INFLUENCE OF GA_3 AND BORON ON GROWTH AND YIELD OF SUMMER TOMATO

RIAJUL ISLAM

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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RIAJUL ISLAM
REG. NO. 17-08289

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Approved by:

Prof. Dr. Md. Ismail Hossain
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

Associate Professor Dr. Jasim Uddain
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Co-Supervisor

Prof. Dr. Mohammad Humayun Kabir
Chairman
Examination Committee

DEPARTMENT OF HORTICULTURE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Ref. no.: *Date:*

CERTIFICATE

*This is to certify that thesis entitled, **"INFLUENCE OF GA$_3$ AND BORON ON GROWTH AND YIELD OF SUMMER TOMATO"** 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 **RIAJUL ISLAM,** Registration: **17-08289** 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.

………………………………..

Date: …………...

Dhaka, Bangladesh

Prof. Dr. Md. Ismail Hossain

Department of Horticulture

Sher-e-Bangla Agricultural University

Dhaka - 1207

Supervisor

DEDICATED TO

MY

BELOVED PARENTS

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INFLUENCE OF GA_3 AND BORON ON GROWTH AND YIELD OF SUMMER TOMATO

RIAJUL ISLAM

ABSTRACT

A pot experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka from April 2018 to September 2018 to study the effect of GA_3 and boron on the growth and yield of summer tomato, (CV- BARI Hybrid Tomato-4). There were four concentrations of GA_3 viz. G_0: 0 ppm, G_1: 50 ppm, G_2: 100 ppm and G_3: 150 ppm and three levels of boron viz. B_0: 0 ppm, B_1: 25 ppm and B_2: 50 ppm. The experiment was laid out in a Completely Randomized Design (CRD) with 3 replications and there were altogether 36 pots. Application of GA_3 and boron significantly influenced the growth, yield and size of tomato. The highest yield (1600.87 g/plant) was found from G_2 and the lowest yield (678.85 g/plant) was obtained from G_0. Due to application of boron, the highest yield (1515.31 g/plant) was obtained from B_1 and the lowest yield (794.14 g/plant) was recorded from B_0. In case of combined effect, the highest yield (1689.44 g/plant) was found from G_2B_1 and the lowest yield (487.41 g/plant) was found from G_0B_0. So, application of 100 ppm GA_3 along with 25 ppm boron was the best for growth and yield of tomato.

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LIST OF ACRONYMS

ABBREVIATIONS		ELABORATIONS
%	:	Percent
@	:	At the rate
AEZ	:	Agro –Ecological Zone
Agric.	:	Agriculture
Agril.	:	Agricultural
ANOVA	:	Analysis of variance
BARI	:	Bangladesh Agricultural Research Institute
BBS	:	Bangladesh Bureau of Statistics
cm	:	Centi-meter
df	:	Degrees of Freedom
DMRT	:	Duncan’s Multiple Range Test
et al.	:	and others
etc.	:	Etcetera
FAO	:	Food And Agriculture Organization of United Nations
LSD	:	Least Significant Difference
etc.	:	Etcetera
MoA	:	Ministry of Agriculture
MSE	:	Mean square of the error
ppm	:	Parts per million
RCBD	:	Randomized Complete Block Design
SAU	:	Sher-e- Bangla Agricultural University
SE	:	Standard Error
TSS	:	Total Soluble Solid

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicum esculentum*) is a flowering plant belongs to the family Solanaceae. It was originated in tropical America (Salunkhe *et al*., 1987), particularly in Peru, Ecuador and Bolivia of the Andes (Kalloo, 1986). Tomato is the rich source of vitamin A, Vitamin C and minerals and it keeps eye sight good. Night blindness occurs due to lack of Vitamin A. 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. It 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.

Tomato ranks next to potato and sweet potato in the world vegetable production. It ranks third in terms of world vegetable production (FAO, 2000) and tops the list of canned vegetables. The leading tomato production countries of the world are China, the United States of America, India, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (FAO, 1999). It is cultivated in almost all home gardens and also in the field due to its adaptability to wide ranges of soil and climate (Ahmed, 1986). It is one of the most highly praised vegetables consumed widely and it is one of the most popular salad vegetables and is taken with great relish. It is widely employed in cannery and made into soups, conserves, pickles, ketchup, sauces, juices etc. Tomato juice has become an exceedingly popular appetizer and beverage.

Tomato can be grown on a wide range of soil types, ranging from light sand to heavy loam or, even clay that are well supplied with organic matter. It is cultivated all over the Bangladesh; however, the yield is very low in the summer-rainy season (from April to October). The maximum temperature in summer reaches 34-38°C and causes very poor fruit set. Due to the excellent nutritional and processing potentials of tomato, the demand of tomato remains higher round the year, but production is far below the demand, especially in the summer season. Tomato fruit set is hampered at high temperature, for example, when day and night temperatures exceed above 32°C and 21°C, respectively, due to abnormal stamen development and pollen dehiscence (Sasaki *et al.*, 2005). As a consequence, efficient tomato production in Bangladesh is mainly confined during winter (November-March) season. At higher temperature, the probability of floral abscission is high after anthesis.

In Bangladesh, the temperature during summer remains high both in the day and at the night which affect fruit-set of tomatoes. Although the influence of plant growth regulators (PGRs), such as auxin and gibberellin, over fruit development already acknowledged back in the early 20th century. In summer, tomato fruit set can be increased by applying plant growth regulators. The use of plant growth regulators (PGR) improved the production of many horticultural crops including tomato which attracts the researchers and growers for its commercial application for summer tomato production. Application of PGR like gibberellic acid (GA_3) brings the possibility of tomato production under adverse environmental conditions.

Gibberellic acid has great effects on plant physiological systems including fruit setting, leaf expansion, germination, breaking dormancy, increasing fruit size, improving fruit quality and in many other aspects of plant growth and thereby increased crop production. Along with other PGR, gibberellic acid (GA_3) is used extensively in tomato to enhance yield by improving fruit set, size and number of fruits (Batlang, 2008; Serrani *et al.*, 2007). Tomato fruit set was promoted by GA_3 at low concentration (Khan *et al.*, 2006).

GA_3 is also an important factor for tomato good yield. The application of Gibberellic acid had significantly increased the number of fruits plan than the untreated controls. Tomar and Ramgiry (1997) and Adlakha and Verma (1995) reported that GA_3 (55 ppm) sprayed on flower cluster resulted is an increase in fruit weight. To increase the yield and to avoid flower and fruit dropping, application of GA_3 at right concentration and right time is important.

Boron has a pronounced effect on the production and quality of tomato. Boron is needed by the crop plants for cell division, nucleic acid synthesis, uptake of calcium and transport of carbohydrates (Bose and Tripathi, 1996). Boron also plays an important role in flowering and fruit formation (Nonnecke, 1989). Boron deficiency affects the growing points of roots and youngest leaves. The leaves become wrinkled and curled with light green colour. Its deficiency affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins (Stanley *et al*., 1995).

Application of Boron (B) promotes the receptivity of stigma by extending the time of pollination and makes viable the pollen resulting higher fertilization and fruit setting. Application of B increased fruit firmness which increased shelf life of tomato (Abdur *et al*., 2010), increase fruit sets per plant, increase individual fruit weight per plant and increase brix % in tomatoes.

Research on the effect of GA_3 in association with application of boron on the growth and yield of tomato under Bangladesh conditions is limited. However, considering the above circumstances, the study was conducted with the following objectives:

i. to optimize the suitable level of GA_3 on growth and yield of heat tolerant tomato;
ii. to determine the optimum level of boron on growth and yield of heat tolerant tomato;
iii. to find out the suitable combination of GA_3 and boron for ensuring the maximum growth and yield of tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato (*Lycopersicum esculentum* Mill.) is one of the most important vegetable crops in Bangladesh and received much attention to the researcher throughout the world. The production level of summer tomato never meets the demand of Bangladesh. Moreover, the country with high temperature and dry weather round the year lead the loss of production. Plant growth regulators are the substances, which affect the growth of plants quite miraculously. GA_3 is one of them. Application of this growth regulator has different modifying influences on growth, yield and yield contributing characters of tomato as well as other vegetables. Micronutrients, like boron also plays an important role in the production of tomato. Some of the available research works in this connection have been reviewed with the hope that these may contribute useful information to the present study. In this chapter, literature available in this aspect in the country and abroad was reviewed.

2.1 Literatures on GA_3

Desai *et al*. (2012) conducted an experiment to find out the effect of different plant growth regulators and micronutrient on fruit characters and yield of tomato cv. GUJARAT TOMATO-3 (GT-3) at Horticulture Farm, Junagadh Agricultural University, Junagadh, Gujarat, India during December, 2010 to 10 April, 2011. Eleven different treatments consisted of four plant growth regulators and three micronutrients were used, viz., T_1 = gibberellic acid @ 50 ppm, T_2 = gibberellic acid @ 75 ppm, T_3 = naphthalene acetic acid @ 50 ppm, T_4 = naphthalene acetic acid @ 75 ppm, T_5 = boron 50 ppm, T_6 = boron 75 ppm, T_7 = zinc 0.5per cent, T_8 = zinc 1per cent, T_9 = iron 100 ppm, T_{10} = iron 150 ppm and T_{11} = Control (No application of plant growth regulator and micronutrients) in the study. The fruit characters and yield parameters in plant significantly differed due to different plant growth regulators and micronutrient on tomato. The maximum fruit length (7.57 cm), girth (6.47 cm) and pulp-seed ratio (12.93)was found in T_2 = gibberellic acid @ 75 ppm, whereas fruit weight (57 g), yield plant-1 (2.47 kg) and yield hectare^{-1} (913.258 q/ha) were found in treatment T_4 = naphthalene acetic acid @ 75 ppm and the minimum for all the parameters were found in control treatment.

Nibhavanti *et al*. (2006) carried out an experiment on the effect of gibberellic acid, NAA, 4-CPA and boron at 25 or 50 ppm on the growth and yield of tomato (cv. Dhanshree) during the summer season of 2003. Plant height was greatest with gibberellic acid at 25 or 50 ppm (74.2 cm and 75.33 cm, respectively) and 4-CPA at 50 ppm (72.22 cm). The number of primary branches per plant did not among the treatments. Gibberellic acid at 50 ppm resulted in the lowest number of primary branches per plant.

An experiment was conducted by Rahman *et al.* (2015) at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh to test the impact of plant growth regulators on growth and yield of summer tomato. The experiment consisted of two tomato varieties viz. BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8 and four types of plant growth regulator (PGR) viz., (i) control (without PGR), (ii) 4-CPA (4-chlorophenoxy acetic acid), GA_3 (gibberellic acid) and 4-CPA +GA_3. The two-factor experiment was laid out in randomized complete block design with three replications. The results of the experiment revealed that significant variations were observed for most of the characters studied. At 75 DAT, the tallest plant (79.35 cm), number of flowers and fruits (38.11 and 19.04, respectively) plant^{-1}, individual weight (58.44 g) and fruit yield (22.75 t ha^{-1}) were found in BARI Hybrid Tomato-8. At 75 DAT the maximum plant height (87.90 cm), number of flowers and fruits (49.04 and 21.9, respectively) plant^{-1}, individual fruit weight (61.16 g), and fruit yield (27.28 tha^{-1}) were found when 4-CPA + GA_3 applied together, whereas the minimum for these characters were recorded from control plants. In case of combined effect of variety and plant growth regulator, the maximum plant height (87.90 cm), number of flowers and fruits (49.04 and 21.91, respectively) $plant^{-1}$, individual fruit weight (61.16 g) and fruit yield (27.28 t ha^{-1}) were observed in BARI Hybrid Tomato-8 when treated with 4-CPA + GA_3 together, and the minimum for all these parameters were found in control plants. The results of the present study suggest thatboth 4-CAP and GA_3 together can be practiced for increasing summer tomato production for both the varieties.

Naeem *et al.* (2001) reported that, both time and concentrations of GA_3 significantly affect the growth parameters of tomato plants. Maximum days to flowering (42.67), fruit per plant (77.69), plant height (77.78 cm), fruit weight (71.15 gm), number of branches (12.33) per plant and total yield (26840 kg ha^{-1}) were recorded in the plants sprayed with 60 mg/lit of gibberellic acid 10 days before transplantation, while minimum values were noted in controlled treatment. They found that, maximum fruit drop per plant was in control treatment and minimum in the plants treated with gibberellic acid at 60 mg/lit. They suggested that, tomato should be supplied with gibberellic acid at 60 mg/lit 10 days before transplantation under the agroclimatic conditions of Peshawar.

Shittu and Adeleke (1999) investigated the effects of foliar application of GA_3 (0, 10, 250 or 500 ppm) on growth and development of tomatoes cv, 158-3 grown on pots. Plant height and number of leaves were significantly enhanced by GA_3 treatment. Plants treated with GA_3 with 250 ppm were the tallest plant the highest number of leaves.

EI- Habbasha *et al*. (1999) carried out a field experiment with tomato cv. castel rock over two growing seasons (1993-94). The effects of GA_3 and 4-CPA on fruit yield and quality were investigated. Many of the treatments significantly increased fruit set percentage and total fruit yield, but also the percentages of puffy and parthenocarpic fruits compared to the controls.

Tomar and Ramgiry (1997) studied that tomato plant treated with GA_3 showed significantly greater number of branches plant^{-1} than untreated controls.

An experiment was conducted by Akand *et al.* (2015) to find out the effect of GA_3 on the growth and yield of tomato. The experiment consisted of four concentration of GA_3 such as control G_0= control (no GA_3), G_1= 75 ppm GA_3, G_2 = 100 ppm GA_3 and G_3= 125 ppm .The experiment was laid out in RCBD with three replications. All parameter varied significantly at different concentration of GA_3. The highest yield (92.99 t/ha) was obtained from G_3 treatment whereas the G_0 gave lowest yield (60.46 t/ha).

Gabal *et al*. (1990) found that 100 ppm of GA_3 was more effective treatment in increasing leaf number plant^{-1} compared to control.

Sanyal *et al*. (1995) studied the effects of plant growth regulators (IAA or NAA at 15, 25 or 50 ppm or GA_3 at 50, 75 or 100 ppm) and methods of plant growth regulator application on the quality of tomato fruits. Plant growth regulators had profound effects on fruit length, weight and sugar : acid ratio. The effects of presoaking seeds and foliar application of plant growth regulators were more profound than presoaking alone.

Hathout *et al*. (1993) found that application of 10 ppm IAA as foliar sprays or to the growing media of tomato plants had a stimulatory effect on plant growth, development and fruit which was accompanied by increases in endogenous auxin, gibberellins and cytokinin contents. However, IAA at 80 ppm had an inhibitory effect on plant growth and development, which was accompanied by increase in the level and activity of indigenous inhibitors and by low levels of auxins, cytokines and gibberellins.

Uddain *et al.* (2009) conducted an experiment with four different plant growth regulators (denoted as PGR) as treatments, viz. PGR_0 = Control (No application of plant growth regulator), PGR_1 = NAA (Naphthalene acetic acid) @ 30 ppm, PGR_2 = GA (Gibberellic Acid) @ 30 ppm and PGR_3= 2, 4-D (2, 4- Dichloro-phenoxy acetic acid) @ 30 ppm. The growth and yield contributing characters were significantly differed due to different plant growth regulators on tomato. The maximum plant height at 15 DAT (33.41 cm), 30 DAT (59.07 cm) and 45 DAT (76.36 cm), number of leaves plant^{-1} at 15 DAT (15.08), 30 DAT (47.20) and 45 DAT (72.86), number of branches plant^{-1} at 15 DAT (8.06), 30 DAT (12.13) and 45 DAT (17.85), number of flowers cluster^{-1} (5.81), number of flower cluster plant^{-1} (8.83), number of flowers plant^{-1} (9.62), number of fruits cluster^{-1} (4.81), number of fruits plant^{-1} (42.66), average weight of individual fruit (92.06 g), yield plant^{-1} (2.49 kg) and yield hectare^{-1} (93.23 t/ha) were found in PGR_2 and the minimum for all the parameters were found in control (PGR_0) treatment.

Choudhury and Faruque (1972) reported that the percentage of seedless fruit increased with an increase in GA_3 concentration from 50 ppm to 100 ppm and 120 ppm. However, the fruit weight was found to decrease by GA_3 effects.

Mehta and Mathi (1975) reported that treatments with NAA at 0.1 or 0.2 ppm improved the yield of tomato irrespective of planting date. Maximum fruit set, early and total yield, fruit number and weight were obtained in response to 4-D at 5 ppm followed by NAA at 0.2 ppm. He also reported that GA_3 treatments at 10 or 25 ppm improved the yield of tomato cv. Pusa Ruby irrespective of planting date. GA_3 gave earlier setting and maturity.

An experiment was conducted by Akand *et al.* (2016) at the farm of Sher-e-Bangla Agricultural University, Dhaka to study the effect of potassium and GA_3 on the growth and yield of tomato. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and consisted of two factors. Factor A is consisting K_0 = Control (No fertilizer), K_1 = 120 kg, K_2 = 150 kg and K_3 = 180 kg K_2O/ha, respectively and Factor B is consisting G_0 = Control (No GA_3), G_1 = 40 ppm and G_2 = 60 ppm GA_3, respectively. In case of potassium, K_1 produced the highest yield (59.45t/ha) and K_0 produced the lowest yield (51.33 t/ha). In case of GA_3, G_1 produced the highest yield (58.66 t/ha) and G_0 produced the lowest yield (46.55 t/ha). Combined effect of K_1G_1 produced the highest yield (70.77 t/ha) and K_0G_0 produced the lowest yield (43.89 t/ha). The highest (4.75) benefit cost ratio was recorded from the combination of K_1G_1. Therefore, 120 kg K_20/ha with 40 ppm GA_3 was found suitable for growth and yield of tomato.

Sumiati (1987) reported that tomato cultivars, “Gondol”, “Meneymaker”, “Intan” and “Ratan” sprayed with 1000 ppm chlorflurenol,100 ppm IAA, 50 ppm NAA or 10 ppm GA_3 or left untreated ,compared with controls, fruit setting was hastened by 4-5 days in all cultivars following treatment with 100 ppm IAA or 10 ppm GA_3.

Kataoka *et al*. (2003) conducted an experiment on the effect of uniconazole on fruit growth in tomato cv. Severianin and reported that uniconazole (30 mg/litre) reduced fruit weight when applied to parthenocarpic fruits at approximately 0, 1 and 2 weeks after anthesis, but had no effect on fruit weight when applied at approximately 3 weeks after anthesis. To determine the antagonism between gibberellic acid (GA_3)

and uniconazole in the regulation of fruit growth, flower clusters were treated with uniconazole (5 mg/L) and GA_3 (5 or 50 mg/L). They reported that no notable gibberellin's activity was detected in treated fruits at 3 days to 4 weeks after treatment was lower than that of the control value. The results suggest that endogenous gibberellins in the early phase are important for fruit set and development.

Gulnaz *et al*., (1999) reported that seeds of wheat treated with to 10 ppm of GA_3 resulted in 36-43% increase in dry weight at 13.11 dSm^{-1}.

Van Tonder and Combrink (2003) evaluated the role of various plant growth regulators including: synthetic cytokinin (CPPU) at 1 $ml.L^{-1}$, auxins 1-naphthylacetic acid at 1 $ml.L^{-1}$ and 4- chlorophenoxyacetic acid (4-CPA) at 30 $mg.L^{-1}$, gibberellins (GA_3) 'ProGibb 4%′ and SupaGibb 4SL' both at 1 $ml.L^{-1}$, and a mixture of benzyladenine (6-BA) plus GA_{4+7} at 1 $ml.L^{-1}$. Treatments were applied in improving fruiting characteristics of out of season tomatoes up to three times successively when three or more flowers of an inflorescence reached anthesis. PGR's, CPPU, 1-NAA, 4-CPA, 'ProGibb', 'SupaGibb' and BA plus GA_{4+7}, at three applications, induced higher tomato yields by increasing the truss mass. Synthetic auxins, 1-NAA and 4-CPA, increased the average fruit mass as well as the number of fruit with a diameter larger than 37 mm but also increased the percentage of malformed fruit. Three applications of the mixture BA plus GA_{4+7} provided the most promising results by improving the yield of marketable fruit through increases in the number of fruit set, the number of fruit per truss and the overall truss mass. No detrimental affects on fruit shape were associated with this treatment.

Gurdev and Saxena (1991) observed that the growth regulators (GA_3 at 10^{-5} M) increased total dry matter. Application of 10^{-5} M GA_3 on mustard at 40 or 60 days after sowing significantly increased total dry matter (Khan *et al*., 1998).

Saleh and Abdul (1980) performed an experiment with GA_3 (25 or 50 ppm) applied 3 times in June or early July. They reported that GA_3 stimulated plant growth. The substance reduced the total number of flowers plant^{-1} but increased the total yield compared with the control. GA_3 also improved fruit quality.

Onofeghara (1981) carried out an experiment with tomato and sprayed GA_3 at 25-1000 ppm. He observed that GA_3 promoted flower primordia production and the number of primordia produced or the pattern of primordia production over time.

Leaf area index measures leafiness and photosynthetic surface area of a crop and it depends on the leaf growth number of leaf, plant density and leaf senescence (Khan, 1981).

Kumar *et al.* (2014) conducted an experiment with the objective to determine the effects of Gibberellic acid (GA_3) on growth, fruit yield and quality of tomato. The experiment consisted of one tomato variety- Golden, and six treatments with five levels of gibberellic acid (GA_3- 10 ppm, 20 ppm, 30 ppm, 40 ppm and 50 ppm), arranged in randomized block design with three replications. The highest plant height, number of leaves, number of fruits, fresh fruit weight has been observed and ascorbic acid, total soluble solid (TSS) was estimated for GA_3 50 ppm.

Lilov and Donchev (1984) observed that by the application of GA_3 at 20, 40 or 100 mg/L the yields were increased compared with the non-treated control.

Khan *et al.* (2006) conducted an experiment to study the effect of 4 level of gibberellic acid spray on the growth, leaf NPK content, yield and quality parameters of 2tomato cultivars (*Lycopersicon esculentum* Mill.), namely "Hyb-SC-3''and "Hyb-Himalata''. They reported that irrespective of its concentration , spray of gibberellic acid proved beneficial for most parameters especially in the case of "Hyb-SC-3''.

Leonard *et al*. (1983) reported that inflorescence development in tomato plants grown under low light regimes was promoted by GA_3 application directly on the inflorescence.

Mehraj *et al.* (2014) conducted an experiment to assess the response of foliar application of GA3 with different concentrations to cherry tomato plants. The assessment expressed that, the foliar application of 200 ppm gibberellic acid solution provided maximum number of leaves (16.7), tallest plant (70.0 cm), early flower bud initiation (13.0 days), early flowering (16.0 days) and early fruiting (20.3 days); utmost fruit diameter (25.9 mm) and number of fruits (105.0 fruits) per plant; maximum single fruit weight (11.1 g) and total fruit weight (1.2 kg) per plant, whereas the control was lowest.

Wu *et al*. (1983) sprayed GA_3 on one-month old transplanted tomato plants at 1, 10 or 100 ppm and reported that GA_3 100 ppm increased plant height and leaf area.

Briant (1974) sprayed GA_3 on the leaves of young tomato plants and observed that total leaf weight and area were increased by GA_3.

Masroor *et al.* (2006) conducted a pot experiment according to a factorial randomized design at Aligarh to study the effect of 4 levels of gibberellic acid spray (0, 10^{-8}, 10^{-6} and 10^{-4} M GA_3) on the growth, leaf-NPK content, yield and quality parameters of 2 tomato cultivars (*Lycopersicon esculentum* Mill.), namely Hyb-SC-

3 and Hyb-Himalata. Irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters, especially in the case of Hyb-SC-3.

Chern *et al*. (1983) reported that one month old transplanted tomato plants were sprayed with 1, 10 or 100 ppm GA_3 and observed that GA_3 at 100 ppm increased leaf area, plant height and stem fresh and dry weight but 10 ppm inhibited growth.

Kaushik *et al*. (1974) carried out an experiment with the application of GA_3 at 1, 10 or 100 mg/L on tomato plants at 2 leaf stages and at weekly interval until 5 leaf stages. They reported that GA_3 increased the number and weight of fruits per plant at higher concentration.

Bora and Selman (1969) worked with tomato demonstrated that four foliar sprays of GA_3 (0, 5, 50 or 500 ppm) applied at 7, 17, 22, 27 or 37^0 increased the leaf area, weight and height of tomato plants. The best treatment was 5 ppm GA_3 at 22^0C.

Mehta and Malhi (1970) reported that GA_3 application at 25 ppm improved the yield of tomato. GA_3 produced earlier fruit setting and maturity.

Hossain (1974) investigated the effect of GA_3 along with 4-CPA on the production of tomato. He found that GA_3 applied with 50, 100 and 200 ppm produced an increased fruit set. However, GA_3 treatment induced small size fruit production A gradual increase in the yield plant^{-1} was obtained with higher concentration of GA_3.

Rahman *et al.* (2015) conducted a pot experiment at Bangladesh Institute of Nuclear Agriculture, Bangladesh to evaluate influence of different concentrations of GA_3 on biochemical parameters at different growth stages in order to maximize yield of summer tomato var. Binatomato-2. The concentrations of GA_3 were 0, 25, 50, 75 and 100 ppm. They were applied at three stages, namely root soaking of seedlings before transplanting, vegetative and flowering stages. The experiment was laid out in a randomized complete block design with four replications. Results indicated that the highest chlorophyll and soluble protein contents were recorded when GA_3 was applied through root soaking followed by vegetative stage and the lowest was found at the flowering stage. In contrast, the highest nitrate reductase activity was observed when GA_3 was applied at the vegetative stage and the lowest activity was recorded at the flowering stage. The applications of 50-75 ppm GA_3 had significantly encouraged the bio-chemical parameters studied at 50 DAT. The amount of GA_3 applied at different stages had significant influence on the yield and yield attributes of summer tomato. The highest plant height was recorded when 50 ppm of GA_3 was applied at the vegetative stage. While, the longest time to first fruit setting was required when the roots of the seedlings were soaked in 100 ppm GA_3 solution. The application of 50 ppm GA_3 by root soaking had significantly increased the number of flowers, fruits and fruit yield per plant but similar results were achieved when only 25 ppm GA_3 was applied at the flowering stage. The fruit yield of tomato per plant increased linearly with the increased number of flowers and fruits per plant.

Sawhney and Greyson (1972) reported that application of GA_3 on non-flowering plants of tomato induced multilocular, multicarpellary ovaries which were larger at anthesis than control upon pollination produced fruits which were significantly larger with higher fresh weight.

Adlakha and Verma (1964) observed that when the first four clusters of tomato plants were sprayed three times at unspecified intervals with GA_3 at 50 and 100 ppm, the fruit setting increased by 5% with higher concentration.

Adlakha and Verma (1965) observed that when the first four clusters of tomato plants were sprayed three times at unspecified intervals with GA_3 at 50 and 100 ppm, the fruit setting, fruit weight and total yield increased by 5, 35 and 23%, respectively with the higher concentration than the lower.

Rapport (1960) noted that GA_3 had no significant effect on fruit weight and size either at cool (11^0 C) or warm (23° C) night temperatures; but it strikingly reduced fruit size at an optimum temperature (17^0 C).

Chowdhury and Faruque (1972) reported that the percentage of seedless fruit increased with the increase in GA_3 concentration from 50 ppm to 100 ppm. However the fruit weight was found to decrease by GA_3.

Gustafson (1960) worked with different concentration of GA_3 and reported that when 35 and 70 ppm GA_3 were sprayed to the flowers and flower buds of the first three clusters, percentage of fruits set increased but there was a decrease in the total weight. When only the first cluster was sprayed, the number of fruit set and the total weight per cluster was increased, but this response did not occur in subsequent clusters.

2.2 Literatures on Boron

Boron is an essential micronutrients required for normal plant growth and development. It performs a wide range of functions in tomato plants. It is a very sensitive element and plants differ widely in their requirements but the ranges of deficiency and toxicity are narrow. It maintains a balance between sugar and starch in plant body. It translocates sugar and carbohydrates in different parts of the plant body. It is important in pollination and seed production. It is necessary for normal cell division, nitrogen metabolism and protein formation. It is essential for proper cell wall formation. Boron plays an important role in the proper function of cell membranes and the transport of K to guard cells for proper control internal water balance. The requirement of B in vegetables generally more than other crops.

Naz *et al*. (2012) conducted an experiment to study the effect of boron on the growth and yield of Rio Grand and Rio Figue cultivar of tomato at Horticultural Research Farm, NWFP Agricultural University, Peshwar during 2008-09. They used different doses of B (0, 0.5, 1.0, 2.0, 3.0 and 5.0 kg ha^{-1}) with constant doses of nitrogen, phosphorus and potash was incorporated at the rate of 150, 100 and 60 kg ha^{-1}. Boron showed a significant effect on the growth and yield of tomato. In the experiment 2 kg ha^{-1} resulted in maximum numbers of flower clusters per plant, fruit set percentage, total yield and total soluble solid. Rio Grand cultivar of tomato showed significant effect on all parameters. Maximum number of flower clusters per plant, fruit set percentage and total yield were recorded with Rio Grand cultivar of tomato. They have further mentioned that 2 kg B ha^{-1} significantly affected flowering and fruiting of Rio Grand cultivar.

Yuanxin and Junhua (2011) conducted some experiments in a perlite bag culture under nutrient drip irrigation to study the effects of different concentrations of the trace elements boron and manganese on the yield, fruit quality and antioxidative capacity in tomato. The study showed that under reduced concentrations of boron, tomato yields and the antioxidative content in tomato were significantly reduced. Under high boron concentrations yields and the antioxidative capacity were increased however the ascorbic acid content was reduced. Similarly, under low manganese both yields and the total antioxidative capacity were reduced, however under high manganese levels, yields were not reduced nor were the concentration of ascorbic acid. Total solids were reduced under a high concentration of the micronutrient manganese.

Salam *et al*. (2010) conducted an experiment at the vegetable research farm of the Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydevpur, Gazipur during the period 2006-2007 to investigate the effects of boron and zinc in presence of different level of NPK fertilizers on quality of tomato. There were twelve treatment combination which comprised for level of boron and zinc viz., i) B_0Zn_0 = 0 kg B + 0 kg Zn/ha ii) $B_{15}Zn_{20}$ = 1.5 kg B + 2.0 kg Zn/ha iii) $B_{20}Zn_{40}$ = 2.0 kg B + 4.0 kg Zn/ha iv) $B_{25}Zn_{60}$ = 2.5kg B + 6.0 kg Zn/ha and three levels of NPK fertilizers viz., i) 50% less than the recommended NPK fertilizer dose (50%< RD), ii) Recommended NPK fertilizer dose (RD), iii) 50% more than the recommended NPK fertilizer dose (50% >RD). The highest pulp weight (88.14%), dry matter content (5.34%), TSS (4.50%), ascorbic acid (10.95mg/100gm), lycopene content (112.00 µg/100gm), chlorophyll-b (56.00 µg/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 Kg and K = 125kg/ha).

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. The minimum number of days (30.00) for initiation of flowering and 50% flowering (38.86) were recorded with Boron 50 ppm and 100 ppm while the maximum number of days were recorded in control. The treatment Boron 100 ppm + Iron 200 ppm + Zinc 200 ppm was most effective in increasing number of clusters (13.85) and number of flowers (51.24) per plant. 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

Luis *et al*. (2012) conducted a study to evaluate the effect of boron on two variety of tomato. The objective of this research was to study the how B toxicity (0.5 and 2 m MB) 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). Under the treatments of 0.5 and 2 m MB, the tomato plants showed a loss of biomass and foliar area. At the same time, in the leaves of both cultivars, the B concentration increased rapidly from the first day of the experiment. These results were more pronounced in the cv. Josefina, indicating greater sensitivity than in cv. Kosaco with respect to excessive B in the environment. The levels of (O_2 and anthocyanins presented a higher correlation coefficient ($r>0.9$) than did the levels of B in the leaf, followed by other indicators of stress, such as GPX, chlorophyll b and proline ($r>0.8$). 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.

Sivaiah *et al*. (2013) was conducted field experiment during rabi-2010 to find out the response of foliar application of micronutrients on vegetative and reproductive growth attributes, 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 and the experiment was laid out in RBD with three replications. All the Micronutrients except manganese at 50 ppm were applied at 100 ppm in three sprays at an interval of ten days starting from 30 days after transplanting. A `ll the treatments resulted in improvement of plant growth characteristics viz. plant height, number of primary branches, compound leaves, tender and mature fruits per plant in both the varieties out of which application of micronutrients mixture showed the maximum effect. In tomato cv. Utkal Kumari, maximum growth rate (85.7%) was observed with application of zinc, followed by application of micronutrients mixture (78.2%) and boron (77.5%). Tomato cv. Utkal Raja, maximum increase in branches per plant was observed with the application of manganese (148.7%) followed by micronutrient combination (144.1%). In UtkalKumari, the fruit yield per plant ranged from 1.336 kg to1.867 and in Utkal Raja, it ranged from 1.500 kg to 1.967 kg. In both the varieties, combined application of micronutrients produced the maximum fruit yield followed by application of boron and zinc.

Basavarajeshwari *et al*. (2007) carried out a field experiment to study the effect of foliar application of micronutrients on growth and yield of tomato at the all Indian Coordinated Vegetables Improvement Project (AICVIP) in the University of Agricultural Sciences, Dharwad. The result based on two years mean revealed that out of nine different treatments, the application of boric acid @ of 100 ppm resulted in maximum number of primary branches (18.30), yield per plant (2.07 kg) and fruit yield (30.50 t/ha). Followed by the 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 treatments.

Smith and Combrink (2004) used four nutrient solutions with only B at different levels (0.2, 0.16, 0.32 and 0.64 mgL^{-1}) in greenhouse tomatoes planted in acidwashed river sand. Leaf analysis indicated that the uptake of Ca, Mg, Na, Zn and B increased with higher B levels. At the low B level, leaves were brittle and appeared pale-green and very high flower abscission percentages were found. Fruit lacked firmness at the low B level and this problem worsened during storage. At the 0.16 mg kg^{-1} B-level; fruit set, fruit development, colour, total soluble solids, firmness and shelf life seemed to be close to optimum. The highest B-level had no detrimental effect on any of the yield and quality related parameters. However using

“Solubor” as a source of B, high levels decreased soluble Mn concentrations in nutrient solutions, probably owing to the precipitation of insoluble MnO_2. This was reflected in reduced leaf-Mn concentrations.

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

Patil *et al*. (2008) conducted a field experiment to study the effect of foliar application of micronutrients on growth and yield of tomato (Megha) during 2005-06 and 2006-07 at the All India Coordinated Vegetables Improvement Project (AICVIP) in the University of Agricultural Sciences, Dharward. 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 of primary branches (18.30), yield per plant (2.07 kg) and fruit yield (30.50 t/ha). Followed by best treatment was the mixture of micronutrients (B, 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 treatments. The maximum benefit ratio of 1.80 was obtained with application of boron recording Rs 97.850/ha of net returns followed by the mixture of micronutrients (1.74) recording (1.74) recording Rs 88.900/ha net returns compared to control (1.40) which recorded minimum net returns of Rs 53.250/ha.

Chude and Oyinlola (2001) showed that B deficiency on crop field led to reduction in yield of crops. They further mentioned that application of compound fertilizer (NPK) mixed with B fertilizer increased the yield of tomatoes. Sobulo (1975) obtained the highest yield of tomato when a mixture of NPK and 0.01% borax was applied compared with mixtures of NPK and other micronutrients. Gulati *et al*. (1980) got the highest yield of tomato with 1.5 $mgkg^{-1}$ in green house trial. Adelana (1986) obtained significant increase in yield of tomato when he applied between 0.5 to 1.5 kg ha^{-1} for rain fed trial.

Paithankar *et al*. (1995) was conducted a field trial at the main garden of the Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India in a randomized block design with 16 treatments and three replications to evaluate the effect of boron and diammonium phosphate (DAP) on the quality and performance of tomato. Foliar sprays of 0.1, 0.2 and 0.3% borax as well as 1, 2 and 3% DAP were given each alone and in combination at 60 days after transplanting. They have conclude that Borax at 0.3% provided the maximum fruit size and ascorbic acid content and the 0.3% borax + 3% DAP treatment recorded the maximum total soluble solids. The treatment 0.3% borax + 2% DAP reduced the cracking of fruits.

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. In tomato topped at the first truss, B concentrations higher than 2 ppm in nutrient solution resulted in a significant increase in leaf B concentration. At the fruit developmental stage, fresh weights of leaf and fruit were suppressed at 8 ppm and 4 ppm B in nutrient solution, respectively. Photosynthetic rate, respiration rate and stomatal conductance decreased with excess B at 4 ppm or higher concentration from the first truss flowering stage to fruit developmental stage. When tomato was topped at the second truss and limited to two fruits in each truss, excess B did not affect fruit growth or maturation in the first truss. However, fruit size and Brix were reduced in the second truss. These may be caused by decrease in the photosynthate distribution to fruit in the second truss because of the decrease in photosynthetic activity. Furthermore, excess B could promote fruit maturity in the second truss because of production of ethylene with increase in injured leaves. 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.

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 fertilizers (75:40:25 N, P_2O_5 and K_2O kg ha^{-1}; RDF) and RDF + farmyard manure (FYM; 25 tons ha^{-1}) on growth, yield, and quality of tomato as well as the B status of a lateritic soil in southern Kerala. Boron significantly increased plant height and number of primary branches. It also reduced the days to flowering and increased fruit set (12.5 to 20% more at the highest level) both with and without FYM. Benefit–cost ratio was 40% greater for the highest level of B when applied in conjunction with RDF compared with RDF alone (no B). Quality parameters like reducing sugars, total sugars, vitamin C, and lycopene concentrations also improved following B application. Nevertheless, B availability in these soils attained sufficiency levels (2 mg kg^{-1}) at 0.5 kg ha^{-1} of applied B, implying the need to exercise caution especially when applying higher doses.

Kamruzzaman (2007) conducted a field experiment on tomato at the field laboratory of Crop Botany Department, BAU, Mymensingh during 2006-07. The experiment comprised of four levels of boron viz. @ 0, 0.4, 0.6 and 0.8 kg B ha^{-1} as foliar application. Application of standard dose of boron Ca. 0.4 kg B ha^{-1} was found to produce highest fruit yield (2166.6 kg ha^{-1}).

Sathya (2006) conducted an experiment to evaluate the various levels of B on yield of PKM1 tomato. The results revealed that the highest fruit yield of 33 t ha^{-1} was recorded in treatment that received borax @ 20 kg ha^{-1} and was found to be significantly superior to rest of the treatments (0, 5, 10, 15 and 25 kg ha^{-1}). The yield increase was about 33.6 per cent over control.

Yadav *et al*. (2006) evaluated the effects of boron (0.0, 0.10, 0.15, 0.02,0.25, 0.30 or 0.35%), applied to foliage after transplanting, on the yield of tomato cv. DVRT-1 in Allahabad, Uttar Pradesh, India, during 2003-04. The highest number of fruits per plant (44.0), number of fruits per plot (704.0), yield per plant (0.79 kg), yield per plot (12.78 kg) and yield ha^{-1} (319.5019 quintal) were obtained with 0.20% boron, whereas the greatest fruit weight (27.27 g) was recorded for 0.10% boron.

The effect of micronutrient boron application on dry matter yield, uptake and distribution in the plant parts of two tomato verities (Roma VF and Dandino) were studied by Oyinlola (2004) in a rainfed trial. Results showed variations in boron distribution among plant parts. The concentration of boron (B) ranged from 6.0-109.0, 5.8-18.3 and 3.1-13.6 mg/kg, in leaves, stem and roots, respectively. The effect of boron rates on the DMY, B20 concentration and uptake was highly significant (P 0.010) on the leaves and stem, but not on the roots. The concentration of boron (B) in both varieties was more in the leaves, than in the stem. The roots had the least B concentration. Among the varieties "Dandino" recorded higher B concentration in the various plant parts than RomaVF. Application of B increased fruit yield of tomato fruit by 233 and 192% relative to the control for "Roma VF" and “Dandino” varieties, respectively.

Chude and Oyinloda (2001) concluded that plant responses to soil and applied boron vary widely among species and among genotypes within a species. This assertion was verified by comparing the differential responses of Roma VF and Dandino tomato cultivars to a range of boron levels in field trials at Kadawa (11 degrees 39' N, 8 degrees 2' E) and Samaru (11 degrees 12', 7 degrees 3 7` E) in Sudan and northern Guinea savanna, respectively, in Nigeria. Boron levels were 0, 0.5, 1.0, 1.50, 2.0 and 2.5 kg/ha replicated three times in a randomized complete block design. Treatment effects were evaluated on fruit yield and nutritional qualities of the two tomato cultivars at harvest. There was a highly significant (P=0.01) interaction between B rates and cultivars, with Dandino producing higher yields than Roma VF in both years and locations. Total soluble solids, titratable acidity and reducing sugar contents of the two cultivars differed significantly (P=0.05). Dandino contained higher amounts of these indexes than Roma VF. This cultivars seems to be more B efficient than Roma VF even at low external B level.

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

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

CHAPTER III

MATERIALS AND METHODS

The pot experiment was conducted at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka - 1207, Bangladesh in 2018 to determine the productive potentiality of summer tomato (BARI Hybrid-4) by the influence of foliar application of GA_3 and Boron. This chapter includes a brief description of materials used, treatments, location of the experiment, characteristics of soil, weather and climate and process of experimentations etc.

3.1 Experimental site

A pot experiment was conducted at the horticulture farm of Sher-e-Bangla Agriculture University, Dhaka, Bangladesh during the period from April 2018 to September, 2018.

3.2 Location

The location of the study site is situated in $23^0 74^/$N latitude and $90^0 35^/$E longitude (Anon., 1989). The altitude of the location was 8 m from the sea level (The Meteorological Department of Bangladesh, Agargaon, Dhaka).

3.3 Experimental period

The experiment was carried out during the Kharif season from April 2018 to August 2018. Seeds were sown on 19 April, 2018, seedling transplanting was done on 13 May, 2018 and harvested upto 23 August, 2018.

3.4 Climate and soil

The climate of the experimental area was sub-tropical in nature. It is characterized by its high temperature and heavy rainfall during Kharif season i.e. April to September and scanty rainfall associated with moderate temperature during robi season i.e. October to March (Anonymous, 1989).

3.5 Experimental material

The tomato variety BARI Hybrid Tomato-4(Summer) was used in the experiment. It is developed by Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh by hybridization method. It is heat tolerant hybrid tomato variety, medium round attractive. Fruit color is red. Seed was collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.6 Raising of seedlings

Soil of the seed bed was made loosen and friable as much as possible and organic matter mixed with soil. All weeds, stones and dead roots were removed. The seeds were sown on 19 April, 2018 in the raised seed bed of 3m×1m size. The seed bed was supported with partial shed at 1:00-3:00 pm in the high hot day by using coconut leaves and was protected from rain by polythene shed. To raise healthy seedlings proper care was taken.

3.7 Fertilizer application in the pot soil

The collected soil was measured as a cubic meter by applying length (m) × width (m) ×high (m). For field crops, a depth of soil is considered 15 centimeter (0.15m). So, one decimal land is ($40.5m^2 \times 0.15$ m) = 6.075 m^3 (approximate) which has considered as a root zone soil. Total volume of collected soil was calculated which has found 14.65 m^3 considering Length 3.5 m × width 3.1 m × height 1.35 m. Recommended fertilizer dose for summer tomato (BARI Hybrid-4) for very low status soil: Organic Matter, Urea (Total nitrogen: minimum 46%), MP (as Muriate of potash: 60% K_2O), TSP (as Triple Super Phosphate: 48% P_2O_5) and Gypsum (as $CaSO_4.2H_2O$ containing 19% S) for one decimal land is 50 kg, 1.6 kg, 0.68 kg, 0.5 kg, and 0.43 kg which has considered for 6.075 m^3 of root zone soil, respectively (Source: FRG 2012). Our total soil volume was 14.65 m^3 and one decimal is equal to 6.075 m^3. So, a comparison was made to estimate the exact amounts of organic matter, MP, TSP and Gypsum which has found organic matter (OM) = 120.6 kg, *M*P: = 1.64 kg, *T*SP =1.20 kg, Gypsum = 1.04 kg, respectively. Finally, the calculated amount of organic matter, half of MP and all required TSP and Gypsum were applied prior 21 days of filling the pot with soil. One decimal land can be accommodating 162 plants considering spacing row to row and plant to plant 50 cm × 50 cm. Our total plants under experimentation were 120 which have needed 1185 g of urea for three time of application. Each time @ 3.30 g urea per plant was applied at 10, 25 and 40 days after transplanting as a ring method. Rest half of MP (820 g for 120 plants) was applied in two split dose at 25 and 40 days after transplanting at the time of 2nd and 3rd dose of urea application. Each time @ 3.42 g MP was applied per plant.

3.8 Pot preparation

Plastic pots were used in this experiment. The height and width of each pot was 35 and 30 cm, respectively. Two holes were made in the middle of the bottom of each pot and holes were covered by the broken pieces of earthen pot. All the pots were washed with ash and tap water by rubbing and sun dried. The fertilizer mixed soil was made well pulverized and dried in the sun. Final check was made to remove plant propagates, inert materials, visible insect and pests. In the lower part of all the pots were filled with general sun dried and clean soil; only upper 20 cm of the pot was filled with fertilizer mixed well prepared soil and topmost upper 5 cm of the pot was blank for irrigation purpose.

3.9 Transplanting of seedlings in the pot

25 days aged single seedlings were transplanted on 13 May, 2018 in the middle of each pot in the late afternoon of the same day. Immediate after transplanting the plants

were irrigated with tap water. The pots were arranged inside the polythene shed as per design of experiment.

3.10 Experimental treatments

The two factor experiment consisted of four levels of GA_3 (Factor A) and three levels of Boron (Factor B). The factors were as follows:

Factor A: Level of GA_3	**Factor B: Level of Boron**
G_0 = 0 ppm	B_0 = 0 ppm
G_1 = 50 ppm	B_1 = 25 ppm
G_2 = 100 ppm	B_2 = 50 ppm
G_3 = 150 ppm	

There were all together 12 treatments combination used in each block were:

G_0B_0, G_0B_1, G_0B_2, G_1B_0, G_1B_1, G_1B_2, G_2B_0, G_2B_1, G_2B_2, G_3B_0, G_3B_1, G_3B_2

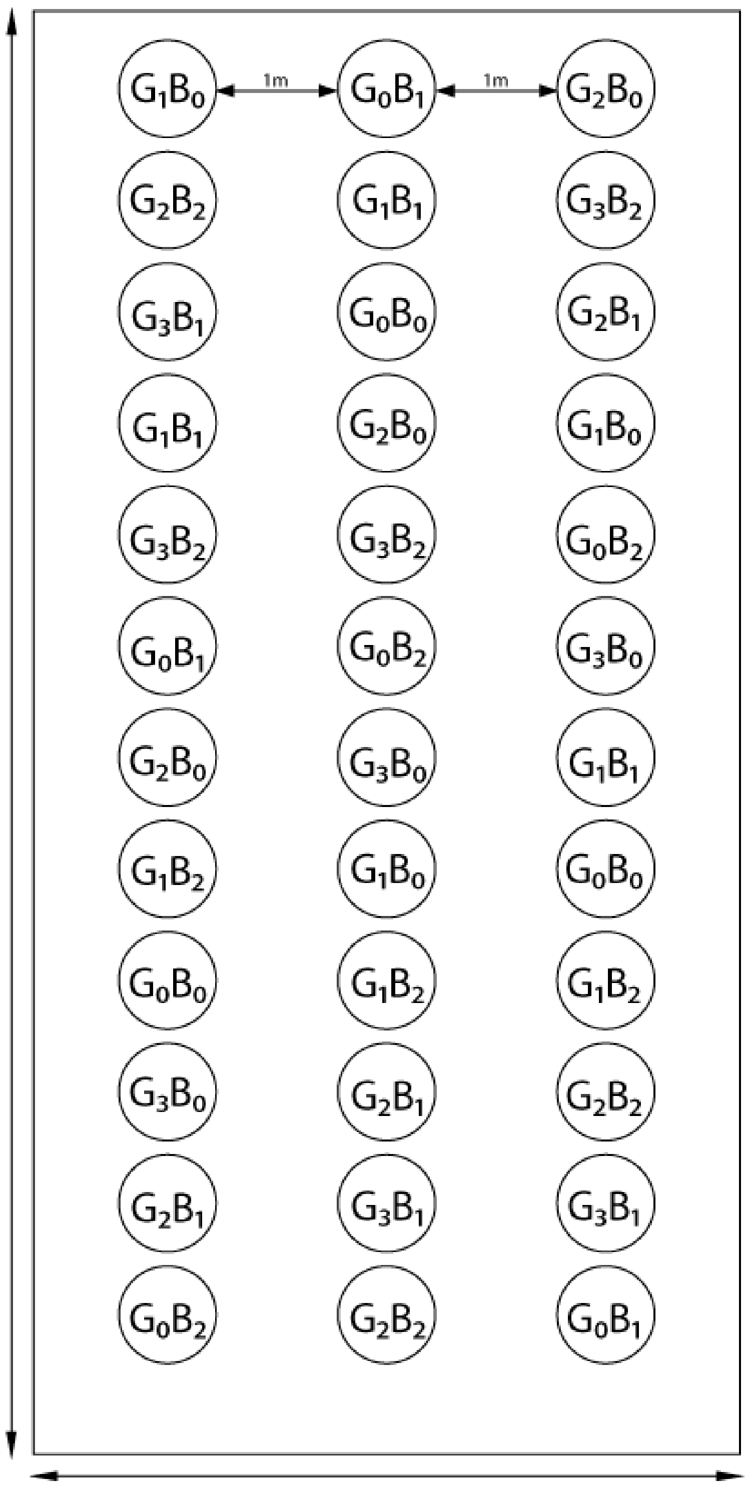
3.11 Experimental design and layout

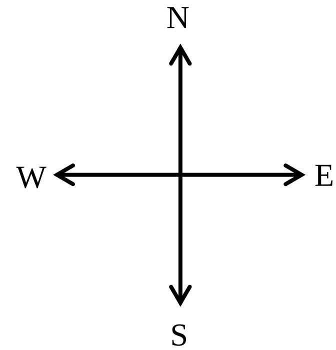
The experiment was laid out in Completely Randomized Design (CRD) with three replications. The space was kept 1m between replications. Pot to pot distance in a row was 50cm. The layout of the experiment is shown in Figure 1.

3.12 Intercultural operation

3.12.1 Irrigation

Immediate after transplanting, light watering to the individual seedling was provided to overcome water deficit. As a regular basis, the plants were supported with water at two days interval.





Pot size: 35 cm × 30 cm
Pot spacing: 50 cm

Spacing between replication : 1.0m

Factor A: Level of GA_3
G_0 = 0 ppm G_1 = 50 ppm G_2 = 100 ppm G_3 = 150 ppm
Factor B: Level of Boron
B_0 = 0 ppm B_1 = 25 ppm B_2 = 50 ppm

Fig. 1. Layout of the Experiment

3.12.2 Supporting

All the plants were supported with bamboo sticks and threads as and when required. It helped to keep the plants upright.

3.12.3 Weeding

Weeding and soil loosening was done as and when required. It was done three times during experimentations.

3.12.4 Mulching

A layer of dried straw was putted in each container as mulch.

3.12.5 Pruning

All shoots from the base of all plants were removed at an 8 cm height from the ground. By removing all side shoots at least once a week, the plants were maintained to a single stem. The shoots were removed early in the morning on sunny days when they are very small (one inch or smaller).

3.12.6 Fertilizer application

Urea was applied in three times as a ring method at 10, 25 and 40 days after transplanting. MP also applied at 25 and 40 days after transplanting (DAT) together with urea application as per prescription of Olericulture Division, Horticulture Research Centre (HRC), Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh.

3.12.7 Plant protection

Admire was sprayed @ 1 ml per liter of water for 3 times at 10, 25 and 40 DAT of seedling in the all plants of the inside polythene shade and outside also.

3.12.8 Use of fungicide

Ridomil was sprayed @ 1 gm per liter of water for 3 times at 15, 30 and 45 DAT of seedling in the pot soil.

3.13 Application of the treatments

All the treatments were applied considering the design of the experiment. First application was made at 15 DAT in the day when first flower initiation was found in the experimental plot and second & third application was made at a 15 days interval which was 30 and 45 DAT. A specific concentration of the each nutrient solution was maintained.

3.14 Measurement of plant height

Height of plant was measured with a meter scale from the base of the plant to the tip of the leaf of the main stem for four times. First height was measured at 15 days after transplanting (DAT) before applying the first treatment on the same day. Second, third and fourth plant height was measured at 30, 45 and 60 DAT. The final height was measured at the final harvesting time. The plant height was measured and expressed in centimeter. Recorded data was made an average.

3.15 Number of leaves per plant

Number of leaves was measured from the plants in centimeter from the ground level to the tip of the longest stem and means value was calculated. Number of leaves was recorded 15, 30, 45, 60 days after planting to observe the growth rate.

3.16 Number of flowers per plant

The number of flower clusters was counted from the plants periodically at 50 and 65 DAT and the average number of flower clusters produced per plant was calculated.

3.17 Number of fruits per plant

The total number of fruit was recorded from the plants at 50, 65 and 80 DAT and the average number of fruit produced per plant was recorded.

3.18 Weight of individual fruit

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

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

3.19 Fruit length and diameter

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 10 selected marketable fruit from each pot and their average was calculated in centimeter. Diameter of fruit was measured at the middle portion of 10 selected marketable fruits from each pot with a slide calipers and their average was in centimeter.

3.20 Fruit yield per plant

A pan scale balance was used to take the weight of fruit per plant. It was measured by totaling of fruit yield from each plant during the period from first to final harvest and was recorded in gram.

3.21 Statistical analysis of data

The data in respect of growth, yield contributing characters and yield were statistically analyzed to find out the statistical significance. The means for all the treatments were calculated and the analysis of variance for all the characters was performed by F test. The significance of the difference among the treatment mean was estimated by Least

Significant Difference (LSD) Test at 5% and 1% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The research work was accomplished to identify the effect of different treatments on growth and yield of summer tomato in Bangladesh. Some of the data have been presented and expressed in Table(s) and others in Figures for case of discussion, comparison and understanding. The analysis of variance of data respect of all the parameters has been shown in Appendix. The results of each parameter have been discussed and possible interpretations where ever necessary have been given under following headings.

4.1 Plant height

Plant height of tomato varied significantly due to the application of different concentrations of GA_3 at 15, 30, 45 and 60 DAT (Appendix I). At 15 DAT, the longest plant (43.78 cm) was observed in G_2 (100 ppm GA_3) which was statistically similar to G_3 (43.78 cm), whereas the shortest plant (31.56 cm) was found in G_0 (0 ppm GA_3). The longest plant (70.67 cm) was recorded from G_2 which was statistically similar to G_1 (68.23 cm) and G_3 (69.89 cm) while the shortest plant (60.67 cm) was recorded from G_0 at 30 DAT. At 45 DAT, the longest plant (92.89 cm) was also recorded from G_2 and the shortest plant (81.67 cm) was found in G_0. At 60 DAT, the longest plant (107.67 cm) was found from G_1 and the shortest plant (100.12 cm) was recorded from G_0 (Fig. 2). Chern *et al.* (1983) observed that, application of GA_3 at 100 ppm gave the highest plant height of tomato. This is due to the fact that, GA_3 induces cell division and cell enlargement. GA_3 stimulate cell elongation and cause plants to grow taller. Since plants are composed of single cells stacked on top of one another, this elongation of thousands of individual cells results in the overall growth of the plant. It ultimately leads to better growth of plants. Chaudhary (2004), Shittu and Adeleke

(1999) and Sanyal *et al*. (1995) reported similar results in their experiment.

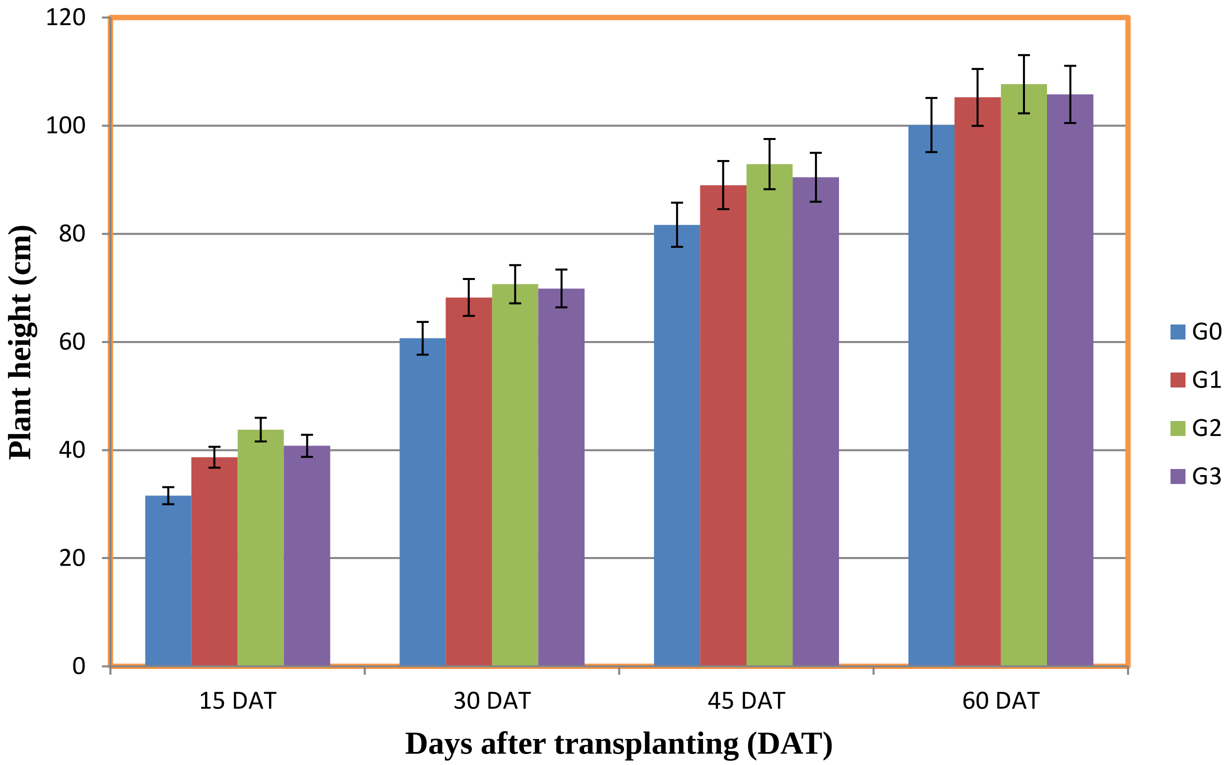


Fig. 2. Effect of different levels of GA_3 on plants height of tomato at different days after transplanting

Plant height of tomato varied significantly due to the application of different levels of boron at 15, 30, 45 and 60 DAT (Appendix I). At 15 DAT, the highest plant height (42.09 cm) was observed in B_1 (25 ppm) which is statistically similar to B_2 and control treatment (B_0) gave the shortest plant (34.09 cm). The longest plant (70.17 cm) was recorded from B_1 while the shortest plant (63.92 cm) was recorded from B_0 at 30 DAT. At 45 DAT, the highest plant height (91.67 cm) was also observed in B_1 and the lowest plant height (84.42 cm) was observed in B_0. At 60 DAT, the longest (107.42 cm) and the shortest (101.51 cm) plant were recorded from B_1 and B_0, respectively (Fig. 3). Sakamoto (2012) illustrated that in agriculture, both deficient and excess levels of soil boron impair plant growth, resulting in the reduction of quantity and quality of crops. Deficiency of boron in tomato and several other crops is responsible for stunted growth (Gupta and Cutcliffe, 1985; Nelson *et al*., 1977).

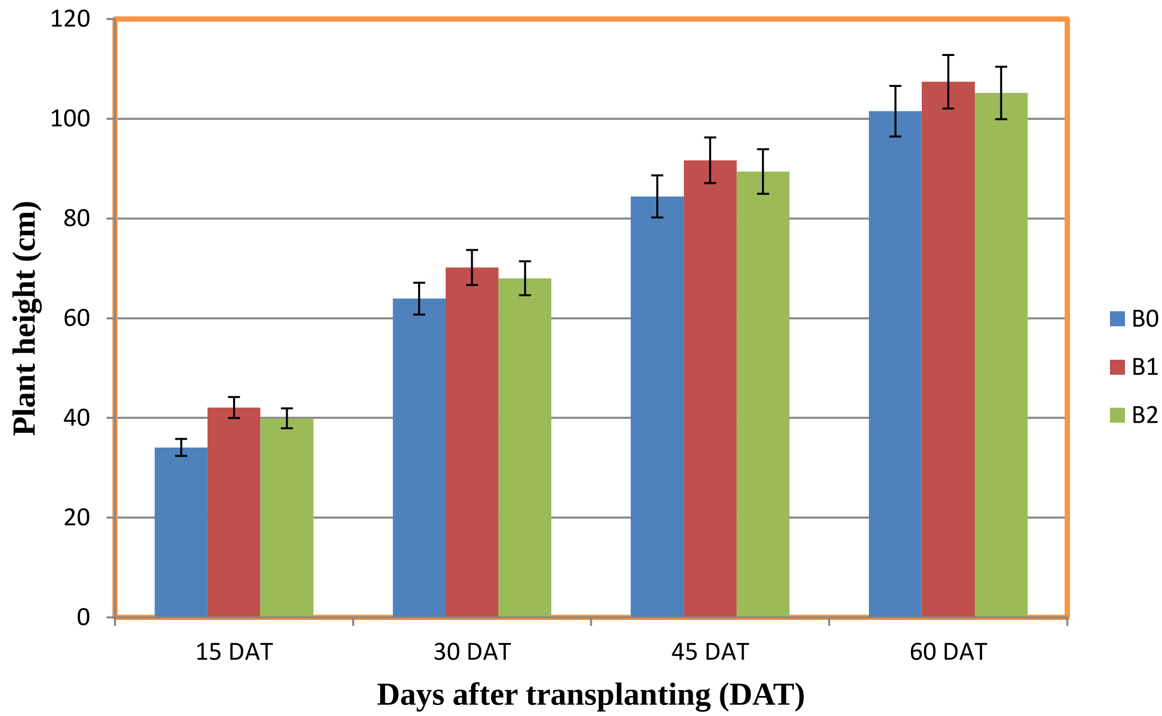


Fig. 3. The effect of different levels of boron on plants height of tomato at different days after transplanting

Due to combined effect of GA_3 and boron showed statistically significant variation on plant height at 15, 30, 45 and 60 DAT (Appendix I). At 15 DAT, the longest plant (48.34 cm) was obtained from G_2B_1 (100 ppm GA_3 with 25 ppm boron) which is statistically similar to G_2B_2 (100 ppm GA_3 with 50 ppm boron) while the shortest plant (31.01 cm) was obtained from G_0B_0 (0 ppm GA_3 with 0 ppm boron), which is statistically similar to G_0B_1, G_0B_2 and G_1B_0. At 30 DAT, the highest plant height (73.02 cm) was observed in G_2B_1 which was statistically identical to G_1B_1 (72.02 cm), G_2B_2 (72.36 cm) and G_3B_1 (72.38 cm) and the lowest plant height (57.01 cm) was observed in G_0B_0. The longest plant (94.67 cm) was recorded from G_1B_1 while the shortest plant (78.67 cm) was recorded from G_0B_0 at 45 DAT. At 60 DAT, the longest plant (111.34 cm) was recorded from G_1B_1 whereas the shortest plant (96.34 cm) was recorded from G_0B_0 (Table 1).

Table 1. Combined effect of GA_3 and boron on the plant height of tomato

Treatments	Plant height (cm) @			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
G_0B_0	31.01 e	57.01 f	78.67 g	96.34 e
G_0B_1	32.34 de	63.34 de	84.01 ef	102.34 d
G_0B_2	31.34 e	61.69 e	82.34 f	101.67 d
G_1B_0	33.68 de	65.04 cd	85.67 de	103.01 d
G_1B_1	43.35 b	72.02 a	92.68 b	108.34 b
G_1B_2	39.02 c	67.64 bc	88.67 c	104.35 cd
G_2B_0	37.39 c	66.68 c	87.01 cd	103.34 d
G_2B_1	48.34 a	73.02 a	97.01 a	111.34 a
G_2B_2	45.68 ab	72.36 a	94.67 ab	108.34 b
G_3B_0	34.34 d	67.01 c	86.34 cde	103.34 d
G_3B_1	44.36 b	72.38 a	93.01 b	107.67 b
G_3B_2	43.68 b	70.34 ab	92.02 b	106.34 bc
LSD (0.05)	0.98	0.92	0.77	0.46
CV (%)	1.49	0.80	0.51	0.26

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

G_0 = 0 ppm, G_1 = 50 ppm

G_2 = 100 ppm, G_3 = 150 ppm

B_0 = 0 ppm, B_1 = 25 ppm, B_2 = 50 ppm

4.2 Number of leaves

Number of leaves per plant of tomato varied significantly due to the application of different concentrations of GA_3 at 15, 30, 45 and 60 DAT (Appendix II). At 15 DAT, the maximum number of leaves (9.45) was observed in G_2 (100 ppm) which is statistically similar to G_3 (150 ppm), while the minimum number of leaves (4.17) was obtained from G_0 (0 ppm). The maximum number of leaves (13.89) was recorded from G_2 which is statistically similar to G_0 and G_3 and the minimum number of leaves (12.42) was recorded from G_1 at 30 DAT. At 45 DAT, the maximum number of leaves (22.12) was recorded from G_2 and the minimum number of leaves (16.34) was recorded from G_0. At 60 DAT, the maximum number of leaves (33.01) was found from G_2 and the minimum (28.01) was obtained from G_0 (Fig. 4). GA_3 application in tomato plant helps in synthesis of protein including various enzymes which increases the rate of photosynthetic capacity, leading to increase total leaf area and leaf dry weight (Ballantyine, 1995; Mostafa and Saleh, 2006). Briant (1974) found similar result with application GA_3 in tomato.

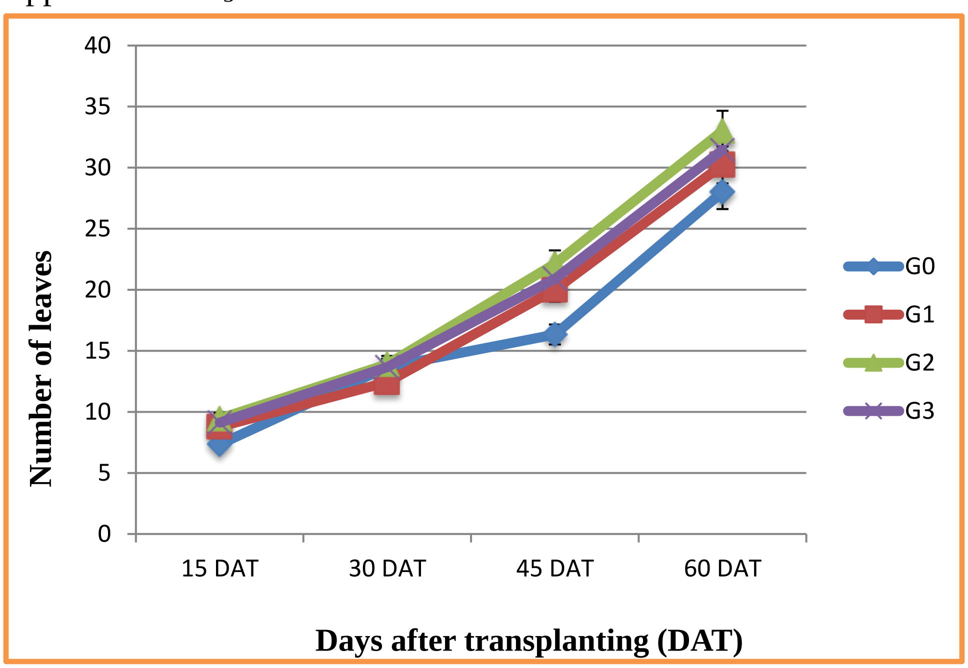


Fig. 4. Effect of different levels of GA_3 on number of leaves of tomato at different days after transplanting

Due to the application of different levels of boron number of leaves of tomato varied significantly at 15, 30, 45 and 60 DAT (Appendix II). At 15 DAT, the maximum number of leaves (9.76) was recorded from B_1 (25 ppm), while the minimum (8.51) was found from B_0 (0 ppm) which is statistically similar to B_2. The maximum number of leaves (14.42) was recorded from B_1 and the minimum (12.17) was recorded from B_0 at 30 DAT. At 45 DAT, the maximum number of leaves (21.34) was recorded from B_1, which is statistically identical to B_2 (20.09) while the minimum (18.09) was obtained from B_0. At 60 DAT, the maximum number of leaves (32.92) was recorded from B_1 and the minimum (28.26) was produced by B_0 (Fig. 5). Boron plays an important role in the proper function of cell membranes and the transport of K to guard cells for proper control of internal water balance. Oyinlola (2004) reported that, application of boron significantly increased the number of leaves on tomato plant compared to control.

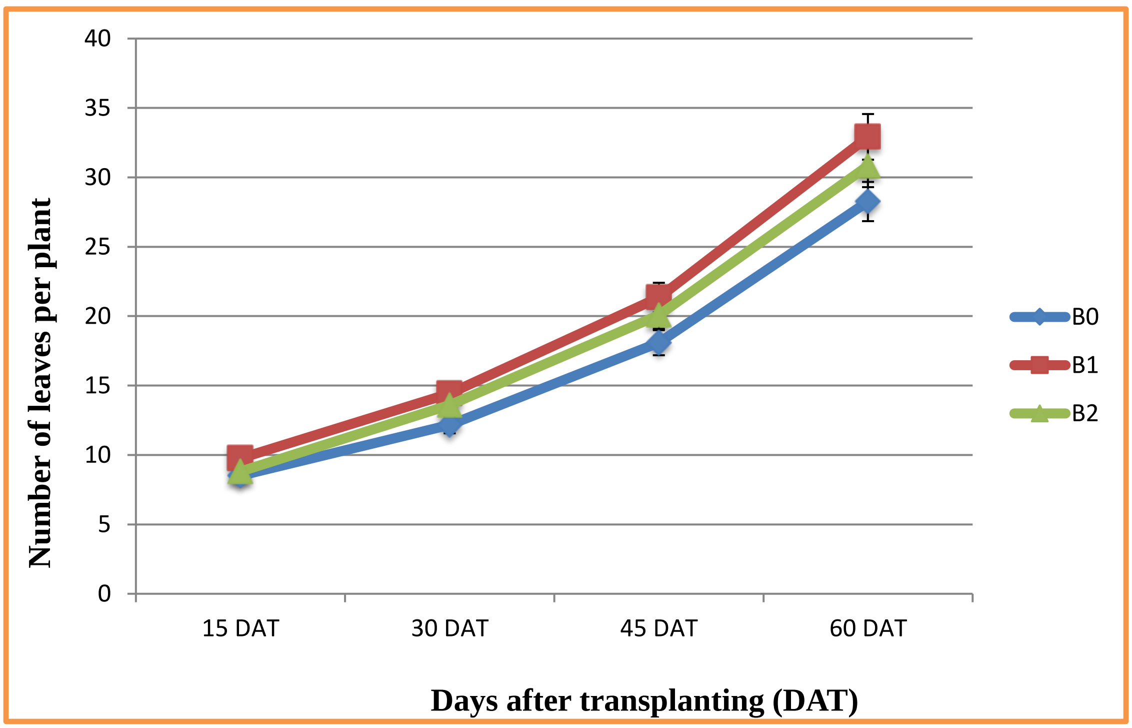


Fig. 5. Effect of different levels of boron on number of leaves of tomato at different days after transplanting

Combined effect of GA_3 and Boron showed statistically significant variation for number of leaves at 15, 30, 45 and 60 DAT (Appendix II). At 15 DAT, the maximum number of leaves (10.67) was recorded from G_2B_1 (100 ppm GA_3 and 25 ppm Boron) and the minimum (7.67) was recorded from G_0B_0 (0 ppm GA_3 and 0 ppm Boron). The maximum number of leaves (15.67) was recorded from G_2B_1 which is statistically similar to G_3B_0 and G_3B_2 and the minimum number of leaves (11.01) was recorded from G_0B_0 which is statistically similar to G_0B_1 and G_1B_2 at 30 DAT. At 45 DAT, the maximum number of leaves (24.34) was recorded from G_2B_1 and the minimum (14.34) was recorded from G_0B_0. At 60 DAT, the similar trends of results were obtained from the combined effect of different levels of GA_3 and Boron (Table 2).

4.3 Number of flowers

Number of flowers per plant of tomato varied significantly due to the application of different concentrations of GA_3 (Appendix III). The maximum number (39.78) of flowers per plant was counted from G_2 (100 ppm GA_3), whereas, the minimum number (26.12) was counted from G_0 (0 ppm GA_3) (Table 3). Onofeghara (1981) also illustrated similar result. This is due to the fact that, GA_3 regulates flower initiation and its development and it is essential for male and female fertility (Griffiths *et al.*, 2006).

As a result of the application of different levels of boron, number of flowers per plant of tomato also varied significantly (Appendix III). The highest number of flowers per plant (39.01) was recorded from B_1 (25 ppm) and the lowest number (29.17) was obtained from B_0 (0 ppm) (Table 3). Naresh (2002) observed that boron also had positive effects on number of flowers per plant resulting in an increase in the number of fruits per plant and total yield. Boron involved in the metabolism of protein, synthesis of pectin, maintaining the correct water relation within the plant, resynthesis of adenosine triphosphate (ATP) and translocation of sugar at development of the flowering and fruiting stages (Bose and Tripathi, 1996).

Table 2. Combined effect of GA_3 and boron on the number of leaves per plant of tomato

Treatments	Number of leaves @			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
G_0B_0	7.67 b	11.01 d	14.34 g	26.34 h
G_0B_1	9.34 ab	11.67 cd	18.01 ef	29.34 efg
G_0B_2	8.01 b	13.34 bcd	16.67 fg	28.34 fgh
G_1B_0	8.36 ab	14.34 bcd	18.67 def	27.67 gh
G_1B_1	9.67 ab	12.67 bcd	21.34 bcd	32.34 bdc
G_1B_2	8.34 ab	12.67 cd	20.01 bcd	30.67 def
G_2B_0	8.67 ab	13.91 bc	19.34 cde	30.01 efg
G_2B_1	10.67 a	15.67 a	24.34 a	36.01 a
G_2B_2	9.01 ab	14.34 bcd	22.67 ab	33.01 bc
G_3B_0	9.34 ab	15.34 ab	20.01 bcd	29.01 efg
G_3B_1	9.38 ab	13.67 bcd	21.67 bc	34.01 ab
G_3B_2	8.67 ab	14.75 ab	21.01 bc	31.34 cd
LSD (0.05)	0.9665	0.6860	0.6424	0.5708
CV (%)	6.40	2.99	1.91	1.10

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

G_0 = 0 ppm
G_1 = 50 ppm
G_2 = 100 ppm
G_3 = 150 ppm

B_0 = 0 ppm
B_1 = 25 ppm
B_2 = 50 ppm

Number of flowers per plant varied significantly due to the combined effect of different levels of GA_3 and boron (Appendix III). The highest number (45.01) of flowers per plant was counted from G_2B_1 (100 ppm GA_3 with 25 ppm boron) which was statistically similar with G_1B_1 (42.01) while the lowest number (24.01) was counted from G_0B_0 (0 ppm GA_3 with 0 ppm boron) (Table 4).

4.4 Number of fruits

Number of fruits per plant of tomato varied significantly due to the application of different concentrations of GA_3 (Appendix III). The maximum number (21.23) of fruits per plant was counted from G_2 (100 ppm GA_3), whereas, the minimum number (10.56) was counted from G_0 (0 ppm GA_3) (Table 3). Adlakha and Verma (1964) observed that, when the first four clusters of tomato plants were sprayed with GA_3 at 50 and 100 ppm three times at unspecified intervals, the fruit setting increased by 5% with higher concentration. Kaushik *et al*. (1974) reported that GA_3 increased the number of fruits per plant in tomato while Jansen (1970) mentioned that increasing concentration of GA_3 reduced both the number and size of fruits.

Significant variation of the number of fruits per plant was found due to the application of different levels of boron (Appendix III). The highest number of fruits per plant (19.09) was recorded from B_1 (25 ppm) and the lowest number (14.17) was obtained from B_0 (0 ppm) (Table 3). Ejaz *et al*. (2011) also reported that application of boron provide better results in number of fruits per plant of tomato as compared to control. This may be because boron takes part in active photosynthesis, which ultimately help towards increase in number and weight of fruits per plant (Kumar and Sen, 2005).

Number of fruits per plant varied significantly due to the combined effect of different levels of GA_3 and boron (Appendix III). The highest number (24.34) of fruits per plant was counted from G_2B_1 (100 ppm GA_3 with 25 ppm boron) which was statistically similar with G_1B_1 (22.71) while the lowest number (9.34) was counted from G_0B_0 (0 ppm GA_3 with 0 ppm boron) (Table 4).

4.5 Fruit length

The variation in fruit length among the different concentrations of GA_3 was found to be statistically significant (Appendix III). The maximum length of fruit (7.04 cm) was obtained from 100 ppm GA_3 (G_2) which is statistically similar to G_3 (6.43 cm) whereas, the minimum fruit length (5.06 cm) was obtained from control (G_0 = 0 ppm GA_3) plants (Table 3). Adlakha and Verma (1964) observed that when the first four clusters of tomato plants were sprayed with GA_3 at 50 and 100 ppm three times at unspecified intervals, GA_3 at 100 ppm could appreciably increase fruit size. Desai *et al*. (2012) found the maximum fruit length and girth in gibberellic acid @ 90 ppm. Sawhnuy and Greyson (1972) also reported the similar findings.

Length of tomato fruit also varied significantly due to the application of different doses of boron (Appendix III). The highest length of fruit (6.74 cm) was recorded from B_1 (25 ppm). The lowest length (5.49 cm) was recorded from B_0 (0 ppm boron) (Table 3). Yadav *et al*. (2001) also found similar results. Boron plays important role in maintaining cell integrity, improving respiration, enhancing metabolic activities and uptake of nutrients; which leads to bigger fruits.

Different levels of GA_3 and boron significantly influenced the length of fruit for their combined effect (Appendix III). The highest length of fruit (7.89 cm) was obtained from the treatment combination of 100 ppm GA_3 and 25 ppm boron (G_2B_1) while the lowest length of fruit (4.58 cm) was obtained from G_0B_0 (0 ppm GA_3 with 0 ppm boron) (Table 4).

Table 3. Effect of GA_3 and boron on yield contributing characters of tomato

Treatments	Number of flowers / Plant	Number of fruits / Plant	Fruit length (cm)
GA_3			
G_0	26.12 c	10.56 d	5.06 c
G_1	36.56 b	16.67 c	6.19 b
G_2	39.78 a	21.23 a	7.04 a
G_3	36.12 b	18.67 b	6.43 ab
LSD (0.05)	1.3999	0.3577	0.0871
Boron			
B_0	29.17 c	14.17 c	5.49 c
B_1	39.01 a	19.09 a	6.74 a
B_2	35.76 b	17.09 b	6.31 b
LSD (0.05)	1.2124	0.3097	0.0754
CV (%)	4.13	2.18	1.44

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

G_0 = 0 ppm
G_1 = 50 ppm
G_2 = 100 ppm
G_3 = 150 ppm

B_0 = 0 ppm
B_1 = 25 ppm
B_2 = 50 ppm

Table 4. Combined effect of GA_3 and boron on yield contributing characters of tomato

Treatments	Number of flowers / Plant	Number of fruits / Plant	Fruit Length (cm)
G_0B_0	24.01 g	9.34 f	4.58 f
G_0B_1	28.34 ef	12.01 e	5.45 e
G_0B_2	26.01 fg	10.34 f	5.16 ef
G_1B_0	30.67 de	15.01 d	5.45 e
G_1B_1	42.01 ab	22.71 ab	6.68 bc
G_1B_2	37.01 c	18.01 c	6.44 bc
G_2B_0	33.34 d	16.01 d	6.19 cd
G_2B_1	45.01 a	24.34 a	7.89 a
G_2B_2	41.01 b	20.34 b	7.03 b
G_3B_0	28.67 ef	16.34 d	5.75 de
G_3B_1	40.67 b	20.01 b	6.93 b
G_3B_2	39.01 bc	19.67 b	6.61 bc
LSD (0.05)	2.4248	0.6195	0.1509
CV (%)	4.13	2.18	1.44

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

G_0 = 0 ppm
G_1 = 50 ppm
G_2 = 100 ppm
G_3 = 150 ppm

B_0 = 0 ppm
B_1 = 25 ppm
B_2 = 50 ppm

4.6 Fruit diameter

The variation in fruit diameter among the different concentrations of GA_3 was found to be statistically significant (Appendix IV). The maximum diameter of fruit (6.38 cm) was obtained from 100 ppm GA_3 (G_2) whereas, the minimum fruit diameter (4.92 cm) was obtained from control (G_0 = 0 ppm GA_3) plants (Table 5). GA_3 induces cell division, cell elongation, cell enlargement and ultimately leads to significantly increases the fruit girth as reported by Shittu and Adeleke, (1999) and Sanyal *et al.* (1995). Desai *et al.* (2012) found the maximum fruit length and girth in gibberellic acid @ 90 ppm. Sawhnuy and Greyson (1972) also reported the similar findings.

Diameter of tomato fruit also varied significantly due to the application of different doses of boron (Appendix IV). The highest diameter of fruit (6.43 cm) was recorded from B_1 (25 ppm). The lowest diameter (5.06 cm) was recorded from B_0 (0 ppm boron) (Table 5). Yadav *et al.* (2001) also found similar results.

Different levels of GA_3 and boron significantly influenced the diameter of fruit for their combined effect (Appendix IV). The highest diameter of fruit (7.13 cm) was obtained from the treatment combination of 100 ppm GA_3 and 25 ppm boron (G_2B_1) while the lowest diameter of fruit (4.28 cm) was obtained from G_0B_0 (0 ppm GA_3 with 0 ppm boron) (Table 6).

4.7 Individual fruit weight

Weight of individual fruit of tomato varied significantly due to the application of different levels of GA_3 (Appendix IV). The highest weight of individual fruit (63.51 g) was found from G_2 (100 ppm GA_3) followed by G_3 (60.11 g) and G_2 (58.04 g). The lowest individual fruit weight (45.65 g) was observed from G_0 (0ppm GA_3) (Table 5). Lilov and Donchev (1984) also showed similar results. Naeem *et al.* (2001) indicated reduced fruit drop and increased fruit weight due to GA_3 spray.

Application of different levels of boron also showed significant differences for weight of individual fruit (Appendix IV). The highest individual fruit weight (61.32 g) was found from B_1 (25 ppm) which is statistically similar to B_2 (58.17 g) while the lowest individual fruit weight (50.99 g) was obtained from B_0 (no boron application) (Table 5). Oyinlola and Chude (2004) also found the similar results.

Significant variation was recorded due to the combined effect of different levels of GA_3 and boron for weight of individual fruit (Appendix IV). The highest individual fruit weight (69.41 g) was recorded from G_2B_1 (100 ppm GA_3 with 25 ppm boron), whereas, the lowest individual fruit weight (43.44 g) was observed from control treatment (0 ppm GA_3 with 0 ppm boron) (Table 6).

4.8 Yield per plant

Different levels of GA_3 significantly influenced on the yield of fruit per plant (Appendix IV). It was evident from the highest yield (1600.87 g/plant) was recorded from 100 ppm GA_3 and the lowest yield was (678.85 g/plant) from control condition (Table 5). Prasad *et al*. (2013) reported that fruit yield/ha significantly increased with the application of GA_3 compared to control. It is due to the fact that application of GA_3 checks the flowers and fruit drop and ultimately increase the percent of fruit set. Kaushik *et al*. (1974) supported these findings.

Application of different levels of boron also showed significant differences for fruit yield per plant (Appendix IV). The highest individual yield (1515.31 g/plant) was found from B_1 (25 ppm) while the lowest individual fruit weight (794.14 g/plant) was obtained from B_0 (no boron application) (Table 5). Ullah *et al*. (2015) also showed that application of boron gave higher yield per hectare than untreated control in tomato.

Due to combined effect of different levels of GA_3 and boron performed significant effect on yield per hectare (Appendix IV). The treatment combination of 100 ppm GA_3 and 25 ppm boron gave the maximum yield (1689.44 g/plant) and the minimum yield (487.41 g/plant) was found from the treatment combination on 0 ppm GA_3 and 0 ppm boron (Table 6).

Table 5. Effect of GA_3 and boron on yield contributing characters and yield of tomato

Treatments	Fruit diameter (cm)	Individual fruit weight (g)	Yield / Plant (g)
GA_3			
G_0	4.92 d	45.65 c	678.85 c
G_1	5.77 c	58.04 b	1360.83 b
G_2	6.38 a	63.51 a	1600.87 a
G_3	6.08 b	60.11 ab	1443.01 ab
LSD (0.05)	0.0900	0.2875	25.321
Boron			
B_0	5.06 c	50.99 b	794.14 c
B_1	6.43 a	61.32 a	1515.31 a
B_2	5.88 b	58.17 a	1391.22 b
LSD (0.05)	0.0780	0.2490	21.929
CV (%)	1.59	0.63	3.16

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

G_0 = 0 ppm
G_1 = 50 ppm
G_2 = 100 ppm
G_3 = 150 ppm

B_0 = 0 ppm
B_1 = 25 ppm
B_2 = 50 ppm

Table 6. Combined effect of GA_3 and boron on yield contributing characters of tomato

Treatments	Fruit diameter (cm)	Individual fruit weight (g)	Yield / Plant (g)
G_0B_0	4.28 g	43.44 j	487.41 g
G_0B_1	5.48 def	48.09 h	557.67 f
G_0B_2	5.01 f	45.44 i	526.45 fg
G_1B_0	4.98 f	50.22 g	603.85 e
G_1B_1	6.44 b	63.55 bc	1391.89 b
G_1B_2	5.89 cd	60.34 d	1206.74 c
G_2B_0	5.66 de	56.31 e	1141.34 d
G_2B_1	7.13 a	69.41 a	1689.44 a
G_2B_2	6.35 bc	64.81 b	1449.71 b
G_3B_0	5.31 ef	53.99 f	1018.97 d
G_3B_1	6.66 b	64.23 b	1485.11 b
G_3B_2	6.28 bc	62.11 cd	1424.97 b
LSD (0.05)	0.1560	0.4979	43.858
CV (%)	1.59	0.63	3.16

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

G_0 = 0 ppm
G_1 = 50 ppm
G_2 = 100 ppm
G_3 = 150 ppm

B_0 = 0 ppm
B_1 = 25 ppm
B_2 = 50 ppm

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University Dhaka 1207, (Tejgaon series under AEZ No. 28) from April 2018 to September 2018, to study the effect of different levels of GA_3 and different levels of boron on the growth and yield of summer tomato. Four concentrations of GA_3 (0 ppm, 50 ppm, 100 ppm and 150 ppm) and three levels of boron (0 ppm, 25 ppm and 50 ppm) were used in the study. Levels of these two nutrient elements make 12 treatment combinations. The experiment was carried out in Completely Randomized Design (CRD) with three replications. The experiment was conducted in pots. Data on growth and yield contributing parameters were recorded and the collected data were statistically analyzed to evaluate the treatment effects. The summary of the results has been presented in this chapter.

Application of different levels of GA_3 had a significant effect on summer tomato plant height at 15, 30, 45 and 60 days after transplantation. Longest plants at 15 DAT (43.78 cm), 30 DAT (70.67 cm), 45 DAT (92.89 cm) and 60 DAT (107.67 cm) were found from G_2 (100 ppm) treatment and the shortest plants at 15, 30, 45 and 60 DAT were 31.56 cm, 60.67 cm, 81.67 cm and 100.12 cm, respectively, recorded from G_0 (0 ppm) treatment.

Different levels of GA_3 showed significant effect on total number of leaves of summer tomato. Collected data from 15, 30, 45 and 60 DAT showed the maximum number of leaves as 7.34, 13.67, 16.34 and 33.01, respectively, which were found from G_2 (100 ppm) treatment and the minimum number of leaves were obtained from G_0 (0 ppm) treatment at 15, 30, 45 and 60 DAT.

Number of flowers per plant showed significant difference by the application of different levels of GA_3. The highest value (39.78) of this character was obtained from 100 ppm GA_3 and the lowest (26.12) was obtained from the control (0 ppm GA_3) treatment. For number of fruits per plant, the highest value (21.23) of this character was obtained from 100 ppm GA_3 and the lowest (10.56) was obtained from the control (0 ppm GA_3) treatment. Different levels of GA_3 showed significant effect on number of fruit length, fruit diameter and individual fruit weight. The highest values of these characters were obtained from 100 ppm GA_3 and the lowest were obtained from the control (0 ppm GA_3) treatment. Different levels of GA_3 showed significant effect on fruit yield per plant. The maximum value (1600.87 g/plant) of this character was found from 100 ppm GA_3 and the minimum value (678.85 g/plant) was obtained from control (0 ppm GA_3) treatment.

In case of boron, application of different levels of boron had a significant effect on summer tomato plant height at 15, 30, 45 and 60 days after transplantation. Longest plants at 15 DAT (34.09 cm), 30 DAT (63.92 cm), 45 DAT (84.42 cm) and 60 DAT (101.51 cm) were found from B_1 (25 ppm boron) treatment and the shortest plants at 15, 30, 45 and 60 DAT were 34.09 cm, 63.92 cm, 84.42 cm and 101.51 cm, respectively, recorded from B_0 (0 ppm boron) treatment.

As a result of application of different levels of boron, total number of leaves of summer tomato influenced significantly. Collected data from 15, 30, 45 and 60 DAT showed the maximum number of leaves as 8.51, 12.17, 18.09 and 28.26, respectively, which were found from B_1 (25 ppm) treatment and the minimum number of leaves were obtained from B_0 (0 ppm) treatment at 15, 30, 45 and 60 DAT.

In case of boron application, maximum number (39.01) of flower was obtained from 25 ppm boron while the lowest value (29.17) was obtained from 0 ppm boron. For number of fruits character, application of different levels of boron showed significant difference among treatments and the highest value (19.09) of this character was obtained from the 25 ppm boron while the lowest value (14.17) was obtained from 0 ppm boron. Different levels of boron showed significant effect on number of fruit length, fruit diameter and individual fruit weight. Highest values of these characters were 6.74 cm, 6.43 cm and 61.32 g, respectively and all of them were obtained from B_1 (25 ppm) boron, while the lowest values were obtained from 0 ppm boron (B_0). Yield per plant parameter was also significantly influenced by different levels of boron. The values of this character was maximum (1515.31 g/plant) in 25 ppm boron, and the minimum (794.14 g/plant) was from control (0 ppm boron).

The treatment combinations demonstrated significant variation in plant height at 15, 30, 45 and 60 DAT. Longest plants at 15 DAT (48.34 cm), 30 DAT (73.02 cm), 45 DAT (97.01 cm) and 60 DAT (111.34 cm) were produced by 100 ppm GA_3 with 25 ppm boron, whereas, the shortest plants at 15, 30, 45 and 60 DAT were 31.01 cm, 57.01 cm, 78.67 cm and 96.34 cm, respectively, were shown from treatment combination of 0ppm GA_3 and 0 ppm boron.

Combined effect of GA_3 and boron showed statistically significant variation on number of leaves at 15, 30, 45 and 60 DAT. Collected data from 15, 30, 45 and 60 DAT showed the maximum number of leaves as 10.67, 15.67, 24.34 and 36.01, respectively, which were found from treatment combination of 100 ppm GA_3 with 25 ppm boron (G_2B_1) and the minimum number of leaves were obtained from G_0B_0 (0 ppm GA_3 and 0 ppm boron) treatment at 15, 30, 45 and 60 DAT.

In case of interaction effect of GA_3 and boron, the highest number (45.01) of flowers per plant was produced by the treatment combination of 100 ppm GA_3 and 25 ppm boron. On the other hand, the lowest number (24.01) of flowers per plant was produced by the control treatment (100 ppm GA_3 with 0 ppm boron). In case of interaction effect of GA_3 and boron, the highest number (24.34) of fruits per plant was produced by the treatment combination of 100 ppm GA_3 and 25 ppm boron. On the other hand, the lowest number (9.34) of fruits per plant was produced by the control treatment (100 ppm GA_3 with 0 ppm boron). In case of interaction effect of GA_3 and boron, the maximum fruit length (7.89 cm), fruit diameter (7.13 cm) and individual fruit weight (69.41 g) were produced by the treatment combination of 100 ppm GA_3 and 25 ppm boron. On the other hand, the minimum fruit length (4.58 cm), fruit diameter (4.28 cm) and individual fruit weight (43.44 g) were produced by the control treatment (0 ppm GA_3 with 0 ppm boron). The treatment combination of 100 ppm GA_3 with 25 ppm boron gave the maximum yield (1689.44 g/plant) whereas, the minimum yield (487.41 g/plant) was found from the control treatment.

Conclusion:

The overall results obtained from the study facilitated to draw the following conclusions:

i. The plants was produced the maximum growth and yield of summer tomato due to the application of 100 ppm GA_3.

ii. Boron played an important role on the growth, fruit formation and fruit yield of summer tomato. In respect of all the yield attributes and yield, 25 ppm boron application showed better performance.

iii. It may be drawn the conclusion from above fact, 100 ppm GA_3 and 25 ppm boron is suitable combination for the summer tomato production. Further investigation may be needed to observe in different agroecological zones before more conformation of the results.

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APPENDICES

Appendix- I. Analysis of variance of plant height of summer tomato

Source of variation	Degree of freedom	Mean Square			
		Plant height @			
		15 DAT	30 DAT	45 DAT	60 DAT
Replications	2	27.694*	27.111*	24.083*	28.861*
Factor- A (GA_3)	3	243.435*	188.620*	209.963*	93.880*
Factor- B (Boron)	2	205.444*	120.861*	165.250*	107.028*
Interaction-(AxB)	6	19.630*	2.343**	4.991*	4.102*
Error	22	0.331*	0.293*	0.205*	0.073*

**Significant at 1% level
*Significant at 5% level

Appendix- II. Analysis of variance of number of leaves of summer tomato

Source of variation	Degree of freedom	Mean Square			
		Number of leaves @			
		15 DAT	30 DAT	45 DAT	60 DAT
Replications	2	15.750*	25.527*	24.083*	20.083*
Factor- A (GA_3)	3	2.027**	1.731**	55.740*	40.074*
Factor- B (Boron)	2	6.250*	7.194*	32.250*	65.583*
Interaction-(AxB)	6	0.583**	10.453*	1.657*	1.324*
Error	22	0.325*	0.164*	0.143*	0.113*

**Significant at 1% level
*Significant at 5% level

Appendix- III. Analysis of variance of different characters of summer tomato

Source of variation	Degree of freedom	Mean Square		
		Number of flowers / Plant	Number of fruits / Plant	Fruit length
Replications	2	19.111*	9.528*	1.704*
Factor- A (GA_3)	3	314.917*	164.815*	6.149*
Factor- B (Boron)	2	301.194*	73.361*	4.781*
Interaction-(AxB)	6	13.972**	5.176*	0.113*
Error	22	2.051*	0.134*	0.007*

**Significant at 1% level
*Significant at 5% level

Appendix- IV. Analysis of variance of different characters of summer tomato

Source of variation	Degree of freedom	Mean Square		
		Fruit diameter	Individual fruit weight	Yield / Plant
Replications	2	0.808*	13.159*	44296*
Factor- A (GA_3)	3	3.556*	545.071*	870899*
Factor- B (Boron)	2	5.674*	336.421*	541556*
Interaction-(AxB)	6	0.031**	15.101*	44251*
Error	22	0.008*	0.086*	671*

**Significant at 1% level
*Significant at 5% level