GROWTH, YIELD AND NUTRIENT CONTENT OF TOMATO AS INFLUENCED BY DIFFERENT GROWTH HORMONES

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JUNE, 2017

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A Thesis
Submitted to the Department of Agricultural Chemistry
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE
IN
AGRICULTURAL CHEMISTRY

SEMESTER: JANUARY-JUNE, 2017

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CERTIFICATE

This is to certify that the thesis entitled **"GROWTH, YIELD AND NUTRIENT CONTENT OF TOMATO AS INFLUENCED BY DIFFERENT GROWTH HORMONES"** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (M.S.)*** *in* ***AGRICULTURAL CHEMISTRY****, embodies the results of a piece of bona fide research work carried out by* **SHAMIMA ARA SHORNA**, *Registration no.* **11-04292** *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**:**

Place: Dhaka, Bangladesh

Prof. Dr. Md. Abdur Razzaque
Supervisor

Dedicated to my

Beloved Parents

&

Teacher

ACKNOLEDGEMENT

All the praises, gratitude and thanks are due to the omniscient, omnipresent and omnipotent Allah who enabled me to pursue education in Agriculture discipline and to complete this thesis for the degree of Master of Science (M.S.) in Agricultural Chemistry.

I wish to express my sincere appreciation, profound gratitude and best regards to my supervisor, **Prof. Dr. Md. Abdur Razzaque**, Dept. of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, for his guidance and supervision in carrying out the research work, continuous inspiration, constructive comments and encouragement during my research work and guidance in preparation of manuscript of the thesis. I am grateful to my co-supervisor **Dr. Jasim Uddain**, Associate Professor, Dept. of Horticulture, Sher-e-Bangla Agricultural University, Dhaka Bangladesh, for his valuable advice, constructive criticism and factual comments in upgrading the research with all possible help during the research period and preparation of the thesis.

I would like to show my gratitude and honour to all teachers and staff, the Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Dhaka for their co-operation and encouragement during the study period.

I am indebted and like to express my profound and grateful gratitude to my beloved parents, classmates and friends for their blessings, encouragement and inspiration.

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ABSTRACT

A field experiment was carried out at Horticulture field, Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2016 to February, 2017 to study the growth, yield and nutrient content of *tomato* with different levels of auxin and gibberellic acid. The experiment consisted of two factors as four auxin level viz., Control (A_0**)**, 20 ppm (A_1), 40 ppm (A_2), 60 ppm (A_3) and three gibberellic acid level viz., Control (G_0**)**, 30 ppm (G_1), 50 ppm (G_2). The experiment was laid out in Randomized Complete Block design (RCBD) with three replications. Experimental results showed that auxin had significant effect on growth, yield and nutrient content parameters except niacin content. The highest yield (4.35 kg $plant^{-1}$) was obtained from the 40 ppm auxin level and the lowest (2.67 kg $plant^{-1}$) was from control level. The 40 ppm auxin level also produced maximum content of Potassium (2.63%), Phosphorous (1.11%) and Iron (306 ppm); 20 ppm produced Calcium (1.45%) and Magnesium (0.88%) maximum. Gibberellic acid also significantly influenced all the growth, yield and nutrient content parameters of tomato. The results revealed that 50 ppm gibberellic acid produced the highest yield (4.01 kg $plant^{-1}$) and lowest (3.338 kg $plant^{-1}$) was from control that was significantly similar with 30 ppm gibberellic acid level. Maximum Niacin (2.85%), Phosphorous (1.09%) and Iron (290.60 ppm) also produced by 50 ppm gibbelrellic acid, maximum Calcium (1.70%) and Magnesium (1.03%) from 30 ppm level and control produced the maximum Potassium (2.54%) content. In case of interaction effect of auxin and gibberellic acid, the highest yield (4.95 kg $plant^{-1}$) was observed in 40 ppm auxin + 50 ppm gibberellic acid level. The maximum number of fruit per plant (44.15) was also obtained from 40 ppm auxin + 50 ppm gibberellic acid level. Maximum Calcium (2.24 %) and Magnesium (1.35 %) content was found from 20 ppm auxin + 30 ppm gibberellic acid level. 60 ppm auxin + control gibberellic acid produced the highest Potassium (3.66 %) content. 20 ppm auxin + control gibberellic acid and 20 ppm auxin + 50 ppm gibberellic acid produced the maximum Niacin (3.34 %) and Iron (414.7 ppm) content. The maximum phosphorous (1.2 %) content was found 60 ppm auxin + 30 ppm gibberellic acid level.

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CHAPTER 1

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) belongs to family Solanaceae having chromosome number (2n=24). It is a self pollinated crop and Peru-Ecuador region is considered to be the centre of origin but cultivated tomato originated in Mexico (Kallo, 1986).Tomato was introduced by the Portuguese. Tomato is cultivated in tropics and subtropics of the world. It ranks next to potato and sweet potato in the world vegetable production and top the list of canned vegetable (Choudhury, 2015). It is an important source of vitamins and an important cash crop for small holders and medium scale commercial farmers. It is one of the most popular salad vegetables and is taken with great relish. Tomato adds flavour to the foods and it is also rich in medicinal value (Uddain *et al*., 2009). Tomato has a significant role in human nutrition because of its rich source of lycopene, minerals and ß-carotene which are anti-oxidants and promote good health. Tomato is highly nutritious as it contains 94.1% water, 23 calories energy, 1.90 gm protein, 1 gm calcium, 7 mg magnesium, 1000 IU vitamin A, 31 mg vitamin C, 0.09 mg thiamin, 0.03 mg riboflavin, 0.8 mg niacin per 100 g edible portion (*Rashid, 1999).* Tomato is cultivated generally in winter season. In Bangladesh, the recent statistics shows that tomato was grown in 58,854 acres of land and the total production was approximately 1,90,213 metric tons during the year 2010-2011 and the average yield of tomato was 28,55kg/acre (BBS, 2012). The yield of tomato in our country is not satisfactory in comparison to its requirement (Aditya *et al*., 1999).

Auxin helps in vegetative growth of the plant. Its play a pivotal role in root development, branching, flower initiation, fruiting, lycopene development, synchronization and early maturation, parthenocarpic fruit development, ripening, acidity, seed production etc. Application of substances closely related to auxins onto the stigmas of tomato and several other species causes the ovary to develop into a parthenocarpic fruit (Jong *et al.* 2009). The application of pollen extracts to the outside of the ovary showed similar results, which led to the hypothesis that pollen grains contain plant hormones similar to the growth substance auxin. After pollination, the pollen may transfer a sufficient quantity of these hormones to the ovary to trigger fruit growth (Jong *et al.* 2009). The use of auxin improves the production of tomato in respect of better growth and quality which ultimately led to generate interest the farmers for commercial application of auxin.

Gibbrelliic acid is one kind of plant growth regulator that responsible for growth and development of plant. Chemically speaking, gibberellins are actually acids. They are produced in the plant cell's plastids, or the double membrane-bound organelles responsible for making food, and are eventually transferred to the endoplasmic reticulum of the cell, where they are modified and prepared for use (Prmanik *et al*., 2017). It is most widely available plant growth regulator which induces stem and internodes elongation, seed germination, enzyme production during germination and fruit setting and growth (Davies, *1995*). Gibberellic acid is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant *(*Rafeekher *et al. 2002)*. Gibberellic acid has a positive effect on seed germination, earliness, number of leaves, leaf area, number of branches, plant height, number of flowers, cluster fruit setting, number of fruits cluster, fresh fruit weight, reducing pre-harvest fruit drop, increasing fruit yield and dry matter in tomato plant.

Over the years, it has been well established that tomato fruit set depends on successful pollination and fertilization, which trigger the fruit developmental programme through the activation of the auxin and gibberellic acid. However, the exact role of each of these two hormones is still poorly understood. The present study was therefore carried out to study the growth and yield of tomato by spraying different level of auxin and gibbrellic acid with the following objectives:

i. To find out the optimum level of auxin on growth, yield and nutrient content of tomato.
ii. To determine the optimum level of gibberellic acid on growth, yield and nutrient content of tomato.
iii. To find out the sustainable combination of auxin and gibberellic acid for maximum growth, yield and nutrient content of tomato.

CHAPTER 2
REVIEW OF LITERATURE

2.1 Effect of Auxin on growth, yield and nutrient content of tomato

Alam and Khan (2002) reported that spray of synthetic auxin (NAA) at variable concentration significantly increased the fruits yield and nutrient contents of fruits of tomato as compared to control.

Ali *et al.* (2012) reported that auxin produces highest number of branches per plant, number of flower per plant and yield in tomato. Application of synthetic auxin increases the yield in tomato due to enhanced plant growth and faster rate of plant development by the action of synthetic auxin in cell elongation and there by increased cell enlargement, cell division and differentiation which in turn result into increase in number of flowers, fruit set, size and weight of fruit as reported by Rodrigues *et al.* (2001), Kishan *et al.* (2001), Rai *et al.* (2002), Nibhavanti *et al.* (2004), Singh and Sant (2005) and Bokade (2006).

Anwar (2010) indicated that application of 2, 4-D at 5 mg l-1 significantly improved growth attributes and fruit yield of tomato plant but those attributes decreased beyond this concentration.

Application of Auxin as foliar sprays or to the by moderately high rainfall during Kharif (April growing media of tomato plants had a stimulatory effect September) season and low temperature (15°-20°C) in on plant growth and development (Hathout *et al.* 1993).

Arvind (2012) reported that combination of variety "NBH NO-1" and 15 ppm NAA was found best in respect increasing productivity of tomato crop.

Chhonkar and Singh (1959) recorded increasing yield of tomato by seedling treatment with growth substances. They reported that high concentration of auxin increases yield through increased flower induction and fruit set. High concentration of auxin reduced plant height.

Chhonkar and Ghufran (1968) reported that plant height decreased with the increased concentration of synthetic auxin concentration.

Gupta *et al.* (2001) recorded significantly maximum plant height at 75 DAT and maximum number of branches at 60 with 75 ppm synthetic auxin alone with 2000 ppm synthetic auxin as compared to control.

Gupta *et al.* (2003) found highest yield with application of auxin + Multiplex micronutrient mixture at the maturity stage. Largest fruit size, most attractive ripe fruit color, highest dry matter and ash content with application of IAA + Multiplex micronutrient mixture at the maturity stage. Synthetic auxin application in tomato increased total soluble solid percentage significantly (Pudir and Yadav, 2001).

Singh *et al.* (2011) revealed application synthetic auxin have positive effect on yield of three tomato cultivars viz., NUN-1560 (V1), NUN-964 (V2) and NUN-963 (V3).

Habbasha *et al.* (1999) found that application of auxin increased fruit set percentage and total fruit yield compared to control and reduces the percentage of puffy and parthanocarpic fruit.

Hathout *et al.* (1993) found that application of 10 ppm auxin 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, auxin 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 auxms, cytokines and gibberellins.

Auxin is required for fruit growth and development and delays fruit senescence and plays also a minor role in the initiation of flowering and development of reproductive organs (Asahira *et al.* 1967).
Patel *et al.* (2012) revealed that application auxin increases the fruit diameter in tomato.

Karim *et al.* (2015) observed that 4-chlorophenoxy acetic acid (4-CPA) had a significant influence on growth and yield of tomato var. BARI Hybrid Tomato-8.

Kaushik *et al.* (1974) reported that 10 ppm of auxin increased the number and weight of fruits per plant significantly.

Khaled *et al.* (2015) reported that Plant height, number of leaves, number of branches, days required for 50% flowering, days required for fruit setting, fruit cluster plant^{-1}, fruit plant^{-1}, weight tomato^{-1}, yield plant-^{1}, yield plot^{-1} and yield hectare^{-1}were significant influenced by the combined application of auxin in BARI tomato 7, Manik and Ratan varieties of tomato.

Kishan *et al.* (2001) recorded maximum number of primary branches in the treatment synthetic auxin 25 ppm. While the lowest number of primary branches was recorded in the treatment boron 50 ppm. Number of primary branches was not influenced by the growth regulatory substances.

Mehrotra *et al.* (1971) reported that quality of fruit was improved with the application of synthetic auxin 25 ppm, had a little effects on plant height but there was no effect on number of branches when tomato seedling where treated for 30 minutes before transplanting. It was also reported that quality of fruit was improved with the application of synthetic auxin 25 ppm.

Auxin is required for fruit growth and development and delays fruit senescence and plays also a minor role in the initiation of flowering and development of reproductive organs (Asahira *et al.* 1967).

Mukharji and Roy (1966) found that application of auxin had protected the flower and premature fruit drop and increased length of size fruit in tomato plant.

Pandita *et al.* (1978) found higher fruit acidity in tomato plant treated with synthetic auxin 100 ppm as foliar spray at appearances of first flowering. The highest vitamin C content was in fruit from the plant treated with synthetic auxin 50 ppm. The beneficial effect of synthetic auxin at 100 ppm on fruit T.S.S. was also observed.

Pandolfini *et al. (*2002) indicated that synthetic auxin like 2, 4-D has herbicidal or ephinastic effect which lead to flower bud abscission, poor fruit set, fruit defects and puffiness beyond certain concentrations. Patel *et al.* (2012) revealed that application 2, 4-D increases the plant height and number of branches, fruit diameter, yield, acidity and TSS in tomato.

Pramanik *et al.* (2017) reported that application of 10 ppm IAA, 50 ppm PCPA, 20 ppm NAA or 5ppm 2, 4-D as foliar sprays had a stimulatory effect on plant growth, flowering and, fruit setting, yield and quality of fruit which was accompanied by increases in endogenous auxin, gibberellins and cytokinin contents in tomato plant. So applying of both natural and synthetic auxin helps farmer in cultivating tomato in adverse climatic condition which can give good fruit yield by increasing vegetative and reproductive growth and reducing the flower and fruit drop.

Patil and Mahajan (1971) noted that higher concentration of synthetic auxin 0.4 ppm induced more height in tomato seedling when seedling roots wee dipped for 24 hours prior to transplanting, while the average diameter of branches number and leaves were not affected. Synthetic auxin 0.1 ppm resulted more weight of fruits per plant and NAA 0.05 ppm as seedling root dipping from 24hrs gave higher percent of yield in fruit and second picking.

Perez and Ramirez (1980) carried out an experiment with the application of IAA at 25 and 35 ppm on tomato. They found increased fruit size quality with minimum seeds.

Petronk and Loban (1975) obtained quality of tomato seed by treating the seed with IAA at 100 mg/kg or NAA at 50mg/kg before sowing.

Rai *et al.* (2002) reported that maximum chlorophyll content and acidity were obtained with NAA at 75 ppm along with Humaur at 2000 ppm. NAA at 75 ppm along with Multiplex at 2500 ppm gave the highest sugar content.

Serrani *et al.* (2007) reported that, tomato fruits induced by 2, 4-D had thicker pericarp than pollinated fruits throughout its development, and more in response to 2, 4-D than GA_3.

Singh and Upadhayaya (1967) studied the effect of auxin and synthetic auxin on tomato and reported that the regulators increased the fruit set, size and yield of fruit. The chemicals could be applied on seeds, roots whole plants or flowers, but foliar application was very effective for increasing the size of fruit and the yield.

Singh *et al.* (1981) reported that auxin and synthetic auxin resulted highest yield in tomato. Height of the main stem of the plant varied due to the plant growth regulators treatment.

Singh *et al.* (2005) saw that yield, plant growth and number of branches of tomato positively affected by auxin. Synthesized auxin are often used for promotion of fruit set in some fruit and vegetable production including tomatoes (Batlang, 2008).

Thakur *et al.* (1996) indicated that the ascorbic acid content increased with higher concentrations of 2, 4- D and Para-chlorophenoxy acetic acid. The synthetic auxin 2, 4-D mimics the function of natural auxins which control "a multitude of plant growth and development processes" (Hess, 1993).

Verma *et al.* (2014) revealed that fruit set in tomato was successfully improved by application of NAA.

2.2. Effect of gibberellic acid (GA_3) on growth, yield and nutrient content of tomato

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 and GA_3 at 100 ppm could appreciably increase fruit size. Gibberelic acid plays role on controlling fruit setting, pre-harvest fruit drop and increasing fruit yield. Concentration of 50 and 100 ppm on flower cluster at anthesis and noted that the application of GA_3 at 100 ppm could appreciably increase fruit size, weight, protein sugar and ascorbic acid contents.

Afaf *et al.* (2007) indicated that GA_3 application increased phosphorous accumulation in leaves and stems of tomato plants that was also responsible for required lycopene content in the fruit.

Akash *et al*. (2014) conducted a study with the objective to determine the effects of gibberellic acid (GA_3) on growth, fruit yield and quality of tomato. The experiment consisted of six treatments with five levels of gibberellic acid (GA_3- 10 ppm, 20 ppm, 30 ppm, 40 ppm and 50 ppm). 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.

Bora and selman (1969) working 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 C increased the leaf area, weight and height of tomato plants. The best treatment was 5ppm GA_3 at 22^0C.

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

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

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.

El-Habbasha *et al*. (1999) studied the response of tomato plants to foliar spray with some growth regulator under late summer conditions. Field experiments were carried out with tomato (cv.Castelrock) over two growing seasons (1993-94) at shalakan, Egypt. The effect of GA_3, IAA, TPA (tolyphthalamic acid) and 4-CPA (each at 2 different concentrations) 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 with controls.

GA_3 applications help in improvement in number of fruits per cluster, fruit set, and marketable fruit number per plant and extended maturity time and harvest of tomato, (Gelmesa *et al.* 2012).

Ghulam *and* Ballesteros (2006) reported that the tomato was treated with different concentrations of gibberellic acid (GA_3; at 10-1 M) as foliar spray. The application of growth regulators minimized the detrimental effect of parasite on the host.

Graham (1980) reported that, Gibberellic acid increased proteins, soluble carbohydrates, and ascorbic acid in all the products, starch and β-carotene in the tomato. Gibberellic acid caused extended growth, production of smaller tomatoes and beans, and more disease-susceptible plants.

Graham and Ballesteros (2006) reported that GA_3 increased proteins, soluble carbohydrates, ascorbic acid, starch and β-carotene in the tomato.

Groot *et al*. (1987) reported 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.

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

Gustafson (1960) worked with different concentration of GA_3 and observed 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.

Hasanuzzaman *et al.* (2015) revealed that application of GA_3 @ 125 ppm showed an increased fruit, number of flowers, fruit clusters, and fruits per plant, length and diameter of fruit, yield per plant, yield per plot and yield per hectare.

Hossain (1974) investigated the effect of gibberellic acid (GA_3) along with parachlorophenoxy acetic acid (4-CPA) on the production of tomato. He found that GA_3 applied at 50, 100 and 200 ppm produced an increased fruit production. However, GA_3 treatment induced a small size fruit production. A gradual increase in the yield per plant was obtained with higher concentration of GA_3.

Jansen (1970) reported that tomato plants treated with GA_3 neither increased the yield nor accelerated fruit ripening. He also mentioned that increasing concentration of GA3 reduced both the number and size of fruits.

Kataoka *et al*. (2003) conducted an experiment on the effect of uniconazole on fruit growth in tomato 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 (5mg/L) and GA_3(5or 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.

Kaushik *et al*. (1974) carried out 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.

Khan *et al.* (2006) indicated the significant role of GA_3 in tomato plant to increase fruit set that leads to larger number of fruits per plant and increased fruit size and final yield. They also observed an increase in leaf phosphorous, nitrogen, and potassium content in addition to increased lycopene content of tomato fruit when treated with GA_3. Even after the end of GA_3 treatment there was a positive effect on petal elongation and inflorescence stalk length both in wild type and pat mutants of tomato plants.

Leonard *et al*. (1983) observed that inflorescence development in tomato plants grown under a low light regime was promoted by GA_3 applied directly on the inflorescence.

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

Masroor *et al.* 2006 reported that foliar application of gibberelic acid significantly increased lycopene content of tomato fruits.

Nibhavanti *et al*. (2006) carried out an experiment on the effect of gibberellic acid, NAA, 4-CPA and boron at 25 or 50ppm on the growth and yield of tomato during the summer season of 2003. Plant height was greatest with gibberellic acid at 25 or 50ppm (74.21cm and 75. 33 cm, respectively) and 4-CPA at 50ppm (72.22 cm). Gibberellic acid at 50ppm resulted in the lowest number of primary branches per plant.

Onofeghara (1983) conducted an experiment on tomato sprayed with GA_3 at 20-1000 ppm and NAA at 25-50 ppm. He observed that GA_3 promoted flower primordia production and the number of primordia and NAA promoted flowering and fruiting.

Pramanik *et al*. (2017) reported application of GA_3 @ 50 ppm and 100 ppm have positive effect on seed germination, earliness, number of leaves, leaf area, number of branches, plant height, number of flowers, cluster fruit setting, number of fruits cluster, fresh fruit weight reducing pre-harvest fruit drop, increasing fruit yield, ascorbic acid TSS and dry matter in tomato plant. So spraying of gibberelic acid helps farmer in cultivating tomato in adverse climatic condition which can give good fruit yield by increasing vegetative and reproductive growth and reducing the flower and fruit drop.

Rai *et al*. (2006) conducted an experiment during the 2003 winter season in Meghalaya, India on tomato to study the effect plant growth regulators on yield. The treatments comprised 25 and 50 mg GA_3/ litre; water spray. Data were recorded for growth, flowering and fruiting characteristics, GA_3 significantly reduced the number of seeds per fruit but increased plant height and number of branches per plant.

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

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

Sawhney and Greyson (1972) reported that application of GA_3 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.

Shittu and Adeleke (1999) and Sanyal *et al.* (1995) reported Gibberellin induces cell division, cell elongation, cell enlargement and ultimately leads to significantly increases the fruit length, girth and pulp-seed ratio. Plant height and number of leaves were significantly enhanced by GA_3 treatment. Plants treated with GA_3 with 250ppm were the tallest plant and highest number of leaves.

Thakur *et al*. (1996) indicated that acidity of tomato fruits was reduced when the whole plant was sprayed with GA_3 and 2,4-D.

Tomar and Ramgiry (1997) found that plants treated with GA_3 showed significantly greater plant height, number of branches/plant, number of fruits/plant and yield than untreated controls. GA_3 treatment at the seedling stage offered valuable scope for obtaining higher commercial tomato yields.

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

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the Horticulture field Laboratory, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October, 2016 to February, 2017.

3.1 Site Description

3.1.1 Geographical Location

The experimental area was situated at 23°77′N latitude and 90°33′E longitude at an altitude of 8.2 meter above the sea level.

3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Climate

The area has sub tropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Appendix II.

3.1.4 Soil

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.1-6.5 and had organic matter 1.29%. The experimental area was flat having available irrigation and drainage system and above flood level.

3.2 Details of the Experiment

3.2.1 Treatments

Two sets of treatments included in the experiment were as follows:

(A) Auxin level: 4

i. A_0 = Control
ii. A_1 = 20 ppm
iii. A_2 = 40 ppm
iv. A_3 = 60 ppm

(B) Gibberellic acid level: 3

i. G_0 = Control
ii. G_1 = 30 ppm
iii. G_2 = 50 ppm

3.2.2 Experimental Design

The experiment was laid out in a Randomized Control Block Design (RCBD) with three replications having two factor. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 2 m X 2 m (4 m^2). The distances between each plots were .50 m and replications were 1 m.

3.3 Crop/Planting Material

BARI tomato 7 (Apurba) was used as plant material.

3.3.1 Description of Variety

BARI tomato 7 is a tomato variety, released in 1998, suitable for cultivation winter season. It is very rich in beta carotene and tolerant to bacteria wilt disease. Crop duration is 100-110 days. Fruit colour deep yellow to orange, fruit round, slight flat and very fleshy. Average fruit weight 145-155 gm. Fruit set per plant 30-32. Yield 100-105 t/ha.

3.4 Crop Management

3.4.1 Seedling Raising

3.4.1.1 Seed Collection

Seeds of BARI tomato 7 were collected from Genetic Resource and Seed Division, BARI, Joydebpur, Gazipur, Bangladesh.

3.4.1.2 Preparation of Seedling Nursery

Tomato seedlings were raised in a seedbed of 2 m x l m size. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed and 5 kg well rotten cowdung was mixed with the soil. The seeds were sown in the seedbeds in October 29, 2016. Seven gram of seeds was sowed on seedbed. After sowing, edges were covered with light soil. Sevin-85 SP was applied around the seedbed as precautionary measure against ants, worm and other harmful insects. The emergence of the seedlings took place within 5 days. Shading by polythene with bamboo structure was provided over the seedbed to protect the young seedlings from the scorching sunshine. Dithane M-45 @ 2 g L^{-1} was sprayed in the seedbeds, to protect the seedlings from damping off and other diseases. Weeding and irrigation were done whenever necessary.

3.4.2 Preparation of Experimental Land

The experimental field was first ploughed on November 15, 2016 with the help of a tractor, later on November 22, 2016 the land was prepared by three successive ploughings and cross ploughings with a tractor drawn plough and subsequently leveled by laddering. All weeds and other plant residues of previous crop were removed from the field. Manure and fertilizers were applied as per recommendation of Bangladesh Agricultural Research Institute (BARI). Cowdung @ 15 t ha^{-1}, TSP @ 250 kg ha^{-1} and MoP @ 150 kg ha^{-1} were applied during final land preparation. Immediately after final land preparation, the field layout was made on November 23, 2016 according to experimental specification. Furadan 10 G (an insecticide) was also applied during final land preparation to control soil insects. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.4.3 Uprooting and transplanting of seedlings

25 days old seedlings were uprooted from the seedbed and transplanted on November 24, 2016. The seedbed was watered before uprooting the seedlings in order to minimize damage of the root system. The seedlings were watered just after transplanting. Shading was provided for four days to protect the seedling from the hot sun.

3.4.4 Intercultural operations

3.4.4.1 Weeding

Weeding was accomplished as and when necessary with the help of *khurpi* to keep the crop free from weeds, for better soil aeration and to break the crust. It also helped in soil moisture conservation.

3.4.4.2 Irrigation

Irrigation was provided immediately after transplanting the seedlings and it was continued until the seedlings were established in the plot. After that rrigation was provided twice in a week in general but sometimes the plants demanded, irrigation is done as and when necessary.

3.4.4.3 Stalking

As tomato is a herbaceous plant with higher fruit weight it was needed a high level of support at its growth and developmental stages. So, after the well establishment of the plants, staking was done to each plant by means of bamboo sticks to keep them upright.

3.4.5 Plant protection

Furadan 10 G an insecticide @ 0.5 gm/liter was applied for control cut worm and other soil insects. Aktara was applied @ 0.5 gm/liter for control Aphid as well as virus infection every 7 days interval for three weeks. White fly infested the crop at early reproductive stage, which was controlled by means of spraying with Admire 200 SL @ 0.5 ml L^{-1} of water at 7 days interval for 2 weeks.

3.5 Preparation and application of hormones

3.5.1 Preparation of Auxin

I. For 20 ppm solution, auxin was prepared by dissolving 20 mg of it with distilled water then distilled water was added to make the volume 1 litre 20 ppm solution.
II. For 40 ppm solution, auxin was prepared by dissolving 40 mg of it with distilled water then distilled water was added to make the volume 1 litre 40 ppm solution.
III. For 60 ppm solution, auxin was prepared by dissolving 60 mg of it with distilled water then distilled water was added to make the volume 1 litre 60 ppm solution.

3.5.2 Preparation of Gibberellic acid

I. For 30 ppm solution, **Gibberellic acid** was prepared by dissolving 30 mg of it with distilled water then distilled water was added to make the volume 1 litre 30 ppm solution.
II. For 50 ppm solution, **Gibberellic acid** was prepared by dissolving 50 mg of it with distilled water then distilled water was added to make the volume 1 litre 50 ppm solution.

Auxin and gibberellic acid was sprayed two times. The 1st dose was applied at 20 days after transplanting (DAT) and 2nd at 45DAT.

3.6 Harvesting

Tomatoes were harvested early in the morning when the fruits were developed red colors (breakers). Always avoided full sunny and hot weather and soon after
harvesting fruits were stored at room temperature. A fruit harvested at the red ripe stage will be subjected to more bruising without enhancing quality. Fruit were harvested at 3 days intervals during early ripe stage.

3.7 Data collection

Five plants were allotted for each treatment in each plot for each replication. Data was collected from each sample plant and mean value was calculated.

The following data were recorded.

i. Plant height
ii. Number of leaves plant^{-1}
iii. Number of branches plant^{-1}
iv. Days to first flower
v. Days to first Harvest
vi. Total number of Flower plant^{-1}
vii. Total number of fruits plant^{-1}
viii. Fruit yield plant^{-1}
ix. Fruit yield plot^{-1}
x. Fruit yield hectare^{-1}
xi. Nutrient content of fruit

3.7.1 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 at 60, 75, 90 and 105 days after sowing to observe the growth rate.

3.7.2 Leaves plant^{-1}

Number of leaves was counted from the sample plants and means value was calculated. Number of leaves was recorded 60, 75, 90 and 105 days after sowing to observe the growth rate.

$$\text{Leaf plant}^{-1} = \frac{\text{Total number of leafs from five sample plants}}{5}$$

3.7.3 Number of branches plant^{-1}

Total number of branches was counted from all sample plants and mean was calculated by the following formula:

$$\text{Branches plant}^{-1} = \frac{\text{Total number of branches from five sample plants}}{5}$$

3.7.4 Days to first flower

The date of first flower appearance of the sample plants was recorded, and the mean value of the period required in days from the date of sowing was calculated.

3.7.5 Days to first Harvest

The date of first harvest of tomato of the sample plants was recorded, and the mean value of the period required in days from the date of sowing was calculated.

3.7.6 Total number of Flower plant^{-1}

Total number of flower was counted from all sample plants and mean was calculated by the following formula:

$$\text{Flower plant}^{-1} = \frac{\text{Total number of flowers from five sample plants}}{5}$$

3.7.7 Total number of Fruits plant^{-1}

It was recorded by the following formula:

$$\text{Fruits plant}^{-1} = \frac{\text{Total number of fruits from five sample plants}}{5}$$

3.7.8 Fruit yield plant^{-1}

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 and means value was calculated.

3.7.9 Fruit yield plot^{-1}

There was 20 plant in each plot. Fruit per plant was multiply with 20 and values are analyzed.

3.7.10 Fruit yield hectare^{-1}

The size of per plot was four meter square. Plot yield was converted to 10000 meter square and analyzed.

3.7.11 Nutrient content of fruit

Fruit sample were analyzed for nutrient content in the laboratory of BARI, joydebpur, Bangladesh. The nutrient content studied included Calcium (Ca), Magnesium (Mg), Potassium (K), Niacin (N), Phosphorous (P) and Iron (Fe). The nutrient content was analyzed following standard methods.

3.7.12 Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique using MSTAT-C package and the mean difference were adjusted by LSD. (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

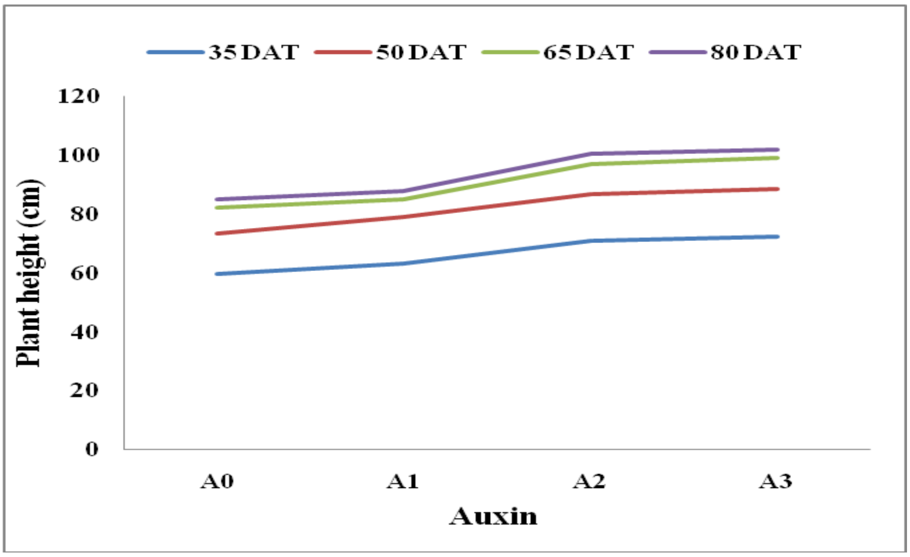
Results obtained from the present study regarding the effects of Auxin, Gibberellic acid and their interactions on the growth and yield components of tomato and have been presented, discussed and compared in this chapter. The analytical results have been presented in Table 1 to 9, Figure 1 to 12 and Appendix III to VIII.

4.1 Crop growth parameters

4.1.1 Plant height

i. Effect of auxin

The plant height of tomato was significantly influenced by different auxin level at 35, 50, 65 and 80 days after transplanting (DAT) (Appendix III and Figure 1). The result revealed that at 35, 50, 65 and 80 DAT, 60 ppm auxin produced the tallest plant (72.53, 88.72, 99.04 and 102.10 cm respectively). The lowest plant height was observed in control level of auxin at 35, 50, 65 and 80 DAT (59.70, 73.49, 82.15 and 85.09 cm respectively). In the initial stage of growth, the increase of plant height was very slow and then the crop remained in vegetative stage. The rapid increase of plant



A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin

Figure 1. Effect of auxin on plant height (cm) at different growth stages of BARI tomato 7 ($LSD_{0.05}$ = 35, 50, 65 and 80 DAT 0.13, 0.33, 0.21 and 0.41 respectively)

height was observed from 50 to 65 DAT. After reaching the maximum vegetative stage, the growth of plant became very slow. Similar result was found Gupta *et al.*, (2001). They mentioned maximum plant height of tomato is increase with the increase of of auxin level as compared to control. General increase in plant height is maximized with application of auxin compared to control (Rastogi *et al*., 2013).

ii. Effect of Gibberellic acid

Significant variation of plant height was found due to different Gibberellic acid level in all the studied durations (Appendix III and Figure 2). It is observed that high

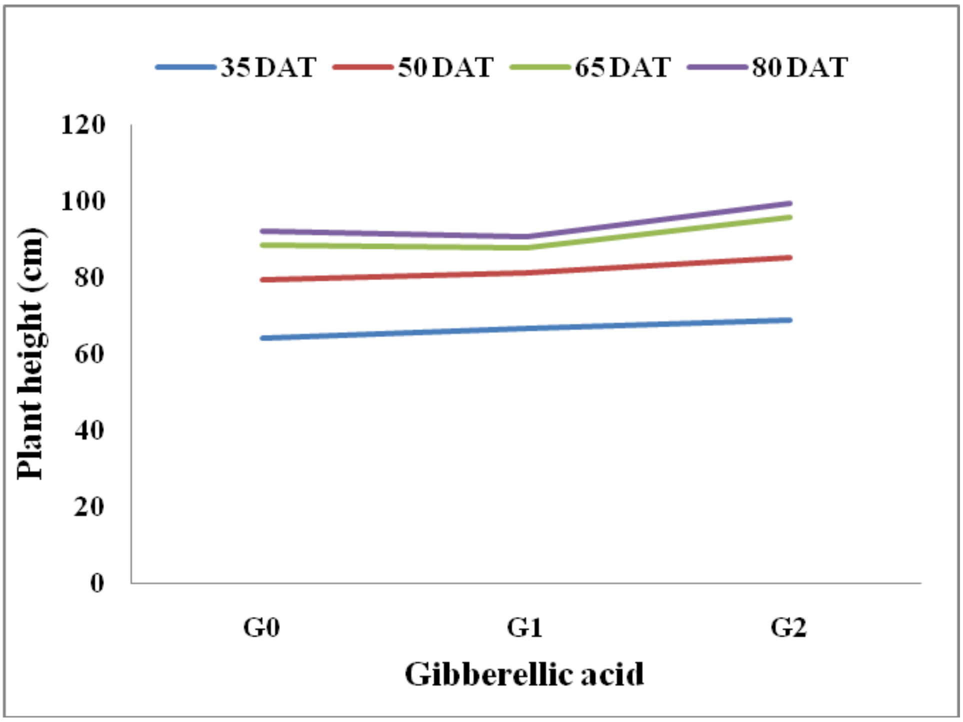


Figure 2. Effect of gibberellic acid on plant height (cm) at different growth stages of BARI tomato 7 ($LSD_{0.05}$ = 35, 50, 65 and 80 DAT 0.12, 0.28, 0.17 and 0.36 respectively)

concentration of gibberelic acid increase the height of tomato plant. At 35, 50, 65 and 80 DAT, 50 ppm Gibberellic acid produced the tallest plant (69.07, 85.13, 95.76 and 99.53 cm respectively) and no Gibberellic acid level (control) produces the shorter plant of tomato (64.32, 79.63, 88.74 and 92.00 cm respectively). Increase in height is perhaps the most widely observed effect of gibberellic acid on plants. Gibbrelic acid produces longer internodes. The increased length of an internode has been variously ascribed to increases in numbers of cells, increases in length of cells and to both.

Table 1. Interaction effect of auxin and gibberelic acid on plant height (cm) at different growth stages of BARI tomato 7

Treatments	Plant height (cm) at different days after transplanting			
	35	50	65	80
A_0G_0	58.97 k	72.15 j	80.48 i	83.42 j
A_0G_1	60.17 j	72.15 j	79.40 j	81.42 k
A_0G_2	59.97 j	76.15 i	86.48 h	90.42 h
A_1G_0	62.97 h	77.30 h	86.38 h	89.32 i
A_1G_1	62.37 i	79.30 g	78.48 k	81.42 k
A_1G_2	64.97 g	80.90 f	90.48 g	93.42 g
A_2G_0	67.17 f	84.30 e	93.04 f	97.14 f
A_2G_1	71.17 d	86.30 d	96.54 d	99.14 d
A_2G_2	75.17 b	90.30 b	101.00 b	106.1 b
A_3G_0	68.17 e	84.75 e	95.04 e	98.14 e
A_3G_1	73.27 c	88.25 c	97.04 c	100.10 c
A_3G_2	76.17 a	93.15 a	105.00 a	108.10 a
LSD $_{(0.05)}$	0.23	0.57	0.35	0.71
CV (%)	2.1	4.1	3.2	4.5

A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin, G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

Stowe and Yamaki, (1957) reviewing earlier (especially Japanese) work, conclude that "cell elongation in most cases seems to predominate as the result of gibberellin application." The present finding also agreed to the result of (Rai *et al*., 2006) and (Nibhavanti *et al*., 2006). They observed that GA3 increased plant height at 25 and 50 ppm. Bokode *et al., (*2006) reported the tomato treatment with GA3 50 ppm concentration gave maximum height of plant.

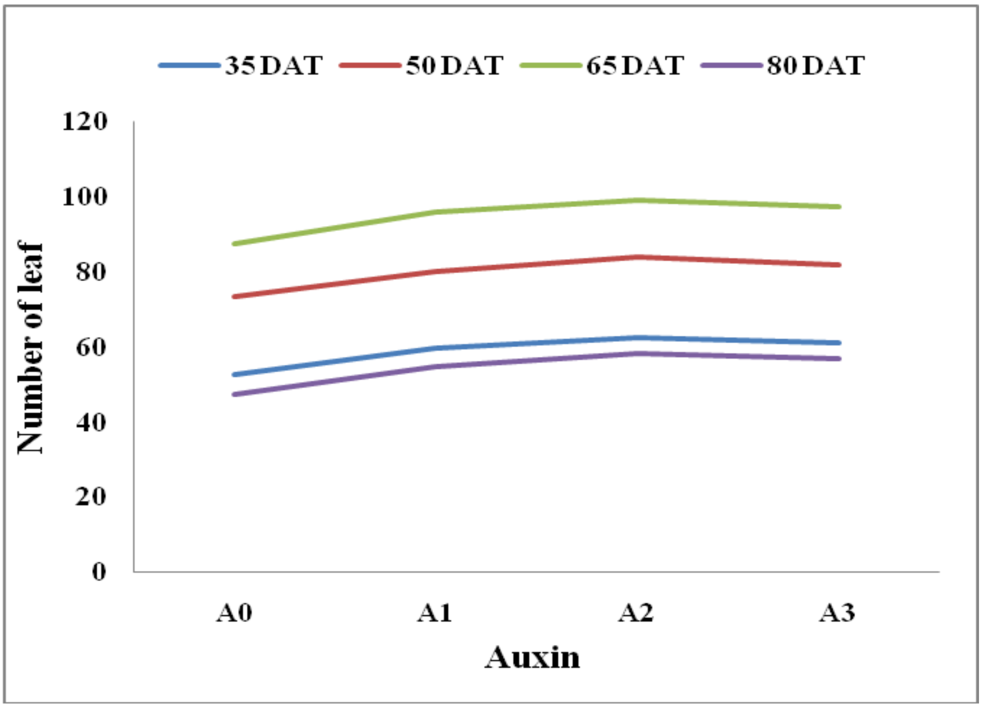
iii. Interaction effect of auxin and gibberelic acid

Significant interaction effect between the auxin and gibberelic acid was observed at 35, 50, 65 and 80 DAT (Appendix III and Table 1). The tallest plant (76.17, 93.15, 105.00 and 108.10 cm respectively) was obtained from 60 ppm auxin + 50 ppm gibbrelic acid at all four different DAT. At 35 and 50 DAT the lowest plant was observed with control auxin + control gibberelic acid (58.97 and 72.15 cm). At 65 and 80 DAT the lowest plant was observed with control auxin + 30 ppm gibberelic acid (79.48 and 81.42 cm). The Holganix blog, (2013) reported that, auxins positively influence gibberlins that promote cell elongation. This increases plant length. Essentially, gibberlins and thereby auxins, increase the distance between nodes, spacing the branch points further apart.

4.1.2 Number of leaf plant^{-1}

i. Effect of auxin

The production of total number of leaf of tomato was significantly influenced by different auxin level at 35, 50, 65 and 80 DAT (Appendix IV and Figure 3). The highest number of leaf was observed in 40 ppm auxin level (62.53, 84.17, 99.18 and 58.30 respectively) and lowest was observed in control auxin (52.53, 73.60, 87.60 and 47.50 respectively). In tomato plant leaf number is increased with the increase of growth duration until 65 DAT. After 65 DAT the leaf number is decreased because of plants produces fruits in that stage. Auxin, though produced in the leaves, is mainly responsible for apical shoot growth and root formation, while leaf expansion and growth is maintained through cytokinins. When high levels of auxin is present in plant leaves that negates and inhibits the effects of cytokinins resulting in leaf expansion inhibition. That’s why 40 ppm auxin produces higher number of leaf compare to 60 ppm auxin.

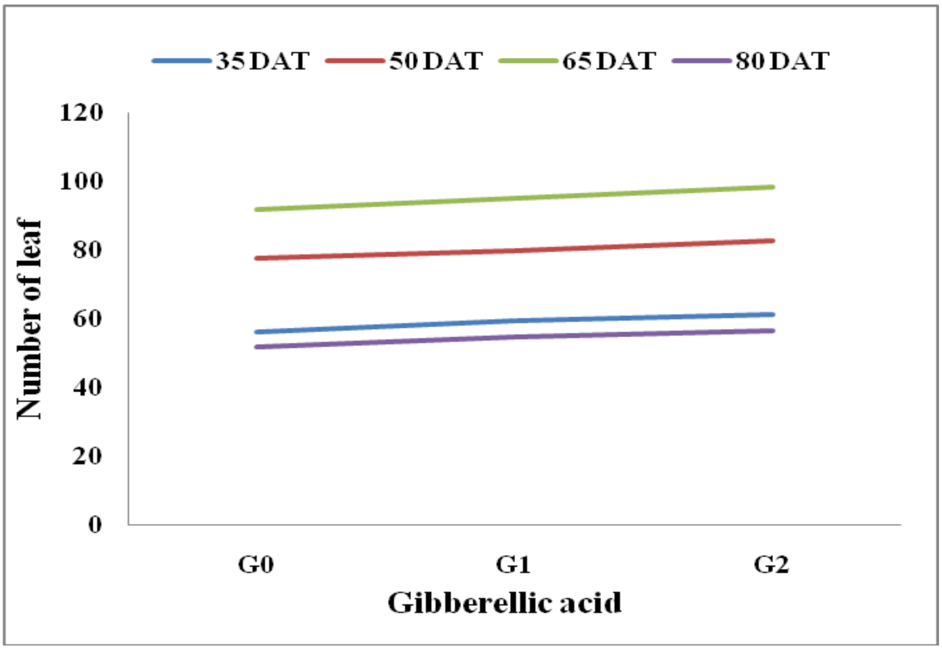


A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin

Figure 3. Effect of auxin on number of leaf at different growth stages of BARI tomato 7 ($LSD_{0.05}$ = 35, 50, 65 and 80 DAT 0.62, 0.48, 0.32 and 0.33 respectively)

ii. Effect of gibberelic acid

The production of total number of leaf plant^{-1} was significantly influenced by different gibberellic acid level at 35, 50, 65 and 80 DAT (Appendix IV and Figure 4). The highest number of leaf plant^{-1} was recorded from 50 ppm gibberellic acid (61.22, 82.78, 98.21 and 56.72 respectively) and lowest was recorded in control level (56.29, 77.51, 91.73 and 51.74 respectively). These results were agreement with the findings of (Rai *et al*., 2006) and (Nibhavanti *et al*., 2006), who reported that GA3 increased the number of leaves per plant at 25 and 50 ppm.



G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

Figure 4. Effect of gibberellic acid on number of leaf at different growth stages of BARI tomato 7 ($LSD_{0.05}$ = 35, 50, 65 and 80 DAT 0.54, 0.42, 0.27 and 0.28 respectively)

iii. Interaction effect of auxin and gibberelic acid

Interaction effect of auxin and gibberellic acid significantly influenced the production of leaf number at 35, 50, 65 and 80 DAT (Appendix IV and Table 2). The highest number of leaf plant $^{-1}$ was obtained from 40 ppm auxin + 50 ppm gibberelic acid at all four different growth stage (64.67, 88.30, 103.30 and 61.10 repectively) and lowest number of leaf plant $^{-1}$ was found from control auxin + control gibberelic acid (45.87, 68.27, 79.60 and 40.83 respectively). This result is supported by Wang and Irving, (2011). They showed interaction of auxin and gibberelic acid increase production of leaf by increasing the regulation of cell expansion and tissue differentiation of plant.

Table 2. Interaction effect of auxin and gibberelic acid on number of leaf at different growth stages of BARI tomato 7

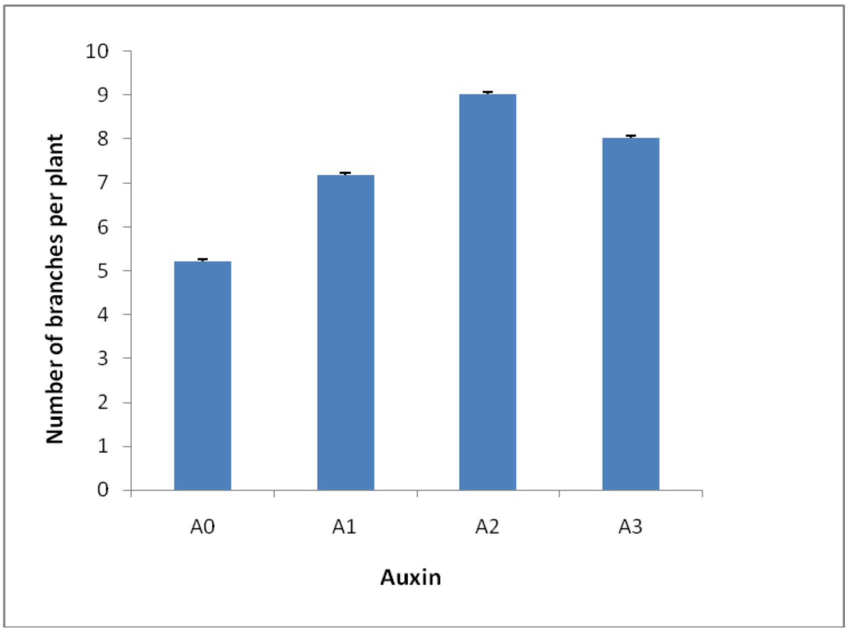
Treatments	Number of leaf at different days after transplanting			
	35	50	65	80
A_0G_0	45.87 h	68.27 j	79.60 i	40.83 i
A_0G_1	54.87 g	75.27 i	90.60 h	49.83 h
A_0G_2	56.87 f	77.27 h	92.60 g	51.83 g
A_1G_0	57.87 f	79.27 g	94.60 f	53.83 f
A_1G_1	60.07 e	80.27 f	95.80 e	55.03 e
A_1G_2	60.87 cde	81.27 de	97.60 c	55.83 d
A_2G_0	61.27 c	81.90 cd	96.91 d	56.70 c
A_2G_1	61.67 bc	82.30 c	97.31 cd	57.10 c
A_2G_2	64.67 a	88.30 a	103.3 a	61.10 a
A_3G_0	60.17 de	80.60 ef	95.81 e	55.60 de
A_3G_1	61.17 cd	81.80 cd	96.81 d	56.60 c
A_3G_2	62.47 b	84.30 b	99.31 b	58.10 b
LSD $_{(0.05)}$	1.07	0.84	0.55	0.57
CV (%)	10.7	6.2	4.3	6.2

A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin, G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

4.1.3 Number of branches plant^{-1}

i. Effect of auxin

Different auxin level significantly influenced the number of branches plant^{-1} of tomato (Appendix V and Figure 5). It was observed that, the highest number of of branches plant^{-1} (9.023) was observed at 40 ppm auxin level and lowest number of of branches plant^{-1} (5.22)



A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin and A_3 = 60 ppm auxin

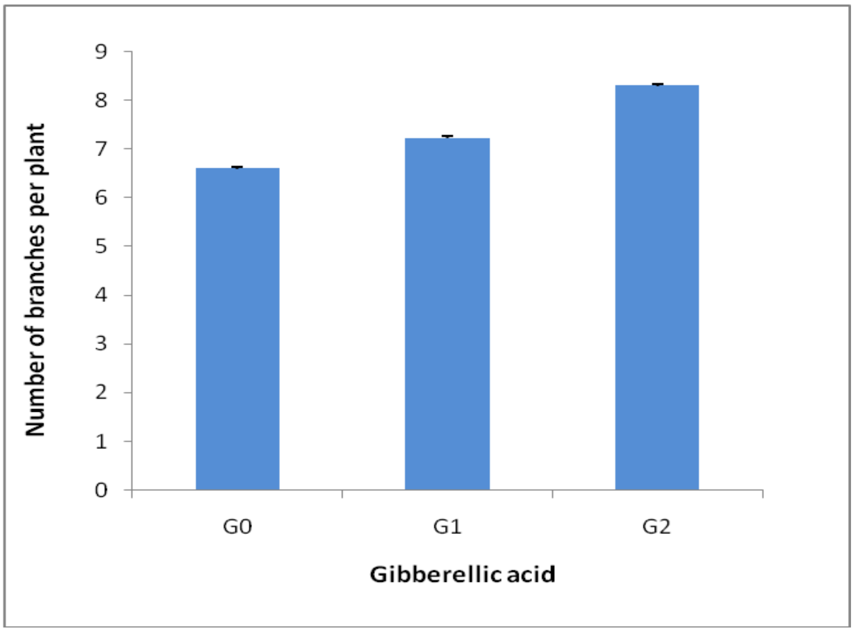
Figure 5. Effect of auxin on number of branches plant^{-1} of BARI tomato 7 ($LSD_{0.05}$ =0.35)

was found at control auxin. Ali *et al.*, (2012) reported that Auxin produces highest number of branches per plant in tomato. Singh *et al.*, (2005) saw that plant growth and number of branches of tomato positively affected by auxin but there is no effect at higher dose.

ii. Effect of gibberelic acid

The total number of branches plant^{-1} of tomato was significantly influenced by different gibberelic acid level (Appendix V and Figure 6). The highest dry weight number of branches (8.29) was recorded in 50 ppm gibberelic acid level and lowest

(6.59) was found in control level. This findings is agreed to result of Tomar and Ramgiry (1997). They found that plants treated with gibberelic acid showed significantly number of branches/plant.



G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

Figure 6. Effect of gibberellic acid on number of branches plant^{-1} of BARI tomato 7 ($LSD_{0.05}$ =0.45)

iii. Interaction Effect of auxin and gibberellic acid

Interaction effect of auxin and gibberellic acid influenced the number of branches plant^{-1} of tomato (Appendix V and Table 3). The highest number (10.52) was observed at 40 ppm auxin + 50 ppm gibberellic acid level and lowest number (4.55) was found in control auxin + control gibberellic acid level that is statistically similar with control auxin+ 30 ppm gibberellic acid.

Table 3. Interaction effect of auxin and gibberelic acid on Number of branches plant^{-1}, Days to flowering and Days to first harvest of BARI tomato 7

Treatments	Number of branches plant^{-1}	Days to flowering	Days to first harvest
A_0G_0	4.55 l	55.54 a	90.42 a
A_0G_1	5.05 k	55.52 a	90.40 a
A_0G_2	6.05 j	54.65 b	89.53 b
A_1G_0	6.85 i	52.15 c	87.03 c
A_1G_1	7.15 g	50.25 d	85.13 d
A_1G_2	7.55 f	48.05 e	82.93 e
A_2G_0	7.92 e	47.03 g	81.91 g
A_2G_1	8.62 c	46.61 h	81.49 h
A_2G_2	10.52 a	45.05 i	79.93 i
A_3G_0	7.02 h	48.05 e	82.93 e
A_3G_1	8.02 d	47.85 f	82.73 f
A_3G_2	9.02 b	47.05 g	81.93 g
LSD $_{(0.05)}$	0.23	0.053	0.054
CV (%)	5.2	5.7	7.8

A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin, G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

4.1.4 Days to flowering

i. Effect of auxin

The flowering significantly varied among the auxin level (Appendix VI and Table 4), where 40 ppm auxin level needed the shortest duration for flowering (46.23 days) that is statistically similar with 60 ppm auxin level. The control level needed the longest duration for flowering (55.23 days). This result is supported by Khaled *et el*., (2015). He reported days required for 50% flowering is significantly influenced by the application of auxin in BARI tomato 7. Gelmesa *et al.,* 2012 reported that application of auxin helps to produce early flowering of tomato.

Table 4. Influence of auxin and gibberelic acid on flowering and first fruit harvest duration of BARI tomato 7

Treatments	Days to flowering	Days to first harvest
Auxin		
A_0	55.23 a	90.12 a
A_1	50.15 b	85.03 b
A_2	46.23 c	81.11 c
A_3	47.65 c	82.53 c
LSD $_{(0.05)}$	1.55	1.67
CV (%)	5.7	7.8
Gibberellic acid		
G_0	50.69 a	85.58 a
G_1	50.05 a	84.94 b
G_2	48.70 b	83.58 c
LSD $_{(0.05)}$	1.02	0.26
CV (%)	5.7	7.8

A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin, G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

ii. Effect of gibberelic acid

Different gibberelic acid level affected flowering time (Appendix VI and Table 4). The control level needed the longest duration for flowering (50.69 days) that is statistically similar with 30 ppm gibberelic acid level and 50 ppm gibberelic acid needed the shortest duration (48.7 days). This result is agreed to finding of Wanjao and Waithaka, (1983). They reported gibberelic acid helps to earlier flowering compare to control.

iii. Interaction effect of auxin and gibberelic acid

Interaction effect of auxin and gibberelic acid significantly influenced the flowering duration (Appendix VI, Table 3). Control auxin + control gibberelic acid required the highest duration for flowering (55.54 days) which is statistically similar with control auxin + 30 ppm gibberelic acid. 40 ppm auxin + 50 ppm gibberelic acid required the shortest duration (45.05 days) for flowering.

4.1.5 Days to first harvest

i. Effect of auxin

There was a significant effect of auxin on days to first harvest (Appendix VI and Table 4) of tomato. The shortest duration of days to first harvest (81.11 days) was needed for the application of 40 ppm auxin level that is statistically similar with 60 ppm auxin level. The longest duration (90.12 days) required for days to first harvest was control level auxin. This result is exactly same as days to first flowering. In same plant for application of hormones that treatment gives the early fruit which can give the early flowering. Verma et al., (2014) revealed that fruit set in tomato was successfully improved by application of auxin. Khaled et al., (2015) reported that days required for fruit setting is significant influenced by the application of auxin in BARI tomato 7.

ii. Effect of gibberelic acid

Days to first harvest of tomato was significantly influenced by different level of gibberelic acid application (Appendix VI and Table 4). The lowest duration (83 .58 days) for Days to first harvest was found in 50 ppm level of gibberelic acid application and longest duration (85.58 days) was found in control level gibberelic acid. Pramanik et al., (2017) reported that application of 50 ppm and 100 ppm gibberelic acid has an effect of earliness to fruit harvest of tomato plant. This result is the agreement of experiment findings.

iii. Interaction effect of auxin and gibberellic acid

Days to first harvest was significantly influenced by the interaction effect between auxin and gibberellic acid (Appendix VI and Table 3). The longest duration (90.42 days) for days to first harvest of tomato was found in control auxin + control gibberellic acid which was statistically similar with control auxin + 30 ppm gibberellic acid. The shortest duration (79.93 days) was observed in 40 ppm auxin level + 50 ppm gibberellic acid level.

4.2 Yield parameters

4.2.1 Total number of flower plant^{-1}

i. Effect of auxin

Auxin showed significant effect on total number of flower per plant (Appendix V and Table 5). The highest number of flower per plant (73.85) was found from 40 ppm auxin level and lowest number (50.63) was found from control level. Leopold *et. al*., (1964) observed that with the increase in concentration of auxin there was a comparable increase in percentage of number of flower. But concentration more than 50 ppm there is not any difference for flower production in tomato.

ii. Effect of gibberellic acid

Total number of flower per plant also significantly influenced by different gibberellic acid level (Appendix V and Table 5). The highest number of flower (69.91) was found from 50 ppm gibberellic acid level and lowest number (61.36) was found in control level. This result is the agreement of Pundir and yadav, (2001). They reported that treatment with GA3 50 ppm produces highest number of flower per plant in tomato.

Table 5. Influence of auxin and gibberelic acid on number of flower and fruit per plant of BARI tomato 7

Treatments	Number of flower per plant	Number of fruit per plant
Auxin		
A_0	50.63 d	23.80 d
A_1	66.43 c	31.80 c
A_2	73.85 a	38.15 a
A_3	71.15 b	35.98 b
LSD $_{(0.05)}$	1.46	0.52
CV (%)	10.8	16.4
Gibberellic acid		
G_0	61.36 c	29.10 c
G_1	65.28 b	31.72 b
G_2	69.91 a	36.47 a
LSD $_{(0.05)}$	1.26	0.45
CV (%)	10.8	16.4

A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin, G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

iii. Interaction effect of auxin and gibberellic acid

There was a significant effect with interaction between auxin and gibberellic acid in respect of total number of flower per plant of tomato (Appendix V and Table 6). The highest number of flower per plant (80.18) was recorded in 40 ppm auxin + 50 ppm gibberellic acid level. The lowest number (45.63) was found in control auxin + control gibberellic acid level. Choudhury, et. Al., (2013) reported combination effect of auxin and gibberellic acid increase the number of flower per plant of tomato.

Table 6. Interaction effect of auxin and gibberelic acid on number of flower per plant and number of fruit per plant of BARI tomato 7

Treatments	Number of flower per plant	Number of fruit per plant
A_0G_0	45.63 i	20.80 j
A_0G_1	51.63 h	24.80 i
A_0G_2	54.63 g	25.80 h
A_1G_0	62.03 f	29.80 g
A_1G_1	66.63 e	30.80 f
A_1G_2	70.63 cd	34.80 d
A_2G_0	69.18 d	33.15 e
A_2G_1	72.18 bc	37.15 c
A_2G_2	80.18 a	44.15 a
A_3G_0	68.58 de	32.65 e
A_3G_1	70.68 cd	34.15 d
A_3G_2	74.18 b	41.15 b
$LSD_{(0.05)}$	2.53	0.9
CV (%)	10.8	16.4

A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin, G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

4.2.2 Total number of fruit plant^{-1}

i. Effect of auxin

Auxin showed significant effect on total number of fruit per plant (Appendix VII and Table 5). The highest number of fruit per plant (38.15) was found from 40 ppm auxin level and lowest number (23.80) was found from control level. Jagdish *et al.*, (2002) confirmed that spraying of auxin at 50 ppm significantly improved the fruit set per cluster compared with the control but increasing the concentration more had no significant effect on fruit set and number of fruit per plant. Alam and Khan, (2002) reported sprays of auxin at the time of flowering resulted in reduced pre-harvest fruit drop and increased the number of fruits per plant.

ii. Effect of gibberellic acid

Total number of fruits per plant also significantly influenced by different gibberellic acid level (Appendix VII and Table 5). The highest number of fruit (36.47) was found from 50 ppm gibberellic acid level and lowest number (29.10) was found in control level. Naeem *et al.*, (2001) revealed gibberellic acid spray on tomato plant reduces fruit drop and contributes better number of fruits per plant. Tomar and Ramgiry, (1997) found that plants treated with gibberellic acid showed significantly greater number of fruits per plant than untreated controls.

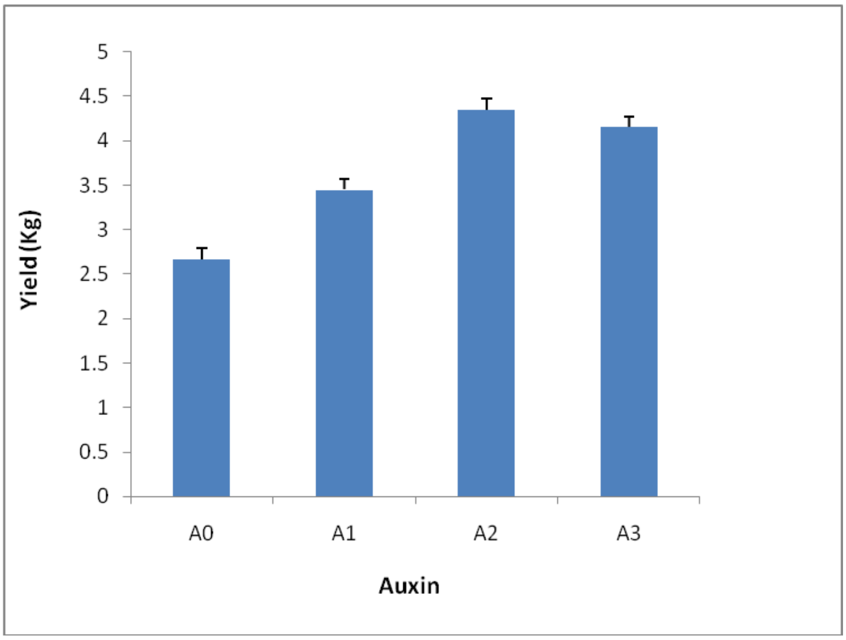
iii. Interaction effect of auxin and gibberellic acid

Interaction effect between auxin and gibberellic acid was significant in respect of total number of fruit per plant of tomato (Appendix VII and Table 6). The highest number of fruit per plant (44.15) was recorded in 40 ppm auxin + 50 ppm gibberellic acid level. The lowest number (20.80) was found in control auxin + control gibberellic acid level. Choudhury, et. Al., (2013) reported combination effect of auxin and gibberellic acid increase the number of fruit per plant of tomato.

4.2.3 Fruit yield per plant

i. Effect of auxin

Fruit yield was significantly influenced by the different auxin level (Appendix VII and Figure 7). The highest yield per plant (4.353 kg) was obtained from the 40 ppm auxin level and the lowest (2.667 kg) was from control level. Patel *et al.*, (2012) revealed that application of auxin increases the fruit diameter and yield in tomato. Application of auxin increases the yield in tomato due to enhanced plant growth and faster rate of plant development by the action of auxin in cell elongation and there by increased cell enlargement, cell division and differentiation which in turn result into increase in number of flowers, fruit set, size and weight of fruit as reported by Rodrigues *et al.*, (2001).

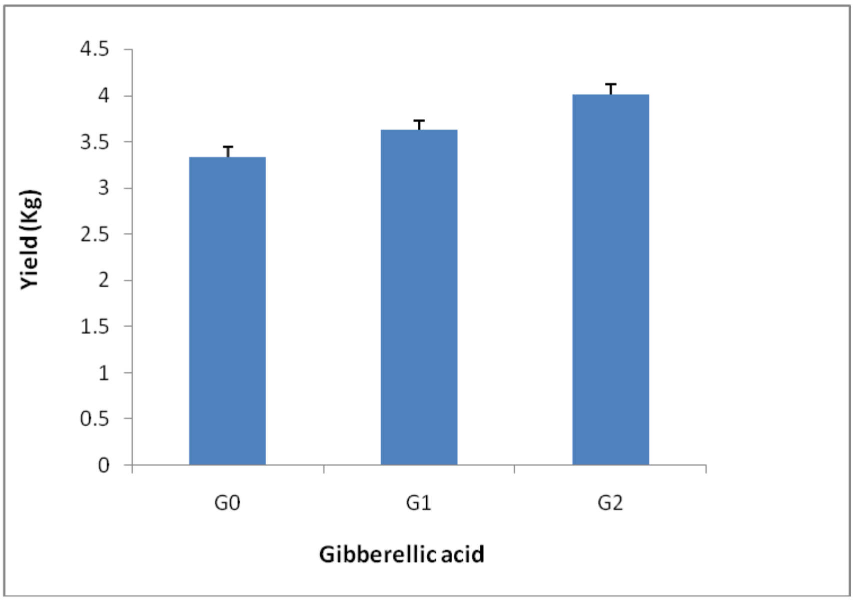


A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin and A_3 = 60 ppm auxin

Figure 7. Effect of auxin on Yield (Kg) per plant of BARI tomato 7 ($LSD_{0.05}$ =0.19)

ii. Effect of gibberellic acid

Gibberellic acid has significant effect on yield of tomato (Appendix VII and Figure 8). 50 ppm gibberellic acid produced significantly the highest yield (4.01 kg) and lowest (3.338 kg) yield was from control that was similar with 30 ppm gibberellic acid level. Khan *et al.*, (2006) indicated the significant role of gibberellic acid in tomato plant to increase fruit set that leads to larger number of fruits per plant and increased fruit size and final yield. Tomar and Ramgiry, (1997) found that plants treated with gibberellic acid showed significantly greater yield per plant than untreated controls. Sultana, (2013) concluded that application of gibberellic acid at 50 ppm increases the weight of fruits per plant and yield of tomato.



G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

Figure 8. Effect of gibberellic acid on Yield (Kg) per plant of BARI tomato 7 ($LSD_{0.05}$ =00.32)

iii. Interaction effect of auxin and gibberellic acid

Interaction between auxin and gibberellic acid played an important role for promoting the yield. Yield was significantly influenced by the interaction effect (Appendix VII and Table 7). Among the treatments, the highest yield (4.95 kg) was observed in 40 ppm auxin + 50 ppm gibberellic acid. The lowest yield (2.467 kg) was observed in control auxin + control gibberellic acid that similar with control auxin + 30 ppm gibberellic acid and control auxin + 50 ppm gibberellic acid level.

Table 7. Interaction effect of auxin and gibberelic acid on number of flower per plant and number of fruit per plant of BARI tomato 7

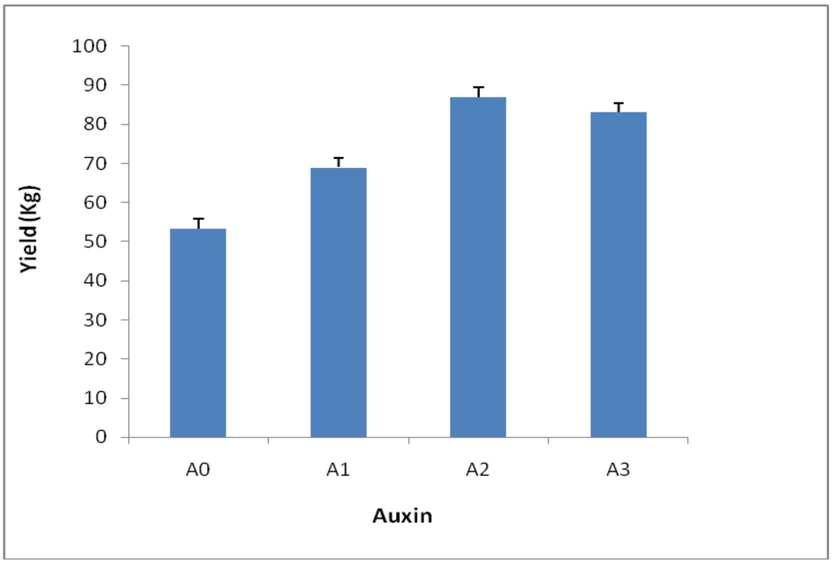
Treatments	Yield plant^{-1} (kg)	Yield plot^{-1} (kg)	Yield hectare^{-1} (ton)
A_0G_0	2.46 f	49.34 f	123.35 f
A_0G_1	2.76 ef	55.34 ef	138.35 ef
A_0G_2	2.76 ef	55.34 ef	138.35 ef
A_1G_0	3.26 de	65.34 de	163.35 de
A_1G_1	3.41 d	68.34 d	170.85 d
A_1G_2	3.66 cd	73.34 cd	183.35 cd
A_2G_0	3.85 cd	77.06 cd	192.65 cd
A_2G_1	4.25 bc	85.06 bc	212.65 bc
A_2G_2	4.95 a	99.06 a	247.65 a
A_3G_0	3.76 cd	75.26 cd	188.15 cd
A_3G_1	4.05 bc	81.06 bc	202.65 bc
A_3G_2	4.65 ab	93.06 ab	232.65 ab
LSD $_{(0.05)}$	0.63	12.6	31.5
CV (%)	10.2	10.2	10.2

A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin, G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

4.2.4 Fruit yield per plot

i. Effect of auxin

Fruit yield per plot was also significantly influenced by the different auxin level as like as fruit yield per plant (Appendix VII and Figure 9). The highest yield per plot (87.06 kg) was obtained from the 40 ppm auxin level and the lowest (53.34 kg) was from control level. Application of auxin increases the yield in tomato due to enhanced plant growth and faster rate of plant development by the action of auxin in cell elongation and there by increased cell enlargement, cell division and differentiation which in turn result into increase in number of flowers, fruit set, size and weight of fruit as reported by Rodrigues *et al.*, (2001).

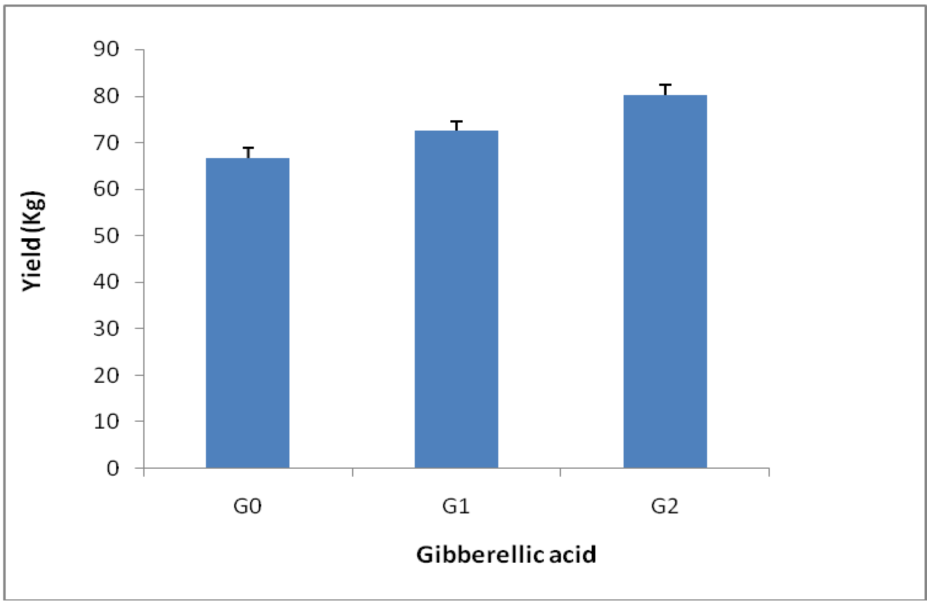


A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin and A_3 = 60 ppm auxin

Figure 9. Effect of auxin on Yield (Kg) per plot of BARI tomato 7 ($LSD_{0.05}$ =3.8)

ii. Effect of gibberellic acid

Gibberellic acid was also significant effect on yield of tomato per plot (Appendix VII and Figure 10). 50 ppm gibberellic acid produced significantly the highest yield (80.20 kg) and lowest (50.69 kg) yield was from control that was similar with 30 ppm gibberellic acid level.



G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

Figure 10. Effect of gibberellic acid on Yield (Kg) per plot of BARI tomato 7 ($LSD_{0.05}$ =6.4)

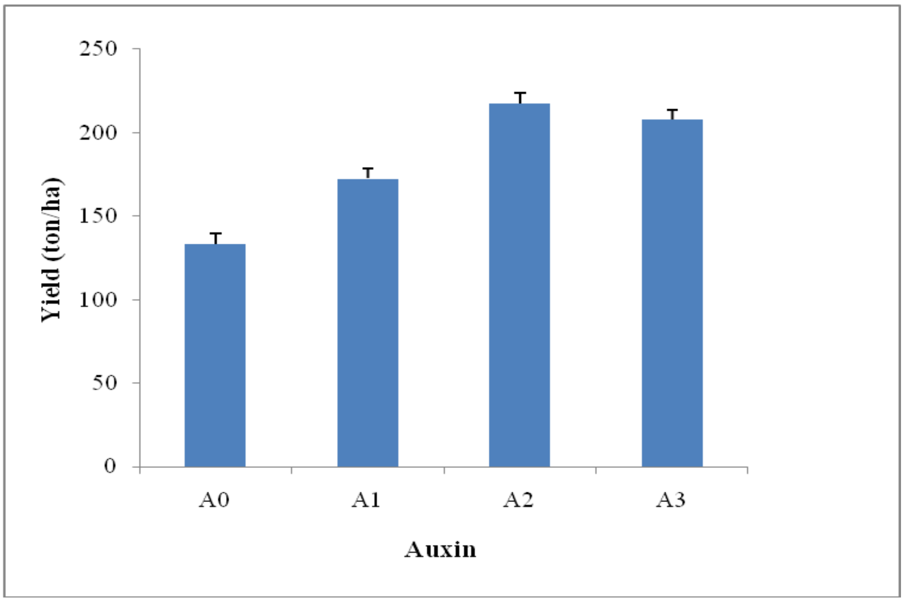
iii. Interaction effect of auxin and gibberellic acid

Interaction between auxin and gibberellic acid played an important role for promoting the yield. Yield per plot was significantly influenced by the interaction effect (Appendix VII and Table 7). Among the treatments, the highest yield (99.06 kg) was observed in 40 ppm auxin + 50 ppm gibberellic acid. The lowest yield (49.34 kg) was observed in control auxin + control gibberellic acid that similar with control auxin + 30 ppm gibberellic acid and control auxin + 50 ppm gibberellic acid level.

4.2.5 Fruit yield per hectare

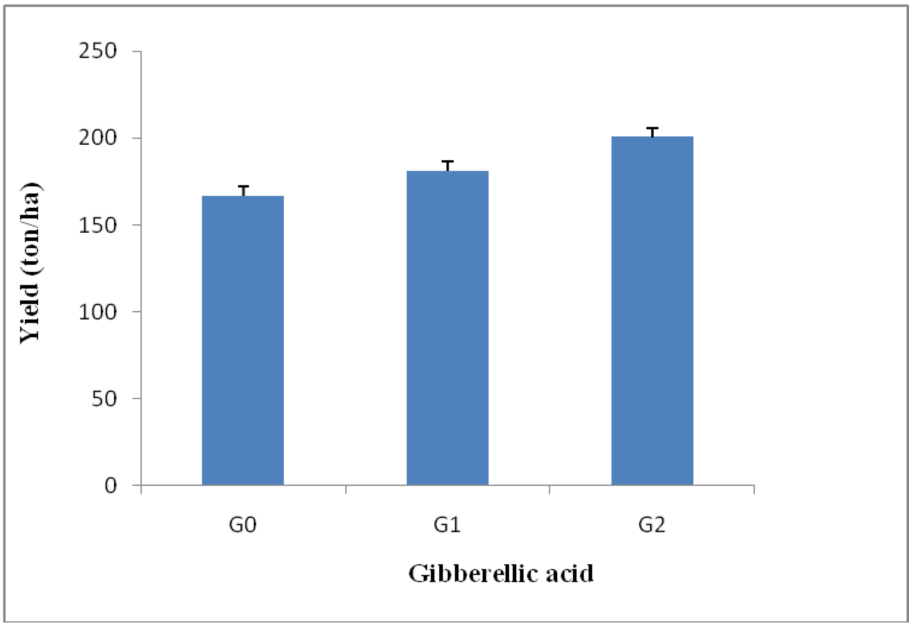
i. Effect of auxin

Fruit yield per hectare also significantly influenced by the different auxin level as like as fruit yield per plant and plot (Appendix VII and Figure 11). The highest yield per hectare (217.65 ton) was obtained from the 40 ppm auxin level and the lowest (133.35 ton) was from control level. Patel *et al.*, (2012) revealed that application of auxin increases the fruit diameter and yield in tomato.



A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin and A_3 = 60 ppm auxin

Figure 11. Effect of auxin on Yield (ton) per hectare of BARI tomato 7 ($LSD_{0.05}$ =9.5)



G_0 = Control, G_1 = 30 ppm gibberellic acid and G_2 = 60 ppm gibberellic acid

Figure 12. Effect of gibberellic acid on Yield (ton) per hectare of BARI tomato 7 ($LSD_{0.05}$ =16.00)

ii. Effect of gibberellic acid

Gibberellic acid was also significant effect on yield of tomato per hectare (Appendix VII and Figure 12). 50 ppm gibberellic acid produced significantly the highest yield (200.5 ton) and lowest (166.9 ton) yield was from control that was similar with 30 ppm gibberellic acid level.

iii. Interaction effect of auxin and gibberellic acid

Interaction between auxin and gibberellic acid was also significant effect of yield per hectare (Appendix VII and Table 7). Among the treatments, the highest yield (232.65 ton) was observed in 40 ppm auxin + 50 ppm gibberellic acid. The lowest yield (123.35 ton) was observed in control auxin + control gibberellic acid that similar with control auxin + 30 ppm gibberellic acid and control auxin + 50 ppm gibberellic acid level.

4.3 Nutrient Content

i. Effect of auxin

Tomato was significantly influenced by different auxin level at nutrient content of Calcium (Ca), Magnesium (Mg), Potassium (K), Phosphorous (P) and Iron (Fe) but there is not any significant difference in Niacin (N) content (Appendix VIII and Table 8). The result revealed that 20 ppm auxin produce maximum Ca (1.45 gm) and Mg (0.88 gm) and control level gave the lowest Ca (0.99 gm) and Mg (0.60 gm) in per 100 gm tomato. In case of K content 60 ppm auxin level have maximum K (2.63 gm) in per 100 gm tomato which was statistically similar with 40 ppm auxin level. The lowest K (1.62 gm) was found in 20 ppm auxin level. The 60 ppm auxin level also gave the highest P (1.11 gm) and Fe (306 ppm) in per 100 gm tomato and lowest was observed in 20 ppm auxin level for P (0.93 gm) and control level for Fe (208.20 ppm) content.

Table 8. Influence of auxin and gibberelic acid on nutrient content of BARI tomato 7

Treatments	Nutrient content of BARI tomato 7					
	Calcium (gm)	Magnesium (gm)	Potassium (gm)	Niacin (gm)	Phosphorous (gm)	Iron (ppm)
Auxin						
A_0	0.985d	0.597 c	1.737 b	2.657	0.972 c	208.20 c
A_1	1.449 a	0.876 a	1.617 c	2.563	0.934 c	284.40 b
A_2	1.246 b	0.755 b	2.583 a	2.64	1.018 b	200.90 c
A_3	1.209 c	0.732 b	2.633 a	2.637	1.114 a	306.00 a
LSD $_{(0.05)}$	0.03	0.04	0.08	NS	0.043	19.66
CV (%)	3.15	5.6	3.5	6.48	4.76	8.09
Gibberellic acid						
G_0	0.775 c	0.470 c	2.541 a	2.604 b	0.905 c	234.90 b
G_1	1.699 a	1.028 a	2.066 b	2.419 c	1.038 b	224.10 b
G_2	1.192 b	0.722 b	1.821 c	2.849 a	1.086 a	290.60 a
LSD $_{(0.05)}$	0.03	0.04	0.07	0.14	0.04	17.03
CV (%)	3.15	5.6	3.5	6.48	4.76	8.09

A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin, G_0 = Control, G_1 = 30 ppm gibberellic acid, G_2 = 60 ppm gibberellic acid and NS = Non significant

ii. Effect of gibberellic acid

There was a significant effect of Ca, Mg, K, N, P and Fe with the different level of gibberellic acid (Appendix VIII and Table 8). It was observed that 30 ppm level of

Table 9. Influence of interaction effect of auxin and gibberelic acid on nutrient content of BARI tomato 7

Treatments	Nutrient content of BARI tomato 7					
	Calcium (gm)	Magnesium (gm)	Potassium (gm)	Niacin (gm)	Phosphorous (gm)	Iron (ppm)
A_0G_0	0.950 f	0.576 ef	2.483 cd	3.087 abc	0.893 f	149.2 ef
A_0G_1	1.160 d	0.703 d	1.443 g	2.107 f	0.840 f	195.2 d
A_0G_2	0.846 g	0.513 f	1.283 h	2.777 de	1.183 ab	280.1 b
A_1G_0	0.720 h	0.436 g	1.403 gh	3.337 a	0.720 g	312.5 b
A_1G_1	2.240 a	1.353 a	1.773 ef	1.627 g	0.990 e	125.9 f
A_1G_2	1.387 c	0.840 c	1.673 f	2.727 e	1.093 cd	414.7 a
A_2G_0	1.020 e	0.620 e	2.613 bc	1.747 g	1.030 de	193.3 d
A_2G_1	1.187 d	0.720 d	2.693 b	2.917 cde	1.120 bc	177.0 de
A_2G_2	1.530 b	0.926 b	2.443 d	3.257 ab	0.903 f	232.5 c
A_3G_0	0.410 i	0.250 h	3.663 a	2.247 f	0.980 e	284.5 b
A_3G_1	2.210 a	1.337 a	2.353 d	3.027 bcd	1.200 a	398.2 a
A_3G_2	1.007 e	0.610 e	1.883 e	2.637 e	1.163 abc	235.2 c
$LSD_{(0.05)}$	0.05	0.08	0.13	0.29	0.08	34.05
CV (%)	3.15	5.6	3.5	6.48	4.76	8.09

A_0 = Control, A_1 = 20 ppm auxin, A_2 = 40 ppm auxin, A_3 = 60 ppm auxin, G_0 = Control, G_1 = 30 ppm gibberellic acid, G_2 = 60 ppm gibberellic acid and NS = Non significant

gibberellic acid produces the maximum Ca (1.70 gm) and Mg (1.03 mg) content of per 100 gm tomato and control level produce the minimum content of Ca (0.78 gm) and Mg (0.47 gm). In case of K control level produces the maximum (2.54 gm) content and 50 ppm level produces the minimum content of K (1.82 gm). The 50 ppm level of gibberelic acid produces the highest N (2.85 gm), P (1.09 gm) and Fe (290.6 ppm); 30 ppm level produces the minimum N (2.42 gm) and Fe (224.1 ppm); and control level produces the minimum P (0.91 gm) content. But 30 ppm level produces Fe content is statistically similar with control level gibberellic acid produces Fe.

iii. Interaction effect of auxin and gibberelic acid

Interaction effect of auxin and gibberelic acid significantly influenced the Ca, Mg, K, N, P and Fe content (Appendix VIII and Table 9). 20 ppm auxin + 30 ppm gibberelic acid produces the highest Ca (2.24 gm) and Mg (1.35 gm) that was statistically similar with 60 ppm auxin + 30 ppm gibberellic acid. 60 ppm auxin + control gibberellic acid produces the highest K (3.66 gm) content and control auxin + 50 ppm gibberellic acid produces the lowest K (1.28 gm) that was similar with 20 ppm auxin + control gibberellic acid. In case of N 20 ppm auxin + control gibberellic acid produces the maximum N (3.34 gm) that statistically similar with 40 ppm auxin + 50 ppm gibberellic acid and control auxin + control gibberellic acid. The minimum N (1.63 gm) was found in 20 ppm auxin + 30 ppm gibberellic acid level that is similar with 40 ppm auxin + control gibberellic acid level. The highest P (1.20 gm) was found in 60 ppm auxin + 30 ppm gibberellic acid level that was similar with 60 ppm auxin + 50 ppm gibberellic acid and control auxin + 50 ppm gibberellic acid level. The highest Fe (414.70 ppm) was found in 20 ppm auxin + 50 ppm gibberellic acid that similar with 60 ppm auxin + 30 ppm gibberellic acid. The minimum Fe (125.9 ppm) was observed in 20 ppm auxin + 30 ppm gibberellic acid that similar with control auxin + control gibberellic acid level.

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the period from October, 2016 to February, 2017 to study the growth, yield and nutrient content of tomato with different level of auxin and gibberellic acid under the Modhupur Tract (AEZ-28). The experiment consisted of two factors as four auxin level viz., Control (A_0**),** 20 ppm (A_1), 40 ppm (A_2), 60 ppm (A_3) and three gibberellic acid level viz., Control (G_0**),** 30 ppm (G_1), 50 ppm (G_2). The experiment was laid out in Randomized Complete Block design (RCBD) with three replications.

Results showed that auxin had significant effect on growth, yield and nutrient content parameters except niacin content. The rapid increase of plant height was observed from 50 to 65 DAT of growth stages which was higher in the 60 ppm auxin level compared to the other auxin level. however, at 35, 50, 65 and 80 DAT, 60 ppm auxin produced the tallest plant (72.53, 88.72, 99.04 and 102.10 cm respectively) and the lowest plant height was observed in control level of auxin at 35, 50, 65 and 80 DAT (59.70, 73.49, 82.15 and 85.09 cm respectively). The higher number of leaf at all the growth stages was found in 40 ppm auxin level. Again, the higher number of branches plant^{-1} (9.023) was found also 40 ppm auxin level and lowest number of of branches plant^{-1} (5.22) was found at control auxin. This level auxin needed shorter duration for flowering (46.23 days) that is statistically similar with 60 ppm auxin level and control level needed the longest duration for flowering (55.23 days). The highest number of flower per plant, fruit per plant and yield per plant were obtained from 40 ppm auxin level and lowest were from control level. Tomato was significantly influenced by different auxin level at nutrient content of Calcium (Ca), Magnesium (Mg), Potassium (K), Phosphorous (P) and Iron (Fe) but there is not any significant difference in Niacin (N) content. 20 ppm auxin gave the highest Ca and M; and 60 ppm gave the highest K, P and Fe content of tomato.

Gibberellic acid also significantly influenced all growth, yield and nutrient content attributes. The results revealed that 50 ppm gibberellic acid level produced the tallest plant height and higher number of leaf per plant at all the growth stages and control level produced the smallest plant height and less number of leaf per plant. The highest number of branches per plant, flower per plant, fruit per plant and yield per plant were obtained from 50 ppm gibberellic acid level and lowest were from control level. The maximum duration required for flowering and days to first harvest found in control level gibberellic acid and 30 ppm level was statistically similar with control level for flowering. The shortest duration was required for flowering and days to first harvest found in 50 ppm level. There was significant effect of all tested nutrient content of tomato like Ca, Mg, K, N, P and Fe by the different level of gibberellic acid applied. 30 ppm gibberellic acid gave the highest Ca and M, control gave highest K and 50 ppm gibberellic acid gave the highest N, P and Fe content of tomato.

Interaction effect of auxin and gibberellic acid also significantly affected all parameters of growth, yield and yield contributing characters and nutrient content. The tallest plant height was found in 60 ppm auxin + 50 ppm gibberellic acid at 35, 50, 65 and 80 DAT. The lowest plant height was observed with control auxin + control gibberellic acid at 35 and 50 DAT; and control auxin + 30 ppm gibberellic acid gave lowest height at 65 and 80 DAT. The highest number of leaf, number of branches, flower per plant, fruit per plant and yield were found from 40 ppm auxin + 50 ppm gibberellic acid level and lowest were control auxin + control gibberellic acid level. Lowest yield was statistically similar with control auxin + 30 ppm gibberellic acid level and control auxin + 50 ppm gibberellic acid level. The early flowering and early harvesting was observed by 40 ppm auxin + 50 ppm gibberellic acid level and maximum duration were required by control auxin + control gibberellic acid level that statistically similar with control auxin + 30 ppm gibberellic acid level. All tested nutrient content like Ca, Mg, K, N, P and Fe were significantly influence by interaction effect of auxin and gibberellic acid level. 20 ppm auxin + 30 ppm gibberellic acid produced highest Ca and Mg, 60 ppm auxin + control gibberellic acid produced highest K, 20 ppm auxin + control gibberellic acid produced highest N, 60 ppm auxin + 30 ppm gibberellic acid produced highest P and 20 ppm auxin + 50 ppm gibberellic acid produced highest Fe content of tomato.

Based on the results of the present study, the following conclusions may be drawn-

- The highest number of fruit and yield was observed in 40 ppm auxin level.
- 50 ppm gibberellic acid level gave the highest number of fruit and yield.
- The highest yield and most of the yield contributing characters were observed in 40 ppm auxin + 50 ppm gibberellic acid level.
- Different level of auxin, gibberellic acid and their interaction produced different type higher nutrient content.

However, to reach a specific conclusion and recommendation the same experiment need to be repeated and more research work should be done over different Agro-ecological zones.

REFERENCES

Aditya, T. L., Rahman, L., Shah-E-Alam, M., and Ghosh A. K. (1999). Correlation and Path Coefficient Analysis in Tomato. *Bangladesh Agril. Sci. Al.* **26**(1): 119-122.

Adlakha, P. A. and Verma, S. K. (1964). Effect of gibberllic acid on the quality of tomato fruit**.** *Punjab Hort. J***. 4** (4): 148-151.

Afaf, T. M. K., Abd-El-hameid, A. M., El-Greadly, N. H. M. (2007). A comparison study on the effect of some treatments on earliness, yield and quality of globe artichoke (*Cynarascolymus* L.). *Res. J. Agric. Biol. Sci.* **3**: 695-700.

Akash, K., Biswas, T.K., Singh, N. and Lal, E.P. (2014). Effect of gibberellic acid on growth, quality and yield of tomato (*Lycopersiconesculentum* Mill.). *J. Agric. Vet. Sci.* **7**(7): 28-30.

Alam, S.M. and M.A. Khan, (2002). Fruit yield of tomato as affected by NAA spray. *Asian J. Plant Sci.* **1**(1): 24.

Ali, M., Sharmin, A., Saki, S., M-ul-Hasan, A. I. and Moniruzzaman, M. (2012). Effect of plant growth regulators on growth and yield of tomato (*Lycopersiconesculentum* Mill.) varieties. *Inter. J. of Sus. Agri. Tech*. **8**(1): 1-6.

Anwar, W., Aziz, T., Naveed, F. and Sahi, S.T. (2010). Short Communication. Foliar applied 2, 4-dichlorophenoxy acetic acid improved tomato growth and yield. *Soil Environ*. **29**(1): 77- 81.

Arvind, J. (2012). Effect of plant growth regulators on different varieties of tomato (*Lycopersiconesculentum* Mill.). M. Sc. Thesis, R.A.K College of Agriculture (M.P.).

Asahira, T., Takeda, Y., Nishio, T., Hirabayashi, M. and Tsukamoto, Y. (1967). Studies on fruit development in tomato. I. Ovule development and content of diffusible auxin- and gibberellin-induced parthenocarpic tomato fruits in relation to their development. Memoirs of the Research Institute for Food Science, Kyoto University. pp. 47–74.

BBS. (2012). Monthly Statistical Bulletin. Bangladesh Bureau of Statistics. Stat. Div., Mi Plan., Govt. Peoples Rep. Bangladesh, Dhaka. p. 55.

Bokade, N., Bhalekar, M. N., Gupta, N. S. and Deshpande, A. (2006). Effect of growth regulators on growth and yield of summer tomato. *J. Maharashtra Agric. Univ.* **31**(1): 64-65.

Bora, P.C. and Selman, I.W. (1969). Growth and nitrogen accumulation in young tomato plants treated with gibberellic acid. *J. Exp. Bot*. **20**: 288-301.

Briant, R. E. (1974). An analysis of the effect of gibberellic acid on tomato leaf growth. *J. Exp. Bot.* **25**: 764-771.

Chern, J. K., Wu, C.W., Lin, J.K. and Tarng, S.F. (1983). Effect of plant growth regulators on the growth and development of tomato. *J. Agric.Assoc. China* **124**: 31-42.

Chhonkar, V. S. and Singh, S. N. (1959). Effect of alpha naphthalene acetic acid on growth, quality and yield of tomato. *India. J. Hort*. **l6**: 236- 242.

Chhonkar, V.S. and Ghufran, M.H. (1968). Effect of starters and NAA on growth and yield of *Lycopersiconesculentum*. *IndIan J. Hort*. **25**: 72-75.

Choudhury, B. (2015. Vegetables. Sixth Revised Edn., The Director, National Book Trust. New Delhi, India.

Choudhury, S., Islam, N., Sarkar, M. D. and Ali, M. A. (2013). Growth and Yield of Summer Tomato as Influenced by Plant Growth Regulators. *Inter. J. of Sus. Agri*. **5**(1): 25-28

Choudhury, S.H. and Faruque, A.H.M. (1972). Effect of GA_3 on seedlessness of tomato. *Bangladesh Hort*. **1**(1):13-16.

Davies, P.1. (1995). Plant Hormones, Physiology, Biochemistry and Molecular Biology. Kiuwer Academic Publishers, Dordrecht.

EI- Habbasha, K.M., Gomaa, H.M., EI- Gizawy, A.M. and Mohamed, S.S. (1999). Response of tomato plants to foliar spray with some growth regulators under later summer conditions. *Egypt. J. Hort.* **26**: 3546.

Gelmesa, D., Abebie, B. and Lemma, D. (2012). Regulation of tomato (*Lycopersiconesculentum*Mill.) fruit setting and earliness by gibberellic acid and 2, 4-dichlorophenoxy acetic acid application. *African J. of Bio.* **11**(51): 11200-11206.

Ghulam, J., Munir, S., Bano, A. and Ullah, H. (2006). Effect of growth regulators on growth and yield of tomato cv. Roma parasitized by Orobanche. *Sarhad J. of Agri*. **22**(2): 229-232.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedure for agricultural research. Second Edn. Intl. Rice Res. Inst., John Wiley and Sons. New York. pp. 1-340.

Graham, H. D. and Ballesteros, M. (1980). Effect of plant growth regulators on plant nutrients. *J. of food sci*. **45**: 502–505.

Gulnaz, A., Iqbal, J. and Awn, F. (1999). Seed treatment with growth regulators and crop productivity. II. Response of critical growth stages of wheat (*Triticumaestivum* L.*)* under salinity stress. *Cereal Res.Communications*. **27**(4): 419-426.

Gupta, P.K., Gupta, N.K. and Reddy S. (2003). Reponse of plant growth regulators and micronutrient mixture on fruit size, colour and yield of tomato. *Anal. Agri. Res.* **24**(1): 100-103.

Gupta, P.K., Gupta, N.K. and Reddy, S. (2001). Efficiency of plant growth regulators and micronutrient mixture on growth and shelf life of tomato (*LycopersiconesculentumMill.*) fruit. *India J. Agric. Biocem.* **14**(1): 63-65.

Gustafson, F.G. (1960). Influence of gibberellic acid on setting and development of Fruits in tomato. *Plant Physiol*. **35**: 521-23.

Habbasha, K.M., Gomea, H.M., Glasy, A.M. and Mohamed, S.S. (1999). Response of tomato plantto foliar spray with some growth regulators under late summer conditions. *Egyptium J. Horti.* **26**(1) 35-36.

Hasanuzzaman, A, Md-Mazed, K, H. E. M., Ashraful, M. D., Chowdhury, M. S. N. and Moonmoon, J. F. (2015). *International J. of App. Res*. **1**(3): 71-74.

Hathout T.A., Sheteawi, S.A. and Khallal, S.M. (1993). I. Effect of mode of application of some growth regulators on the physiology of tomato plants. *Egyptian J. Physiol. Sci*. **17**(1): 45-62.

Hossain, M.A.E. (1974). Studies on the effect of parachlorophenoxy acetic acid and gibberellic acid on the production of tomato. M.Sc. Ag, Thesis, Dep. Hort. Bangladesh Agril. Univ. Mymensingh.

Jagdish, S., Singh, K. P. and Kalloo, G. (2002). Effect of some plant growth regulators on fruit set and development under cold climatic conditions in tomato (*Lycopersiconesculentum*Mill.). *Progressive Hort*. **34**(2): 211-214.

Jansen, H. (1970). The effect of gibberellic acid and CCC on the yield of tomatoes. *Garteribauwissen-Chaft*. **35**: 303-306.

Jong, M., Celestina, M. and Vneze, W. (2009). The role of auxin and gibberellin in tomato fruit set. *Journal of Exp. Bot.* **60**(5): 1523-1532

Kalloo. (1986). Tomato (Lycopersicon esculenium Mill). Allied Publishers Pvt. Ltd. New Delhi, pp. 203-226.

Karim, M. R., Nahar, M., Altaf-Un and Sahariar, M. S. (2015). Improvement of summer tomato (*Lycopersiconesculentum*Mill.) production using 4-chlorophenoxy acetic acid. *Journal of Bio. and Agri. Res*. **4**(2): 86- 91

Kataoka, K., Yashiro, Y., Habu, T., Sunamoto, K. and Kitajima, A. (2009). The addition of gibberellic acid to auxin solutions increases sugar accumulation and sink strength in developing auxin-induced parthenocarpic tomato fruits. *Scientia Hort*. **123**(2): 228-233.

Kataoka, K., Uemachi, A. and Yazawa, S. (2003). Fruit growth and pseudoembryo development affected by uniconazole, an inhibitor of gibberellin biosynthesis, in pat-2 and auxin-induced parthenocarpic tomato fruits. *Scientia Hort*. **98**: 9-16.

Kaushik M. P., Shanna J.K and Singh I. (1974). Effect of alpha naphthalene acetic acid, gibberellic acid, kinetin and morphactin on yield of tomato. *Plant Sci*. **6**: 51-53.

Khaled, A. M., Sikder, S., Islam, M. R., Hasan, M. A. and Bahadur M. M. (2015). Growth Yield and Yield Attributes of Tomato (Lycopersiconesculentum Mill.) as Influenced by Indole Acetic Acid. *J. Environ. Sci. & Natural Resources*. **8**(1): 139-145.

Khan, M.M.A., Gautam, A.C., Mohammad, F., Siddiqui, M.H., Naeem, M. and Khan, M.N. (2006). Effect of gibberellic acid spray on performance of tomato. *Turk. J. Biol*. **30**: 11-16.

Kishan-swaroop, T. V., Sharma, R.S. and Attri, B.I. (2001). Effect of alpha-naphthalene acetic acid and 2-4-D, on growth, quality and yield tomato cultivars. *Madras Agri.* **12**: 723-726.

Leonard, M., Kinet, K.M., Bodson, M. and Bernier, G. (1983). Enhanced Inflorescence development in tomato by growth substance treatments In relation to C assimilate distribution. *Physiological plant arun*. **57**(1): 85

Leopold, L.B., Wolman, M.G. and Miller, J.P. (1964) Fluvial Processes in Geomorphology. Freeman, San Francisco. p. 522

Lilov, D. and Donchev, T. (1984). Effect of a Bulgarian gibberellin preparation on tomato fruiting. *Gradinarska, Lozarska Nauka* **21**(1): 49-55.

Masroor, A., Champa, K., Manzer, F., Naeem, H. and Nasir, M. (1988). Effect of Indole acetic Acid Spray on Performance of Tomato. *Turk J. Biol*. **30**: 11-16.

Mehrotra,O.N., Grag, R.C. and Singh, I. (1971). Growth, fruiting and quality of tomato (*Lycoperconesculentum*Mill.) as influenced by growth regulators. *Prog. Hort.* **2**(1): 57-64.

Mukherji, S.K. and Roy, B.K. (1966). Reducing fruit drop in West Bengal. *World Crops*. **18**(3): 34.

Naeem, N., Ishtiaq, M., Khan, P., Mohammad. N., Khan, J. and Jamiher, B. (2001). Effect of gibberellic acid on growth and yield of tomato cv. Roma. *J Biol. Sci.* **1**(6): 448-450.

Nibhavanti, B.K., Bhalekar. M.N., Gupta, N.S. and Deshpande, A.N. (2004). Effect of growth regulators on growth and yield of tomato. *J. Maharashtra Agric.Univ.* **31**(1): 64-65.

Onofeghara, F.A. (1983). The effects of growth substances on flowering and fruiting of *Lycopersiconesculentum* and *Vignaunguiculata. Phytol. Argentina*. **40**(1): 107-116.

Pandita, M.L., Arora, S.K. and Singh, K. (1978). Effect of plant growth regulator on the chemical composition of tomato (*Lycopersiconesculentum*Mill.) C.V.H.S.-101. *Haryana J. Hort. Sci.* **5**(1): 65-72.

Pandolfini, T., Rotino, G.L., Camerini, S., Defez, R. and Spena, A. (2002). Optimization of transgene action at the post-transcriptional level: High quality parthenocarpic fruits in industrial tomatoes. *BMC Biol*. **2**: 1-11.

Patel, J. S., Sitapara, H.H. and Patel, K.A. (2012). Influence of plant growth regulators on growth, yield and quality of tomato and brinjal, *Internat. J. Forestry & Crop Improv*. **3**(2): 116-118.

Patil, A.V. and Mahajan, P.H. (1971). Effect of plant growth regulator on growth, yield and eariness in tomato. Res. *J. Mahatma Phule Agril. Univ.* **2**(1): 56-60.

Perenz, Z. M. and Olivers, G.R. (1980). Effect of season and growth regulators on flowering, fruit set and development of the tomato. *J. Agic. Univ. Puerto Rice.* **64**(4): 460-473.

Petronk, A.V. and Lovan, T.I. (1975). Application of synthetic growth substance in green house tomato cultivation. *Balovusakgo Univ. Hort.* **2**: 101-105.

Pramanik, K. and Mohapatra, P. P. (2017). Role of Auxin on Growth, Yield and Quality of Tomato - A Review. *Int. J. Curr. Microbiol. App. Sci.* **6**(11): 1624-1636.

Pramanik, K., Das, S.P., Acharya, L.K. and Jayapuria, D. (2017). Role of gibberellic acid on growth, yield and quality of tomato: A Review. *Inter. J. of Chemical Studies.* **5**(6): 826-830.

Pundir J.P.S. and Yadav, P.K. (2001). Note on effect of GA3 NAA and 2, 4-D on growth, yield and quality of tomato var. Punjab Chuhara. *Curr. Agric*. **25**: 137-138.

Rafeeker, M., Nair, S.A., Sorte, P.N., Hatwal, G.P. and Chandhan, P.N. (2002). Effect of growth regulators on growth and yield of summer cucumber. *Soils Crops*. **12**(l): 108-110.

Rai, G.K., Singh, J., Singh, S. and Gupta, A.K. (2002). Effect of plant growth regulators (IAA and NAA) and micronutrient mixture on growth yield and quality of tomato. *Annak. Boil.* **18**(1): 13-17.

Rai, N., Yadav, D.S., Patel, K.K., Yadav, R.K., Asati, B.S. and Chaubey, T. (2006). Effect of plant growth regulators on growth, yield and quality of tomato, *Solanumlycopersicon* Mill. grown under mid hill of Meghalaya. *Vegetable Sci*. **33**(2): 180-182.

Rapport, L. (1960). Effect of temperature and gibberellin on the growth of tomato fruits. *Nature wissen cha*. **17**: 285.

Rashid, M.M. (1999). Origin and distribution of tomato. Rashid Publishing House. DOHS, Dhaka-l000, pp.495-497.

Rastogi, A., Siddiqui, A., Mishra, B.K., Srivastava, M., Pandey, R., Misra, P., Singh, M. and Shukla, S. (2013). Effect of auxin and gibberellic acid on growth and yield components of linseed (*Linumusitatissimum* L.). *Crop Breed. Appl. Biotechnol.* **13**(2): 5.

Rodrigues, M.J., Warade, S.D. and Patil, S.D. (2001). Effect of growth regulators and truss sequence on hybrid seed yield of tomato hybrid. *Adv. Plant Sci*. **14**(2): 495-499.

Saleh, M.M.S. and Abdul, K.S. (1980). Effect of gibberellic acid and cycocel on growth, flowering and fruiting of tomato *(Lycopersiconesculentum*Mill.) *Plants Mesopotarma J. Agric.***15**(1): 137-166.

Sawhney, V.K. and Greyson, R.I. (1972). Fruit size increase in tomato following application on gebberellic acid. *J. Amer. Soc. Hort. Sci*. **97**(5): 589-590.

Serrani, J.C., Fos, M., Atare´s, A. and Garcı´a-Martı´nez, J. L. (2007). Effect of gibberellin and auxin on parthenocarpic fruit growth induction in the cv. Micro-Tom of tomato. *J. Plant Growth Regul*. **26**: 211-221.

Shittu, G.A. and Adeleke, I.A. (1999). Effect of gibberellic acid on the growth and development of tomato *(Lycopersiconesculetum* Mill.) cultivar. *Global J. Pure Apply Sci.* **5**(1):27-30.

Singh B. K., Singh, A. K. and Rai, V. K. (2011). Role of NAA on growth, yield and quality of tomato (*Lycopersiconesculentum* Mill.) cultivars. *Envir. and Ecology*. **29**(3): 1091-1093.

Singh, J., Singh, M.P., Rajput, R.P. and Singh, D.B. (1981). Effect of pre-sowing treatment with growth regulators on tomato. *Food Farming and Agric*. **14**(6): 70-71.

Singh, K. and Upadhayaya, S. K. (1967). A comparative study of soil and foliar application of IAA and NAA on several response of tomato. *Horticulturist*. **2**: 3-9.

Singh R. and Sant, A.K. (2005). Effect of plant growth regulator's and micronutrient mixture on the growth and yield of tomato. *Bioved.* **16**(1): 101-105.

Stowe, B. B. and Yamaki, T. (1957). The history and physiological action of the gibberellins. *Ann. Rev. Plant Physiol.* **8**: 181.

Thakur, B. R., Singh, R. K. and Nelson, P. (1996). Quality attributes of processed tomato products: A review. *Food Res. Int*. **12**: 375-401.

The Holganix Blog (2013). What are plant auxins? And how do they affect plant growth? (https://www.holganix.com/blog/what-are-plant-auxins-and-how-do-they-affect-plant-growth)

Tomar, I. S. and Ramgiry, S. R. (1997). Effect of growth regulators on yield and yield attributes in tomato (*Lycopersiconesculentum* Mill.). *Advances Pl. Sci*. **10**(2): 29-31.

Uddain, J., Hossain, A., K.M, Mostafa, M.G. and Rahman, M.J. (2009). Effect of Different Plant Growth Regulators on Growth and Yield of Tomato. *International J. of Sus. Agri.* **1**(3): 58 - 63

Verma, P. P. S., Meena, M. and Meena, S. K. (2014). Influence of Plant Growth Regulators on Growth, Flowering and Quality of Tomato (*LycopersiconEsculentum* Mill.). *Indian J. of Hill Farm.* **27**(2): 19-22.

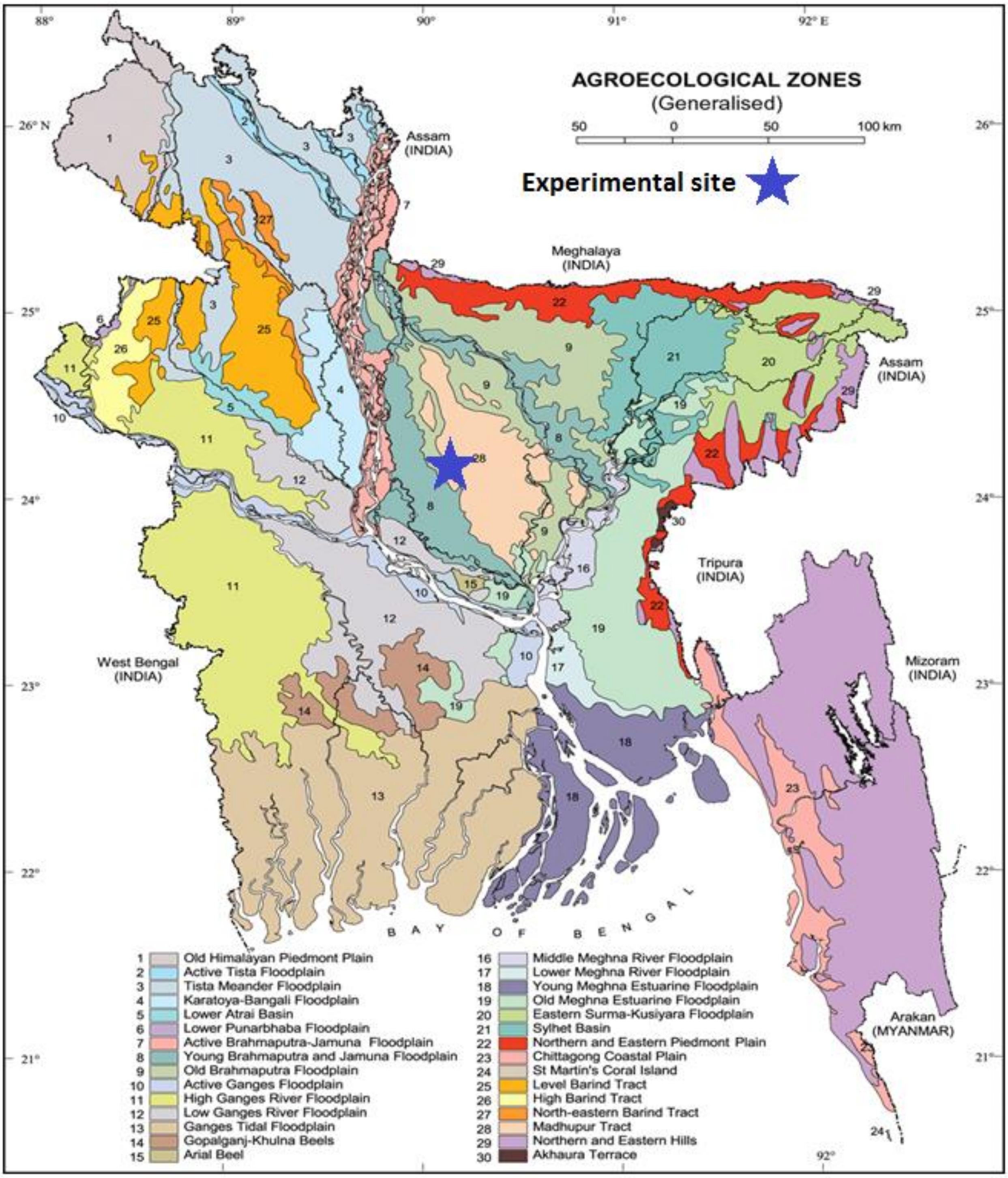
Wang, and Irving, H. R. (2011). Effects of several plant growth regulators on the yield of plant. *Notulae Botanicae Horti Agro botanici Cluj.* 38: 104-110

Wanjao, L. W. and Waithaka, K. (1983). The effect of GA_3-application on growth and flowering of liatris. *Scientia Hort*. **19**(4): 343-348

Wu, C.W., Lin, J.Y., Tarug, S.F. and Cheru, J.L. (1983). Effect of growth regulators on the growth and development of tomato and effect of plant growth regulators on vegetative growth of tomato. *J. Agric.China*. **124**: 31-42.

Appendices

Appendix I. Map showing the experimental site under study



Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from October 2016 to March 2017

Months	Maximum temperature (c^0)	Minimum temperature (c^0)	Relative humidity at 12 pm (%)	Rainfall (mm)
October 2016	36	24	64.5	76.1
November 2016	34	19	67	44.3
December 2016	30	16	65.5	0
January 2017	29	14	59.5	0
February 2017	32	15	54.5	8.1
March 2017	32	17	57.5	57.3

Source: Bangladesh Meteorological Department (Climate and weather division) Agargaon, Dhaka

Appendix III. Mean square values for Plant Height of BARI tomato 7 at different days after transplanting

Source of variation	Degrees of freedom	Plant Height of BARI tomato 7 at			
		35 DAT	50 DAT	65 DAT	80 DAT
Replication	2	104.47	60.405	125.803	81.973
Auxin	3	340.95**	450.90**	636.00**	681.89**
Gibberellic acid	2	67.70**	93.81**	224.17**	279.60**
Interaction	6	12.10**	4.45**	20.89**	16.66**
Error	22	0.019	0.113	0.042	0.176

**Significant at 1 % level

Appendix IV. Mean square values for number of leaves per plant of BARI tomato 7 at different days after transplanting

Source of variation	Degrees of freedom	Number of Leaves of BARI tomato 7			
		35 DAT	50 DAT	65 DAT	80 DAT
Replication	2	164.77	414.91	436.04	196.84
Auxin	3	179.39**	190.08**	235.74**	206.00**
Gibberellic acid	2	74.65**	83.70**	125.88**	74.93**
Interaction	6	16.64**	11.84**	25.42**	17.87**
Error	22	0.401	0.246	0.105	0.113

**Significant at 1 % level

Appendix V. Mean square values for number of branches and number of flowers per plant of BARI tomato 7

Source of variation	Degrees of freedom	Number of branches per plant	Number of flowers per plant
Replication	2	3.19	317.114
Auxin	3	23.49**	970.32**
Gibberellic acid	2	8.87**	219.79**
Interaction	6	0.56**	6.59**
Error	22	0	2.23

**Significant at 1 % level

Appendix VI. Mean square values for flowering and maturity duration of BARI tomato 7

Source of variation	Degrees of freedom	Days to flowering	Days to first Harvest
Replication	2	3.918	12.04
Auxin	3	141.13**	141.38**
Gibberellic acid	2	12.43**	12.53**
Interaction	6	1.69**	1.59**
Error	22	0	0

**Significant at 1 % level

Appendix VII. Mean square values for number of fruit and yield per plant of BARI tomato 7

Source of variation	Degrees of freedom	Total Number of fruit per plant	Yield/plant	Yield/plot	Yield/hectare
Replication	2	90.427	1.048	20.96	52.4
Auxin	3	360.47**	5.27**	105.40**	263.50**
Gibberellic acid	2	167.68**	1.36**	27.20**	68.00**
Interaction	6	9.68**	0.13**	2.60**	6.50**
Error	22	0.281	0.139	0.139	0.139

**Significant at 1 % level

Appendix VIII. Mean square values for nutrient content of BARI tomato 7

Source of variation	Degrees of freedom	Calcium	Magnesium	Potassium	Niacin	Phosphorous	Iron
Auxin	3	0.32**	0.12**	2.63**	0.015	0.05**	25413.84**
Gibberellic acid	2	2.57**	0.94**	1.61**	0.56*	0.10**	15290.34**
Interaction	6	0.66**	0.24**	0.79**	1.59*	0.06**	28558.53**
Error	24	0.001	0.002	0.006	0.03	0.002	408.333

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

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