APPLICATION OF PLANT GROWTH REGULATORS AND MICRONUTRIENTS ON GROWTH, YIELD AND QUALITY OF TOMATO

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APPLICATION OF PLANT GROWTH REGULATORS AND MICRONUTRIENTS ON GROWTH, YIELD AND QUALITY OF TOMATO

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CERTIFICATE

This is to certify that thesis entitled, **"APPLICATION OF PLANT GROWTH REGULATORS AND MICRONUTRIENTS ON GROWTH, YIELD AND QUALITY OF TOMATO"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRICULTURAL BOTANY**, embodies the result of a piece of research work carried out by **M. ASADUZZAMAN ABHI, Registration No.12-04907** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated:
Dhaka, Bangladesh

Prof. Dr. Md. Ashabul Hoque
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DEDICATED TO
MY
BELOVED PARENTS

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ABSTRACT

The growth, yield and quality of tomato largely depend on soil and climatic conditions and also on BARI Tomato 14. Among these, proper application of plant growth regulators and B plays a vital role.A field experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during October 2017 to April 2018 to evaluate the effect of foliar application of IBA, GA_3 and B on yield and quality of tomato. Single variety BARI Tomato-14, and foliar application of IBA 5ppm, GA_3 5ppm and B 2mg/L were used to conduct this experiment. The experiment was laid out in a Randomized Complete Block Design (RCBD) having single factor and replicated three times. Data were collected on plant height, number of leaves plant^{-1}, number of branches plant^{-1}, Leaf Area Index(LAI), chlorophyll content of leaf, number flowers cluster pant^{-1}, number of fruit plant^{-1}, weight of fruit, yield hectare^{-1}, Vitamin-C content and TSS% content. A statistically significant variation was recorded in terms of all the characters related to growth and yield quality of tomato. The maximum plant height, number of branches plant^{-1}, length of branch respectively 103.03 cm at 90 DAT, 65.70 at 90 DAT, 13.11 at 90 DAT was observed in treatment of T_7(IBA 5ppm+$GA_3$5ppm+B). The minimum plant height, number of branches plant^{-1}, length of branch respectively 82.22 cm at 90 DAT, 47.88 at 90 DAT, 10.33 at 90 DAT was observed in treatment of T_0(control). The maximum number flowers cluster plant^{-1} at 90 DAT in treatment both T_7(IBA 5ppm+GA_3 5ppm+B) and T_4(IBA 5ppm+GA_3 5ppm) and number of fruit plant^{-1} 160 at 90 DAT was observed by treatment of T_7(IBA 5ppm+GA_3 5ppm+B). The minimum number flowers cluster plant^{-1} 8.89 at 90 DAT in treatment both T_0(control) and number of fruit plant^{-1} 60.00 at 90 DAT was observed by treatment of T_0(control). The maximum yield of fruits hectare^{-1} (83.30 tones) was obtained from treatment of T_7(IBA 5ppm+$GA_3$5ppm+B). The lowest yield of fruits hectare^{-1} (33.75 tones) was obtained from treatment of T_0(B).

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
B	=	Boron
GA_3	=	Gibberellic acid
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muirate of Potash
RCB	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Per cent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER I

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a solanaceous self-pollinated vegetable crop. It's chromosome number 2n=24. It is one of the important, popular and nutritious vegetable grown in Bangladesh in both winter and summer season around all the parts of the country (Haque *et al*., 1999). The origin of tomato is South America (Salunkhe *et al.,* 1987). Tomato is one of the most popular, important and widely used vegetable crops ranked as second position vegetable of the world after potato (Dorais *et al.,* 2008; Olaiya *et al.,* 2010). The leading tomato producing countries of the world are China, India, Egypt, Turkey, Iran, Mexico, Brazil and Indonesia (FAO, 1999).

Tomato is widely used as salad as well as for cooking purpose. It is well known for its nutritional importance as it is very rich in nutrients, especially potassium, folic acid, vitamin C and contains a mixture of different carotenoids, including vitamin A, effective β-carotene as well as lycopene (Wilcox *et al*., 2003). It contains Calories 97, Iron 2.7 mg, Protein 4.5 g, Riboflavin 0.15 mg, Calcium 50 mg, Niacin 3.2 mg, Phosphorus 123 mg and Ascorbic acid 102 mg per 1 pound edible portion (Lester, 2006). Lycopene is an antioxidant which protect the cell from oxidative damage, so it decrease the risk of chronic diseases such as coronary heart diseases and cancer diseases (Giovannucci, 2002, Taber *et al*., 2008). The mode of action is tentative, but they are believed to reduce risk of cancer by successfully trapping oxygen and intermediate of free oxygen radical. Lycopene is soluble in fat and it is the precursor of β-carotene. It has two folds antioxidant capacity of β-carotene (Taber *et al*., 2008). Lycopene concentration in tomato fruit depends upon maturity, genetics, environmental conditions, cultivation techniques and production techniques. The environmental conditions like temperature, light, fertility and others affect fruit lycopene (Robertson, 1995).

In Bangladesh, it is cultivated as winter vegetable, which occupied on area of 59000 acres of land, and the total production of tomato were 255 thousands metric tons in Bangladesh in the year 2011-2012 (BBS, 2014). Thus the average yield of tomato was 14.35 ton ha^{-1}, while it was 41.81 ton ha^{-1} in the world which is very low in compare with that of other countries, namely India (15.67 t ha^{-1}), Japan (52.82 t ha^{-1}) and USA (63.66 t ha^{-1}).The yield of tomato in

our country is not satisfactory enough in compare to requirement (Aditya *et al.*, 1999). It is cultivated in almost all home gardens and also in field due to it's adaptability to wide range of soil and climate (Ahmed, 1976).

The growth promoting hormones is used in commercial horticulture to improve plant growth and yield can used safely on fruits, vegetables and leafy crops. Products produce under hormonal treatment are safe to eat, like wise naturally organic product producer. Indole 3-Butyric Acid is a plant bio-regulator belonging to the auxin group referred as organic compound either natural or synthetic that modifies or controls one or more specific physiological processes within a plant. IBA that regulate growth and influence various developmental process, including stem elongation, early root formation, callus formation, enhance flowering, enzyme induction and leaf and fruits senescence. They can accelerate or retard the growth and maturation rate (Olaiya *et al*., 2009). Indole 3-Butyric Acid (IBA) is the leading plant hormone used to promote the formation of roots and to generate new roots in the cloning of tomato plants through cuttings (Rao *et al*., 2005).

Gibberellic acid is one of the most important growth stimulating substances used in agriculture since long. It may promote cell elongation, cell division and thus helps in growth and development of tomato plant. Gibberellic acid when applied to flowers controlled fruit drop in tomato (Feofanova, 1960). Fruit set in tomato can be increased by applying plant growth regulators to compensate the deficiency of natural growth substances required for its development (Singh and Choudhury, 1966). The effect of spray of Gibberellic acid (GA_3) at very low concentrations could be exploited beneficially as its natural occurrence in plants in minute quantities is known to control their development. It is an established phytohormone used commercially for improving the productivity and quality of a number of crop plants.

Adequate supply of micronutrients also plays an important role in tomato production. Among the micro elements, Boron plays an important role directly and indirectly in improving the yield and quality of tomato in addition to checking various diseases and physiological disorders. It gives a rosette appearance and yellowing between veins of new growing leaves occur in plant (Marchner, 1995). B is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes (Grotz and Guerinot, 2006). Boron deficiency is thought to restrict RNA synthesis, which in turn inhibits protein synthesis (Katyal and Randhawa, 1983).

Although, tomato is the second major crop of the world after potato, but there is lack of research, particularly under field conditions, to show interactive effects of IBA, Gibberellic acid and B on tomato.

Keeping the above point of view, the present study was undertaken to evaluate the effect of IBA, Gibberellic acid (GA_3) and Boron and on tomato with the following objective:

- To study the effect of Plant Growth Regulators and Boron on growth and yield of tomato.

- To investigate the effect of Plant Growth Regulators and Boron on quality of tomato.

CHAPTER II
REVIEW OF LITERATURE

Tomato *(Solanum lycopersicum L.*) is one of the most important vegetable crops in Bangladesh and received much attention to the researcher throughout the world. Application of the growth regulators like IBA, GA_3 and Boron has different modifying influences on growth, yield and yield contributing characters of tomato as well as other vegetables. 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 these chapter morphological characters, growth, yield and biochemical parameters have been reviewed as follows:

2.1 Effect of IBA on growth, yield and quality of tomato

Olaiya *et al.* (2009) found that IBA that regulate growth and influence various developmental process, including stem elongation, early root formation, callus formation, enhance flowering, enzyme induction and leaf and fruits senescence. They can accelerate or retard the growth and maturation rate.

Rao *et al.* (2005) examined that Indole 3-Butyric Acid (IBA) is the leading plant hormone used to promote the formation of roots and to generate new roots in the cloning of tomato plants through cuttings. However, IAA promotes the shoot growth. It had a very positive effect on the number of adventitious roots formation in tomato cuttings.

Olaiya *et al.* (2010) also found that treated seed of tomato with IAA, IBA and NAA with concentration of 25 mg/L, 50mg/L, 75mg/L, 100mg/L,125mg/L and 150mg/L apply on six genotypes in CRD with three replications showed that seedlings emergence was enhanced by all bio-regulator treatments at 100mg/L relative to control, the highest values being 92.1, 88.4 and 89.4% for the IAA, IBA and NAA treatments, respectively, marked reduction was recorded at higher concentrations of 125 and 150 mg/L for all test genotypes.

Olaiya *et al.* (2010) examined that Bio-regulators affect fundamental processes of plant growth and development. Indole-3-acetic acid (IAA), Indole-3-butyric acid (IBA) and

Naphthalene acetic acid (NAA) are plant bio-regulators belonging to the auxin group. Plant bio regulators are organic compounds, that modify or controls one or more specific physiological processes within a plant. They can accelerate or retard the growth or maturation rate or otherwise alter the behavior of plants or their products.
Singh *et al.*(1999) investigate that tomato cuttings required plant growth regulators such that IBA, IAA and NAA to promote rooting.

Chao *et al.* (2001)reported that use of IAA and IBA concentrations (500 and 1000 ppm) on tomato side shoots along with control showed enhancement in rooting and growth of side shoots revealed that raising of tomato seedlings had some difficulties especially in early spring and winter because of lack of appropriate method, there should be an appropriate methods to enhance raising of tomato seedlings.

Lopez *et al.* (2001) investigated that at the lowest concentration of IAA stimulated stem elongation as well as root numbers and roots length. Effect of different concentrations (1500, 3000, 45000 and 10,000 ppm) of IBA on ten tomato cultivars. Naphthalene Acetic Acid (NAA) significantly increased the number of root and root length.
Gad *et al.* (2006) observed that adventitious root formation in tomato cuttings was totally suppressed with the application of IAA and IBA combination. They further observed the best root formation in tomato cuttings in 1.00 mg NAA/L.

Olaiya *et al.* (2010) reported the effect of Indole-3-acetic acid (IAA), Indole-3butyric acid (IBA) and Naphthalene acetic acid (NAA) at 60, 100 and 140 mg/L was evaluated on some biochemical indices of the nutritional quality of tomato (*Solanum lycopersicum L.*). The parameters evaluated were crude proteins, crude fat, crude fibre, ash, dry matter, titratable acidity, total carbohydrate, total soluble solids (%Brix), pH and %Brix/Acid ratio. The results showed that all the concentrations of IAA, IBA and NAA increased the levels of crude proteins, crude fat, crude fibre, ash, titratable acidity but decreased the total carbohydrate content.

A decrease in dry matter content was evident in 60 mg/L of IAA, IBA, NAA and 100 mg/L of NAA. The pH of tomato pulp decreased in treatments involving 100 mg/L of IAA and 140

mg/L of IAA and NAA, respectively. The total soluble solid content and %Brix/Acid ratio were significantly higher ($P < 0.05$) in the 100 mg/L NAA treatment. The results indicated that the bioregulators could enhance the basic tomato nutrients of importance in human diet.

2.2 Effect of GA_3 on growth, yield and quality of tomato

Gustafson (1960) worked with different concentration of GA_3 and found that when 35 and 70 ppm GA_3 were sprayed to the flowers and floral 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.

Adlakha and Verma (1964) sprayed GA_3 in concentration of 50 and 100 ppm on flower cluster at anthesis and observed that the application of GA_3at 100 ppm could appreciably increase fruit size, weight, protein, sugar and ascorbic acid contents.

Adlakha and Verma (1965) noticed 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.

Jansen (1970) found that tomato plants treated with GA_3 neither increased the yield nor accelerated fruit ripening. He mentioned that increasing concentration of GA_3 reduced both the numbers and size of the fruits.

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.

Hossain (1974) examined the effect of gibberellic acid along with parachlorophenoxy acetic acid on the production of tomato. He found that GA_3 applied at 50, 100 and 200 ppm produced an increased fruit set. However, GA_3 treatment induced a small size fruit

production. A gradual increase in the yield plant^{-1} was obtained with higher concentration of GA_3

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 stage and then at weekly interval until 5 leaf stage. They inspect that GA_3 increased the number and weight of fruits plant^{-1} at higher concentration.

Mehtha and Mathi (1975) found 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 2, 4-D at 5 ppm followed by NAA at 0.2 ppm. He also reported that GA treatments at 10 or 25 ppm improved the yield of tomato cv. Pusa Ruby irrespective of planting date. GA gave earlier setting and maturity.

Mozer (1980) noted that GA_3 enhance plant height and leaf area. The promoting effect of GA_3 on DNA, RNA and protein synthesis and ribose and polyribosome multiplication.

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

Onofeghara (1981) conducted an experiment on tomato sprayed with GA_3 at 20-1000 ppm and NAA at 25-50 ppm. He found that GA_3 promoted flower primodia production and the number of primordia and NAA promoted flowering and fruiting.

In China, Wu *et al.* (1983) sprayed one month old transplanted tomato plants with GA_3 at 1,10 or 100 ppm. They noticed that GA_3 at 100 ppm increased plant height and leaf area.

Leonard *et al.* (1983) found that GA_3 application directly on the inflorescence promoted inflorescence development in tomato plants (cv. King plus) grown under a low light regime.

Groot *et al.* (1987) noted that GA_3 was indispensable for the development of fertile flowers and for seed germination, but only stimulated in later stages of fruit and seed development.

Sumiati (1987) observed 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

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

Hathout *et al.,* (1993) investigated 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 gibberellins contents.

Patel and Saxena (1994) observed that presoaking of seed of gram in varying concentrations of GA_3 showed the best results on dry weights.

Davies (1995) stated that the most widely available plant growth regulators is GA_3 or gibberellic acid, which induces stem and internode elongation, seed germination, enzyme production during germination and fruit setting and growth.

El-Abd *et al.* (1995) studied the effect of plant growth regulator for improving fruit set of tomato. Two tomato cv. in pots, Alicante crops were produced in the greenhouse. When the third flower of the second cluster reached anthesis, the second cluster was sprayed with IAA, GA_3 or ABA at 10-4, 10-6 or 10-8 M each and ACC at 10-9, 10-10 or 10-11 M. All concentrations of IAA, GA_3, ACC and ABA induced early fruit set compared with controls sprayed with distilled water.

Sanyal *et al.,* (1995) examined that 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.

Singh (1995) studiedthat the effect of spray of gibberellic acid (GA_3) at very low concentrations could be exploited beneficially as its natural occurrence in plants in minute quantities is known to control their development. It is an established phytohormone used commercially for improving the productivity and quality of a number of crop plants.

Takano *et al.,*(1995) stated that application of GA_3 at 50 and 100 ppm increased leaf number and number of branches.

Tomar and Ramgiry (1997) experimented that number of branches plant^{-1}, plant height, number of fruits plant^{-1} and yield were significantly greater than untreated control when plants treated with GA_3. Application of GA_3 treatment at the seedling stage gives valuable scope for obtaining higher commercial tomato yields.

Khan *et al., (* 1998) found that application of 10^{-5} M GA_3 on mustard at 40 or 60 days after sowing significantly increased total dry matter.

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

Gulnaz *et al.*(1999) noted that seeds of wheat treated with GA_3 (10 ppm) resulted in 36-43% increase in dry weight at 13.11 dS/m.

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

Sun *et al.* (2000) observed the role of growth regulators on cold water for irrigation reduces stem elongation of plug-grown tomato seedlings. The effect of growth regulators (abscisic acid, gibberellic acid (GA), paclobutrazol, ethephon, IAA and silver thiosulfate) and cold water irrigation at different temperatures (5, 15, 25, 35, 45 and 55 °C) on the reduction of stein elongation of plug-grown tomato seedlings was investigated. Paclobutrazol, ethephon and GA reduced the stem length of the tomatoes at several water temperatures. Cold water irrigation with the addition of 1.8 ppm GA or irrigation at room temperature could promote stem elongation. Irrigation at room temperature with the addition of 10 ppm paclobutrazol (GA_3 biosynthesis inhibitor) or cold water irrigation could inhibit stem elongation. The reduction in stem elongation in plug-grown tomato seedlings was due to the relationship of GA_3 metabolism and sensitivity.

Rafeekher *et al.* (2002) noticed that Gibberellic acid is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters, quality of plant .

Sheeja et al., (2004) found that GA_3 found to be the best among all treatments for producing calli with very good growth from leaf and stem explants of tomato cultivars. Callus induction was observed within 8-10 days of culturing the leaf explants source.

Sasaki *et al.* (2005) reported the effect of plant growth regulators on fruit set of tomato *(Lycopersiconesculentum*cv. Momotaro) under high temperature and in a field (Japan) under rain shelter. Tomato fruit set reduced by high temperature.

Khan *et al.* (2006) examined the effect of 4 levels of gibberellic acid spray on the growth, leaf-NPK content, yield and quality parameters of 2 tomato cultivars *(Lycopersiconesculentum*Mill.*)*, namely "Hyb-SC-3" and "Hyb-Himalata".
They stated that irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters, especially in the case of "Hyb-SC-3".

2.3Effect of Boron on growth, yield and quality of tomato

Cakmak *et al.* (1989) investigated that plant growth was severely depressed by boron deficiency, but high concentration of boron also reduced dry weight of crop.
Singh *et al.* (1990) noted that B deficiency may enhance boron absorption and transport to such an extent that boron may possibly accumulate to toxic levels in plant tops.

Dongre*et al.* (2000) carried an experiment and that showed that the highest percentage of TSS (3.12 %) content was attained in fruits treated with foliar application of 50 mg/L Zn+100 mg/L Fe and the lowest was achieved in control. Also highest pH was attained in fruits treated with 200 mg/L foliar Fe. Increase in B and Fe concentration significantly increased TSS content when accompanied by B and Fe alone or in combination, and the highest and lowest values of this parameter were found at 50 mg/L Zn+100 mg/L Fe and control, respectively .

Swan *et al.* (2001) observed that balance fertilization of macro and micro nutrients i.e. Nitrogen, Phosphorus, Boron is essential for the production of high yield and quality products.
Kaya and Higgs (2002) found that Boron may be required for chlorophyll production, pollen function and fertilization.

Imtiaz *et al.* (2003) stated that boron is essential for normal plant growth and development as carbohydrates, protein metabolism and sexual fertilization also depend on Boron.

Kumari and Sharma(2006) was conducted an experiment to determine the effects of boron, zinc, molybdenum, copper, iron and/or manganese, applied as foliar sprays, on the growth and fruit and seed yield of tomato. All the treatments were applied at 100 ppm starting 30 days after transplanting and repeated twice at 10-day interval.

The recommended NPK rate (100 kg N, 75 kg P_2O_5 and 55 kg K_2O/ha) were uniformly applied in all the treatments including the control where no spraying of micronutrients was carried out. Variations in plant height, number of days taken to first flowering, number of branches plant^{-1}, number of fruits plant^{-1}, fruit yield plant^{-1}, yield ha^{-1}, seed yield and 1000-seed weight were observed. Foliar application of boron at 100 ppm resulted in the highest growth and seed yield, with net returns of Rs. 150 811.44/ha and cost: benefit ratio of 1:2.13.

Silspour and Omidghaemi (2006) carried out an experiment to study on the effects of different irrigation water quantities and use of Fe and B on yield and water use efficiency of tomato. Treatment comprise of three irrigation water regimes based on evaporation from pan class A (60, 80 and 100 percent evaporation) and four fertilizer treatments (NPK, NPKZn, NPKFe and NPKFeZn) in clay loam soil on tomato yield were studied and result showed that use of B and Fe increase yield and water use efficiency significantly. In general, use of NPK +Fe + B and irrigation based on 100 100% evaporation was best treatment with 48.1 t/ha.

Cakmak (2008) examined that Boron also plays an important role in the production of biomass.

Salam *et al.* (2010) carried out a field experiment to investigate the effects of boron and zinc in presence of different levels of NPK fertilizers on quality of tomato. There were twelve treatment combinations which comprised four levels of boron and zinc viz., i) 0 kg B + 0 kg B/ha, ii) 1.5 kg B + 2.0 kg B/ha, iii) 2.0 kg B + 4.0 kg B/ha , iv) 2.5 kg B + 6.0 kg B/ha and three levels of NPK fertilizers viz., i) 50% less than the recommended NPK fertilizer dose (50% RD). The highest pulp weight, dry matter content, TSS, acidity, ascorbic acid, lycopene content, chlorophyll-a, chlorophyll-b, marketable fruits at 30 days after storage and shelf life were recorded with the combination of 2.5 kg B+ 6 kg Zn/ha and recommended dose of NPK fertilizers (N= 253, P= 90, and K= 125 kg/ha).

Aghtape *et al.* (2011) found that foliar application of micronutrients to plant is the most effective and safest way.

Irshad (2011) carried out a study on the effect of organic manures and inorganic fertilizers on biochemical constituents of tomato. In this study tomato plants were treated with organic manures (F.Y.M, Sewage sludge) and inorganic fertilizers (N, P, K, B, S) were analyzed for biochemical composition. TSS, lycopene, carbohydrate, vitamin C, acidity and carotenoid content exhibited an increase at all the test concentrations and were found maximum in sewage sludge treated along with N.P.K, followed by @ FYM along with NPK.

Salam *et al*. (2011) examined the effect of boron, zinc, and cow dung on quality of tomato. There were 16 treatments comprising four rates of boron and zinc viz., B0Zn0, B1.5Zn2,B2Zn4 and B2.5Zn6 kg/ha and four rates of cow dung viz., CDo, CD10, CD15, and CD20 t/ha. Every plot received at the rate of 253 kg N, 90 kg P, 125 kg K, and 6.6 kg S hectare^{-1}. The results revealed that the highest pulp weight, dry matter content, ascorbic acid, lycopene content, chlorophyll-a, chlorophyll-b, marketable fruits at 30 days after storage and shelf life were recorded with the combination of @2.5 kg B/ha + 6 kg Zn/ha, and 20 t/ha cow dung.

Naga *et al.* (2013) carried out a study to find out the effect of Foliar application of Micronutrients on growth parameters in tomato (*Lycopersicon esculentum* Mill.).The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese and mixture. 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. All 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. UtkalKumari, 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 plant^{-1} was noticed with the application of manganese (148.7 %), followed by micronutrient combination (144.1 %). In UtkalKumari, the fruit yield plant^{-1} ranged from 1.336 kg to1.867kg.

CHAPTER III

MATERIALS AND METHODS

This chapter includes location of the experiment, characteristics of soil, climate, materials used, land preparation, manuring and fertilizing, transplanting and gap filling, stalking, after care, harvesting and collection of data.

3.1 Location of the experiment field

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka -1207 during the period from October, 2017 to March, 2018. The location of the experimental site was at $23^{0}74^{/}$ N latitude and $90^{0}35^{/}$ E longitude with an elevation of 8.45 meter from the sea level. This Experiment focus to find out the effect of different concentration of IBA, $GA_3$and B on the growth,yield and quality of tomato.

3.2 Climate of the experimental area

The experimental area was subtropical in nature. It is characterized by heavy rainfall, high temperature, high humidity and relatively long day during kharif season (April to September) and a scanty rainfall associated with moderately low temperature, low humidity and short day period during rabi season (October to March). Meteorological data details in respect of monthly maximum, minimum and average temperature, rainfall, relative humidity, average sunshine hours and soil temperature during the period of experiment were presented in Appendix II.

3.3 Soil of the experimental field

Study site soil was silty clay loam in texture. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5. The soil sample collected from the experimental area were analyzed in the Soil Resources and Development Institute (SRDI), Soil Testing Laboratory, Farmgate, Dhaka and the characteristics was presented in Appendix III.

3.4 Plant materials used

In the experiment, Tomato variety "BARI Tomato-14" was used. It was a high yielding, heat tolerant and indeterminate type variety. The seeds were collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Raising of seedlings

Tomato seedlings were raised in the seedbed situated on a relatively high land at Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the seedbed was 3 m x l m. The soil was well prepared with the help of spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and 5 kg well rotten cowdung was applied during seedbed preparation. The seeds were sown in the seedbed on 15 october, 2017 and after sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg/ha around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place within 5 to 6 days after sowing. Necessary shading by banana leaves was provided over the seedbed so that the young seedlings were safe from scorching sun or heavy rain. Weeding, mulching and irrigation were done from time to time as and when required and no chemical fertilizer was used in the seedbed.

3.6 Treatments of the experiment

The experiment consisted of single factor as follows:-

Total 8 treatments were as follow with symbolically:

T_0= control

T_1= IBA 5ppm

T_2= GA_3 5ppm

T_3= B (5g/L)

T_4= IBA 5ppm+ GA_3 5ppm

T_5= IBA 5ppm+B

T_6= GA_3 5ppm+B

T_7= IBA 5ppm+ GA_3 5ppm+B

3.7 Design of the experiment

Field layout was done after final land preparation. The experiment was laid out in a Randomized Complete Block Design (RCBD) having with three replications. The treatment combinations were accommodated randomly in the unit plots.

3.8 Layout of the experiment

An area of 19.5 m x 8 m was divided into three equal blocks. Each block consisted of 8 plots where 8 treatments were allotted randomly. There were 24 unit plots altogether in the experiment. The size of each plot was 2 m x 1.8 m. The distance between two blocks and two plots were 0.5m and 0.5 m respectively. (Figure 1)

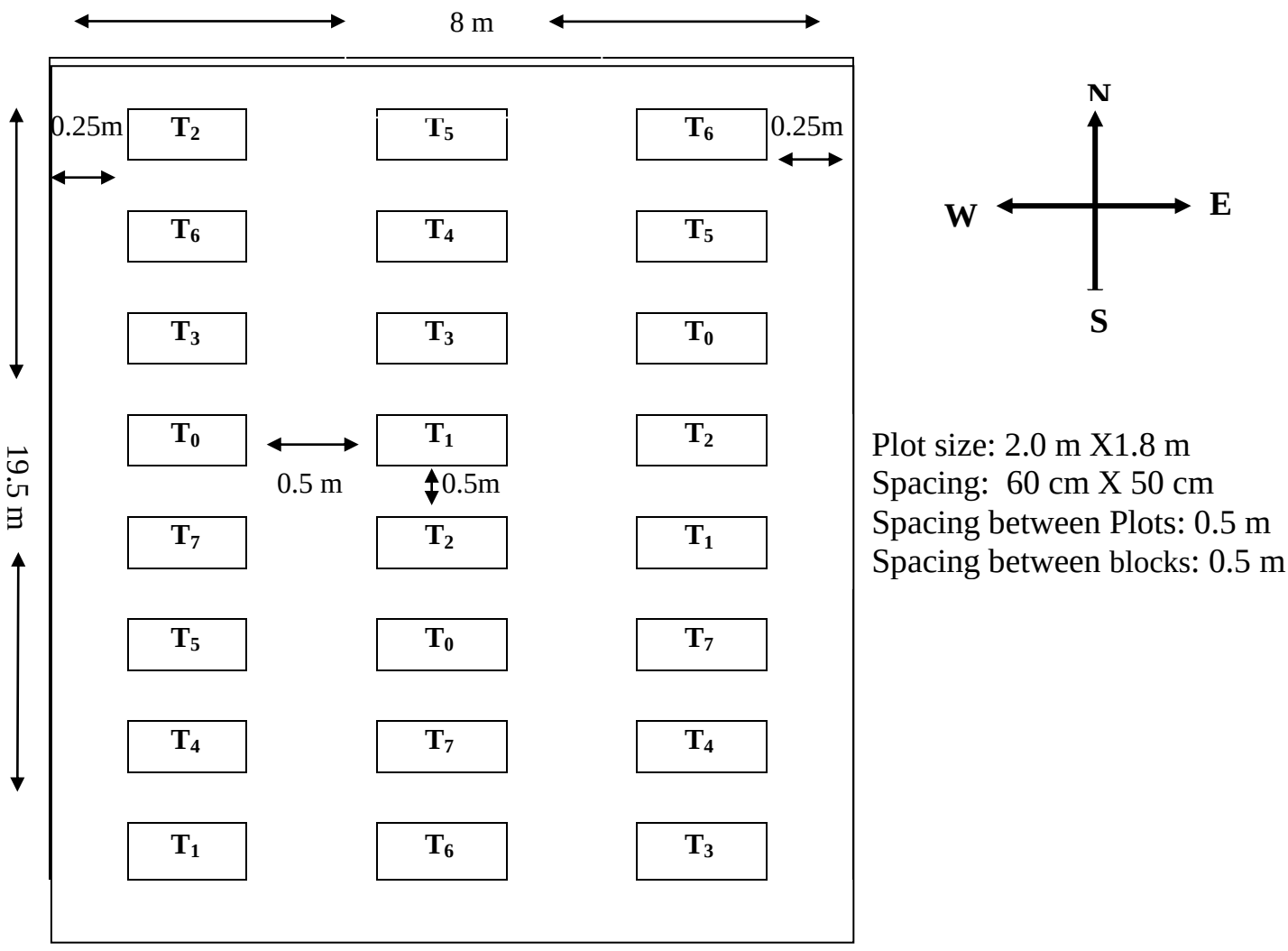

Fig. 1: Layout of the experimental plot

3.9 Cultivation procedure:

3.9.1 Land preparation:

The experimental field was thoroughly ploughed and cross ploughed and cleaned prior to seed sowing and application of fertilizers and manure were done in the field.The soil was well prepared and good tilth was ensured for tomato crop production. The land of the experimental field was ploughed with a power tiller. Later, the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed.

Finally the land was properly leveled before transplanting. Then plots were prepared as per the design. The unit plots were prepared as 15 cm raised beds. Twelve pits were made in each plot with row to row and plant to plant spacing of 60cm X 50 cm.

3.9.2 Manuring and Fertilizing:

Manure and fertilizers such as cowdung, urea, triple super phosphate (TSP) and murate of potash (MOP) were applied in the experimental field as per recommendation of BARI (2005).

Table1. Fertilizer and manure applied for the experimental field preparation.

Manure and fertilizers were used as recommended by BARI (1996).

Manure/ Fertilizer	Rate/ha	Application (Kg)			
		Basal	20 DAT	30 DAT	40 DAT
Cowdung	10 ton	100	_	_	_
Urea	550 kg	_	200	175	175
TSP	250 kg	_	100	75	75
MOP	175 kg	100	75	_	_
B	2 mg/L				

The sources of N, P_2O_5, K_2O as urea, TSP and MP were applied, respectively. The entire amounts of TSP and MP were applied during the final land preparation. Urea was applied in three equal installments at 20, 30 and 40 days after seedling transplanting. Well-rotten cow dung 20 t/ha also applied during final land.

3.9.3 Transplanting of seedlings

Healthy and uniform 35 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 15 November, 2017maintaining a spacing of 60 cm x 50 cm between the rows and plants, respectively. This allowed 12 plants in each plot. The seedbed was watered before uprooting the seedlings to minimize damage to the roots. The seedlings were watered after transplanting. For shading purpose banana leaf sheath was used for three days to protect the seedling from the hot sun and removed after seedlings were established. For gap filling, Seedlings were also planted around the border area of the experimental plots.

3.9.4 Preparation of IBA and GA3 solution

By means of electric balance desirable amount of IBA and GA_3 was weighed separately. After dissolving them in 95% ethyl alcohol, the solution was replaced in 1000 c.c. volumetric flask then distilled water added to it to make up the volume 1000 c.c. of solution and then used for foliar spray.

3.9.5 Intercultural operation

After seedlings transplanting , various intercultural operations such as irrigation, weeding, staking and top dressing etc. were accomplished for better growth and development and quality of the tomato seedlings.

3.9.5.1 Gap filling

Gap filling was done as and when needed.

3.9.5.2 Weeding and mulching

Weeding was done whenever it was necessary. To help in soil moisture conservation, mulching was also done. Mulching helps for breaking the crust of the soil.

3.9.5.3 Staking

When the plants were well established, staking was given to each plant by bamboo sticks to keep them erect. Within a few days of staking, as the plants grew up, the plants were pruned as per the treatments.

3.9.5.4 Application of IBA and GA_3

Application of IBAand $GA_3$was done at 15 , 30 , 45 days after transplanting as per treatment.

3.9.5.5Application of Boron

Application of B was done at 15 , 30, 45days after transplanting at the rate of 5 g/L.

3.9.5.6 Irrigation

Light watering was given with watering can immediately after transplanting the seedlings and then flood irrigation was done as and when necessary throughout the growing period upto harvest.

3.9.6 Plant protection

Malathion 57 EC was applied @ 2 ml/L against the insect pests like cut worm, leaf hopper fruit borer and others. The insecticide application was made fortnightly for a week after transplanting to a week before first harvesting. Furadan 10 G was also applied during final land preparation as soil insecticide. During foggy weather, spraying Dithane M-45 fortnightly @ 2 g/L taken as precautionary measured against disease infection of tomato, at the early vegetative stage.

3.9.7 Harvesting

Fruits were harvested at 3 days interval during early ripe stage when they developed slightly red color. Harvesting was started from 20 February, 2018 and completed by 10 March, 2018.

3.9.8 Parameters assessed

Randomly five plants were selected and uprooted carefully at the time of collecting data and mean data on the following parameters were recorded:-

Plant height
Number of leaves per plant
Number of branches per plant
Leaf Area Index
SPAD value
Number of flower cluster per plant
Number of fruit per plant
Fruit weight per plant
Fruit yield (t/ha)
Total soluble solid percent (TSS%)

3.9.9 Collection of data

Five plants were selected randomly from each unit plot for data collection in such a way that the border effect could be avoided at the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment.

Plant height:

Plant height was measured from the sample plants in centimeter from the ground level to the tip of the longest stem and means value was calculated. Plant height was recorded 30, 45, 60, 75 and 90 days after transplanting to observe the growth rate.

Number of leaves per plant:

The number of leaves of the sample plants was counted at 30, 45, 60, 75 and 90 DAT and the average number of leaves produced per plant was recorded.

Number of branches:

The number of branches of five tagged plants in each plot were counted and recorded 30, 45, 60, 75 and 90 DAT 30 days after transplanting stages of growth and then mean number of branches per plant was calculated.

Leaf area (cm^2):

The leaf areas of five randomly selected plants in each experimental plot were measured Systronics leaf area meter at 60, 75 and 90 days and then mean area was calculated.

SPAD Value:

The Chlorophyll percentage of leaf of the plant was measured by Chlorophyll meter at 60 days after transplanting from randomly selected five tagged plants. The Chlorophyll percentage of five tagged leaves of each plant was measured and calculated the average Chlorophyll percentage of leaf of each plant of five sample plants.

Number of flower clusters per plant:

The number of flower clusters was counted from the sample plants periodically and the average number of flower clusters produced per plant was calculated.

Number of fruits per plant:

Total number of fruits was counted from selected plants and their average was taken as the number of fruits per plant.

Fruit weight per Plant:

A pan scale balance was used to take the weight or fruits per plot . Fruits of four randomly selected plants are weighted. Their average value was recorded.

Fruit Yield (t/ha):

From the yield per plot, yield per hectare was calculated.

$$\text{Fruit Yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg)} \times 1000\text{m}^2}{\text{Area of plot in square meter (m}^2\text{)} \times 1000\text{kg}}$$

Vitamin C content

Vitamin C content of green and dry fruits were determined by 2, 6- dichlorophenol indophenols visual titration method. The following reagents were used for the estimation of vitamin C contains.

Reagents

i. **3% Metaphosphoric acid (HPO_3)** Is was prepared by dissolving 30 g of HPO_3 and 80 ml glacial acetic acid in distilled water and volumes made up to one liter.
ii. **Standard ascorbic acid solution** 10 % of L- ascorbic acid solvent was made by dissolving ascorbic acid in 3 metaphosphoric acid solution.
iii. **Dry solution** It was prepared by dissolving 260 mg of sodium salt of 2, 6-dicholophenol indophenols in one liter of distilled water.

Procedure

Standardization of dye solution

Dilute 5 ml of standard ascorbic acid solution with 5 ml of Meta phosphoric acid. A micro burette was loaded with dye solution and the mixed solution was titrated with dye solution using phenolphthalein as indicator to a the pink colored end point which insisted for at least 15 sec.

Dye factor was enumerated using the following formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of sample

Five grams of fresh fruit and dry fruits was taken in a 100ml beaker with 50 ml 3% metaphosphoric acid and then it was transferred to blender and homogenized with same concentration of metaphosphoric acid. First blending then it was filtered and centrifuged at

2000 rpm for 5 minutes. The homogenized liquid was transferred to a 100 ml volumetric flask and was made up to the mark with 3 % metaphosphoric acid.

Titration

Five ml of the aliquot was taken in conical flask and titrated with 2, 6- dicholophenol indophenols dye, phenolphthalein was used as indicator to a pink colored end point, which persisted at least 15 seconds. The ascorbic acid content (Vitamin C) of the sample was calculated by using the following formula:

$$\text{Ascorbic acid (mg/100g)} = \frac{T \times d \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titrate value (ml)

D = Dye factor

V_1 = Volume to be made (ml)

V_2 = Volume of extract taken for titration (ml)

W = Weight of sample taken for estimation (gm)

Measurement of Total Soluble Sugar (TSS %):

One drop ripens tomato juice was used to take the TSS reading in a digital brix meter (ATOGA, JAPAN). Reading from brix meter recorded in percentage.

3.9.10 Analysis of data

Data were statistically analyzed by a computer program MSTAT-C software and Duncan's multiple range tests was used to analyze the growth, yield and quality contributing characters of tomato to find out the statistical significance. The significance of the difference was evaluated by Duncan's Multiple Range Test (DMRT) according to Gomez and Gomez, (1984) for interpretation of the results at 5% level of probability.

CHAPTER IV
RESULTS AND DISCUSSION

The present research was justified to find out the effect of IBA, GA_3 and B on growth, yield and quality of tomato. Data on different yield contributing characters and yield were recorded. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix IV-IX. The results have been arranged and discussed, and possible interpretations were given under the following headings.

4.1 Plant height

The effect of PGR and Boron on plant height of tomato was presented in Table 1. There was significance differences in plant height due to application of different treatments.

At 30 DAT, the highest plant height was observed in treatment of T_7(33.61cm) which is followed by T_5, T_6, Moreover, T_1 showed second highest plant height in tomato and they were statistically similar. However, the lowest plant height was observed in T_0(23.287 cm).

At 45 DAT, the highest plant height was observed in treatment T_7(46.183 cm) which was followed by T_5 showed second highest plant height in tomato and they were statistically similar. On the other hand, the lowest plant height was observed in T_0 (30.147 cm).

At 60 DAT, the highest plant height was observed in treatment T_7 (73.37 cm) which had no significant difference T_4 and T_5 followed by T_4 and T_5 .On the other hand, the lowest plant height was observed in T_0(58.437 cm).

At 75 DAT, the highest plant height was observed in treatment of T_7 (93.533cm) which was followed by T_5 and T_1 showed second highest plant height in tomato and they were statistically similar. On the other hand, lowest plant height was observed T_0 (72.707 cm).

At 90 DAT, the highest plant height was observed in treatment T_7 (100.03 cm) which was followed by T_2 . It showed second highest plant height in tomato and they were statistically similar. On the other hand, lowest plant height was observed in T_0 (82.222 cm) and statistically simillar with T_3 .

The results were similar to the findings of Wu *et al.* (1983). They reported that GA_3 increased plant height which justify the present study.

Table 2. Effect of different plant growth regulators and Boron on plant height at different tomato at different days after transplanting.

Treatments	Plant height (cm)				
	30 DAT	45 DAT	60 DAT	75DAT	90DAT
T_0	23.287c	30.147e	58.437e	72.707d	82.22d
T_1	27.527b	37.820d	66.680bc	83.690b	90.64b
T_2	26.077bc	42.390bc	66.817bc	81.707bc	91.44b
T_3	23.963c	31.107e	52.673d	76.737cd	84.30cd
T_4	28.710b	44.960a	71.440ab	87.347b	96.22a
T_5	28.150b	42.990b	70.940ab	83.690b	91.04b
T_6	29.137b	41.063c	65.633c	82.373bc	87.86bc
T_7	33.617a	46.183a	73.370a	93.533a	100.03a
$LSD_{(0.05)}$	3.151	1.4814	5.246	5.6572	4.7189
CV (%)	6.53	2.05	4.56	3.91	2.98

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

T_0= control
T_1= IBA 5ppm
T_2= GA_3 5ppm
T_3= B
T_4= IBA 5ppm+ GA_3 5ppm
T_5= IBA 5ppm+B
T_6= GA_3 5ppm+B
T_7= IBA 5ppm+ GA_3 5ppm+B

4.2 Number of leaves per plant

The effect of PGR and B on number of leaves of tomato was presented in Table 3. There was significant distant variation in number of leaves due to application of different treatments.

At 30 DAT, the maximum number of leaves was observed in treatment T_7 (32.6), statistically similar with T_4 which was followed by T_6,T_1,T_2 and T_7 showed second highest number of leaves in tomato and they were statistically similar. On the other hand, the minimum number of leaves was observed in T_0 (21.50).

At 45 DAT, the maximum number of leaves was found in treatment T_7 (36.05) which was statistically similar with T_4 and T_5 . On the other hand, the minimum number of leaves was observed in T_0 (27.64).

At 60 DAT, the maximum number of leaves was observed in treatment T_7 (45.30) which was followed by T_4, T_6 and T_5 showed second highest number of leaves in tomato and they were statistically similar. On the other hand, the minimum number of leaves was observed in T_2 (34.11) which had no distant significance with T_0 .

At 75 DAT, the maximum number of leaves was observed in treatment T_7 (51.07) which was followed by T_4 showed second highest number of leaves in tomato and they were statistically similar. On the other hand, the minimum number of leaves was observed in T_3 (38.01).

At 90 DAT, the maximum number of leaves was observed in treatment T_7 (62.71) which was followed by T_4. It showed second highest number of leaves in tomato and they were statistically similar. On the other hand, the minimum number of leaves was observed in T_0 (44.89) which was statistically similar with T_3 .

The results were similar to the findings of Gabal *et al.* (1990). They reported that GA_3 increased leaf number which justify the present study.

Table 3. Effect of growth regulators and Boron on number of leaves of at different days after transplanting in tomato

Treatments	Leaf number				
	30 DAT	45 DAT	60 DAT	75DAT	90DAT
T_0	21.5c	27.64c	34.41c	38.01f	44.89f
T_1	27.53b	30.58cd	37.33bc	41.42dc	48.90de
T_2	27.97b	38.84ab	34.11c	42.45cd	49.86d
T_3	23.09c	28.05de	32.53c	38.78ef	46.27ef
T_4	31.2a	34.78a	42.90a	48.05ab	58.70b
T_5	27.07b	33.94ab	36.96bc	45.34bc	49.24de
T_6	28.33b	31.74bc	40.99ab	43.66cd	54.64c
T_7	32.6a	36.05a	45.30a	51.07a	62.71a
$LSD_{(0.05)}$	2.8712	2.8964	5.0282	3.0882	3.2098
CV (%)	5.98	5.16	7.54	4.05	3.53

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

T_0= control

T_1= IBA 5ppm

T_2= GA_3 5ppm

T_3= B

T_4= IBA 5ppm+ GA_3 5ppm

T_5= IBA 5ppm+ B

T_6= GA_3 5ppm+ B

T_7= IBA 5ppm+ GA_3 5ppm+B

4.3 Number of branches per plant

Effect of PGR and B on number of branches of tomato was presented in Table 3. There were significance variations in number of branches due to application of different treatments.

At 30 DAT, the maximum number of branches was observed in treatment T_7 (2.83) which was followed by T_4,T_6 and T_5 showed second highest number of branches in tomato and they were statistically similar. On the other hand, the minimum number of branches was observed in T_0 (2.12).

At 45 DAT, the maximum number of branches was observed in treatment T_7 (5.8) which was followed by T_4 showed second highest number of branches in tomato and they were statistically similar. On the other hand, the minimum number of branches was observed in T_0 (4.45).

At 60 DAT, the maximum number of branches was observed in treatment T_7(7.73) which was followed by T_4, T_5 and T_6 showed second highest number of branches in tomato and they were statistically similar. On the other hand, the minimum number of branches was observed in T_0(5.56).

At 75 DAT, the maximum number of branches was observed in treatment T_7(11.83) which was followed by T_5 and T_6 showed second highest number of branches in tomato and they were statistically similar. On the other hand, the minimum number of branches was observed in T_0(8.34).

At 90 DAT, the maximum number of branches was observed in treatment T_7 (13.11) which was followed by T_4 showed second highest number of branches in tomato and they were statistically similar. On the other hand, the minimum number of branches was observed in T_0 (10.33).

The results were similar to the findings of Takano *et al.* (1995). They reported that GA_3 increased leaf number which justify the present researchs.

Table 4. Effect of growth regulators and Boron on branch number at different days after transplanting in tomato

Treatments	Branch number.				
	30 DAT	45 DAT	60 DAT	75DAT	90DAT
T_0	2.12d	4.45f	5.56d	8.34de	10.33f
T_1	2.14c	4.99de	6.52c	9.34cde	11.47de
T_2	2.19c	5.08cd	6.21c	8.89e	11.75cd
T_3	2.17c	4.67ef	6.47c	9.13d	10.85ef
T_4	2.55b	5.56ab	6.21c	11.22a	12.48ab
T_5	2.45b	5.37bcd	7.15b	10.13b	12.14cd
T_6	2.37b	5.44bc	7.05b	9.86bc	12.23bc
T_7	2.83a	5.80a	7.73a	11.83a	13.11a
$LSD_{(0.05)}$	0.1237	0.3996	0.3561	0.6117	0.6853
CV (%)	3.31	4.42	3.02	3.55	3.32

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

T_0= control

T_1= IBA 5ppm

T_2= GA_3 5ppm

T_3= B

T_4= IBA 5ppm+ GA_3 5ppm

T_5= IBA 5ppm+B

T_6= GA_3 5ppm+B

T_7= IBA 5ppm+ GA_3 5ppm+B

4.4 Leaf area Index:

The effect of PGR and B on Leaf Area Index of tomato was presented in Figure 1. There showed a significance variation in LAI of tomato at different DAT.

At 60 DAT, the highest Leaf area index was found in treatment T_7 (261.13 cm^2) which was followed by T_4 showed second highest LAI in tomato and they were statistically similar. On the other hand, the lowest was observed in T_0 (100 cm^2).

At 75 DAT, the highest Leaf area index was found in treatment T_7 (309.37 cm^2) which was followed by T_4 showed second highest LAI in tomato and they were statistically similar. On the other hand, the lowest was observed in T_0 (151.17 cm^2).

At 90 DAT, the highest Leaf area index was found in treatment T_7 (412.53 cm^2) which was followed by T_4 showed second highest LAI in tomato and they were statistically similar. On the other hand, the lowest was observed in T_0 (195.95 cm^2).

The results were similar to the findings of Wu *et al.* (1983). They reported that GA_3 increased leaf area which justify the present study.

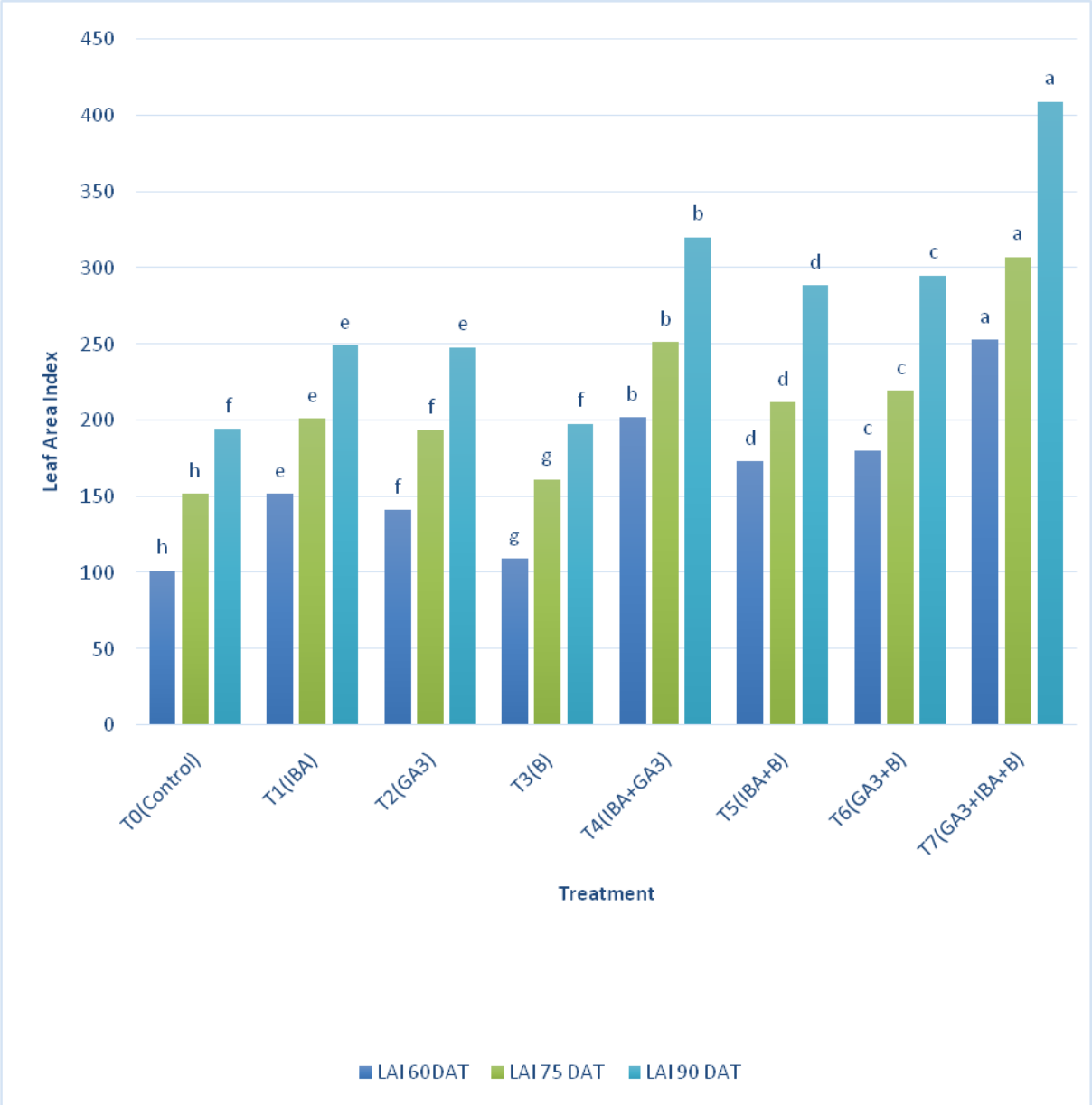

Figure 1. Effect of different plant growth regulators and B on Leaf area index of tomato at different DAT.

4.5 SPAD value of leaf:

Effect of IBA, GA_3 and B showed statistically significant variation on SPAD value of leaf in Figure 2 .There showed a significance variation in SPAD value of leaf of tomato at different DAT.

The highest SPAD value content of leaf (59.32%) was found from T_7 (IBA 5ppm+ GA_3 5ppm+B) and second highest was observed following T_4 and T_6 while the lowest SPAD value content of leaf.(46.61%) was recorded from T_0(control).

The results were similar to the findings of Kaya and higgs (2002). They reported that B increased SPAD value content production which justify the present study.

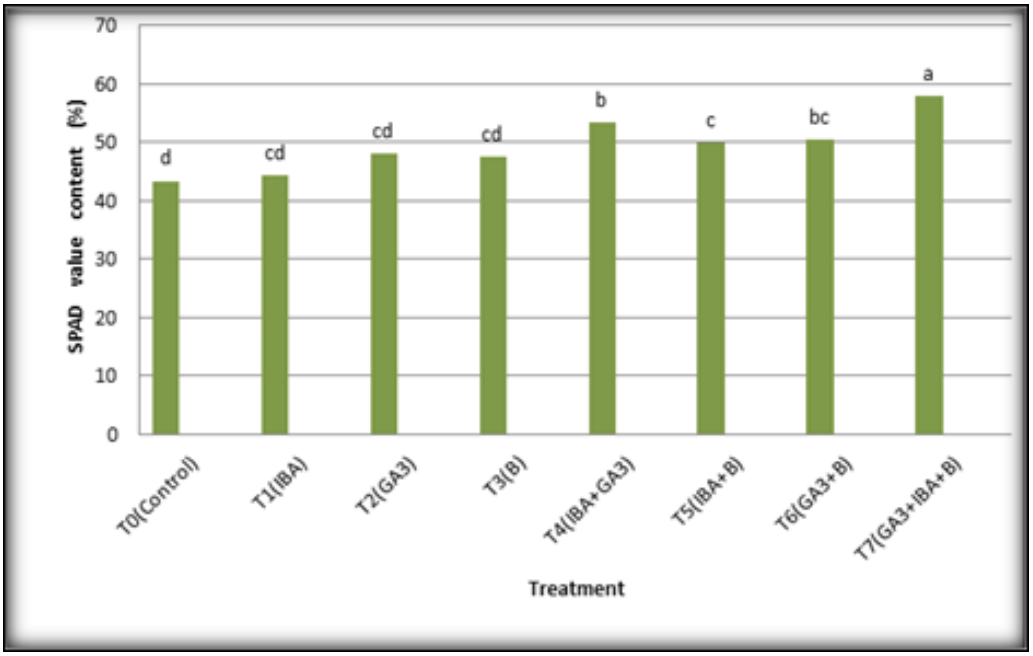

Figure 2. Effect of different plant growth regulators and B on SPAD value of tomato.

4.6 Number of flower cluster per plant

The effect of IBA, GA_3 and B on LAI on tomato was presented in Figure 3. There showed a significance variation in number of flower clusters of tomato at different DAT.

At 60 DAT, the maximum number of flower cluster per plant was found in treatment T_7 (8.7) which was followed by T_4 showed second highest number of cluster in tomato and they were statistically similar. On the other hand, the minimum was observed in T_0 (2.5).

At 75 DAT, the maximum number of flower cluster per plant was found in treatment T_7 (13.5) which was followed by T_4 showed second highest number of cluster in tomato and they were statistically similar. On the other hand, the minimum was observed in T_0 (5.09).

At 90 DAT, the maximum number of flower cluster per plant was found in treatment T_7 (20.0) which was followed by T_6 showed second highest number of cluster in tomato and they were statistically similar. On the other hand, the minimum was observed in T_0 (8.9).

The results were similar to the findings of Gustafson (1960). They reported that GA_3 increased cluster which justify the present study.

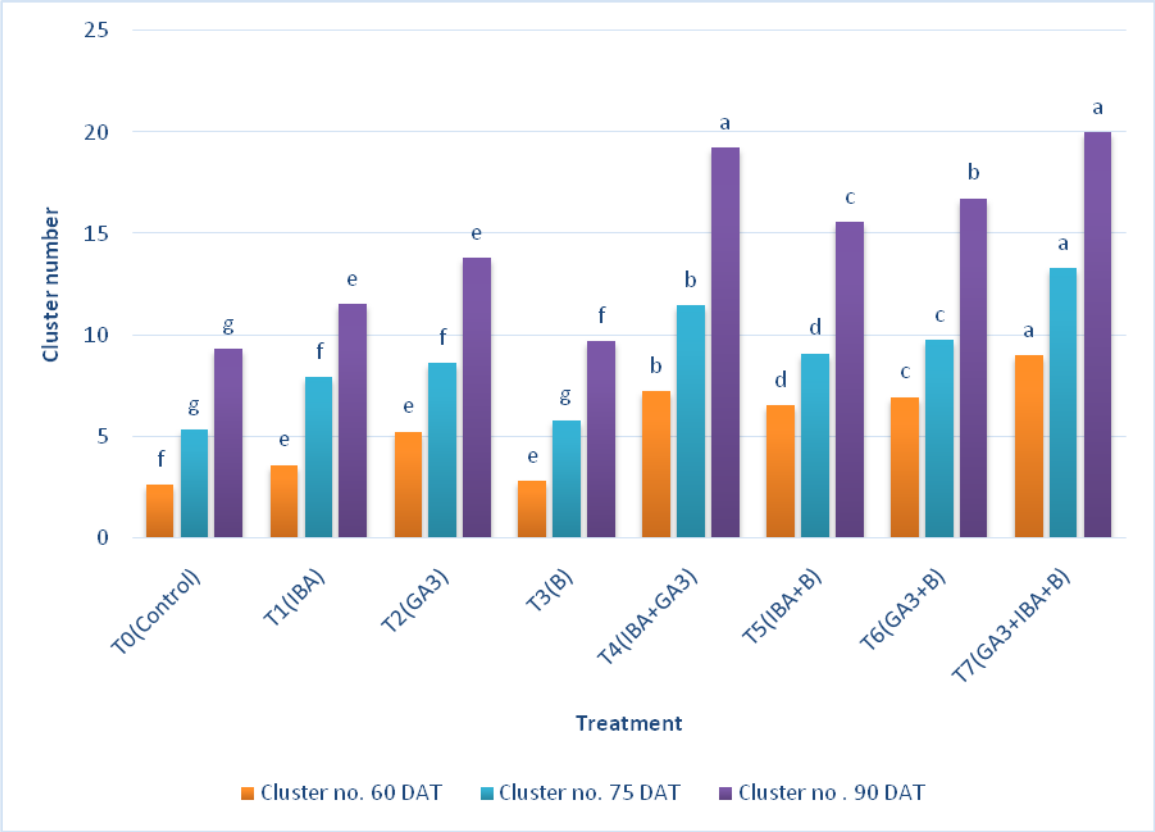

Figure 3. Effect of different plant growth regulators and B on cluster number of tomato at different DAT .

4.7 Number of fruits per plant

The effect of IBA, GA_3 and B on LAI on tomato was presented in Figure 4. There showed a significance variation in number of fruit plant^{-1} of tomato at different DAT.

At 60 DAT, the maximum number of fruit plant^{-1} was found in treatment T_7 (30.0) which was followed by T_4 showed second highest number of fruit plant^{-1} in tomato and they were statistically similar. On the other hand, the minimum was observed in T_0 (13.37).

At 75 DAT, the maximum number of fruit plant^{-1} was found in treatment T_7 (68.6) which was followed by T_4 showed second highest number of fruit plant^{-1} in tomato and they were statistically similar.However, the minimum was observed in T_0(27.3).

At 90 DAT, the maximum number of fruit plant^{-1} was found in treatment T_7 (160.0) which was followed by T_4 showed second highest number of fruit plant^{-1} in tomato and statistically similar. On the other hand, the minimum was observed in T_0 (60.0).

Similar results also reported by Onofeghara (1981). He reported that GA_3 increased fruit number which justify the present study.

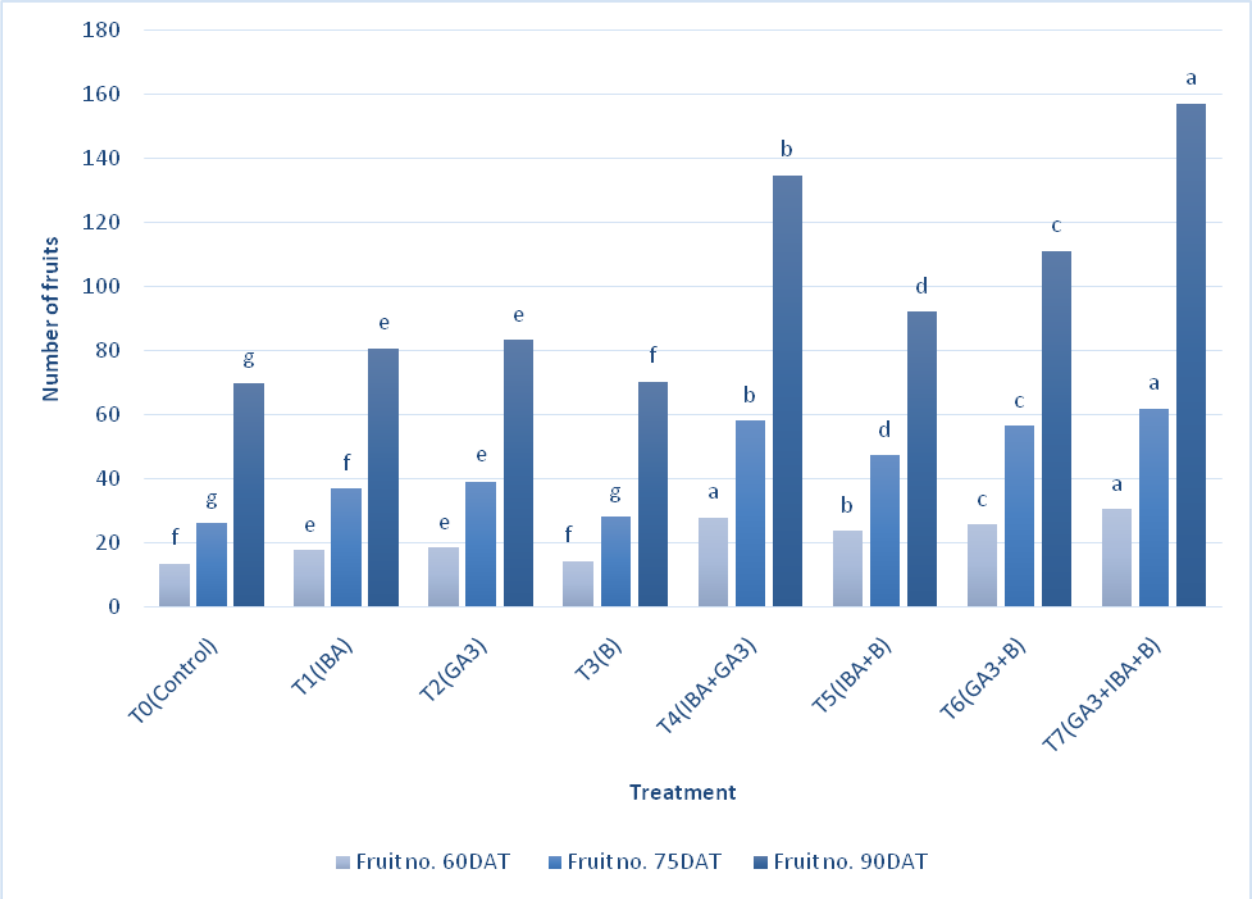

Figure 4. Effect of different plant growth regulators and B on number of fruits of at different DAT in tomato

4.8 Weight of fruits plant^{-1}

The effect of PGR and B on weight of tomato was presented in Table 5. There were significance differences in fruit due to application of different treatments.

At 1st harvest, the maximum weight was observed in treatment T_7 (2.36 kg) which was followed by T_6 and T_4 showed second highest weight of fruit in tomato and they were statistically similar, On the opposite, the minimum weight was observed in T_0 (0.57 kg).

At 2st harvest, the maximum weight was observed in treatment T_7 (4.69 kg) which was followed by T_5 and T_6 showed second highest weight of fruit in tomato and they were statistically similar. In response, the minimum weight was observed in T_0(2.02 kg).

At 3st harvest, the maximum weight was observed in treatment T_7 (3.24 kg) which was followed by T_4 showed second highest weight of fruit in tomato and they were statistically similar. On the other hand, the minimum weight was observed in T_0(1.74kg).

Table 5 .Effect of different plant growth regulators and B fruit weight of at different DAT in tomato

Treatments	Fruit weight (kg)		
	1st harvest	2nd harvest	3rd harvest
T_0	0.57f	2.02f	1.74f
T_1	1.51d	3.17d	2.36e
T_2	1.88c	3.55c	2.49de
T_3	1.37e	2.61e	1.77f
T_4	2.21b	4.61a	3.01b
T_5	1.90c	3.99b	2.57d
T_6	2.17b	3.94b	2.82c
T_7	2.36a	4.69a	3.24a
$LSD_{(0.05)}$	0.1292	0.2295	0.1542
CV (%)	4.23	3.67	3.52

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

T_0= control
T_1= IBA 5ppm
T_2= GA_3 5ppm
T_3= B
T_4= IBA 5ppm+ GA_3 5ppm
T_5= IBA 5ppm+B
T_6= GA_3 5ppm+B
T_7= IBA 5ppm+ GA_3 5ppm+B

4.9. Total soluble solid content (%):

Effect of IBA, GA_3 and B performed significant effect on total soluble solid content. There showed a significance variation in total soluble solid content of tomato at different DAT.

The treatment of T_7 showed the highest total soluble solid content (6.73%)which was followed by T_5 and T_6 the second highest and the lowest (6.213%) was found from the treatment combination on T_0 (control). Graphical presentation about effect of IBA, GA_3 and B shown in Figure 5.

The results were similar to the findings of Swan *et al.* (1972). They reported that B increased total soluble solid content which justify the present study.

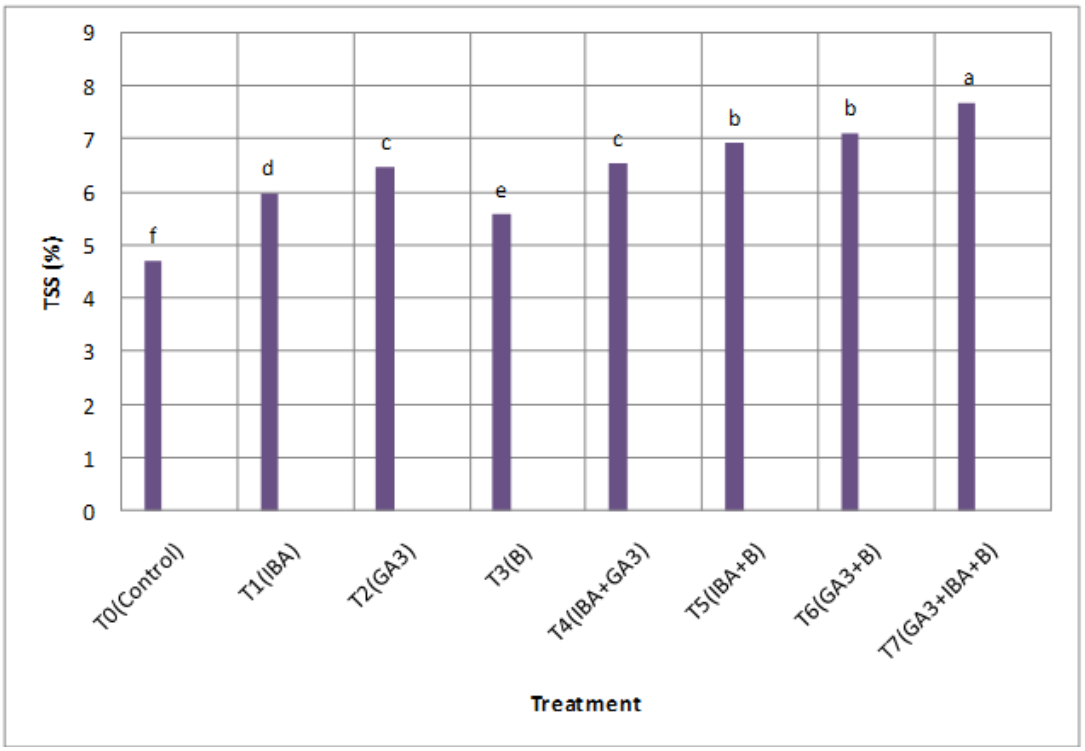

Figure 5. Effect of different treatments and Boron on TSS percentage in tomato

4.10 Vitamin-C content

Effect of IBA, GA_3 and B performed significant effect on Vitamin C content. There showed a significance variation in Vitamin-C content of tomato at different treatments.

The treatment of T_7 showed the highest Vitamin C content (87.10 mg/100gm) which was followed by T_4 the second highest and the lowest (79.77 mg/100gm) was found from the treatment combination on T_0 (control). Graphical presentation about effect of IBA, GA_3 and B shown in Figure 6.

The results were similar to the findings of Swan *et al.* (1972). They reported that B increased Vitamin C content which justify the present study.

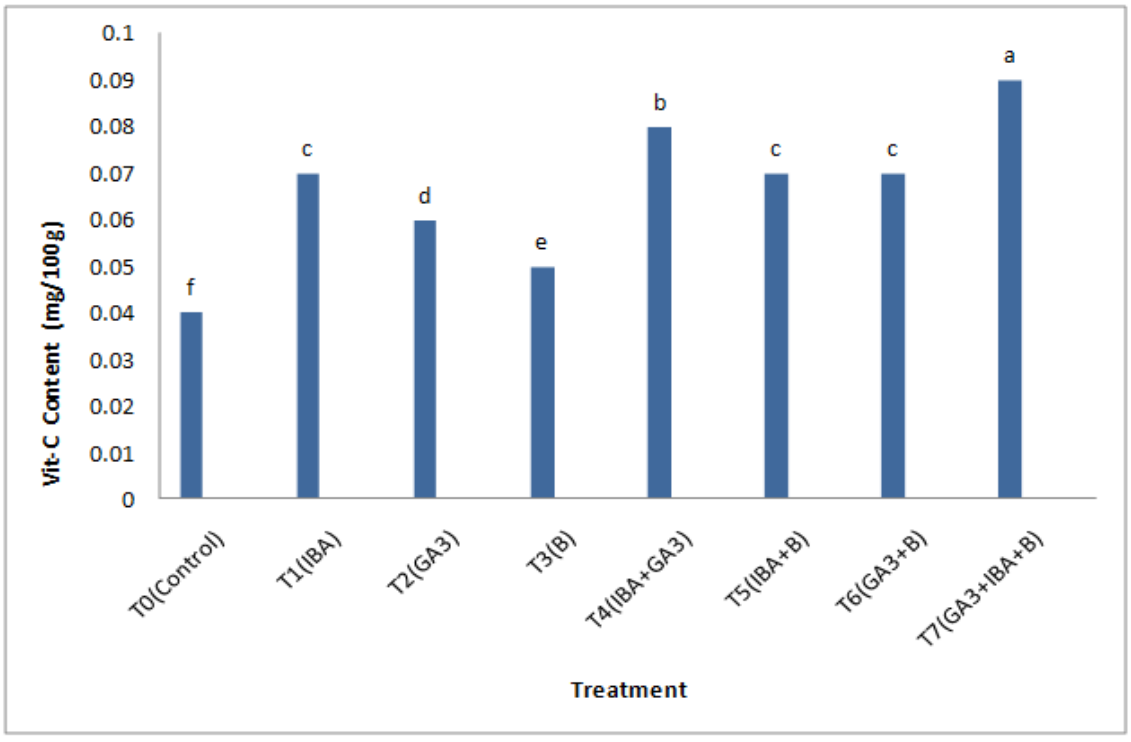

Figure 6. Effect of different plant growth regulators and B on Vitamin C content of tomato

4.11.Fruit yield hectare^{-1}

Effect of IBA, GA_3 and B performed significant effect on yield per hectare. There showed a significance variation in number of fruit per plant of tomato at different DAT.

The treatment combination of T_7 (IBA 5ppm+ GA_3 5ppm+B) and T_4(IBA 5ppm+ GA_3 5ppm) gave the maximum yield (83.30 t/ha) which was followed by T_7 and T_4 the second highest and the minimum yield (33.75 t/ha) was found from the treatment combination on T_0 (control). Graphical presentation about effect of IBA, GA_3 and B shown in Figure 5.

The results were similar to the findings of Hossain (1972) . He reported that GA_3 increased yield which justify the present study .

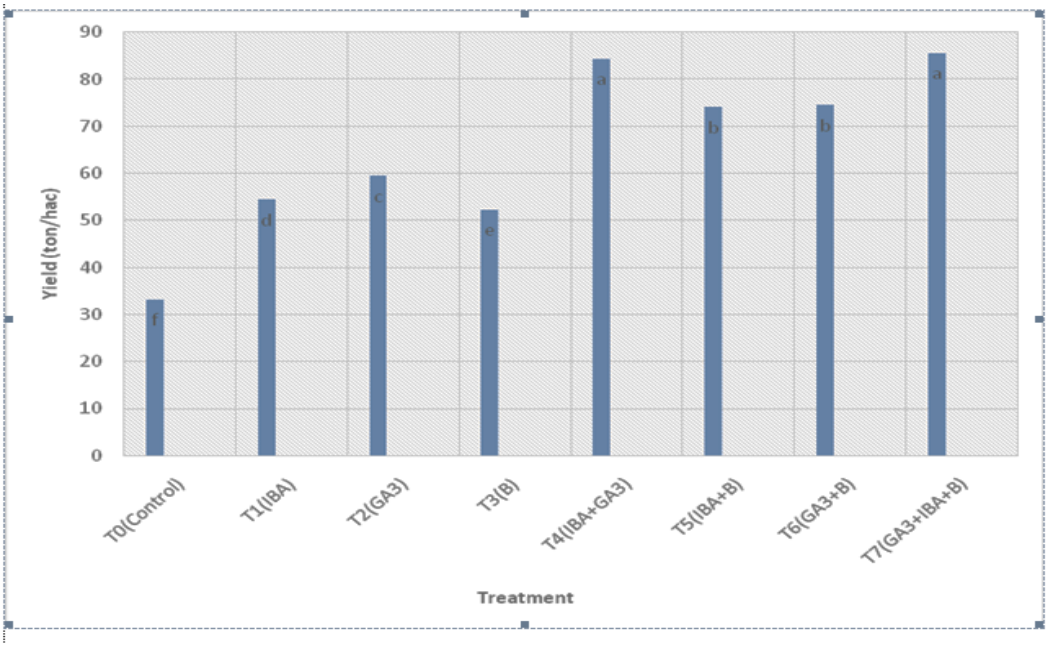

Figure 7. Effect of different plant growth regulators and B on yield of tomato

CHAPTER V

SUMMARY AND CONCLUSION

The growth, yield and quality of tomato largely depend on soil and climatic conditions and also on variety. Among these, proper application of IBA, GA_3 and B play a vital role. The field experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during October 2017 to April, 2018 to evaluate the effect of foliar application of IBA, GA_3 and B on yield and quality of tomato . Single variety BARI Tomato-14, and foliar application of IBA GA_3 and B were used to conduct this experiment. The experiment was laid out in Randomized complete Block Design (RCBD) having three factors and replicated three times. Data were taken on growth, yield contributing characters, yield and the collected data were statistically analyzed for evaluation of the treatment effects. The summary of the results has been described in this chapter.

Plant height at 30, 45, 60, 75 and 90 DAT due to the influence of different varieties was significant. In application of IBA, $GA_3$and B treatment combination, all parameter show significant response. The higher value found in treatment T_7(IBA 5ppm + GA_3 5ppm + B), At 30 DAT the longest (37.55 cm) plant was recorded from T_7 and the shortest (27.69cm) plant was recorded from T_0. At 45 DAT the tallest plant (55.16 cm) was recorded from T_7 and the shortest (36.00 cm) was recorded from T_0. At 60 DAT, the longest (76.37 cm) plant was recorded from T_7 and the shortest (56.01 cm) plant was recorded from T_3.At 75 DAT the tallest plant (96.53 cm) was recorded from T_7 and the shortest (75.70 cm) was recorded from T_0. At 90 DAT the tallest plant (103.03 cm) was recorded from T_7 and the shortest (85.24 cm) was recorded from T_0. At 30 DAT the maximum no. of leaves (35.60) was recorded from T_7 and the minimum (24.50) was recorded from T_0. At 45 DAT the maximum no. of leaves (39.43) was recorded from T_7 and the shortest (31.04) was recorded from T_3. At 60 DAT the maximum no. of leaves (48.30) was recorded from T_7 and the minimum (35.53) was recorded from T_3. At 75 DAT the maximum no. of leaves (54.06) was recorded from T_7 and the minimum (41.00) was recorded from T_3. At 90 DAT the maximum no. of leaves (65.70) was recorded from T_7 and the minimum (47.88) was recorded from T_0. At 30 DAT the maximum no. of branches (2.83) was recorded from T_7 and the minimum (1.22) was recorded from T_0. At 45 DAT the maximum no. of branches (5.78) was recorded from T_7 and the minimum

(4.11) was recorded from T_0. At 60 DAT the maximum no. of branches (7.73) was recorded from T_7 and the minimum (6.22) was recorded from T_0. At 75 DAT the maximum no. of branches (11.83) was recorded from T_7 and the minimum (8.89) was recorded from T_0. At 90 DAT the maximum no. of branches (13.11) was recorded from T_7 and the minimum (10.33) was recorded from T_0. At 60, 75 and 90 DAT the maximum leaf area index was recorded from T_7 and the minimum was recorded from T_0. The highest chlorophyll content of leaf(59.32%) was found from T_7 while the lowest chlorophyll content of leaf.(46.61%) was recorded from T_0.The highest Vitamin C content (113.10 mg/100gm) was recorded and the lowest (79.77mg/100gm) was recorded from T_0.

The treatment combination of T_7 gave the maximum number of flower clusters per plant and the minimum number of flower cluster per plant was recorded from the treatment combination of T_0. The maximum number of fruit per plant was observed in the treatment combination of T_7 and the minimum from T_0. The maximum fruit weight per plant was obtained from the treatment combination of T_7 at 1st and 2nd harvested but at 2nd harvest the maximum fruit weight per plant was recorded the treatment T_7 and T_4. The lowest in this respect was found from the treatment combination T_0. T_7 and T_4 gave the maximum yield (83.30 t/ha) and the minimum yield (33.75 t/ha) was found from the treatment combination on T_0. The highest Vitamin C content (113.10 mg/100gm) was recorded and the lowest (79.77mg/100gm) was recorded from T_0. The highest TSS(%) (7.000) was found from T_7 while the lowest TSS(%) (5.870) was recorded from T_0.

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

- The conclusion from above fact that, the treatment T_7that included IBA 5mg/L, GA_3 5mg/L and B 2mg/L is suitable combination for the tomato production. Further investigation may be done to observe in different agro-ecological zones before more conformation of the results.

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APPENDICES

Appendix I: Experimental site at Sher-e-Bangla Agricultural University, Dhaka-1207

The map of Bangladesh showing experimental site

The map of Bangladesh showing experimental site

Appendix II:Monthly average air temperature, total rainfall,relative humidity and sunshine hours of the experimental site during the period from October 2017 to March 2018

Year	Month	Average Air temperature (^{0}C)			Total rainfall (mm)	Average RH (%)	Total Sun shine hours
		Maximum	Minimum	Mean			
2017	October	34.8	18.0	77	227	80	34.8
	November	32.3	16.3	69	0	65	32.3
	December	29.0	13.0	79	0	68	29.0
2018	January	28.1	11.1	72	1	66	28.1
	February	33.9	12.2	55	1	66	33.9
	March	34.6	16.5	67	45	68	34.6
	April	35.7	17.8	68	65	67	35.1

Source: Meterological Centre, Agargaon, Dhaka (Climate Division)

AppendixIII:The morphological,physical andchemical characteristics of soil of the experimental site as observed prior ti experimentation (0-15cm deapth)

A.Morphological Characteristics

Morphological features	Characteristics
Location	Agronomy Field, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis:Physical

Constituents	Percent
Sand	**26**
Silt	**45**
Clay	**29**
Textural class	**Silty clay**

C.Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Magnesium	1.00 meq/100 g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Boron	3.32 µg/g soil
Potassium	0.30 µg/g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix V. Mean square values for plant height of tomato

Source of variation	Degrees of freedom	Mean square values for plant height at				
		30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Replication	2	1.1191	8.183	18.982	6.331	3.119
Variety	7	30.9237	150.342	177.185	140.094	104.665
Error	14	2.5894	7.122	4.095	4.318	4.421
CV (%)		6.53	2.05	4.56	3.91	2.98

Appendix VI. Mean square values for leaves plant^{-1} of tomato

Source of variation	Degrees of freedom	Mean square values for leaves plant^{-1} at				
		30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Replication	2	0.2915	1.9732	8.4291	3.7443	1.954
Variety	7	41.2782	28.2377	52.2842	59.4268	117.094
Error	14	2.7547	2.1561	2.6228	2.9376	3.402
CV (%)		5.98	5.16	7.54	4.05	3.53

Appendix VII. Mean square values for branch plant^{-1} of tomato

Source of variation	Degrees of freedom	Mean square values for branch plant^{-1} at				
		30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Replication	2	0.00230	0.07675	0.15807	0.13785	0.35270
Variety	7	0.90868	0.86512	0.74967	3.22536	2.42407
Error	14	0.00712	0.03314	0.04492	0.06525	0.15315
CV (%)		3.31	4.42	3.02	3.55	3.32

Appendix VIII. Mean square values for Leaf area index and cluster no. plant^{-1} of tomato

Source of variation	Degrees of freedom	Mean square values					
		Leaf Area Index			Cluster no. plant^{-1}		
		60DAT	75DAT	90DAT	60DAT	75DAT	90DAT
Replication	2	6.87	17.28	8.0	0.0754	0.0795	0.8221
Treatment	7	7496.38	7340.19	14784.7	16.2318	21.4547	50.7594
Error	14	13.91	7.54	5.2	0.0154	0.0546	0.1985
CV (%)		2.26	1.29	0.83	2.26	2.62	3.08

Appendix IX. Mean square values for no. of fruit and weight of fruit of tomato

Source of variation	Degrees of freedom	Mean square values					
		No. of fruit			Weight of fruit		
		60DAT	75DAT	90DAT	1st harvest	2nd harvest	3rd harvest
Replication	2	0.712	11.676	1.22	0.00543	0.00111	0.00100
Treatment	7	122.137	535.017	3307.42	1.03049	2.62512	0.87006
Error	14	0.301	1.313	10.92	0.00545	0.01717	0.00775
CV (%)		2.55	2.61	3.34	4.23	3.67	3.52

Appendix X. Mean square values for chlorophyll content, percentage of TSS, Vitamin C content and yield of tomato plant

Source of variation	Degrees of freedom	Mean square values			
		Chlorophyll content (%)	% of TSS	Vitamin C content	Yield
Replication	2	1.2085	0.19792	47.540	4.59
Treatment	7	46.6986	1.23238	311.039	1530.26
Error	14	3.8741	0.01649	0.554	7.80
CV (%)		3.93	1.90	0.76	3.52

Plate 1.Photograph showing growing of seedling

Plate 2.Photograph showing field visiting by supervisor and treatment of different factors

Plate 3.Photograph showing transplanting of seedlings

Plate 4.Photograph showing experimental field

Plate 5.Photograph showing working in laboratory with supervisor