EFFECT OF GIBBERELLIC ACID ON GROWTH, YIELD AND QUALITY OF TOMATO

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DECEMBER, 2015

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REG. NO. : 14-06311

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

MASTER OF SCIENCE (MS)
IN
AGRICULTURAL BOTANY

SEMESTER: JULY-DECEMBER, 2015

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Gibberellic Acid on Growth, Yield and Quality of Tomato'** submitted to the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Agricultural Botany,** embodies the results of a piece of bonafide research work carried out by **Moury Akter,** Registration No. **14-06311** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
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TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are due to the Almighty Allah, the Supreme Ruler of the universe who enables the author to complete this present piece of work. Tthe author deems it a great pleasure to express her profound gratefulness to her respected parents, who entiled much hardship inspiring for prosecuting her studies, receiving proper education.

The author feels proud to express her heartiest sence of gratitude, sincere appreciation and immense indebtedness to her Supervisor Dr. Md. Ashabul Hoque, Associate Professor and Chairman, Department of Agricultural Botany, Sher-e-Bangla Agricultural University (SAU), Dhaka, for his continuous scholastic and intellectual guidance, cooperation, constructive criticism and suggestions in carrying out the research work and preparation of thesis, without his intense co-operation this work would not have been possible.

The author feels proud to express her deepest respect, sincere appreciation and immense indebtedness to her Co-supervisor Dr. Shahnaz Sarkar, Professor Department of Agricultural Botany, SAU, Dhaka, for her scholastic and continuous guidance, constructive criticism and valuable suggestions during the entire period of course and research work and preparation of this thesis.

The author also expresses her heartfelt thanks to all the teachers of the Department of Agricultural Botany, SAU, for their valuable teaching, suggestions and encouragement during the period of the study.

The author expresses her sincere appreciation to her husband, colleages, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study.

The Author

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ABSTRACT

The experiment was conducted during the period from November 2014 to March 2015 in the experimental field of Sher-e-Bangla Agricultural University, Dhaka to find out the effect of gibberellic acid on growth, yield and quality of tomato. The experiment comprised of two factors. Factor A: Different tomato varieties (2 varieties)-V_1: Ratan and V_2: Mintoo hybrid and Factors B: Different levels of gibberellic acid-GA_3 (4 levels)- G_0: 0 ppm GA_3 (control); G_1: 20 ppm GA_3; G_2: 40 ppm GA_3 and G_3: 60 ppm GA_3. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. For different variety, at 20, 30, 40, 50, 60 days after transplanting (DAT) and at final harvest, the taller plants (15.92, 40.71, 60.72, 75.73, 83.88 and 86.60 cm, respectively) were found from V_2, while the shorter plants (14.78, 37.40, 57.13, 71.05, 79.37 and 82.76 cm, respectively) were found from V_1. The maximum fruit setting (64.94%), maximum fruit yield/hectare (85.08 ton) and maximum total soluble solid (4.29%) was found from V_2 and the minimum fruit setting (63.93%), minimum fruit yield/hectare (70.52 ton) and the minimum total soluble solid (4.20%) was found from V_1. In case of different levels of GA_3, at 20, 30, 40, 50, 60 DAT and final harvest, the tallest plant (16.37, 41.20, 61.69, 77.39, 85.10 and 87.74 cm, respectively) was found from G_3, whereas the shortest plant (13.32, 35.87, 54.37, 65.91, 75.79 and 79.67 cm, respectively) ere found from G_0. The maximum fruit setting (65.83%), maximum fruit yield/hectare (84.91 ton) and maximum total soluble solid (4.38%) was observed from G_3, while the minimum fruit setting (60.97%), minimum fruit yield/hectare (64.87 ton) and minimum total soluble solid (4.05%) was recorded from G_0. Due to the interaction effect of different variety and levels of GA_3, at 20, 30, 40, 50, 60 DAT and final harvest, the tallest plant (18.34, 44.33, 64.91, 82.19, 89.39 and 91.69 cm, respectively) were recorded from V_2G_3 and the shortest plant (12.66, 33.63, 52.44, 64.82, 75.18 and 78.96 cm, respectively) were found from V_1G_0. The maximum fruit setting (66.22%), maximum fruit yield/hectare (97.52 ton) and maximum total soluble solid (4.53%) was found from V_2G_3, whereas the minimum fruit setting (58.57%), minimum fruit yield/hectare (62.65 ton) and minimum total soluble solid (4.05%) was observed from V_1G_0. Among the combination of different variety and levels of GA_3, Mintoo hybrid tomato and 60 ppm GA_3 induced superior growth, yield contributing characters, yield and quality of tomato.

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CHAPTER I

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae is one of the most popular and nutritious vegetables of Bangladesh (Mondal *et al*., 2011). The centre of origin of the genus Solanum is the Andean zone particularly Peru-Ecuador-Bolivian areas (Salunkhe *et al*., 1987), but cultivated tomato originated in Mexico. Tomato ranks top of the list of canned vegetables and next to potato and sweet potato in the world vegetable production (FAOSTAT, 2013). Food value of tomato is very rich due to the higher contents of vitamins A, B and C including calcium and carotene (Bose and Som, 1990). Tomato adds flavor to the foods and it is also rich in medicinal value. It is widely employed in cannery and made into soups, conserves, pickles, ketchup, sauces, juices etc.

Tomato contains 94 g water, 0.5 g minerals, 0.8 g fibre, 0.9 g protein, 0.2 g fat and 3.6 g carbohydrate and other elements like 48 mg calcium, 0.4 mg iron, 356 mg carotene, 0.12 mg vitamin B-1, 0.06 mg vitamin B-2 and 27 mg vitamin C in each 100 g edible ripen tomato (BARI, 2010). More than 7% of total vitamin-C of vegetable origin comes from tomato in Bangladesh. There has been a gradual increase in the area of land cropped to tomato and this led to marginal increases in tomato production. The present leading tomato producing countries of the world are China, United States of America, Turkey, India, Egypt, Italy, Iran, Spain, Brazil Mexico, and Russia (FAOSTAT, 2013). The total production of tomato was 339 lac tons in China, 137 lac tons in USA, 109 lac tons in Turkey, 103 lac tons in India and 92 lac tons in Egyptin (FAO, 2010). Nowadays, tomatoes are grown round the year. Due to increasing consumption of tomato products, the crop is becoming promising. Now Bangladesh is producing a good amount of tomatoes and is grown round the year. In Bangladesh, it is mainly cultivated as winter vegetable, which occupies an area of 26,316.2 hectares in the year of 2012-2013 with the total production of 251 thousand metric tons (BBS, 2013).

In Bangladesh, the yield of tomato is not satisfactory in comparison with other tomato growing countries of the World (Aditya *et al*., 1997). The low yield of tomato in Bangladesh however is not an indication of low yielding potentially of this crop but the fact that the low yield may be attributed to a number of reasons, viz. unavailability of quality seeds of high yielding varieties, land for production based on fertilizer management, pest infestation and improper irrigation facilities as well as improved management technology. Use of high yielding variety and plant growth regulator is prerequisite for increasing the production of tomato. Plant growth regulators (PGR's) are organic compounds, which need in small amounts, somehow modify a given physiological plant process. It plays an important role in many aspects of plant growth and development (Patil *et al*., 1987; Dharmender *et al*., 1996). Generally PGR's are responses differently in terms of yield contributing characters and yield of tomato for different variety/genotypes in different concentration, time and methods of their application.

It is well known that variety plays an important role in producing high yield of tomato because different varieties perform differently for their genotypic characters. Improved variety is the first and foremost requirement for initiation and accelerated crop production program (Ojo *et al*., 2013). Different types of local races, advanced lines and exotic materials of tomato seed are available in our country. Bangladesh Agricultural Research Institute (BARI), Bangladesh Institute of Nuclear Agriculture (BINA) released some tomato varieties. Besides these some hybrid also available in farmers level also but it is necessary to identify the suitable variety in farmer's level. Yield contributing characters and yield of tomato varied significantly due to different variety (Kayum *et al*., 2008; Hossain *et al*., 2013; and Biswas *et al*., 2015). Variety is the key component to produce higher yield of tomato depending upon their differences in genotypic characters, different input requirements and responses, growth process and off course the prevailing growing environmental conditions during the entire growing season of tomato.

Plant growth regulators (PGRs) are extensively used in horticultural crops to enhance plant growth and improve yield by increasing fruit number, fruit set and size. Plant growth regulators like promoters, inhibitors or retardants play a key role in controlling internal mechanisms of plant growth by interacting with key metabolic processes such as, nucleic acid metabolism and protein synthesis (Kumar *et al*., 2014). Recently, there has been global realization of the important role of PGR's in increasing crop yield. The most widely available plant growth regulator is GA_3 or gibberellic acid, which is an important growth stimulating substances promote cell elongation and cell division and help in the growth and development of plants (Prasad *et al*., 2013). The application of GA_3 had significantly increased the number of fruits per plant than the untreated controls (Tomar and Ramgiry, 1997). To increase the yield as well as to avoid flower and fruit dropping, application of GA_3 at optimum concentration and at right time is important. Gibberellin has been reported to be very effective to overcome the problems of flower and fruit development in tomato (Rai *et al*., 2006). So, GA_3 has great effects on plant physiological systems including fruit setting, leaf expansion, germination, breaking dormancy, increasing fruit size, improving fruit quality and in many other aspects of plant growth and thereby on crop production (Rahman *et al*., 2015).

Considering the above mentioned facts and based on the prior observation, an investigation was undertaken with the following objectives:

- To find out the varietal performance in terms of plant growth, yield and quality of tomato;
- To assess the appropriate concentration of gibberellic acid for increasing plant growth, yield and quality of tomato and
- To identify the suitable variety and optimum concentration of gibberellic acid for better plant growth, yield and quality of tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the important popular and nutritious vegetable in Bangladesh and other countries of the world and it has drawn attention by the researchers for it diversified way of consumptions. It is adapted to a wide range of climates ranging from tropics to within a few degree of the Artic Circle. However, in spite of its broad adaptation, production is concentrated facing in diverse type biotic and abiotic factors. Variety and plant growth regulators e.g. GA_3 play an effective role for the growth and yield of tomato. But very few research works available related to growth, yield and development of tomato due to variety and GA_3. The research work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works and research findings related to variety and GA_3 in tomato, so far been done at home and abroad, have been reviewed in this chapter under the following headings-

2.1 Influence of variety on yield contributing characters and yield of tomato

Hamid *et al*. (2005) conducted a research at Research Farm of University College of Agriculture, Rawalakot, Azad Kashmir to study the performance of five Russian (Raickoi Naclazdenie, Belai Nalev, Ceberckoi Ckorocpelai, Novichok, Patris) and one local variety of tomato under Rawalakot conditions. The results indicated that maximum plant height and size of fruit were observed in variety Raickoi Naclazdenie, whereas maximum number of flower clusters and fruits per plant were observed in 'Paths'. Minimum plant height, number of flower clusters and fruits were noted in Novichok, where as minimum number of branches and fruit weight/plant was noted in Local Kashmir. Varieties Ceberckoi ckorocpelai and Patris gave maximum fruit weight of 4.96 and 4.85 kg/plant compared to the minimum of 1.60 kg/plant by local check and Novichok.

A field study was conducted by Rajashekar *et al*. (2006) on the effect of planting seasons on seed yield and quality of tomato varieties *Viz.*, Nandi, Sankranthi, and Vybav resistant to leaf curl virus. The results revealed that in seed crop raised in *rabi* season record significantly higher growth and yield parameters. Maximum fruit yield (71 t/ha) and seed yield (287.38 kg/ha) was noticed in *rabi* season followed by *kharif.* There was drastic reduction in fruit and seed yield in summer. Among varieties, Vybav recorded highest fruit yield in all the three planting seasons, but has recorded lowest fruit to seed ratio (0.19%). While, the highest seed to fruit ratio was observed in Arka Vikas. Nandi recorded highest seed yield/ha (424.87 kg) during *rabi* season.

Three popular tomato varieties namely, Ratan, BARI tomato-3 and BARI tomato-6 were experimentally evaluated by Kayum *et al*. (2008) to identify the potential mulch on growth and yield, where the experiment consisted of four mulching treatments. In the experiment, variety Ratan produced the highest (73.74 t/ha) fruit yield, while BARI tomato-3 showed the lowest (58.89 t/ha) fruit yield. The combination of water hyacinth and Ratan produced the maximum yield (82.16 t/ha).

An experiment was conducted by Ahammad *et al*. (2009) at Jessore to observe the effect of planting date and variety on the yield of late planting tomato. The potentiality of fruiting in the late season were evaluated for BARI tomato 4, 5, 6 and different planting time. A combination of December 01 planting with BARI Tomato 5 variety performed better in respect of yield (57.07 t/ha). The variety BARI Tomato 5 also showed potential fruiting capability during late winter season and February 01 planting produced 11 ton/ha of potential yield.

Three separate field experiments were conducted by Olaoye *et al.* (2009) at the Teaching and Research Farm, University of Ilorin, Nigeria on an alfisol with low inherent fertility status to study the effect of two conventional tillage methods on yield of tomato (*Lycopersicon esculentum*). The conventional tillage treatments were used to assess the response of the varieties to four N-Fertilizer regimes, two different growing seasons and two moisture regimes respectively. Roma (check variety) significantly yielded higher than other varieties under both N-Fertilizer regimes and growing seasons while Periondonta was superior for fruit yield under moisture regime.

Olaniyi *et al*. (2010) conducted experiments at the Teaching and Research farm of the Faculty of Agricultural Sciences, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso to evaluate the growth, fruit yield and quality of seven varieties of tomato in the Guinea Savannah zone of South West Nigeria. The varieties tested were, DT97/162A(R), DT97/215A, Tropical, Roma VF, UC82B, Ibadan local and Ogbomoso local. Growth, yield, mineral content and quality attributes of tomato were assessed. The results showed that DT97/162A(R) gave the highest height whereas Ogbomoso local recorded the highest number of leaves at 6 weeks after transplanting. Higher fruit yield was recorded from UC82B, closely followed by Ibadan and Ogbomoso local. Although, there is inconsistence in the results of the nutritional compositions of tomato fruits, the local varieties (Ogbomoso and Ibadan Local) closely followed by UC82B recorded most of the nutritional values more than the other varieties. Therefore UC82B, Ibadan and Ogbomoso local in that descending order are better in terms of fruit yield and quality.

Three processing and six fresh market tomato varieties were evaluated by Tigist *et al*. (2012) for yield and related traits. The tomato varieties harvested at "mature green” stage were evaluated for changes in physical quality characteristics during the storage period of 32 days under ambient conditions. Physical properties including average fruit weight, fruit volume, specific gravity, juice content and weight loss were assessed during the storage period. Tomato varieties had significant effects on yield and quality. Fresh market tomato variety *Fetane* was the highest yielder. *Marglobe Improved* had the highest physical quality characteristics while *Fetane* showed the lowest values. The highest weight loss was obtained in Metadel compared with all other varieties throughout the storage period. Melkashola had the highest physical quality characteristics than the other two processing varieties while weight loss was almost similar with *Roma VF* during most of the storage periods.

Field experiments were conducted by Ojo *et al*. (2013) at the Teaching and Research Farm of the University of Agriculture, Makurdi rain fed cropping season with the objective of evaluating the performance of tomato varieties in the Southern Guinea Savanna ecology of Nigeria. The experimental designed while four varieties of tomato namely Roma Savanna VF (an improved variety), two hybrid varieties (F_1 Lindo and F_1 Jaguar) and a local variety (Local check) constituted the treatments. Highly significant variety effect was observed for all the traits (days to flowering, fruit length, fruit diameter, number of fruit s/plant, weight of fruits/plant and fruit yield) studied, indicating that the varieties evaluated are genetically diverse. The highest values for fruit length, fruit diameter, number of fruits/plant, weight of fruits/plant and fruit yield observed for Roma Savanna VF is an indication that this variety has the potential for good performance in the southern guinea savanna ecology of Nigeria.

The experiment was conducted by Hossain *et al*. (2013) at Agricultural Research Station, Thakurgaon, Bangladesh to observe the effect of sowing dates on yield of tomato genotypes. Three sowing dates were considered as factor A and tomato variety viz., BARI Tomato-2, BARI Tomato-3, BARI Tomato-4, BARI Tomato-9 and BARI Hybrid Tomato-4 considered as factor B. Among the variety, BARI Tomat-2 produced the highest (68.12 t/ha) marketable yield followed by BARI Tomato-9 (56.16 t/ha) and BARI Tomato-3 while BARI Tomato-4 gave the lowest (36.91 t/ha) marketable yield.

The agronomic response of four tomato (*Solanum lycopersicum L.*) varieties to fertilizer application was examined by Agyeman *et al*. (2014) at the CSIR-Crops Research Institute, Kwadaso-Kumasi in the Forest agro-ecological zone of Ghana. The four tomato varieties Shasta, Heinz, CRI POO and CRI 034 were evaluated on different fertilizer types. The CSIR-CRI breeding lines (CRI P00 and CRI P034) were able to yield higher than the exotic varieties. CRI POO with

Winner + Sulfan fertilizer application also produced significantly higher fruit yield (26.4 t/ha). Results from this study showed that tomato yields in the Forest zones in Ghana can be increased using improved varieties and recommended fertilizer rates.

Field experiments were conducted by Degri and Sani (2015) at Gombe State Agricultural Development trial farm, Kwadon, Gombe State with four improved tomato varieties and one local variety as treatments replicated four times. Different insect pest species were counted and recorded, plant height, mean number of branches, fruits, mean number of holes, damaged and undamaged fruits were recorded. The results indicated that improved tomato varieties used for the study had less insect pest species, produced taller plants, more branches and fruits compared to the local variety. Tomato farmers in the study area should be advised to adopt the use of improved tomato varieties for cultivation.

Field experiments were conducted by Enujeke and Emuh (2015) cropping seasons in the Teaching and Research Farm of Delta State University, Asaba Campus, Asaba, Nigeria. Parameters assessed to achieve the objectives of the study were plant height, number of leaves/plant number of flowers/plant number of fruits/plant and fresh fruit weight at maturity. The results of the 2 years investigation showed that hybrid variety UC82B was superior to other varieties tested with mean height of 52 cm, mean number of leaves/plant of 53 cm, mean number of flowers/plant of 26 cm, mean number of fruits/plant of 27 cm, and mean fresh fruit weight of 18.5 t/ha. Based on the findings of the study, it was recommended that farmers should grow tomato hybrid variety UC82B for increased growth and yield in Asaba area of Delta State, Nigeria.

The response of three varieties of tomatoes to liquid organic fertilizer and inorganic fertilizer and for soil improvements was studied by Nnabude *et al.* (2015) in the Teaching and Research Farm of the Faculty of Agriculture, Chukwuemeka Odumegwu Ojukwu Univerrsity, Igbariam Campus. The treatments comprised 1.4 ml Alfa life (organic fertilizer) mixed with 81 ml of water, 180 g NPK 20:10:10 (mineral fertilizer) and control where no treatment was applied. The results of the study indicated non-significant differences among the tomato varieties and rates of treatment applied in most of the parameters assessed. Higher fruit yield was recorded in local variety and NPK Fertilizer with value of 96.0 g $plant^{-1}$ and 57.20 g $plant^{-1}$, respectively. The interaction between fertilizers and tomato varieties significantly affected the plant height relative to other growth parameters and was effective as week after planting increased.

Biswas *et al*. (2015) conducted an experiment at Agronomy Farm of the Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar Dhaka to study growth and yield responses of tomato varieties. Experiment consisted of four varieties, viz. BARI Tomato-4 (V_1), BARI Tomato-5 (V_2), BARI Tomato-7 (V_3) and BARI Tomato-9 (V_4). Tallest plant (101.3 cm), maximum number of leaves (114.1/plant) and maximum number of branches (10.0/plant) was found from BARI Tomato-7. While maximum number of flowers (6.1/cluster), number of fruits (5.0/cluster), number of clusters (17.9/plant) were found from BARI Tomato-9. However, maximum fruit diameter (20.1 cm), individual fruit weight (115.9 g), yield (34.7 kg/plot and 95.9 t/ha), number of locule (4.4/fruit) were also found from BARI Tomato-7. It was revealed that the virus infestation, fruit length and Total soluble solid (TSS) were statistically identical among the varieties under this study.

2.2 Influence of GA_3 on yield contributing characters and yield of tomato

The effects of NAA (25, 50 and 75 ppm), gibberellic acid (15, 30 and 45 ppm) and 4-CPA (25, 50 and 75 ppm) on the growth and yield of tomato cultivars Dhanashree and Rajashree were determined by Bhosle *et al*. (2002) in a field experiment conducted in Rahuri, Maharashtra, India during the summer of 1997. The number of flowers per cluster, fruit weight and marketable yield increased with increasing rates of the plant growth regulators. Treatment with 30 ppm gibberellic acid resulted in the tallest plants, whereas treatment with 45 ppm gibberellic acid resulted in the highest number of primary branches of Dhanashree (4.16) and Rajashree (5.38), respectively.

Meena (2008) conducted an experiment with foliar spray of GA_3 and found GA_3 at 50 or 75 ppm recorded significantly lower fruit drop percentage. Significantly higher total soluble solids, ascorbic acid content and TSS/acid ratio and lower acidity percentage were observed with application of GA_3 at 50 ppm. The maximum benefit-cost ratio of 5.57 was recorded with application of GA_3 at 50 ppm followed by NAA at 50 ppm (3.04). Significantly more plant height and plant spread at 60 DAT and at harvest, leaf area per plant at harvest, number of flowers per plant, fruit set percentage, number of fruits per plant, average fruit weight and fruit yield and lower fruit drop percentage were recorded with application of boron as foliar spray @ 2.0 kg/ha.

The experiment was conducted by Gelmesa *et al*. (2012) with the objective of determining the effects of different concentrations and combinations of the plant growth regulators (PGRs) 2,4-dichlorophenoxyacetic acid (2,4-D) and gibberellic acid (GA_3) spray on fruit setting and earliness of tomato varieties. The experiment consisted of one processing (Roma VF) and one fresh market (Fetan), tomato varieties, three levels of 2,4-D (0, 5 and 10 ppm) and four levels of GA_3 (0, 10, 15 and 20 ppm) arranged in a $2 \times 3 \times 4$ factorial combinations. Application of GA_3 extended flowering and maturity time and increased fruit number per cluster, fruit set percentage and marketable fruit number per plant over the control.

A field trial was carried out by Prasad *et al*. (2013) on the effect of GA_3 and NAA on tomato cv. Kashi Vishesh during the rabi season. The different concentration of GA_3 (20, 40, 60 and 80 ppm) and NAA (25, 50, 75 and 100 ppm) were sprayed on the crop to study the growth behavior and yield and yield attributes of tomato. It was found that there was a linear increase in growth parameters like plant height and number of branches per plant with increasing level of GA_3 and NAA. The maximum plant height was recorded as 85.3 cm and 82.3 cm with the application of GA_3 @ 80 ppm after 60 days of transplanting. Similarly, the yield and yield attributes were also affected significantly with increasing concentrations of GA_3. A maximum yield of 483.6 q/ha was obtained with the use of GA_3 @ 80 ppm.

A field experiment was carried out by Choudhury *et al*. (2013) at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh to assess the effect of different plant growth regulators on tomato. Different plant growth regulators (PGR) viz. PGR = Control, 0 PGR_1 = 4-CPA (4-chloro phenoxy acetic acid) @ 20 ppm, PGR_2 = GA_3 (Gibberellic Acid) @ 20 ppm and PGR_3 = 4-CPA + GA_3 @ 20 ppm of each were used in the study. The growth and yield contributing characters were significantly differed due to different plant growth regulators. The maximum plant height at 60 DAT (86.01 cm), number of flowers cluster per plant (10.60), number of flowers per plant (39.69), number of fruits per plant (36.54), single fruit weight (74.01 g) and yield (28.40 t /ha) were found in PGR and the minimum for all the parameters were found in control treatment.

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

A field experiment was carried out by Ranjeet *et al.* (2014) to assess the growth, flowering, fruiting yield and quality traits of Tomato cv. Kashi Vishesh (H-86). The experiment consisted of 10 treatments namely, Control, GA_3 20 ppm, GA_3 40 ppm, GA_3 60 ppm, NAA 10 ppm, NAA 20 ppm, NAA 30 ppm, 2, 4-D 10 ppm, 2, 4-D 15 ppm and 2, 4-D 20 ppm to find out the effect of the growth, flowering, fruiting, yield and quality of tomato Application of the plant bio regulators had a significant influence on plant growth, flowering, fruiting, yield and quality traits of tomato and GA_3 gave the highest yield than other plant growth regulators. So, GA_3 was superior among all treatments under investigation for response tomato production.

Mazed *et al.* (2014) carried out an experiment in the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh to find out the effect of GA_3 such as 80, 100 and 120 ppm with control and three different pruning levels. It was revealed that GA_3 significantly influenced the growth and yield contributing characters of tomato. At 75 DAT, the highest plant height (117.30 cm), maximum number of leaves/plant (75.30) and highest yield (29.03 t/ha) were recorded from GA_3 spray at 120 ppm.

An experiment was conducted by Akand *et al.* (2015) in the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh to find out the effect of GA_3 on the growth and yield of tomato. The experiment consisted of four concentration of GA_3 such as control G_0= control (no GA_3), G_1= 75 ppm GA_3, G_2 = 100 ppm GA_3 and G_3= 125 ppm. All parameter varied significantly at different concentration of GA_3. The highest yield (92.99 t/ha) was obtained from G_3 treatment whereas the G_0 gave lowest yield (60.46 t/ha).

An experiment was carried out by Rahman *et al*. (2015) in pots at Bangladesh Institute of Nuclear Agriculture, Bangladesh to evaluate influence of different concentrations of GA_3 on biochemical parameters at different growth stages in order to maximize yield of summer tomato var. Binatomato-2. Results indicated that the highest chlorophyll and soluble protein contents were recorded when GA_3 was applied through root soaking followed by vegetative stage and the lowest was found at the flowering stage. In contrast, the highest nitrate reductase activity was observed when GA_3 was applied at the vegetative stage and the lowest activity was recorded at the flowering stage. The highest plant height was recorded when 50 ppm of GA_3 was applied at the vegetative stage, while, the longest time to first fruit setting was required when the roots of the seedlings were soaked in 100 ppm GA_3 solution. The application of 50 ppm GA_3 by root soaking had significantly increased the number of flowers, fruits and fruit yield per plant but similar results were achieved when only 25 ppm GA_3 was applied at the flowering stage. The fruit yield of tomato per plant increased linearly with the increased number of flowers and fruits per plant.

As per the above cited reviews, it may be concluded that variety and GA_3 are the important factors for attaining optimum growth and as well as highest yield of tomato. The literature revealed that the effects of variety and GA_3 have not been studied well and have no definite conclusion for the production of tomato in the agro climatic condition of Bangladesh.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the effect of gibberellic acid on growth, yield and quality of tomato. The materials and methods those were used for conducting the experiment have been presented in this chapter. It includes a short description of the location of experimental site, soil and climatic condition of the experimental area, materials used for the experiment, design of the experiment, data collection and data analysis procedure.

3.1 Description of the experimental site

3.1.1 Experimental period

The field experiment was conducted during the period from November 2014 to March 2015.

3.1.2 Description of experimental site

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^{0}74^{/}$N latitude and $88^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level.

3.1.3 Climatic condition

The climate of experimental site is subtropical, characterized by three distinct seasons, the post monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall during crop growing period were collected from Weather Yard, Bangladesh Meteorological Department, and presented in Appendix I. During the experimental period the maximum temperature (27.1^{0}C) was recorded from February 2015 and the minimum temperature (12.4^{0}C) from January 2015, highest relative humidity

(78%) was observed from November 2014, whereas the lowest relative humidity (67%) and highest rainfall (30 mm) was recorded in February, 2015.

3.1.4 Characteristics of soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ- 28) and the general soil type is Shallow Red Brown Terrace soil. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The soil was having a texture of silty clay with pH and organic matter 6.1 and 1.13, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay, which have been presented in Appendix II.

3.2 Experimental details

3.2.1 Treatment of the experiment

The experiment comprised of two factors

Factor A: Different tomato varieties (2 varieties)

i) V_1: Ratan

ii) V_2: Mintoo hybrid

Factors B: Different levels of gibberellic acid-GA_3 (4 levels)

i) G_0: 0 ppm GA_3 (control)

ii) G_1: 20 ppm GA_3

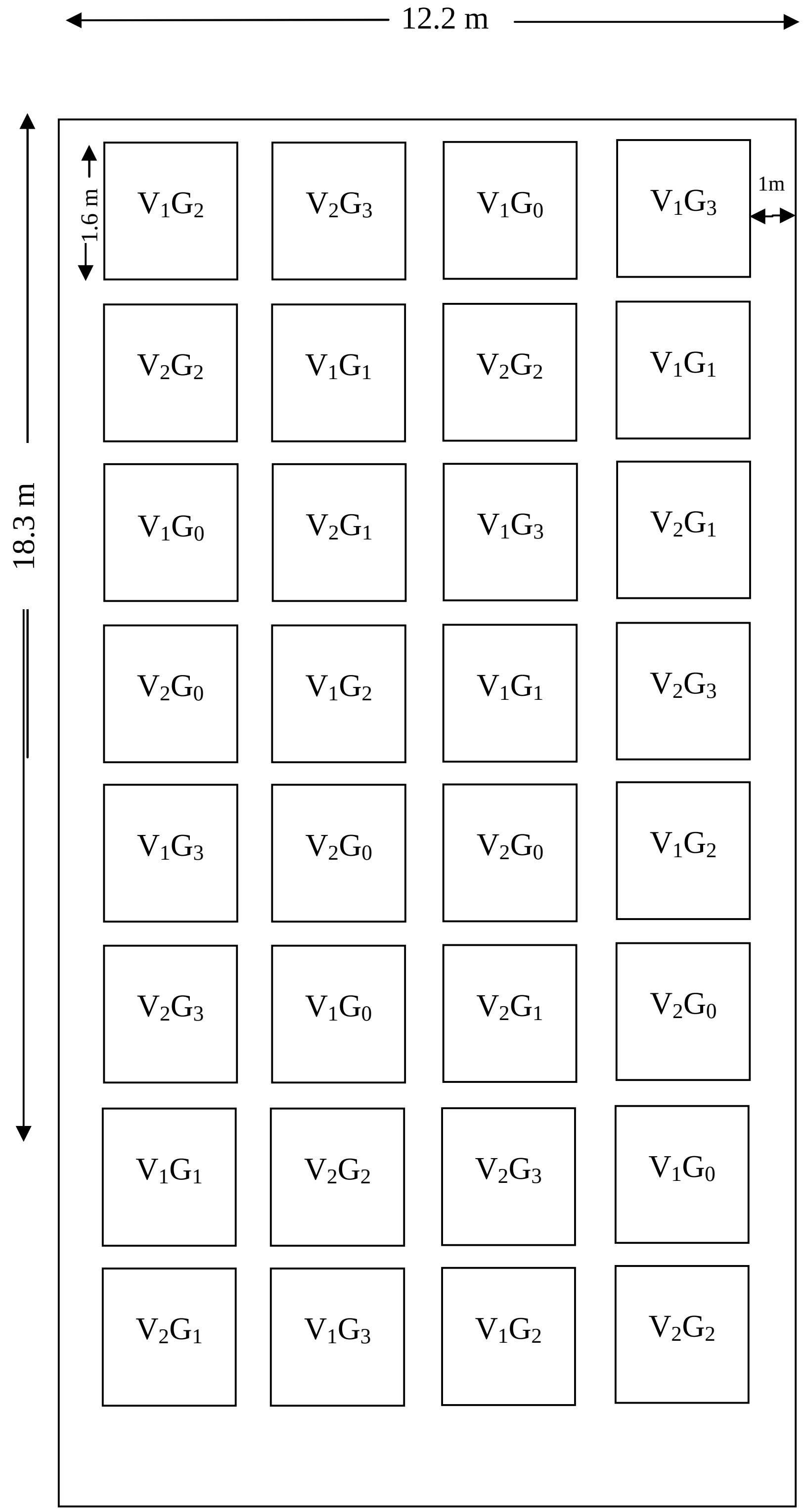
iii) G_2: 40 ppm GA_3

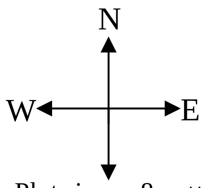
iv) G_3: 60 ppm GA_3

There were in total 8 (2×4) treatment combinations such as V_1G_0, V_1G_1, V_1G_2, V_1G_3, V_2G_0, V_2G_1, V_2G_2 and V_2G_3.

3.2.2 Experimental design and layout

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The experiment area was divided into four equal blocks. Each block contained 8 plots where 8 treatment combinations were allotted at random. There were 32 unit plot altogether in the experiment with the size of 1.8 m × 1.6 m. The distance between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.





Plot si[illegible] .8 m × 1.6 m

Plot spacing: 50 cm

Between replication: 1.0 m

Treatment

Factor A: Different tomato varieties (2 varieties)

i) V_1: Ratan

ii) V_2: Mintoo hybrid

Factors B: Different levels of gibberellic acid-GA_3 (4 levels)

i) G_0: 0 ppm GA_3 (control)

ii) G_1: 20 ppm GA_3

iii) G_2: 40 ppm GA_3

iv) G_3: 60 ppm GA_3

3.2.3 Preparation of the main field

The selected plot of the experiment was opened in the 1st week of November 2014 with a power tiller, and left exposed to the sun for a week. Subsequently ploughing cross ploughing was done five times with a country plough followed by laddering to make the land suitable for transplanting the seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved for transplanting of tomato seedlings. The soil was treated with insecticides (Cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of soil inhibiting insects such as cutworm and mole cricket.

3.2.4 Application of manure and fertilizers

Manures and fertilizers were applied to the experimental plot considering the recommended fertilizer doses of tomato (BARI, 2014). The fertilizers N, P and K were used in the form of urea, TSP and MoP, respectively and were applied following the below mentioned application procedure.

Table 1. Dose and method of application of fertilizers in tomato field

Fertilizers and Manures	Dose/ha	Application (%)			
		Basal	10 DAT	30 DAT	50 DAT
Cowdung	10 tonnes	100	--	--	--
Urea	300 kg	--	33.33	33.33	33.33
TSP	200 kg	100	--	--	--
MoP	220 kg	50	--	25.00	25.00

The total amount of cowdung and TSP was applied as basal dose at the time of final land preparation and mixed with soil properly. The total amount of urea was applied carefully in three equal installments at 10, 25 and 40 day after transplanting. Half amounts of MoP were applied during final land preparation and rest amount of MoP were applied carefully in two equal installments at 25 and 40 day after transplanting.

3.3 Growing of crops

3.3.1 Seed collection

Tomato variety Ratan and Mintoo hybrid, were used as plating materials in this experiment. Variety Ratan as high yielding variety was developed by Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Mintoo hybrid variety was developed by Lal Teer Seed Company. The seeds of Ratan and Mintoo hybrid were collected from BARI, Joydebpur, Gazipur and Siddique bazaar, Dhaka, respectively.

3.3.2 Raising of seedlings

The seedlings were raised at the Laboratory Farm, SAU, Dhaka under special care in a 3 m × 1 m size seed bed. The soil of the seed bed was well ploughed with a spade and prepared into loose friable dried masses and to obtain good tilth to provide a favorable condition for the vigorous growth of young seedlings. Weeds, stubbles and dead roots of the previous crop were removed. The seedbed was dried in the sun to destroy the soil insect and protect the young seedlings from the attack of damping off disease. To control damping off disease Cupravit fungicide were applied. Decomposed cowdung was applied to the prepared seedbed at the rate of 10 t/ha. Ten (10) grams of seeds were sown in seedbed on November 14, 2014. After sowing, the seeds were covered with the finished light soil. At the end of germination shading was done by bamboo mat (chatai) over the seedbed to protect the young seedlings from scorching sunshine and heavy rainfall. Light watering, weeding was done as and when necessary to provide seedlings with ideal condition for growth.

3.3.3 Transplanting of seedlings

Healthy and uniform seedlings were transplanting in the experimental plots on 18 December, 2014. The seedlings were uploaded carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance between row to row was 60 cm and plant to plant was 40 cm. As a result there are 12 seedlings were accommodated in each plot according to the design of the plot size at 1.8 m × 1.6 m. The young transplanted seedlings were shaded by banana leaf sheath during day to protect them from scorching sunshine up to 7 days until they were set in the soil. They (transplants) were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border of the experimental plots for gap filling.

3.3.4 Collection, preparation and application of GA_3

Plant growth regulator Gibberellic Acid (GA_3) was collected from Hatkhola Road, Dhaka. A 1000 ppm stock solution of GA_3 was prepared by dissolving 1 g of it in a small quantity of ethanol prior to dilution with distilled water in one litre of volumetric flask. The stock solution was used to prepare the required concentration for different treatment i.e. 20 ml of this stock solution was diluted in 1 litre of distilled water to get 20 ppm GA_3 solution. In a similar way, 40 and 60 ppm stock solutions were diluted to 1 litre of distilled water to get 40 and 60 ppm solution. Control solution also prepared only by adding a small quantity of ethanol with distilled water. GA_3 as per treatment were applied at two times 15, and 35 days after transplanting (DAT) by a mini hand sprayer.

3.3.5 Intercultural operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the tomato seedlings.

3.3.5.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. Replacement was done with healthy seedling having a boll of earth which was also planted on the same date by the side of the unit plot. The transplants were given shading and watering for 7 days for their proper establishment.

3.3.5.2 Weeding

The hand weeding was done 10, 25 and 40 days after transplanting to keep the plots free from weeds.

3.3.5.3 Earthing up

Earthing up was done at 25 and 40 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

3.3.5.4 Irrigation

Light watering was given by a watering can at every morning and afternoon after seedling transplanting. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings. Beside this a routine irrigation was given at 3 days intervals.

3.3.5.5 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seedling in the field. Cirocarb 3G were applied during final land preparation. Few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some plants were infected by *Alternaria* leaf spot diseases caused by *Alternaria spp.*. To prevent the spread of the disease Rovral @ 2 g per liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field.

3.4 Harvesting

Harvesting of the tomato was not possible on a certain or particular date because the fruits initiation as well as ripening of fruit in different plants were not uniform. Fruits were harvested at 5 days interval when the tomato fruits were attained slightly red color. Harvesting was started from February, 2015 and was continued up to March, 2015.

3.5 Data collection

Data were collected from 5 plants of each unit plot.

3.5.1 Plant height (cm)

Plant height was measured from plant of each unit plot from the ground level to the tip of the longest stem and mean value was calculated. Plant height was recorded at 10 days interval starting from 20 days of planting upto 60 days and at final harvest to observe the growth rate of plants.

3.5.2 Number of branches per plant

The total number of branches per plant was counted from plant of each unit plot. Data were recorded was recorded at 10 days interval starting from 20 days of planting upto 60 days and at final harvest.

3.5.3 Leaf area (cm^2)

Leaf area (LA) was determined from plant samples by using an automatic leaf area meter (Model LI-3100, Li-COR, Lincoln, NE, USA) immediately after removal of leaves from plants to avoid rolling and shrinkage. Leaf area was recorded at 10 days interval starting from 20 days of planting upto 60 days.

3.5.4 Days required to 1st flowering

Days required for transplanting to initiation of flowering was counted from the date of transplanting to the initiation of flowering and was recorded.

3.5.5 Number of flower cluster/plant

The number of flower cluster was counted from plant of each unit plot and the numbers of flower clusters produced per plant were recorded.

3.5.6 Number of flowers per cluster

The number of flower was counted from plant of each unit plot and number of flower produced per cluster was recorded on the basis of flower cluster per plant.

3.5.7 Number of flowers per plant

The number of flower per plant was counted from plant of each unit plot and the number of flowers per plant was recorded.

3.5.8 Number of fruits per cluster

The number of fruits per cluster was counted from plant of each unit plot and the number of fruits per clusters was recorded.

3.5.9 Number of fruits per plant

The number of fruit per plant was counted from plant of each unit plot and the number of fruits per plant was recorded.

3.5.10 Fruit setting (%)

Fruit setting was calculated by using the following formula and recorded -

$$\% \text{ Fruit setting} = \frac{\text{Number of fruits per plant}}{\text{Number of flowers per plant}} \times 100$$

3.5.11 Length of fruit (cm)

The length of fruit was measured with a measure scale from the neck of the fruit to the bottom of 5 selected marketable fruits from each plot and there average was taken and expressed in cm.

3.5.12 Diameter of fruit (cm)

Diameter of fruit was measured at the middle portion of 5 selected marketable fruits from each plot with a slide calipers and there average was taken and expressed in cm.

3.5.13 Dry matter of plant

After harvesting, 150 g plant sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of plant were computed by simple calculation from the weight recorded by the following formula:

$$\text{Dry matter content of plant (\%)} = \frac{\text{Dry weight of plant}}{\text{Fresh weight of plant}} \times 100$$

3.5.14 Dry matter of fruit

After harvesting, randomly selected 150 g fruit sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 60^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of fruit were computed by simple calculation from the weight recorded by the following formula:

$$\text{Dry matter content of fruit (\%)} = \frac{\text{Dry weight of fruit}}{\text{Fresh weight of fruit}} \times 100$$

3.5.15 Weight of individual fruit (g)

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

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

3.5.16 Yield per plant (kg)

Yield of tomato per plant was recorded as the whole fruit per plant harvested in different time and was expressed in kilogram.

3.5.17 Yield per hectare (ton)

The weight of fruits from each plot was measured using a weighing balance and converted into hectare and was expressed in ton.

3.5.18 Total Soluble Solids-TSS content (%)

Total soluble solids content of tomato pulp was estimated by using Abbes, Refractometer. A drop of tomato juice squeezed from the fruit pulp on the prism of the refractometer. Percent TSS was obtained from direct reading of the instrument. Temperature corrections were made by using the methods described by Ranganna (1994).

3.5.19 β-Caroten content (µg/100 g)

Carotenoids exhibit certain absorption spectrum exposed to specific wave length. An absorption spectrum depends on the unique absorption characteristics of a compound. These absorption properties were utilized to make quantitative determination of carotene.

Procedure

Two gm sample (tomato) was taken in a clean mortar. The sample was then grinded in the mortar with 80% acetone in presence of quartz sand (very small amount) and calcium carbonate (0.5mg). The resulting colored solution was then filtered by continuous washing with 80% acetone. The filtered was collected in a 50 ml volumetric flask and made to a final volume of 50 ml with 80% acetone. The filtered colored solution was carefully transferred to a separatory funnel and 20 ml petroleum ether was added to the solution. The funnel was shaken and placed for 20 minutes. The lower aqueous phase was discarded very carefully keeping the ether layer. To the ether layer, about 5 ml ethanol containing 5% KOH was added and shaken well and kept about 10 hours for complete saponification. Then, water was added gently to the saponified solution. By adding water, two distinct phases were visible. The lower aqueous phase was discarded carefully. The upper phase containing β carotene was washed with water several times for complete remove of KOH. The ether layer containing β carotene was transferred to a 25 ml volumetric flask and the flask was volume upto the mark by adding petroleum ether. From the petroleum ether extract, β carotene was estimated with the spectrophotometer at 451 nm wave length against petroleum ether as blank, by using the equation proposed by Shiraishi (1972).

$$\beta \text{ carotene } (\mu g/g) = 3.984\ (OD_{451})\ V/\ 1000\ W$$

Where,

V = Final volume of the petroleum ether β carotene extract (ml)

W = Fresh weight of the sample taken (g)

OD_{451} = Spectrophotometer reading at 451 nm wave length.

For evidence of study, the calculated results of β carotene were multiplied by 100.

3.5.20 Reducing sugar content

Sugar content of fruit pulp was determined to the method of Lane and Eynon (1923) by the following procedure

a) Standardization of Fehling's solution

Fifty ml of both Fehling's solution A and Fehling's solution B were mixed together in a beaker. Ten millimeter of the mixed solution was pipetted into a 250 ml conical flask and 25 ml distilled water was added to it standard sugar solution was taken in a burette. The conical flask containing mixed solution was heated on a hot plate. When the solution began to boil, three drops of methylene blue indicator solution was added to it without removing the flask from the hot plate. Mixed solution was titrated by standard sugar solution. The end point was indicated by depolarization of the indicator. Fehling's Factor was calculated by using the following formula-

Factor for Fehling's solution (g of invert sugar) = Titre × 2.5/1000

b) Preparation of sample

Twenty gram of fresh tomato fruit pulp was taken in a 100 ml beaker an then it was transferred to a blender machine and homogenized with distilled water.

After blending it was made up to the mark with distilled water. The pulp solution was filtered. One hundred milliliter of filtrate was taken in a 250 ml volumetric flask. Five milliliter of 45% neutral lead acetate solution was added to it and then shaken and waited for 10 minute. Five milliliter of 22% potassium oxalate solution was further added to the flask and the volume was made up to the mark with distilled and filtered.

Ten milliliter of mixed Fehling's solution was taken in a 250 ml conical flask and 50 ml distilled water was added to it. Filtrated pulp solution was taken in a burette. Conical flask containing the mixed Fehling's solution was heated on a hot plate. Three to five drops of methylene blue indicator were added to the flask when boiling started, and titrate with solution taken in the burette. The end point was indicated by decoloruization of indicator. Percentage of reducing sugar was calculated according to the following formula-

$$\text{Reducing sugar content (\%)} = \frac{F \times D \times 100}{T \times W \times 100}$$

Where, Fehling's factor

D = Dilution

T = Titre and

W = Weight or volume of the sample

Titration of total invert sugar

Fifty milliliter purified solution (filtrate) was taken in a 250 ml conical flask. Five gram citric acid and 50 ml distilled water were added to it. The conical flask containing sugar solution was boiled for inversion of sucrose and finally cooled. Then the solution was transferred to a 250 ml volumetric flask and neutralized by 1N NaOH using phenolphthalein indicator. The volume was made up to the mark with distilled water. Then the mixed Fehling's solution was titrated using similar procedure followed as in case of invert sugar (reducing sugar) mentioned earlier. The percentage of total invert sugar was calculated by using the formula used in case of reducing sugar.

3.5.21 Non-reducing sugar content

Non-reducing sugar of tomato fruit were computed by simple calculation using the following formula:

% non-reducing sugar = % total invert sugar - % reducing sugar

3.5.22 Total sugar content

Total sugar of tomato fruit were computed by simple calculation using the following formula:

% total sugar = % reducing sugar + % non-reducing sugar

3.6 Statistical analysis

The data obtained for different characters were statistically analyzed by using MSTAT-C computer package program to find out the significance of the difference for variety and levels of gibberellic acid on yield and yield contributing characters of tomato. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the ‘F’ (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of gibberellic acid (GA_3) on growth, yield and quality of tomato. Data on different growth characters, yield components, yield and quality of tomato was recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix III-VIII. The results have been discussed with the help of tables and graphs and possible interpretations given under the following headings:

4.1 Plant height

Different variety of tomato showed statistically significant differences on plant height at 20, 30, 40, 50, 60 days after transplanting (DAT) and final harvest (Appendix III). At 20, 30, 40, 50, 60 DAT and final harvest, the taller plants (15.92, 40.71, 60.72, 75.73, 83.88 and 86.60 cm, respectively) was recorded from V_2 (Mintoo hybrid), while the shorter plants (14.78, 37.40, 57.13, 71.05, 79.37 and 82.76 cm) was observed from V_1 (Ratan) at 20, 30, 40, 50, 60 DAT and final harvest, respectively (Figure 2). Different varieties produced different plant height on the basis of their varietal characteristics. Generally variety is the key component to produce plant height of tomato depending upon their differences in genotypic characters, input requirements and response, growth process and off course the prevailing environmental conditions during the entire growing season of tomato. Different earlier experiment reported that different variety produced different size of tomato plant. Improved variety is the first and foremost requirement for initiation and accelerated a successful crop production program (Ojo *et al*., 2013). Yield contributing characters as well as plant height of tomato varied significantly due to different variety that was also reported by Biswas *et al*. (2015) and from their experiment they recorded the tallest plant (101.3 cm) in BARI Tomato-7.

Plant height of tomato varied significantly due to different levels of GA_3 at 20, 30, 40, 50, 60 DAT and final harvest (Appendix III). At 20, 30, 40, 50, 60 DAT and final harvest, the tallest plant (16.37, 41.20, 61.69, 77.39, 85.10 and 87.74 cm, respectively) was found from G_3 (60 ppm GA_3) which was statistically similar (16.29, 41.08, 61.12, 76.99, 84.50 and 87.08 cm, respectively) to G_2 (40 ppm GA_3) and followed (15.41, 38.06, 58.51, 73.26, 81.11 and 84.24 cm, respectively) by G_1 (20 ppm GA_3), whereas the shortest plant (13.32, 35.87, 54.37, 65.91, 75.79 and 79.67 cm) was recorded from G_0 (control, i.e. 0 ppm GA_3) (Figure 3). Prasad *et al.* (2013) stated that GA_3 is an important growth stimulate substances promote cell elongation and cell division and help in growth and development of plant and reported maximum plant height as 85.3 cm with the application of GA_3 @ 80 ppm which is support the present study.

Interaction effect of different variety and levels of GA_3 showed statistically significant variation in terms of plant height of tomato at 20, 30, 40, 50, 60 DAT and final harvest (Appendix III). At 20, 30, 40, 50, 60 DAT and final harvest, the tallest plant (18.34, 44.33, 64.91, 82.19, 89.39 and 91.69 cm, respectively) was recorded from V_2G_3 (Mintoo with 60 ppm GA_3) and the shortest plant (12.66, 33.63, 52.44, 64.82, 75.18 and 78.96 cm, respectively) was found from V_1G_0 (Ratan with 0 ppm GA_3) treatment combination (Table 2).

4.2 Number of branches/plant

Statistically significant variation was recorded due to different variety of tomato on number of branches/plant at 20, 30, 40, 50, 60 DAT and final harvest (Appendix IV). At 20, 30, 40, 50, 60 DAT and final harvest, the maximum number of branches/plant (2.79, 7.32, 13.13, 14.50, 15.36 and 16.06, respectively) was found from V_2, while the minimum number of branches/plant (2.40, 6.11, 11.52, 12.71, 13.69 and 14.51, respectively) was observed from V_1 (Table 3). Management practices influence the number of branches/plant but varieties itself also manipulated it.

Table 2. Introduction effect of different variety and levels of gibberellic acid on plant height of tomato at different days after transplanting (DAT)

Treatment	Plant height (cm) at					
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	Final harvest
V_1G_0	12.66 d	33.63 e	52.44 d	64.82 d	75.18 d	78.96 e
V_1G_1	15.59 bc	37.28 d	56.89 c	71.77 c	79.33 bc	82.13 cde
V_1G_2	16.45 ab	40.62 bc	60.70 b	75.00 bc	82.17 b	84.73 bcd
V_1G_3	14.40 bcd	38.07 cd	58.47 bc	72.59 c	80.82 b	83.79 cde
V_2G_0	13.98 cd	38.12 cd	56.30 c	67.00 d	76.42 cd	80.38 de
V_2G_1	15.23 bc	38.84 bcd	60.13 b	74.76 bc	82.89 b	86.34 bc
V_2G_2	16.12 abc	41.54 ab	61.53 b	78.97 ab	86.83 a	89.43 ab
V_2G_3	18.34 a	44.33 a	64.91 a	82.19 a	89.39 a	91.69 a
$LSD_{(0.05)}$	2.175	2.852	3.055	4.097	3.931	4.655
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
CV(%)	9.64	4.97	6.53	3.80	4.28	5.74

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

V_1: Ratan　　V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control)　　G_1: 20 ppm GA_3

G_2: 40 ppm GA_3　　G_3: 60 ppm GA_3

Table 3. Effect of different variety and levels of gibberellic acid on number of branches/plant of tomato at different days after transplanting (DAT)

Treatment	Number of branches/plant at					
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	Final harvest
Different variety						
V_1	2.40 b	6.11 b	11.52 b	12.71 b	13.69 b	14.51 b
V_2	2.79 a	7.32 a	13.13 a	14.50 a	15.36 a	16.06 a
$LSD_{(0.05)}$	0.134	0.271	0.399	0.583	0.560	0.736
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.97	5.49	4.40	5.83	5.25	6.54
Levels of gibberellic acid						
G_0	1.92 c	6.03 c	10.68 c	11.85 c	13.00 b	14.00 b
G_1	2.58 b	6.65 b	12.48 b	13.73 b	14.63 a	15.25 a
G_2	2.90 a	7.03 ab	13.05 a	14.23 ab	15.05 a	15.75 a
G_3	2.97 a	7.17 a	13.10 a	14.63 a	15.43 a	16.15 a
$LSD_{(0.05)}$	0.189	0.384	0.564	0.825	0.793	1.040
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.97	5.49	4.40	5.83	5.25	6.54

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

V_1: Ratan — V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control) — G_1: 20 ppm GA_3

G_2: 40 ppm GA_3 — G_3: 60 ppm GA_3

Different levels of GA_3 varied significantly in terms of branches/plant of tomato at 20, 30, 40, 50, 60 DAT and final harvest (Appendix IV). At 20, 30, 40, 50, 60 DAT and final harvest, the maximum number of branches/plant (2.97, 7.17, 13.10, 14.63, 15.43 and 16.15, respectively) was observed from G_3 which was statistically similar (2.90, 7.03, 13.05, 14.23, 15.05 and 15.75, respectively) to G_2 and followed (2.58, 6.65, 12.48, 13.73, 14.63 and 15.25, respectively) by G_1, while the minimum number of branches/plant (1.92, 6.03, 10.68, 11.85, 13.00 and 14.00, respectively) was found from G_0 (Table 3).

Number of branches/plant of tomato at 20, 30, 40, 50, 60 DAT and final harvest showed statistically significant variation due to the interaction effect of different variety and levels of GA_3 (Appendix IV). At 20, 30, 40, 50, 60 DAT and final harvest, the maximum number of branches/plant (3.20, 7.70, 14.30, 16.15, 17.00 and 17.75, respectively) was found from V_2G_3, whereas the minimum number of branches/plant (1.90, 5.55, 10.30, 11.55, 12.90 and 13.90, respectively) from V_1G_0 treatment combination (Table 4).

4.3 Leaf area

Leaf area of tomato showed significant differences between two varieties of tomato at 20, 30, 40, 50 and 60 DAT (Appendix V). At 20, 30, 40, 50 and 60 DAT, the maximum leaf area (54.65, 81.81, 128.68, 156.70 and 160.04 cm^2, respectively) was observed from V_2, while the minimum leaf area (49.27, 77.36, 115.11, 147.24 and 150.01 cm^2, respectively) was found from V_1 (Table 5).

Statistically significant variation was recorded in terms of leaf area of tomato due to different levels of GA_3 at 20, 30, 40, 50 and 60 DAT (Appendix V). At 20, 30, 40, 50 and 60 DAT, the maximum leaf area (54.32, 84.02, 130.94, 167.49 and 170.54 cm^2, respectively) was recorded from G_3 which was statistically similar (53.68, 82.30, 128.56, 163.62 and 166.85 cm^2, respectively) to G_2 and followed (51.92, 78.96, 122.60, 153.96 and 156.67 cm^2, respectively) by G_1, while the minimum leaf area (47.92, 73.07, 105.49, 122.82 and 126.03 cm^2, respectively) was observed from G_0 (Table 5).

Table 4. Interaction effect of different variety and levels of gibberellic acid on number of branches/plant of tomato at different days after transplanting (DAT)

Treatment	Number of branches/plant at					
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	Final harvest
V_1G_0	1.90 e	5.55 c	10.30 e	11.55 e	12.90 c	13.90 d
V_1G_1	2.25 d	5.70 c	11.60 cd	12.70 cde	13.70 c	14.70 cd
V_1G_2	2.70 c	6.55 b	12.30 c	13.50 c	14.10 c	14.70 cd
V_1G_3	2.75 c	6.65 b	11.90 c	13.10 cd	13.85 c	14.55 cd
V_2G_0	1.95 e	6.50 b	11.05 de	12.15 de	13.10 c	14.10 d
V_2G_1	2.90 bc	7.60 a	13.35 b	14.75 b	15.55 b	15.80 bc
V_2G_2	3.10 ab	7.50 a	13.80 ab	14.95 b	16.00 ab	16.80 ab
V_2G_3	3.20 a	7.70 a	14.30 a	16.15 a	17.00 a	17.75 a
$LSD_{(0.05)}$	0.267	0.542	0.797	1.166	1.121	1.471
Level of significance	0.05	0.05	0.05	0.05	0.01	0.01
CV(%)	6.97	5.49	4.40	5.83	5.25	6.54

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

V_1: Ratan　　V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control)　　G_1: 20 ppm GA_3

G_2: 40 ppm GA_3　　G_3: 60 ppm GA_3

Table 5. Effect of different variety and levels of gibberellic acid on leaf area of tomato at different days after transplanting (DAT)

Treatment	Leaf area (cm^2)				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Different variety					
V_1	49.27 b	77.36 b	115.11 b	147.24 b	150.01 b
V_2	54.65 a	81.81 a	128.68 a	156.70 a	160.04 a
$LSD_{(0.05)}$	1.526	2.298	6.489	6.412	6.783
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.00	3.93	7.24	5.74	5.95
Levels of gibberellic acid					
G_0	47.92 c	73.07 c	105.49 b	122.82 c	126.03 c
G_1	51.92 b	78.96 b	122.60 a	153.96 b	156.67 b
G_2	53.68 ab	82.30 a	128.56 a	163.62 a	166.85 a
G_3	54.32 a	84.02 a	130.94 a	167.49 a	170.54 a
$LSD_{(0.05)}$	2.159	3.250	9.177	9.067	9.592
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.00	3.93	7.24	5.74	5.95

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

V_1: Ratan V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control) G_1: 20 ppm GA_3

G_2: 40 ppm GA_3 G_3: 60 ppm GA_3

Different variety and levels of GA_3 varied significantly for their interaction effect in terms of leaf area of tomato at 20, 30, 40, 50 and 60 DAT (Appendix V). At 20, 30, 40, 50 and 60 DAT, the maximum leaf area (58.31, 89.20, 147.92, 178.28 and 181.75 cm^2, respectively) was found from V_2G_3, whereas the minimum leaf area (46.11, 72.49, 103.10, 120.12 and 123.81 cm^2, respectively) was found from V_1G_0 treatment combination (Table 6).

4.4 Days required to flowering

Different variety of tomato varied significantly on days required to flowering (Appendix VI). The maximum days required to flowering (46.69) was observed from V_1, while the minimum days required to flowering (43.31) was recorded from V_2 (Table 7).

Days required to flowering of tomato showed statistically significant variation due to different levels of GA_3 (Appendix VI). The maximum days required to flowering (47.13) was found from G_0, whereas the minimum days required to flowering (43.63) was recorded from G_3 which was followed by G_2 (44.13) and G_1 (45.13) and they was statistically identical (Table 7).

Statistically significant variation was recorded due to the interaction effect of different variety and levels of GA_3 on days required to flowering (Appendix VI). The maximum days required to flowering (48.25) was recorded from V_1G_0, while the minimum days required to flowering (40.50) from V_2G_3 treatment combination (Table 8).

4.5 Number of flower clusters/plant

Number of flower clusters/plant showed statistically significant differences due to different variety of tomato (Appendix VI). The maximum number of flower clusters/plant (6.26) was observed from V_2, whereas the minimum number of flower clusters/plant (5.85) from V_1 (Table 7). Number of flower clusters/plant of tomato varied significantly due to different variety that was also reported by Biswas *et al*. (2015).

Table 6. Interaction effect of different variety and levels of gibberellic acid on leaf area of tomato at different days after transplanting (DAT)

Treatment	Leaf area (cm^2)				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
V_1G_0	46.11 d	72.49 d	103.10 d	120.12 d	123.81 d
V_1G_1	50.24 c	77.30 cd	117.07 bcd	149.35 c	151.86 c
V_1G_2	50.39 c	80.83 bc	126.31 bc	157.39 bc	160.58 bc
V_1G_3	50.33 c	78.83 bc	113.96 cd	156.69 bc	159.34 bc
V_2G_0	49.73 c	73.64 d	107.89 d	125.53 d	128.25 d
V_2G_1	53.60 b	80.63 bc	128.13 b	158.56 bc	161.48 bc
V_2G_2	56.98 a	83.77 b	130.80 b	169.84 ab	173.11 ab
V_2G_3	58.31 a	89.20 a	147.92 a	178.28 a	181.75 a
$LSD_{(0.05)}$	3.053	4.597	12.98	12.82	13.57
Level of significance	0.05	0.05	0.01	0.05	0.05
CV(%)	4.00	3.93	7.24	5.74	5.95

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

V_1: Ratan V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control) G_1: 20 ppm GA_3

G_2: 40 ppm GA_3 G_3: 60 ppm GA_3

Table 7. Effect of different variety and levels of gibberellic acid on yield contributing characters of tomato

Treatment	Days required to flowering	Number of flower clusters/plant	Number of flowers/cluster	Number of flowers/plant	Number of fruits/cluster	Number of fruits/plant
Different variety						
V_1	46.69 a	5.85 b	6.89 b	40.29 b	4.40 b	25.75 b
V_2	43.31 b	6.26 a	7.20 a	45.15 a	4.68 a	29.33 a
$LSD_{(0.05)}$	1.364	0.195	0.123	1.815	0.081	0.852
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	4.12	4.38	4.37	5.78	5.38	4.21
Levels of gibberellic acid						
G_0	47.13 a	5.70 b	6.97	39.78 b	4.25 b	24.20 c
G_1	45.13 b	6.05 a	7.03	42.58 a	4.60 a	27.83 b
G_2	44.13 b	6.22 a	7.08	44.08 a	4.63 a	28.83 ab
G_3	43.63 b	6.25 a	7.10	44.45 a	4.68 a	29.30 a
$LSD_{(0.05)}$	1.929	0.275	--	2.566	0.114	1.205
Level of significance	0.01	0.01	NS	0.01	0.01	0.01
CV(%)	4.12	4.38	4.37	5.78	5.38	4.21

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

V_1: Ratan V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control) G_1: 20 ppm GA_3

G_2: 40 ppm GA_3 G_3: 60 ppm GA_3

Table 8. Interaction effect of different variety and levels of gibberellic acid on yield contributing characters of tomato

Treatment	Days required to flowering	Number of flower clusters/plant	Number of flowers/cluster	Number of flowers/plant	Number of fruits/cluster	Number of fruits/plant
V_1G_0	48.25 a	5.70 de	7.00 bcd	39.90 b	4.10 d	23.40 e
V_1G_1	47.25 ab	5.65 e	6.85 d	38.70 b	4.50 c	25.35 d
V_1G_2	44.50 bcd	6.10 bcd	6.90 d	42.10 b	4.55 bc	27.75 c
V_1G_3	46.75 ab	5.95 cde	6.80 d	40.45 b	4.45 c	26.50 cd
V_2G_0	46.00 abc	5.70 de	6.95 cd	39.65 b	4.40 c	25.00 de
V_2G_1	43.00 de	6.45 ab	7.20 abc	46.45 a	4.70 b	30.30 b
V_2G_2	43.75 cd	6.35 abc	7.25 ab	46.05 a	4.70 b	29.90 b
V_2G_3	40.50 e	6.55 a	7.40 a	48.45 a	4.90 a	32.10 a
$LSD_{(0.05)}$	2.727	0.389	0.246	3.630	0.161	1.704
Level of significance	0.05	0.05	0.01	0.01	0.05	0.01
CV(%)	4.12	4.38	4.37	5.78	5.38	4.21

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

V_1: Ratan　　V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control)　　G_1: 20 ppm GA_3

G_2: 40 ppm GA_3　　G_3: 60 ppm GA_3

Statistically significant variation was recorded in terms of number of flower clusters/plant of tomato due to different levels of GA_3 (Appendix VI). Data revealed that the maximum number of flower clusters/plant (6.25) was found from G_3 which was statistically similar (6.22 and 6.05) to G_2 and G_1. On the other hand, the minimum number of flower clusters/plant (5.70) was observed from G_0 (Table 7). Gelmesa *et al*. (2012) reported that GA_3 increased flower cluster over the control which is supported to the present investigation.

Interaction effect of different variety and levels of GA_3 showed statistically significant variation in terms of number of flower clusters/plant (Appendix VI). The maximum number of flower clusters/plant (6.55) was recorded from V_2G_3 and the minimum number of flower clusters/plant (5.65) from V_1G_1 treatment combination (Table 8) which was followed by V_1G_0 treatment combination.

4.6 Number of flowers/cluster

Different variety of tomato showed statistically significant differences on number of flowers/cluster (Appendix VI). The maximum number of flowers/cluster (7.20) was found from V_2 and the minimum number of flowers/clusters (6.89) from V_1 (Table 7).

Different levels of GA_3 showed statistically non-significant differences for number of flowers/cluster of tomato (Appendix VI). The maximum number of flowers/cluster (7.10) was found from G_3, whereas the minimum number of flowers/cluster (6.97) was observed from G_0 (Table 7).

Number of flowers/cluster showed statistically significant variation due to the interaction effect of different variety and levels of GA_3 (Appendix VI). The maximum number of flowers/cluster (7.40) was found from V_2G_3, while the minimum number of flowers/cluster (6.80) from V_1G_3 treatment combination (Table 8).

4.7 Number of flowers/plant

Statistically significant variation was recorded due to different variety of tomato showed statistically significant differences on number of flowers/plant (Appendix VI). The maximum number of flowers/plant (45.15) was recorded from V_2, whereas the minimum number of flowers/plant (40.29) was found from V_1 (Table 7).

Number of flowers/plant of tomato varied significantly due to different levels of GA_3 (Appendix VI). The maximum number of flowers/plant (44.45) was found from G_3 which was statistically similar (44.08 and 42.58) to G_2 and G_1, while the minimum number of flowers/plant (39.78) was observed from G_0 (Table 7).

Interaction effect of different variety and levels of GA_3 showed statistically significant variation in terms of number of flowers/plant (Appendix VI). The maximum number of flowers/plant (48.45) was recorded from V_2G_3 and the minimum number of flowers/plant (38.70) from V_1G_1 treatment combination (Table 8).

4.8 Number of fruits/cluster

Different variety of tomato showed statistically significant differences on number of fruits/cluster (Appendix VI). The maximum number of fruits/cluster (4.68) was found from V_2 and the minimum number of fruits/cluster (4.40) from V_1 (Table 7).

Number of fruits/cluster of tomato varied significantly due to different levels of GA_3 (Appendix VI). The maximum number of fruits/cluster (4.68) was recorded from G_3 which was statistically similar (4.63 and 4.60) to G_2 and G_1, whereas the minimum number of fruits/cluster (4.25) was found from G_0 (Table 7). Gelmesa *et al*. (2012) reported that GA_3 increased fruit number per cluster over the control which is support the present study.

Statistically significant variation was recorded due to the interaction effect of different variety and levels of GA_3 in terms of number of fruits/cluster

(Appendix VI). The maximum number of fruits/cluster (4.90) was found from V_2G_3 and the minimum number of fruits/cluster (4.10) from V_1G_0 treatment combination (Table 8).

4.9 Number of fruits/plant

Different variety of tomato showed statistically significant differences on number of fruits/plant (Appendix VI). Data revealed that the maximum number of fruits/plant (29.33) was observed from V_2, whereas the minimum number of fruits/plant (25.75) from V_1 (Table 7).

Number of fruits/plant of tomato varied significantly due to different levels of GA_3 (Appendix VI). The maximum number of fruits/plant (29.30) was found from G_3 which was statistically similar (28.83) to G_2 and closely followed (27.83) by G_1. On the other hand, the minimum number of fruits/plant (24.20) was recorded from G_0 (Table 7). The application of GA_3 had significantly increased the number of fruits per plant than the untreated controls (Tomar and Ramgiry, 1997). Gelmesa *et al*. (2012) reported that GA_3 increased marketable fruit number per plant over the control.

Interaction effect of different variety and levels of GA_3 showed statistically significant variation in terms of number of fruits/plant (Appendix VI). The maximum number of fruits/plant (32.10) was recorded from V_2G_3, while the minimum number of fruits/plant (23.40) from V_1G_0 treatment combination (Table 8).

4.10 Fruit setting

Statistically non significant variation was recorded for different variety of tomato on fruit setting (Appendix VI). The maximum fruit setting (64.94%) was found from V_2 and the minimum fruit setting (63.93%) from V_1 (Figure 4). Ahammad *et al*. (2009) reported that variety BARI Tomato 5 showed potential fruiting capability.

Fruit setting of tomato varied significantly due to different levels of GA_3 (Appendix VI). The maximum fruit setting (65.83%) was observed from G_3 which was statistically similar (65.50% and 65.43%) to G_1 and G_2, while the minimum fruit setting (60.97%) was found from G_0 (Figure 5). Gibberellin has been reported to be very effective to overcome the problems of flower and fruit development in tomato (Rai *et al*., 2006). GA_3 has great effects on fruit setting which was reported by Rahman *et al*. (2015). Gelmesa *et al*. (2012) reported that GA_3 increased fruit set percentage over the control.

Different variety and levels of GA_3 showed statistically significant variation due to their interaction effect in terms of fruit setting (Appendix VI). The maximum fruit setting (66.22%) was observed from V_2G_3, whereas the minimum fruit setting (58.57%) from V_1G_0 treatment combination (Figure 6).

4.11 Fruit length

Fruit length statistically varied between two tomato varieties (Appendix VII). The longer fruit (7.21 cm) was recorded from V_2, whereas the shorter fruit (6.56 cm) from V_1 (Table 9). Different varieties responded differently for fruit length to input supply, method of cultivation and the prevailing environment during the growing season.

Fruit length of tomato varied significantly among different levels of GA_3 treatments (Appendix VII). The longer fruit (7.33 cm) was found from G_3 which was statistically similar (7.27 cm) to G_2 and followed (6.77 cm) by G_1, while the shorter fruit (6.17 cm) was recorded from G_0 (Table 9). GA_3 has great effects on plant increasing fruit size (Rahman *et al*., 2015).

Statistically significant variation was recorded due to interaction effect of different variety and levels of GA_3 in terms of fruit length (Appendix VII). The longer fruit (7.84 cm) was recorded from V_2G_3, while the shorter fruit (5.88 cm) from V_1G_0 treatment combination (Table 10).

Table 9. Effect of different variety and levels of gibberellic acid on yield contributing characters and yield of tomato

Treatment	Fruit length (cm)	Fruit diameter (cm)	Dry matter content in plant (%)	Dry matter content in fruit (%)	Weight of individual fruit (g)	Fruit yield/plant (kg)
Different variety						
V_1	6.56 b	3.68 b	8.92 b	7.17 b	65.72 b	1.69 b
V_2	7.21 a	4.27 a	9.34 a	7.76 a	69.39 a	2.04 a
$LSD_{(0.05)}$	0.145	0.161	0.176	0.233	2.333	0.066
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	4.87	5.49	6.61	4.23	4.70	4.85
Levels of gibberellic acid						
G_0	6.17 c	3.47 c	8.75 c	6.79 c	64.38 b	1.56 c
G_1	6.77 b	3.91 b	9.07 b	7.32 b	67.77 a	1.89 b
G_2	7.27 a	4.21 a	9.26 ab	7.83 a	68.85 a	1.98 a
G_3	7.33 a	4.29 a	9.44 a	7.93 a	69.22 a	2.04 a
$LSD_{(0.05)}$	0.205	0.228	0.248	0.329	3.299	0.093
Level of significance	0.01	0.01	0.01	0.01	0.05	0.01
CV(%)	4.87	5.49	6.61	4.23	4.70	4.85

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

V_1: Ratan — V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control) — G_1: 20 ppm GA_3

G_2: 40 ppm GA_3 — G_3: 60 ppm GA_3

Table 10. Interaction effect of different variety and levels of gibberellic acid on yield contributing characters and yield of tomato

Treatment	Fruit length (cm)	Fruit diameter (cm)	Dry matter content in plant (%)	Dry matter content in fruit (%)	Weight of individual fruit (g)	Fruit yield/plant (kg)
V_1G_0	5.88 e	3.30 d	8.62 e	6.71 d	64.42 c	1.50 e
V_1G_1	6.55 cd	3.68 c	8.81 de	7.03 cd	66.84 bc	1.70 cd
V_1G_2	6.98 b	3.92 bc	9.21 bc	7.56 b	66.07 c	1.83 c
V_1G_3	6.82 bc	3.81 bc	9.05 bcd	7.38 bc	65.56 c	1.74 cd
V_2G_0	6.46 d	3.65 c	8.89 cde	6.86 d	64.33 c	1.61 de
V_2G_1	7.00 b	4.14 b	9.33 b	7.60 b	68.70 abc	2.08 b
V_2G_2	7.56 a	4.50 a	9.32 b	8.11 a	71.62 ab	2.14 b
V_2G_3	7.84 a	4.78 a	9.83 a	8.48 a	72.90 a	2.34 a
$LSD_{(0.05)}$	0.290	0.322	0.351	0.465	4.665	0.132
Level of significance	0.05	0.05	0.05	0.05	0.05	0.01
CV(%)	4.87	5.49	6.61	4.23	4.70	4.85

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

V_1: Ratan V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control) G_1: 20 ppm GA_3

G_2: 40 ppm GA_3 G_3: 60 ppm GA_3

4.12 Fruit diameter

Different variety of tomato showed statistically significant differences on fruit diameter (Appendix VII). The higher fruit diameter (4.27 cm) was found from V_2, while the lower fruit diameter (3.68 cm) was observed from V_1 (Table 9).

Fruit diameter of tomato varied significantly due to different levels of GA_3 (Appendix VII). The higher fruit diameter (4.29 cm) was observed from G_3 which was statistically similar (4.21 cm) to G_2 and followed (3.91 cm) by G_1, whereas the lower fruit diameter (3.47 cm) was found from G_0 (Table 9).

Interaction effect of different variety and levels of GA_3 showed statistically significant variation in terms of fruit diameter (Appendix VII). The higher fruit diameter (4.78 cm) was observed from V_2G_3 and the lower fruit diameter (3.30 cm) from V_1G_0 treatment combination (Table 10).

4.13 Dry matter content in plant

Different variety of tomato showed statistically significant differences on dry matter content in plant (Appendix VII). Data revealed that the maximum dry matter content in plant (9.34%) was recorded from V_2 and the minimum dry matter content in plant (8.92%) from V_1 (Table 9).

Statistically significant variation was recorded in terms of dry matter content in plant of tomato due to different levels of GA_3 (Appendix VII). The maximum dry matter content in plant (9.44%) was found from G_3 which was statistically similar (9.26%) to G_2 and followed (9.07%) by G_1, whereas the minimum dry matter content in plant (8.75%) was recorded from G_0 (Table 9).

Interaction effect of different variety and levels of GA_3 showed statistically significant variation in terms of dry matter content in plant (Appendix VII). The maximum dry matter content in plant (9.83%) was recorded from V_2G_3 and the minimum dry matter content in plant (8.62%) from V_1G_0 treatment combination (Table 10).

4.14 Dry matter content in fruit

Different variety of tomato showed statistically significant differences on dry matter content in fruit (Appendix VII). The maximum dry matter content in fruit (7.76%) was found from V_2, whereas the minimum dry matter content in fruit (7.17%) from V_1 (Table 9).

Dry matter content in fruit of tomato varied significantly due to different levels of GA_3 (Appendix VII). The maximum dry matter content in fruit (7.93%) was found from G_3 which was statistically similar (7.83%) to G_2 and followed (7.32%) by G_1. On the other hand, the minimum dry matter content in fruit (6.79%) was observed from G_0 (Table 9).

Different variety and levels of GA_3 showed statistically significant variation for their interaction effect in terms of dry matter content in fruit (Appendix VII). The maximum dry matter content in fruit (8.48%) was found from V_2G_3, while the minimum dry matter content in fruit (6.71%) from V_1G_0 treatment combination (Table 10).

4.15 Weight of individual fruit

Different variety of tomato showed statistically significant differences on weight of individual fruit (Appendix VII). The maximum weight of individual fruit (69.39 g) was recorded from V_2, while the minimum weight of individual fruit (65.72 g) from V_1 (Table 9). Weight of individual fruit varied between two varieties might be due to their genetical and environmental influences as well as management practices. Biswas *et al*. (2015) reported maximum individual fruit weight (115.9 g) from BARI Tomato-7.

Weight of individual fruit of tomato varied significantly due to different levels of GA_3 (Appendix VII). The maximum weight of individual fruit (69.22 g) was found from G_3 which was statistically similar (68.85 g and 67.77 g) to G_2 and G_1, whereas the minimum weight of individual fruit (64.38 g) was recorded from G_0 (Table 9).

Statistically significant variation was recorded due to the interaction effect of different variety and levels of GA_3 on weight of individual fruit (Appendix VII). The maximum weight of individual fruit (72.90 g) was recorded from V_2G_3 and the minimum weight (64.42 g) from V_1G_0 treatment combination (Table 10).

4.16 Fruit yield/plant

Different variety of tomato showed statistically significant differences on fruit yield/plant (Appendix VII). The maximum fruit yield/plant (2.04 kg) was obtained from V_2 and the minimum fruit yield/plant (1.69 kg) from V_1 (Table 9).

Fruit yield/plant of tomato varied significantly due to different levels of GA_3 (Appendix VII). The maximum fruit yield/plant (2.04 kg) was observed from G_3 which was statistically similar (1.98 kg) to G_2 and followed (1.89 kg) by G_1, while the minimum fruit yield/plant (1.56 kg) was found from G_0 (Table 9).

Interaction effect of different variety and levels of GA_3 showed statistically significant variation in terms of fruit yield/plant (Appendix VII). The maximum fruit yield/plant (2.34 kg) was observed from V_2G_3, whereas the minimum fruit yield/plant (1.50 kg) from V_1G_0 treatment combination (Table 10).

4.17 Fruit yield/hectare

Statistically significant variation was recorded between two varieties of tomato on fruit yield/hectare (Appendix VII). The maximum fruit yield/hectare (85.08 ton) was recorded from V_2, while the minimum fruit yield/hectare (70.52 ton) was found from V_1 (Figure 7). Varieties plays an important role in producing high yield of tomato and yield also varied for different varieties might be due to their genetical and environmental influences as well as management practices. Yield of tomato varied significantly due to different variety (Kayum *et al.*, 2008; Hossain *et al.*, 2013; and Biswas *et al.*, 2015). Kayum *et al.* (2008) reported that variety Ratan produced the highest (73.74 t/ha) fruit yield, while BARI tomato-3 showed the lowest (58.89 t/ha) fruit yield. Biswas *et al*. (2015) reported maximum yield (95.9 t/ha) from BARI Tomato-7.

Fruit yield/hectare of tomato varied significantly due to different levels of GA_3 (Appendix VII). The maximum fruit yield/hectare (84.91 ton) was recorded from G_3 which was statistically similar (82.66 ton) to G_2 and followed (78.77 ton) by G_1, whereas the minimum fruit yield/hectare (64.87 ton) was observed from G_0 (Figure 8). Akand *et al*. (2015) recorded the highest yield (92.99 t/ha) was obtained from G_3 (125 ppm) treatment and the lowest yield (60.46 t/ha) from control.

Interaction effect of variety and levels of GA_3 showed statistically significant variation in terms of fruit yield/hectare (Appendix VII). The maximum fruit yield/hectare (97.52 ton) was observed from V_2G_3 and the minimum fruit yield/hectare (62.65 ton) was recorded from V_1G_0 treatment combination (Figure 9).

4.18 Total soluble solid (%)

Total soluble solid significantly varied between two varieties of tomato (Appendix VIII). The maximum total soluble solid (4.29%) was found from V_2 and the minimum total soluble solid (4.20%) from V_1 (Table 11).

Statistically significant variation was recorded in terms of total soluble solid of tomato due to different levels of GA_3 (Appendix VIII). The maximum total soluble solid (4.38%) was obtained from G_3 which was statistically similar (4.31%) to G_2 and followed (4.22%) by G_1, while the minimum total soluble solid (4.05%) was recorded from G_0 (Table 11). GA_3 has great effects on improving fruit quality (Rahman *et al*., 2015).

Interaction effects of variety and levels of GA_3 showed statistically significant variation in terms of total soluble solid (Appendix VIII). The maximum total soluble solid (4.53%) was found from V_2G_3 and the minimum total soluble solid (4.05%) was found from V_1G_0 treatment combination (Table 12).

Table 11. Effect of different variety and levels of gibberellic acid on TSS, β-carotene and sugar content of tomato

Treatment	Total Soluble Solid-TSS (%)	β-carotene (µg/100 g)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
Different variety					
V_1	4.20 b	1661.37	3.33 b	1.37 b	4.70 b
V_2	4.29 a	1659.16	3.55 a	1.49 a	5.04 a
$LSD_{(0.05)}$	0.052	--	0.121	0.023	0.119
Level of significance	0.01	NS	0.01	0.01	0.01
CV(%)	1.64	3.03	4.76	2.57	3.32
Levels of gibberellic acid					
G_0	4.05 c	1647.55	3.23 b	1.33 d	4.56 c
G_1	4.22 b	1659.78	3.43 a	1.40 c	4.82 b
G_2	4.31 a	1669.65	3.52 a	1.47 b	4.99 a
G_3	4.38 a	1664.08	3.57 a	1.53 a	5.09 a
$LSD_{(0.05)}$	0.074	--	0.171	0.033	0.168
Level of significance	0.01	NS	0.01	0.01	0.01
CV(%)	1.64	3.03	4.76	2.57	3.32

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

V_1: Ratan V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control) G_1: 20 ppm GA_3

G_2: 40 ppm GA_3 G_3: 60 ppm GA_3

Table 12. Interaction effect of different variety and levels of gibberellic acid on TSS, β-carotene and sugar content of tomato

Treatment	Total Soluble Solid-TSS (%)	β-carotene (µg/100 g)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
V_1G_0	4.05 d	1660.03	3.20 d	1.31 e	4.51 e
V_1G_1	4.19 c	1648.88	3.33 cd	1.36 de	4.69 de
V_1G_2	4.32 b	1699.93	3.40 bcd	1.40 cd	4.80 cd
V_1G_3	4.23 bc	1636.67	3.37 cd	1.42 c	4.79 cd
V_2G_0	4.07 d	1635.08	3.26 cd	1.36 de	4.61 de
V_2G_1	4.25 bc	1670.67	3.52 abc	1.43 c	4.96 bc
V_2G_2	4.30 b	1639.36	3.64 ab	1.54 b	5.18 ab
V_2G_3	4.53 a	1691.50	3.77 a	1.63 a	5.40 a
$LSD_{(0.05)}$	0.104	--	0.242	0.047	0.237
Level of significance	0.01	NS	0.05	0.01	0.05
CV(%)	1.64	3.03	4.76	2.57	3.32

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

V_1: Ratan V_2: Mintoo hybrid

G_0: 0 ppm GA_3 (control) G_1: 20 ppm GA_3

G_2: 40 ppm GA_3 G_3: 60 ppm GA_3

4.19 β-carotene content

There was no significant difference between the varieties of tomato for β-carotene content (Appendix VIII). The maximum β-carotene (1661.37 µg/100 g) was recorded from V_1, while the minimum β-carotene (1659.16 µg/100 g) from V_2 (Table 11).

β-carotene of tomato varied non-significantly among different levels of GA_3 (Appendix VIII). The maximum β-carotene (1669.65 µg/100 g) was found from G_2 and the minimum β-carotene (1647.55 µg/100 g) from G_0 (Table 11).

Interaction effect of variety and levels of GA_3 showed statistically non-significant variation in terms of β-carotene (Appendix VIII). The maximum β-carotene (1699.93 µg/100 g) was recorded from V_1G_2, while the minimum β-carotene (1635.08 µg/100 g) from V_2G_0 treatment combination (Table 12).

4.20 Reducing sugar content

Different variety of tomato showed statistically significant differences on reducing sugar (Appendix VIII). The maximum reducing sugar (3.55%) was observed from V_2, while the minimum reducing sugar (3.33%) was found from V_1 (Table 11). Tigist *et al*. (2012) reported that tomato varieties had significant effects on quality as well as sugar content.

Reducing sugar of tomato varied significantly due to different levels of GA_3 (Appendix VIII). The maximum reducing sugar (3.57%) was obtained from G_3 which was statistically similar (3.52% and 3.43%) to G_2 and G_1, whereas the minimum reducing sugar (3.23%) was found from G_0 (Table 11).

Statistically significant variation was recorded due to interaction effect of variety and levels of GA_3 in terms of reducing sugar (Appendix VIII). Data revealed that the maximum reducing sugar (3.77%) was observed from V_2G_3 and the minimum reducing sugar (3.20%) from V_1G_0 treatment combination (Table 12).

4.21 Non-reducing sugar content

Different variety of tomato showed significant differences on non-reducing sugar (Appendix VIII). The maximum non-reducing sugar (1.49%) was recorded from V_2 and the minimum non-reducing sugar (1.37%) from V_1 (Table 11).

Non-Reducing sugar of tomato varied significantly due to different levels of GA_3 (Appendix VIII). The maximum non-reducing sugar (1.53%) was recorded from G_3 which was closely followed (1.47%) by G_2. On the other hand, the minimum non-reducing sugar (1.33%) was found from G_0 which was followed (1.40%) by G_1 (Table 11).

Interaction effect of different variety and levels of GA_3 showed statistically significant variation on non-reducing sugar (Appendix VIII). The maximum non-reducing sugar (1.63%) was recorded from V_2G_3, while the minimum non-reducing sugar (1.31%) from V_1G_0 treatment combination (Table 12).

4.22 Total sugar content

Statistically significant variation was recorded due to different variety of tomato on total sugar content (Appendix VIII). The maximum total sugar (5.04%) was observed from V_2, whereas the minimum total sugar (4.70%) was found from V_1 (Table 11).

Total sugar of tomato varied significantly due to different levels of GA_3 (Appendix VIII). The maximum total sugar (5.09%) was found from G_3 which was statistically similar (4.99%) to G_2 and followed (4.82%) by G_1, while the minimum total sugar (4.56%) was recorded from G_0 (Table 11).

Different variety and levels of GA_3 showed statistically significant variation due to their interaction effect in terms of total sugar (Appendix VIII). The maximum total sugar (5.40%) was recorded from V_2G_3 and the minimum total sugar (4.51%) from V_1G_0 treatment combination (Table 12).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from November 2014 to March 2015 in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to find out the effect of gibberellic acid on growth, yield and quality of tomato. The experiment comprised of two factors. Factor A: Different tomato varieties (2 varieties)-V_1: Ratan and V_2: Mintoo hybrid and Factors B: Different levels of gibberellic acid-GA_3 (4 levels)- G_0: 0 ppm GA_3 (control); G_1: 20 ppm GA_3; G_2: 40 ppm GA_3 and G_3: 60 ppm GA_3. The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. Data on different growth characters, yield components, yield and quality of tomato was recorded and significant differences were observed for different treatment.

For different variety, at 20, 30, 40, 50, 60 days after transplanting (DAT) and final harvest, the taller plants (15.92, 40.71, 60.72, 75.73, 83.88 and 86.60 cm, respectively) from V_2, while the shorter plants (14.78, 37.40, 57.13, 71.05, 79.37 and 82.76 cm, respectively) from V_1. At 20, 30, 40, 50, 60 DAT and final harvest, the maximum number of branches/plant (2.79, 7.32, 13.13, 14.50, 15.36 and 16.06, respectively) was found from V_2, while the minimum number (2.40, 6.11, 11.52, 12.71, 13.69 and 14.51, respectively) from V_1. At 20, 30, 40, 50 and 60 DAT, the maximum leaf area (54.65, 81.81, 128.68, 156.70 and 160.04 cm^2, respectively) was observed from V_2, whereas the minimum (49.27, 77.36, 115.11, 147.24 and 150.01 cm^2, respectively) was recorded from V_1. The maximum days required to flowering (46.69) was observed from V_1, while the minimum days (43.31) from V_2.

The maximum number of flower clusters/plant (6.26) was observed from V_2, whereas the minimum number (5.85) from V_1. The maximum number of flowers/cluster (7.20) was found from V_2 and the minimum number (6.89) from V_1. The maximum number of flowers/plant (45.15) was recorded from V_2, whereas the minimum number (40.29) from V_1. The maximum number of fruits/cluster (4.68) was found from V_2 and the minimum number (4.40) from V_1. The maximum number of fruits/plant (29.33) was observed from V_2, whereas the minimum number (25.75) from V_1. The maximum fruit setting (64.94%) was found from V_2 and the minimum fruit setting (63.93%) from V_1. The longer fruit (7.21 cm) was recorded from V_2, whereas the shorter fruit (6.56 cm) from V_1. The higher fruit diameter (4.27 cm) was found from V_2, while the lower fruit diameter (3.68 cm) from V_1. The maximum dry matter content in plant (9.34%) was recorded from V_2 and the minimum (8.92%) from V_1. The maximum dry matter content in fruit (7.76%) was found from V_2, whereas the minimum (7.17%) from V_1. The maximum weight of individual fruit (69.39 g) was recorded from V_2, while the minimum weight (65.72 g) from V_1. The maximum fruit yield/plant (2.04 kg) was obtained from V_2 and the minimum fruit yield/plant (1.69 kg) from V_1. The maximum fruit yield/hectare (85.08 ton) was found from V_2, while the minimum fruit yield/hectare (70.52 ton) from V_1.

The maximum total soluble solid (4.29%) was found from V_2 and the minimum (4.20%) from V_1. The maximum β-carotene (1661.37 µg/100 g) was recorded from V_1, while the minimum (1659.16 µg/100 g) from V_2. The maximum reducing sugar (3.55%) was observed from V_2, while the minimum (3.33%) from V_1. The maximum non-reducing sugar (1.49%) was recorded from V_2 and the minimum (1.37%) from V_1. The maximum total sugar (5.04%) was observed from V_2, whereas the minimum (4.70%) from V_1.

In case of different levels of GA_3, at 20, 30, 40, 50, 60 DAT and final harvest, the tallest plant (16.37, 41.20, 61.69, 77.39, 85.10 and 87.74 cm, respectively) was found from G_3, whereas the shortest plant (13.32, 35.87, 54.37, 65.91, 75.79 and 79.67 cm, respectively) from G_0. At 20, 30, 40, 50, 60 DAT and final harvest, the maximum number of branches/plant (2.97, 7.17, 13.10, 14.63, 15.43 and 16.15, respectively) was observed from G_3, while the minimum number (1.92, 6.03, 10.68, 11.85, 13.00 and 14.00, respectively) from G_0. At 20, 30, 40, 50 and 60 DAT, the maximum leaf area (54.32, 84.02, 130.94, 167.49 and 170.54 cm^2, respectively) was recorded from G_3, while the minimum (47.92, 73.07, 105.49, 122.82 and 126.03 cm^2, respectively) from G_0. The maximum days required to flowering (47.13) was found from G_0, whereas the minimum days (43.63) from G_0.

The maximum number of flower clusters/plant (6.25) was found from G_3 and the minimum number (5.70) from G_0. The maximum number of flowers/cluster (7.10) was found from G_3, whereas the minimum number (6.97) from G_0. The maximum number of flowers/plant (44.45) was found from G_3, while the minimum number (39.78) from G_0. The maximum number of fruits/cluster (4.68) was recorded from G_3, whereas the minimum number (4.25) from G_0. The maximum number of fruits/plant (29.30) was found from G_3 and the minimum number (24.20) from G_0. The maximum fruit setting (65.83%) was observed from G_3, while the minimum (60.97%) from G_0. The longer fruit (7.33 cm) was found from G_3, while the shorter fruit (6.17 cm) from G_0. The higher fruit diameter (4.29 cm) was observed from G_3, whereas the lower fruit diameter (3.47 cm) from G_0. The maximum dry matter content in plant (9.44%) was found from G_3, whereas the minimum (8.75%) from G_0. The maximum dry matter content in fruit (7.93%) was found from G_3 and the minimum (6.79%) from G_0. The maximum weight of individual fruit (69.22 g) was found from G_3, whereas the minimum weight (64.38 g) from G_0. The maximum fruit yield/plant (2.04 kg) was observed from G_3, while the minimum fruit yield/plant (1.56 kg) from G_0. The maximum fruit yield/hectare (84.91 ton) was recorded from G_3, whereas the minimum fruit yield/hectare (64.87 ton) from G_0.

The maximum total soluble solid (4.38%) was obtained from G_3, while the minimum total soluble solid (4.05%) from G_0. The maximum β-carotene (1669.65 µg/100 g) was found from G_2 and the minimum (1647.55 µg/100 g) from G_0. The maximum reducing sugar (3.57%) was obtained from G_3, whereas the minimum (3.23%) from G_0. The maximum non-reducing sugar (1.53%) was recorded from G_3 and the minimum (1.33%) from G_0. The maximum total sugar (5.09%) was found from G_3, while the minimum (4.56%) from G_0.

Due to the interaction effect of different variety and levels of GA_3, at 20, 30, 40, 50, 60 DAT and final harvest, the tallest plant (18.34, 44.33, 64.91, 82.19, 89.39 and 91.69 cm, respectively) was recorded from V_2G_3 and the shortest plant (12.66, 33.63, 52.44, 64.82, 75.18 and 78.96 cm, respectively) from V_1G_0. At 20, 30, 40, 50, 60 DAT and final harvest, the maximum number of branches/plant (3.20, 7.70, 14.30, 16.15, 17.00 and 17.75, respectively) was found from V_2G_3, whereas the minimum number (1.90, 5.55, 10.30, 11.55, 12.90 and 13.90, respectively) from V_1G_0. At 20, 30, 40, 50 and 60 DAT, the maximum leaf area (58.31, 89.20, 147.92, 178.28 and 181.75 cm^2, respectively) was found from V_2G_3, whereas the minimum (46.11, 72.49, 103.10, 120.12 and 123.81 cm^2, respectively) from V_1G_0. The maximum days required to flowering (48.25) was found from V_1G_0, while the minimum days (40.50) from V_2G_3.

The maximum number of flower clusters/plant (6.55) was recorded from V_2G_3 and the minimum number (5.65) from V_1G_1. The maximum number of flowers/cluster (7.40) was found from V_2G_3, while the minimum number (6.80) from V_1G_3. The maximum number of flowers/plant (48.45) was recorded from V_2G_3 and the minimum number (38.70) from V_1G_1. The maximum number of fruits/cluster (4.90) was found from V_2G_3 and the minimum number (4.10) from V_1G_0. The maximum number of fruits/plant (32.10) was recorded from V_2G_3, while the minimum number (23.40) from V_1G_0. The maximum fruit setting (66.22%) was observed from V_2G_3, whereas the minimum (58.57%) from V_1G_0. The longer fruit (7.84 cm) was recorded from V_2G_3, while the shorter fruit (5.88 cm) from V_1G_0. The higher fruit diameter (4.78 cm) was observed from V_2G_3 and the lower fruit diameter (3.30 cm) from V_1G_0. The maximum dry matter content in plant (9.83%) was recorded from V_2G_3 and the minimum (8.62%) from V_1G_0. The maximum dry matter content in fruit (8.48%) was found from V_2G_3, while the minimum dry matter content in fruit (6.71%) from V_1G_0. The maximum weight of individual fruit (72.90 g) was recorded from V_2G_3 and the minimum weight (64.42 g) from V_1G_0. The maximum fruit yield/plant (2.34 kg) was observed from V_2G_3, whereas the minimum fruit yield/plant (1.50 kg) from V_1G_0. The maximum fruit yield/hectare (97.52 ton) was observed from V_2G_3 and the minimum fruit yield/hectare (62.65 ton) was recorded from V_1G_0.

The maximum total soluble solid (4.53%) was found from V_2G_3 and the minimum (4.05%) from V_1G_0. The maximum β-carotene (1699.93 µg/100 g) was recorded from V_1G_2, while the minimum (1635.08 µg/100 g) from V_2G_0. The maximum reducing sugar (3.77%) was observed from V_2G_3 and the minimum (3.20%) from V_1G_0. The maximum non-reducing sugar (1.63%) was recorded from V_2G_3, while the minimum (1.31%) from V_1G_0. The maximum total sugar (5.40%) was found from V_2G_3 and the minimum (4.51%) from V_1G_0.

Conclusion

- Mintoo hybrid showed better yield and quality character than Ratan variety of tomato.
- 60 ppm gibbrellic acid concentration showed better response among the different concentrations.
- Finally Mintoo hybrid with 60 ppm gibbrellic acid concentration combination showed superior growth, yield as well as quality of Tomato.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Another variety and other management practices may be used in future study.
2. Another higher level of GA_3 need to be considered in different agro-ecological zones of Bangladesh for regional trial before final recommendation.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period from November 2014 to March 2015

Month	*Air temperature (°c)		*Relative humidity (%)	Total Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
November, 2014	25.8	16.0	78	00	6.8
December, 2014	22.4	13.5	74	00	6.3
January, 2015	24.5	12.4	68	00	5.7
February, 2015	27.1	16.7	67	30	6.7
March, 2015	28.1	19.5	68	00	6.8

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1207

Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agricultural Botany field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	6.1
Organic matter (%)	1.13
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	23

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

Appendix III. Analysis of variance of the data on plant height of tomato at different days after transplanting (DAT) and at final harvest as influenced by different variety and levels of gibberellic acid

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm) at					
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	Final harvest
Replication	3	1.142	2.014	1.994	7.328	7.002	3.912
Tomato variety (A)	1	10.446*	87.598**	103.207**	175.534**	162.540**	118.272**
Levels of gibberellic acid (B)	3	16.088**	52.861**	88.918**	226.391**	145.679**	107.822**
Interaction (A×B)	3	8.205*	12.613*	10.652*	22.529*	18.708*	30.073*
Error	21	2.188	3.761	4.317	7.763	7.147	10.021

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of branches/plant of tomato at different days after transplanting (DAT) and at final harvest as influenced by different variety and levels of gibberellic acid

Source of variation	Degrees of freedom	Mean square					
		Number of branches/plant at					
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	Final harvest
Replication	3	0.041	0.011	0.227	0.325	0.377	0.588
Tomato variety (A)	1	1.201**	11.761**	20.480**	25.561**	22.445**	19.220**
Levels of gibberellic acid (B)	3	1.831**	2.101**	10.323**	12.051**	9.123**	6.978**
Interaction (A×B)	3	0.125*	0.425*	0.930*	2.125*	3.848**	4.193**
Error	21	0.033	0.136	0.294	0.629	0.581	1.001

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on leaf area of tomato at different days after transplanting (DAT) as influenced by different variety and levels of gibberellic acid

Source of variation	Degrees of freedom	Mean square				
		Leaf area (cm^2)				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	3	0.862	2.469	42.951	13.748	24.598
Tomato variety (A)	1	231.783**	158.085**	1474.093**	716.343**	804.607**
Levels of gibberellic acid (B)	3	66.320**	186.342**	1055.504**	3280.002**	3263.997**
Interaction (A×B)	3	10.246*	32.969*	387.680**	251.379*	245.886*
Error	21	4.310	9.771	77.887	76.043	85.105

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters of tomato as influenced by different variety and levels of gibberellic acid

Source of variation	Degrees of freedom	Mean square						
		Days required to flowering	Number of flower clusters/ plant	Number of flowers/ cluster	Number of flowers/ plant	Number of fruits/ cluster	Number of fruits/plant	Fruit setting (%)
Replication	3	1.583	0.025	0.035	3.741	0.032	1.498	4.071
Tomato variety (A)	1	91.125**	1.361**	0.781**	189.151**	0.605**	102.245**	8.094
Levels of gibberellic acid (B)	3	19.167**	0.515**	0.025	36.061**	0.302**	42.628**	42.905**
Interaction (A×B)	3	11.458*	0.255*	0.145*	30.101**	0.035*	7.948**	13.974*
Error	21	3.440	0.070	0.028	6.092	0.012	1.343	4.863

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on yield contributing characters and yield of tomato as influenced by different variety and levels of gibberellic acid

Source of variation	Degrees of freedom	Mean square						
		Fruit length (cm)	Fruit diameter (cm)	Dry matter content in plant (%)	Dry matter content in fruit (%)	Weight of individual fruit (g)	Fruit yield/plant (kg)	Fruit yield/hectare (ton)
Replication	3	0.021	0.008	0.037	0.094	0.422	0.009	15.778
Tomato variety (A)	1	3.465**	2.779**	1.406**	2.775**	107.438**	0.977**	1695.695**
Levels of gibberellic acid (B)	3	2.311**	1.099**	0.694**	2.225**	38.921**	0.372**	645.694**
Interaction (A×B)	3	0.123*	0.146*	0.169*	0.308*	22.948*	0.085**	147.845**
Error	21	0.039	0.048	0.057	0.100	10.065	0.008	14.215

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on TSS, β-carotene and sugar content as influenced by different variety and levels of gibberellic acid

Source of variation	Degrees of freedom	Mean square				
		Total Soluble Solid-TSS (%)	β-carotene (µg/100 g)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
Replication	3	0.002	1105.302	0.010	0.003	0.011
Tomato variety (A)	1	0.062**	39.391	0.392**	0.111**	0.920**
Levels of gibberellic acid (B)	3	0.161**	705.083	0.180**	0.057**	0.430**
Interaction (A×B)	3	0.040**	5167.965	0.040*	0.011**	0.092*
Error	21	0.005	2525.408	0.027	0.001	0.026

** Significant at 0.01 level of probability; * Significant at 0.05 level of probability

Appendix IX. List of Plates

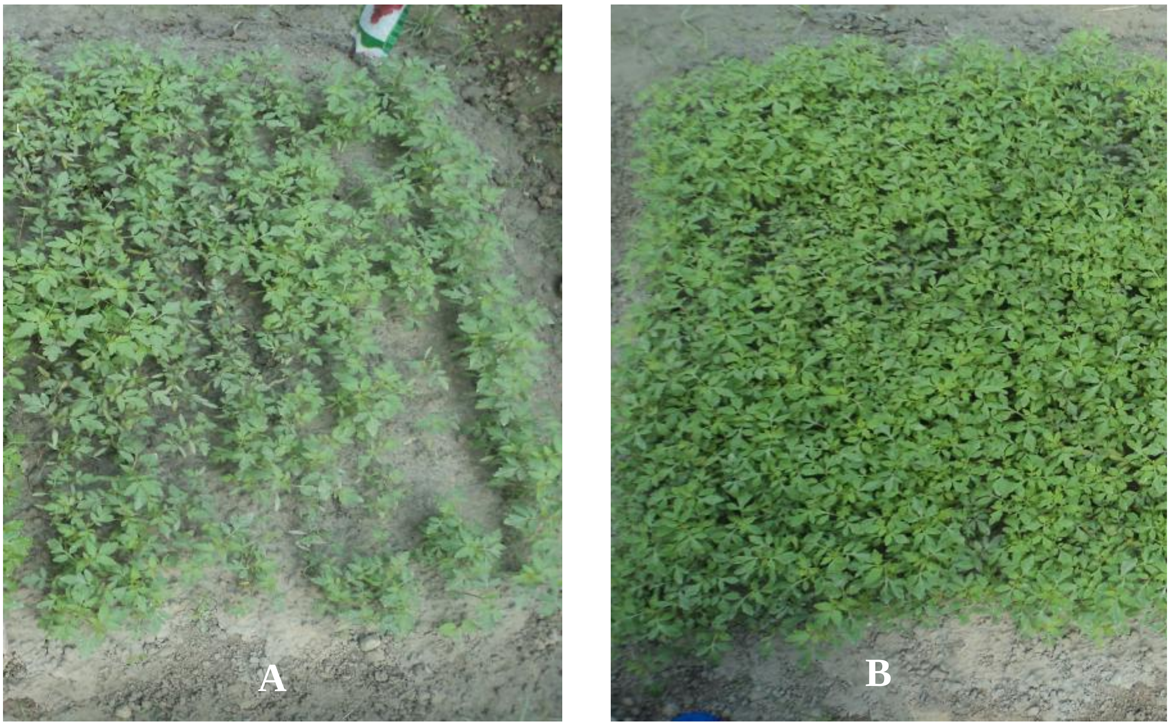

Plate 1. Photograph showing tomato seedlings; A: Ratan and B: Mintoo hybrid

Plate 2. Photograph showing experimental plot

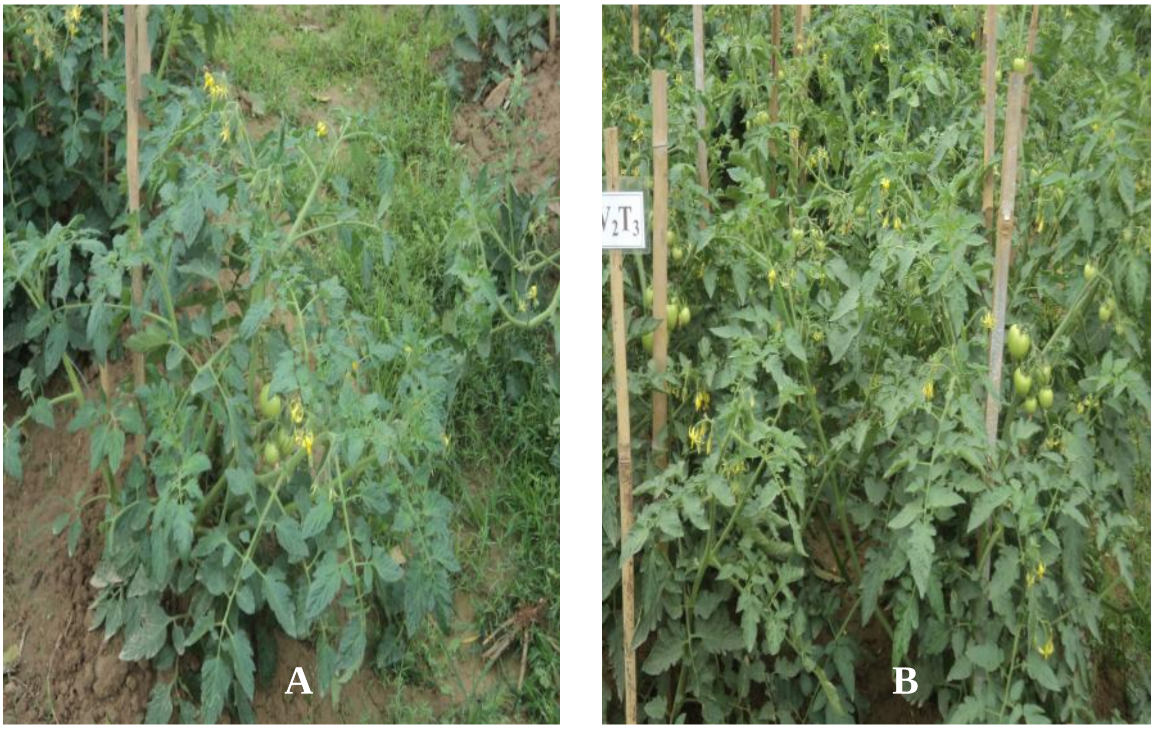

Plate 3. Photograph showing green tomato; A: Ratan and B: Mintoo hybrid

Plate 4. Photograph showing ripen tomato; A: Ratan and B: Mintoo hybrid