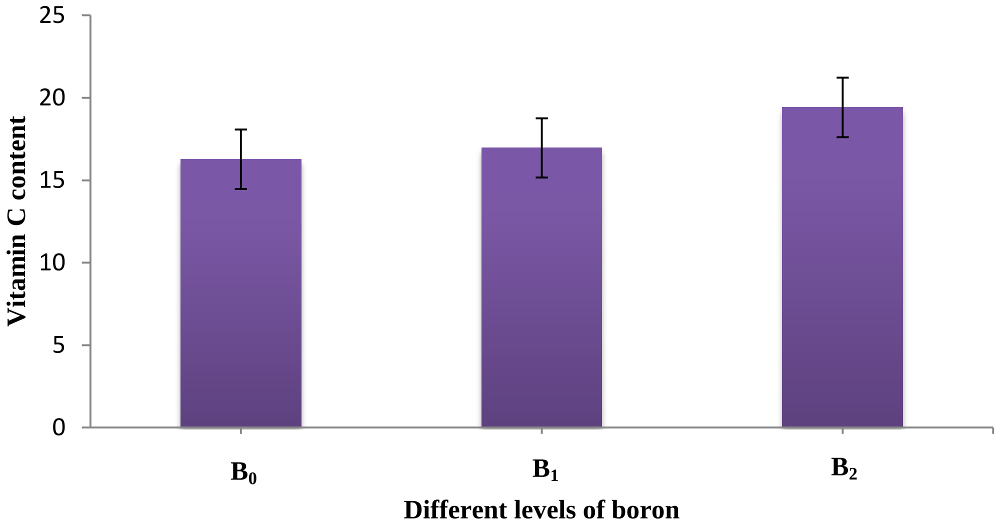

Fig. 44. Effect of different levels of boron on the vitamin C content of tomato (LSD $_{(0.05)}$ = 1.80 showing vertical error bar)
(Here, B_O = control B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid)

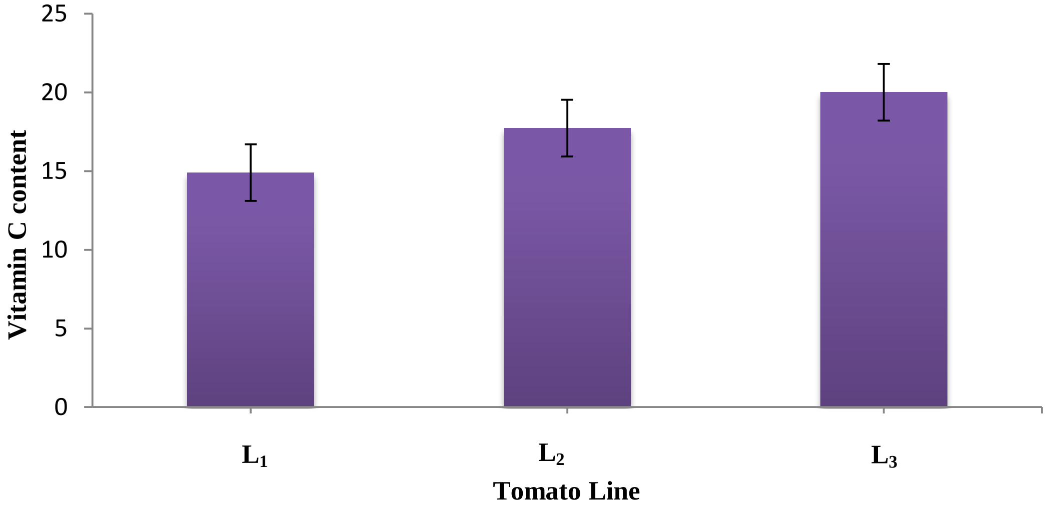

Fig. 45. Effect of tomato line on the vitamin C content of tomato (LSD $_{(0.05)}$ = 1.80 showing vertical error bar)
(Here, L_1=Exotic Tomato Line-1, L_2=Exotic Tomato Line-2 and L_3=BARI Tomato-15)

Table 11. Interaction effect of different levels of boron and tomato line on the TSS %, p^H and vitamin C content of tomato

Treatment combinations	TSS %	pH	Vitamin C
B_0L_1	4.60 ab	4.39 b-d	13.37 e
B_0L_2	4.00 bc	4.17 cd	15.04 de
B_0L_3	3.47 cd	5.09 ab	20.39 ab
B_1L_1	4.73 a	4.81 a-c	13.59 e
B_1L_2	4.47 ab	5.05 ab	16.79 cd
B_1L_3	3.73 cd	5.20 a	20.51 ab
B_2L_1	4.40 ab	3.72 d	17.78 b-d
B_2L_2	3.17 d	4.07 d	21.35 a
B_2L_3	3.40 cd	4.90 ab	19.12 a-c
LSD $_{(0.05)}$	0.63	0.71	3.11
CV (%)	9.04	8.93	10.24

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

Here, B_O = control, B_1= 100 ppm boric acid and B_2 = 200 ppm boric acid

L_1=Exotic Tomato Line-1, L_2 =Exotic Tomato Line-2 and L_3 = BARI Tomato-15

CHAPTER V
SUMMARY AND CONCLUSION

The effect of different levels of boron and tomato line on the growth, yield and quality of tomato were observed during the period from October 2016 to April 2017 in rabi season in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The experiment consisted of two factors, (i) three levels of boron (B) viz., 0, 100, 200 ppm of boric acid , (ii) three tomato lines (L) viz. Exotic tomato line-1, Exotic Tomato Line-2 and BARI Tomato-15. The experiment was laid out in Randomized Complete Block Design (RCBD). The total number of plot was 27 and the date of transplanting was 19 November , 2016. Data on different growth, yield and quality contributing characters of tomato were recorded. The collected data were statistically analyzed for evaluation of the treatment effect. A significant variation among the treatments were found when different levels of boron used on tomato lines.

Significant variations were observed due to different levels of boron in different growth, flowering, yield and quality contributing parameters. The maximum plant height (102.9 cm) at 65 DAT was found from B_1 (102.9) treatment. In addition, the highest leaves per plant (48.34) at 65 DAT, foliage coverage (64.30 cm), internode length (5.08 cm), stem diameter (1.60 cm), number of branches per plant (3.73), leaf area (307.9 cm^2), chlorophyll content at vegetative stage, flowering stage (49.58) and fruiting stage (49.33), number of flower clusters per plant (21.25), days to first flowering (32.11), number of flowers per cluster (4.23), total flowers per plant (88.01), number of fruits per cluster(3.36), number of fruits per plant (69.33), fruit set percentage (56.73 %), individual fruit weight (59.78 gm), fruit length (4.52 cm), fruit diameter (4.86 cm), fruit yield per hectare (64.89 t), TSS (4.31%) , tomato p^H (5.02) was obtained from B_1 (foliar spray with 100 ppm boric acid). But in case of Vitamin C content (19.42 mg) best result found from B_2 (200 ppm boric acid).

The minimum plant height (90.64 cm) at 65 DAT was found from B_2 (foliar spray with 200 ppm boric acid). In addition, the lowest leaves per plant (39.13) at 65 DAT, foliage coverage (55.93 cm), internode length (4.46 cm), stem diameter (1.60 cm), number of branches per plant (3.73), leaf area (212 cm^2), chlorophyll content at vegetative stage (46.21), flowering stage (42.75) and fuiting stage (48.22), number of flower clusters per plant (17.93), days to first flowering (29.44), number of flowers per cluster (3.53), total flowers per plant (70.36), number of fruits per cluster (2.68), number of fruits per plant (50.11), fruit set percentage (47.36 %), individual fruit weight (44.56 g), fruit length (3.95 cm), fruit diameter (3.94 cm), fruit yield per hectare (54.05 t), TSS (3.66 %) , tomato p^H (4.23) was obtained from B_2 (foliar spray with 200 ppm boric acid). But in case of Vitamin C content (16.27 mg) lowest result found from B_0 (Control).

Significant variations were observed due to tomato line in different growth, flowering, yield and quality contributing parameters. The maximum plant height (127.8 cm), the highest leaves per plant (51.16), internode length (5.89 cm), chlorophyll content at flowering stage (49.90), number of flowers per cluster (4.19), number of flower clusters per plant (21.82), number of fruits per cluster (5.04), number of fruits per plant (101.1), fruit set percentage (55.32 %), TSS (4.58 %) was found from L_1 (Exotic Tomato Line-1). The highest foliage coverage (61.39 cm), chlorophyll content at vegetative stage (49.86) and fruiting stage (50.64), days to first flowering (32.56) found from L_2 (Exotic Tomato Line-2). The maximum stem diameter(1.50 cm), number of branches per plant (4.05), leaf area (352.9 cm^2), total flowers per plant (83.91), individual fruit weight (71.33 g), fruit length (4.93 cm), fruit diameter

(5.03cm), fruit yield per hectare (79.87 t), tomato p^H (5.06), Vitamin C content (20 mg) was obtained from L_3 (BARI Tomato-15).

The minimum plant height (74.16 cm), foliage coverage (58.51), internode length (3.88 cm) at 65 DAT, chlorophyll content at vegetative (45.39) and fuiting stage (46.32), number of fruits per cluster (1.97), fruit set percentage (48.65 %) and TSS (3.53 %) were found from L_3 (BARI Tomato-15). In addition, the lowest leaves per plant (33.69), stem diameter (1.028), number of branches per plant (2.64), leaf area (224.9 cm^2) at 65 DAT, chlorophyll content at flowering stage (43.69), number of flower clusters per plant (18.24), days to first flowering (27.89), number of flowers per cluster (3.53), total flowers per plant (70.20), number of fruits per plant (38.22) found from L_2 (Exotic Tomato Line-2). The lowest individual fruit weight (23.89 g), fruit length (3.19 cm), fruit diameter (3.28 cm), fruit yield per hectare (36.74 t), tomato p^H (4.31) and Vitamin C content (14.91) was obtained from L_1 (Exotic Tomato Line-1).

Interaction effect of different levels of boron and tomato line showed significant variations in different growth, flowering, yield and quality contributing parameters. The tallest plant height (135.40 cm), the highest leaves per plant (58.41), internode length (6.25 cm) at 65 DAT, chlorophyll content at flowering stage (52.20), number of fruits per plant (119), number of flowers per cluster (4.57), total flowers per plant (96.69), number of fruits per cluster (5.58), fruit set percentage (63.83 %) and TSS (4.73%) was found from B_1L_1 (100 ppm boric acid + Exotic Tomato Line-1). The maximum foliage coverage (65.92 cm), Chlorophyll content at vegetative stage (51.43) obtained from B_1L_2 (100 ppm boric acid + Exotic Tomato Line-2). In addition, maximum chlorophyll content at fruiting stage (51.23), days to first flowering (34) and Vitamin C content (21.35 mg) result found from B_2L_2 (200 ppm boric acid + Exotic Tomato Line-2). The maximum leaf area (400.4 cm^2), stem diameter (2.30 cm), number of branches per plant (4.48), number of flower clusters per plant (23.97), individual fruit weight (83 g), fruit length (5.47 cm), fruit diameter (5.63 cm), fruit yield per hectare (85 t), tomato p^H (5.20) B_1L_3 (100 ppm boric acid + BARI Tomato-15).

The minimum plant height (68.89 cm), internode length (3.56 cm) at 65 DAT and number of fruits per cluster (1.73) was found from B_2L_3 (200 ppm boric acid + BARI Tomato-15). In addition, the lowest leaves per plant (30.17) at 65 DAT, chlorophyll content at flowering stage (36.96), number of flowers per cluster (3.07), total flowers per plant (64.10), number of fruits per plant (31.67), fruit set percentage (44.80 %), TSS (3.17 %) B_2L_2 (200 ppm boric acid + Exotic Tomato Line-2). The minimum foliage coverage (55.69 cm), leaf area (182 cm^2), stem diameter (0.89 cm), number of flower clusters per plant (17.03), individual fruit weight (19 g), fruit length (3.05 cm), fruit diameter (3.03 cm), fruit yield per hectare (31.23 t), tomato p^H (3.72) was obtained from B_2L_1 (200 ppm boric acid +Exotic Tomato Line-1). The lowest chlorophyll content at fruiting stage (42.07) and Vitamin C content (13.37 mg) found from B_0L_1 (control +Exotic Tomato Line-1). The lowest number of chlorophyll content at vegetative stage (44.03) was resulted from B_0L_3 (control +BARI Tomato-15). The minimum days to first flowering (26.67) and number of flower clusters per plant (17.03) was resulted from B_1L_3 (control +BARI Tomato-15) and B_1L_1 (100 ppm boric acid + Exotic Tomato Line-1) respectively.

It is clearly established from the above given discussion that boron is an essential nutrient for growth, flowering, yield and quality in tomatoes. On the basis of results recorded from this experiment, the following conclusion can be generalized; among various boron concentrations used, 100 ppm boric acid showed better results regarding most of the parameters. Among tomato lines, more significant affects of boron regarding yield and quality were observed with BARI Tomato-15. Exotic Tomato Line-1 showed best result in terms of growth, flowering and quality also.

So tomato growers can consider exotic tomato lines for tomato production in terms of yield and quality in our country.

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APPENDICES

Appendix I(a). Results of mechanical and chemical analysis of soil of the experimental plot

Mechanical analysis

Constituents	Percent
Sand	32.45
Silt	61.35
Clay	6.10
Textural class	Silty loam

Chemical analysis

Soil properties	Amount
Soil pH	6.15
Organic carbon (%)	1.32
Total nitrogen (%)	0.075
Available P (ppm)	19.5
Exchangeable K (%)	0.2

Appendix I(b). Monthwise average recorded data

Month	*Air temperature (ºc)		*Relative Humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
October, 2016	26.5	19.4	81	22	6.9
November, 2016	25.8	16.0	78	00	6.8
December, 2016	22.4	13.5	74	00	6.3
January, 2017	24.5	12.4	68	00	5.7
February, 2017	27.1	16.7	67	30	6.7
March, 2017	31.4	19.6	54	11	8.2

* Monthly average

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargoan, Dhaka –1212

Appendix I(c). Basal fertilizer dose

Sl. No.	Fertilizers/ Manures	Dose	
		Applied in the field	Quantity/ha
1.	Urea	8 kg	450 kg
2.	TSP	6 kg	250 kg
3.	MOP	2 kg	260 kg
4.	Cow dung	200 kg	10 ton

Appendix II. Analysis of variance of data on plant height influenced by interaction effect of different levels of boron and tomato line

Source of variation	df	Mean square of plant height (cm) at different days after transplanting		
		25	45	65
Replication	2	29.36	114.17	89.62
Boron (A)	2	37.87^{NS}	186.23*	6954.37*
Tomato Line (B)	2	1567.97*	3967.42*	338.57*
Boron(A) X Line (B)	4	23.85*	21.66*	11.71*
Error	16	19.22	29.25	59.81

*Significant at 5% level of significance ^{NS} Non significant

Appendix III. Analysis of variance of data on number of leaves per plant influenced by interaction effect of different levels of boron and tomato line

Source of variation	df	Mean square of number of leaves per plant at different days after transplanting		
		25	45	65
Replication	2	1.53	3.60	10.30
Boron (A)	2	2.94 ^{NS}	132.51*	191.41*
Tomato Line (B)	2	224.82*	466.77*	743.89*
Boron(A) X Tomato Line(B)	4	2.46*	4.76*	13.62*
Error	16	1.79	8.06	13.21

*Significant at 5% level of significance ^{NS} Non significant

Appendix IV. Analysis of variance of data on foliage coverage influenced by interaction effect of different levels of boron and tomato line

Source of variation	df	Mean square of foliage coverage(cm) at different days after transplanting		
		25	45	65
Replication	2	18.687	9.731	10.60
Boron (A)	2	12.93 ^{NS}	100.31*	162.81*
Tomato Line (B)	2	202.31*	84.22*	20.85*
Boron(A) X Tomato Line (B)	4	4.90*	2.91*	5.77*
Error	16	9.53	12.373	29.43

*Significant at 5% level of significance ^{NS} Non significant

Appendix V. Analysis of variance of the data on length of internode (cm) of tomato as influenced by interaction effect of different levels of boron and tomato line

Source of variation	df	Mean square on length of internode (cm) at different days after transplanting		
		25	45	65
Replication	2	0.67	0.42	0.58
Boron (A)	2	0.14 ^{NS}	0.56*	0.92*
Tomato Line (B)	2	9.70*	1.88*	9.21*
Boron(A) X Tomato Line (B)	4	0.27*	0.07*	0.02*
Error	16	0.12	0.13	0.11

*Significant at 5% level of significance ^{NS} Non significant

Appendix VI. Analysis of variance of data on stem diameter influenced by interaction effect of different levels of boron and tomato line

Source of variation	df	Mean square of stem diameter (cm) at different days after transplanting		
		25	45	65
Replication	2	0.001	0.004	0.006
Boron (A)	2	0.01^{NS}	0.04*	1.11*
Tomato Line (B)	2	0.07*	0.01*	0.60*
Boron(A) X Tomato Line (B)	4	0.006*	0.001*	0.30*
Error	16	0.003	0.005	0.01

*Significant at 5% level of significance ^{NS} Non significant

Appendix VII. Analysis of variance of data on no. of branches per plant influenced by interaction effect of different levels of boron and tomato line

Source of variation	df	Mean square of no. of branches/plant at different days after transplanting		
		25	45	65
Replication	2	0.004	0.017	0.217
Boron (A)	2	0.93*	0.75*	0.97*
Tomato Line (B)	2	4.56*	4.68*	4.49*
Boron(A) X Tomato Line (B)	4	1.06*	0.02*	0.09*
Error	16	0.01	0.12	0.06

*Significant at 5% level of significance

Appendix VIII. Analysis of variance of the data on leaf area influenced by interaction effect of different levels of boron and tomato line

Source of variation	df	Mean square of leaf area (cm^2) at different days after transplanting		
		25	45	65
Replication	2	77.30	349.25	1070.07
Boron (A)	2	6.29 NS	5219.62*	24378.95*
Tomato Line (B)	2	4679.53*	8848.36*	44912.38*
Boron(A) X Tomato Line (B)	4	195.41*	474.69*	2000.44*
Error	16	23.26	330.92	641.44

*Significant at 5% level of significance NS Non significant

Appendix IX. Analysis of variance of data on Chlorophyll content influenced by interaction effect of different levels of boron an tomato line

Source of variation	df	Mean square of Chlorophyll contentat different stages		
		Vegetative	flowering	fruiting
Replication	2	9.89	19.44	0.28
Boron (A)	2	34.38 NS	115.13*	25.48 NS
Tomato Line (B)	2	45.25 NS	86.84*	52.63 NS
Boron(A) X Tomato Line (B)	4	0.91 NS	12.38*	14.92*
Error	16	23.13	14.15	21.63

*Significant at 5% level of significance NS Non significant

Appendix X. Analysis of variance of the data on flowers and fruits influenced by different levels of boron and tomato line

Source of variation	df	Mean square						
		No. of flower clusters plant^{-1}	Days to 1st flowering	No. of flowers cluster^{-1}	No. of flowers plant^{-1}	No. of fruits cluster^{-1}	No. of fruits plant^{-1}	Fruit set %
Replication	2	2.88	4.93	0.007	48.64	0.005	28	4.10
Boron (A)	2	24.84*	16.04*	1.11*	33729.23*	1.05*	832.11*	103.86*
Tomato Line (B)	2	32.85*	56.26*	1.09*	450.16*	27.67*	11659.11*	200.51*
Boron (A) X Tomato Line (B)	4	1.02*	0.15*	0.081*	24.74*	0.09*	136.06*	8.92*
Error	16	1.67	4.63	0.104	42.40	0.06	25.38	17.22

*Significant at 5% level of significanc

Appendix XI. Analysis of variance of the data on yield and quality influenced by different levels of boron and tomato line

*Significant at 5% level of significance

Source of variation	df	Mean square						
		Individual fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit yield (t ha^{-1})	TSS %	pH	Vitamin C
Replication	2	42.33	0.03	0.18	4.46	0.003	0.24	1.084
Boron (A)	2	523.44*	0.75*	1.96*	264.45*	0.97*	1.42*	24.67*
Tomato Line (B)	2	5558.78*	7.43*	7.86*	4223.84*	2.55*	1.47*	58.54*
Boron (A) X Tomato Line (B)	4	29.56*	0.10*	0.05*	0.17*	0.25*	0.21*	13.77*
Error	16	10.08	0.12	0.15	20.97	0.13	0.17	3.23