EFFECT OF NAA AND GA_3 ON GROWTH AND YIELD OF TOMATO

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF NAA AND GA_3 ON GROWTH AND YIELD OF TOMATO"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE**, embodies the result of a piece of *bona fide* research work carried out by **MD. MAHMUDUL HASAN MIZAN**, Registration No. **10-04061** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: June, 2016
Dhaka, Bangladesh

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Dedicated To

My Beloved Parents

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ABSTRACT

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period November, 2015 to April, 2016 to find out the effect of different levels of NAA and GA_3 on growth and yield of tomato. The experiment consisted of two factors: Factor A: Three levels of NAA viz. N_0: 0 (control), N_1: 25 ppm NAA and N_2: 50 ppm NAA. Factor B: Four levels of GA_3 viz. G_0: control (no GA_3); G_1: 50 ppm GA_3; G_2: 100 ppm GA_3 and G_3: 150 ppm GA_3. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design with three replications. Due to the application of NAA, the longest plant (97.75 cm at 60 DAT), the maximum dry matter of fruit (13.98%) and the highest yield (78.80 t ha^{-1}) and yield contributing characters were recorded from N_2. For the application of GA_3, the longest plant (88.88 cm at 60 DAT), the maximum dry matter of fruit (13.35%) and the highest yield (68.64 t ha^{-1}) and other yield contributing parameters were recorded from G_2. The treatment combination of N_2G_2 performs the highest yield (84.13 t ha^{-1}). So the combination of 50 ppm NAA with 100 ppm GA_3 treatment is the suitable combination for the better growth and yield of tomato.

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LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
@	at the rate of
a.i	Active ingredient
Adv.	Advanced
Agron .	Agronomy
Agric.	Agriculture Agricultural
Agril.	Agricultural
BRRI	Bangladesh Rice Research Institute
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-Bangla Agricultural University
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
RCBD	Randomized Complete Block Design
CV	Coefficient of Variation
cv.	Cultivar
EC	Emulsifiable Concentrate
cm	Centimeter
df	Degrees of Freedom
DAS	Days After Sowing
LSD	Least significance difference
et al.	and others
etc.	etcetera
FAO	Food and Agricultural Organization
Fig	Figure
ns	Non Significant

ABBREVIATIONS	ELABORATIONS
NAA	Napthalene Acetic Acid
GA_3	Gibberellic Acid
J.	Journal
PP.	Pages
g	Gram
ha^{-1}	Per hectare
t	Ton
%	Percent
m^2	Square meter
pod^{-1}	Per pod
J.	Journal
kg	Kilogram
No.	Number
NS	Non Significant
NOS	Number of species
^0C	Degree Celsius
Res.	Research
RH	Relative humidity
WCE	Weed control efficiency
SRDI	Soil Resource Development Institute
Sci.	Science ’s
HI	Harvest Index
Vol.	Volume
CHAPT.	Chapter

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a solanaceous self pollinated vegetable crop. It is one of the important, popular and nutritious vegetables grown in Bangladesh in both winter and summer season around all parts of the country (Haque *et al.*, 1999). It was originated in tropical America, particularly in Peru, Ecuador and Bolivia. It is popular for its taste, nutritional status and various uses. Tomato is cultivated all over the country due to its adaptability to wide range of soil and climate (Ahmad, 1976). It ranks third, next to potato and sweet potato, in terms of world vegetable production (FAO, 2012) and tops the list of canned vegetables (Choudhury, 1979). The present leading tomato producing countries of the world are China, United States of America, India, Egypt, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (FAO, 2012).

Tomato fruit can be consumed either fresh, cooked or in the form of processed products such as jam, jelly, juice, ketchup, sauce etc. It is much popular for consumption as salad in the raw state and as processed soups, juice, ketchup, pickles, sauces, conserved puree, paste, powder and other products (Ahmad, 1976; Thompson and Kelly, 1983 and Bose and Som, 1990).It is considered as 'poor man's apple' because of its attractive appearance and very high nutritive value, containing vitamin A, vitamin C (Thompson and Kelly, 1957) and minerals like calcium, potassium etc. Nutritional value of red tomatoes (raw) per 100 g contains 18 kcal energy, 4.0 g carbohydrates, and 2.6 g sugars, 1.0 g dietary fiber, 0.2 g fat, 1.0 g protein, 95 g water, 13 mg vitamin C (Zhang *et al.*, 2009).

Tomato universally treated as ''Protective Food", is being extensively grown as annual plant. Tomato is also rich in medicinal value. It also contains organic acids like citric, malic and aceitic acids which is found in fresh tomato fruit, promotes gastric secretion, acts as a blood purifier and works as intestinal antiseptic (Pruthi, 1993).Tomato is a rich source of lycopene and vitamins. Lycopene may help counteract the harmful effects of substances called free radicals, which are thought to contribute to age-related processes and a number of types of cancer, including, but not limited to, those of prostate, lung, stomach, pancreas, breast, cervex, colorectum, mouth and oesophagus (Masroor *et al.,* 1988).

In Bangladesh, tomato has great demand throughout the year, but its production is mainly concentrated during the winter season. Recent statistics showed that tomato covered 75602 acres of land and the total production was approximately 413610 metric tons (BBS, 2015). Thus, the average yield of 5471kg/acre which is quite low as compared to that of other tomato growing countries of the World (Aditya *et al*., 1997).

It is expected that improved management practices with modern technology would increase the yield considerably. The plant growth regulators have contributed a great deal to the progress of olericulture. The growth behavior of many crop plants could be modified and controlled by applying small amount of growth regulators. Plant growth regulators (PGRs) are used extensively in agriculture to enhance plant growth and improve yield by increasing fruit number, fruit set and size. Several research workers have studied the effect of plant growth substances on vegetable crops. Among them, Naphthalene Acetic Acid (NAA) and gibberellins particularly GA_3 have been reported to show promising effect on tomato crop. Thus, it is Imperative to determine their concentration.

Naphthalene acetic acid is synthetic plant hormone in the Auxin family.it is known to stimulate cell division, cell elongation, elongation of shoot, photosynthesis, RNA synthesis membrane permeability and water uptake also involved in many physiological processes like prevention of pre harvest fruit drop, flower induction, fruit set, delayed senescence and prevention of bud sprouting, leaf chlorophyll content, and increased yield in fruit crops etc. (Razzak *et al.*, 2011).

On the other hand, Gibberellic acid is one of the most important growth stimulating substances used in agriculture since long. It may promote cell elongation, cell division, flowering, pollination, fertilization, germination, breaking dormancy, leaf expansion, fruit setting, increasing fruit size, improving fruit quality and in many other aspects of plant growth and development and thereby increased crop production. Gibberellic acid when applied to flowers controlled fruit drop in tomato (Feofanova, 1960). So, to increase the yield and to avoid flower and fruit dropping, application of GA_3 at right concentration and right time is important.

Therefore, in accordance with recent agricultural policy to increase yield vertically and to get early yield and better quality fruit, an attempt was made to study the effects of different concentrations of Naphthalene Acetic Acid (NAA) and Gibberellic Acid (GA_3) on plant growth and yield of tomato with the following objectives:

- to study the effect of exogenous application of NAA (Naphthalene Acetic Acid) and GA_3 (Gibberellic Acid) on growth and yield of tomato.
- to find out the suitable combination of NAA and GA_3 concentration on tomato production.

CHAPTER II

REVIEW OF LITERATURE

Tomato is an important vegetable crop and received much attention of the researchers throughout the world to develop its suitable production technique among various research works investigations have been made in various parts of the world to determine the different levels of Naphthalene acetic acid (NAA) and gibberellic acid (GA_3) for its successful cultivation. However, the combined effects of these production practices have not been defined clearly. In Bangladesh, there have not many studies on the influence of different levels of Naphthalene acetic acid (NAA) and gibberellic acid (GA_3) on the growth and yield of tomato. Relevant available information in this connection has been described in this chapter.

2.1 Effect of NAA on growth and yield of Tomato

Pargi *et al.* (2014) conducted a pot experiment on tomato crop at SHIATS, Allahabad. They applied 5 levels of NAA spray (10, 20, 30, 40 and 50 ppm NAA) on the bud initiation stage and found maximum yield of tomato with NAA @ 50 ppm followed by NAA @ 30 ppm.

Verma *et al*. (2014) conducted an experiment to study the effect of varying levels of NAA, 2, 4-D and GA_3 on growth, quality and yield of tomato and to ascertain the best concentration of NAA, 2, 4-D and GA_3 for vegetative growth and fruit quality of tomato. The experiment consisted one tomato variety viz .kashi vishesh (H-86) and different levels of NAA (15, 30, 45 ppm), 2, 4-D (5, 10, 15 ppm) and GA_3 (20, 30, 40 ppm) of different concentrations were used. The result showed maximum yield per hectare.

Tiwari and Singh (2014) reported that number of branches increased by Alar 100ppm, NAA 40ppm and Ethephon 100ppm while 2,4 D 10 and 5 ppm ; CIPA 20 ppm and Ethephon 100 ppm showed early maturity of fruits. More number of fruits per plant was recorded in CIPA 20 ppm, 2-4 D 5 ppm and NAA 40ppm. The percent fruit set was higher in CIPA 20ppm, 2, 4-D 5 ppm and GA_3 10 ppm than control. Equatorial fruit diameter was greater in 2, 4-D 5 ppm, CIPA 20 and 10 ppm whereas polar diameter was higher in Ethephon 100 ppm, Alar 100 ppm and CIPA 10 ppm. More no of locules per fruit was higher in 2, 4-D 5 ppm and CIPA 20ppm on the other hand, NAA 40ppm, 2, 4-D 10ppm and paclobutrazol 20 ppm showed higher TSS and pericarp thickness was greater in Ethephon 50 ppm, NAA 40 ppm, 2, 4-D 5 ppm and CIPA 20 ppm.

Maurya *et al.* (2013) conducted an experiment to study the effect of NAA i.e., (N0: control, N1: 20 ppm, N2:40 ppm, N3:60 ppm, N4: 80 ppm) on tomato crop using three cultivars (V1: Tomato Hybrid-2258, V2: TM-1, V3: TM-3). The observations were recorded on seven parameters which consist of yield and quality parameters. It is evident that irrespective of varieties the NAA application increased the yield and quality attributes in tomato crop. The fruit yield increased by about 30% with application of NAA (40 ppm) under field condition. The application of 40 ppm NAA and cultivar TM-1 was found to be better. On the basis of these results, it can be suggested that NAA has beneficial role on yield and quality of tomato.

Desai *et al.* (2012) conducted an experiment on tomato variety GT-3 (Gujarat tomato-3) at JAU, Junagarh, India. They found maximum fruit length (7.57 cm) , girth (6.47 cm) and pulp seed ratio (12.93) with GA_3 @ 75 ppm, whereas fruit weight (57 g), yield plant^{-1} (2.47 kg) and yield ha^{-1} (913.258 q/ha) found with NAA @ 75 ppm.

Patel *et al.* (2012) observed that plant height of tomato (86.40 cm) and brinjal (74.47 cm) was found to be maximum with 50 ppm NAA. For quality parameters, TSS (5.56 and 5.06 OB) and acidity (0.60 and 0.29 %) were found maximum with foliar spray of 100 ppm NAA in tomato and brinjal, respectively.

Singh *et al.* (2011) carried out an experiment find out the effect of different doses of NAA (N0 0 ppm, N1 50 ppm, N2 100ppm and N3 120 ppm) on vegetative growth, yield and quality of three tomato cultivars viz., NUN-1560 (V1), NUN-964 (V2) and NUN-963 (V3). The results revealed that cultivars, NAA doses and their interaction effect were significant regarding yield and yield contributing characters and quality parameters. The highest plant height (cm), number of branches per plant, number of fruit clusters per plant, number of fruits per plant, fruit length (cm), fruit width (cm), fruit yield per ha (q), storability (day) and total soluble solids (TSS) were recorded with N, (NAA 50 ppm) in all the three cultivars.

Olaiya *et al.* (2010) reported the effect of Indole-3-acetic acid (IAA), Indole-3-butyric acid (IBA) and Naphthalene acetic acid (NAA) at 60, 100 and 140 mg/L was evaluated on some biochemical indices of the nutritional quality of tomato (*Solanum lycopersicon*). The parameters evaluated were crude proteins, crude fat, crude fibre, ash, dry matter, titratable acidity, total carbohydrate, total soluble solids (oBrix), pH and oBrix/Acid ratio. The results showed that all the concentrations of IAA, IBA and NAA increased the levels of crude proteins, crude fat, crude fibre, ash, titratable acidity but decreased the total carbohydrate content. A decrease in dry matter content was evident in 60 mg/L of IAA, IBA, NAA and 100 mg/L of NAA. The pH of tomato pulp decreased in treatments involving 100 mg/L of IAA and 140 mg/L of IAA and NAA respectively. The total soluble solid content and oBrix/Acid ratio were significantly higher ($P < 0.05$) in the 100 mg/L NAA treatment. The results indicated that the bioregulators could enhance the basic tomato nutrients of importance in human diet.

Deb *et al.* (2009) found significant response of NAA (25 ppm) with respect to number of fruits/plant, fruit weight/plant, total soluble solid (TSS) and vitamin C and yield was obtained over the control (Saha *et al.*,2009).

Adventitious root formation in tomato cuttings was totally suppressed with the application of IAA and IBA combination. They further observed the best root formation in tomato cuttings in 1.00 mg NAA/L. (Gad and AttaAli, 2006)

Singh *et al*. (2005) carried out an investigation to see the effects of different doses of PGRs (control, 25 or 75 ppm IAA, and 25 or 75 ppm NAA) and micronutrient (control, 2500 ppm Multiplex or 2000 ppm Humaur) mixtures and their interactions on plant growth, number of branches and yield of tomato at 35 and 70 days after transplanting (DAT). Plant growth was not affected significantly by any treatment and interaction, although the effect of Pl (25 ppm IAA) x M2 (Humaur) interaction was better in increasing the plant growth at 75 DAT. The number of branches was signiticantly and highly increased by the application of 75 ppm IAA and 25 ppm NAA. The initiation time of first flowering and first fruiting was significantly and highly increased by the interaction P4 (75 ppm NAA) x M2 (Humaur). P4 (75 ppm NAA) x M2 (2000 ppm Humaur) was also significantly increased the yield. It can be concluded that addition of PGR and micronutrient in tomato is useful for better production.

Gupta and Gupta (2004) studied the plants were sprayed with 25 or 75 ppm IAA and NAA, alone or in combination with the micronutrient mixtures Multiplex 2500 ppm and 2000 ppm Humaur in a field experiment conducted in Allahahad, India to determine the effects of the treatments on the P content of tomato fruits and products. Application of 75 ppm NAA + multiplex resulted in the highest P content in tomato fruits, as well as in ketchup, and tomato puree and juice during both years.

Singh *et al*. (2002) conducted a field experiment at Allahabad, Uttar Pradesh, India to determine the effect of plant growth regulators (PGRs) and commercially available micronutrient mixtures on growth, yield and quality of tomato cv. Gobi (F_1 Hybrid). The treatments consisted of 2 concentrations (25 and 75 ppm) each of IAA and NAA, and micronutrients Humaur at 2000 ppm and Multiplex at 2500 ppm. PGRs were applied in the form of foliar sprays at intervals of 26 and 29 days, respectively, and micronutrients were applied as a spray at 30 days after planting. Plant growth characters and fruit quality varied with the application of PGR and micronutrient mixture combinations.

Rai *et al*. (2002) conducted an experiment that application of IAA at 75 ppm along with Multiplex at 2500 ppm resulted in highest plant height and yield, and IAA at 75 ppm alone in the highest number of branches. Application of IAA at 25 ppm + Multiplex at 2500 ppm superior for ascorbic acid content. Maximum chlorophyll content and acidity were obtained with NAA at 75 ppm along with Humaur at 2000 ppm IAA at 75 ppm + Humaur at 2000 ppm were the best for total soluble solids and carotenoid content. NAA at 75 ppm along with Multiplex at 2500 ppm gave the highest sugar content.

Singh *et al.* (2002) investigated the effects of p-chlorophenoxy acetic acid (PCPA, 50, 100 and 150 ppm), NAA (50 and 100 ppm) and their combination (PCPA at 50 ppm + NAA at 50 ppm) on the fruit set and development of tomato cv. NAA spray had no effect on fruit set per cluster when compared with the control. No significant variation was observed in fruit length and width over the control with different concentrations of PCPA, NAA or their combination. The number of locules per fruit was significantly higher in PCPA treatments compared with the control. PCPA at 50 ppm gave a non-significant increase in average fruit weight, Where as NAA had no effect on this parameter. PCPA at 50 ppm significantly increased tomato yield, but increasing the concentration to 100 and 150 ppm had no significant effect on tomato yield. Similarly, spraying NAA did not affect tomato yield. PCPA spray induced fruit deformations (30-36% of fruits were deformed), whereas NAA spray had lower effect (5-8% of fruits were deformed).

Gupta *et al*. (2002)[b] conducted an experiment to observed the effect of the plant growth regulators (PGRs) IAA and NAA (15 and 75 ppm), and micronutrient mixtures Multiplex (2500 ppm) [Ca, Mg, S, Fe, Zn, Mo. Mn, B and NAA] and

Humaur (2000 ppm) on the nutritive value of tomato (cv. Krishna) fruits. PGRs were applied at 25 and 75 days after transplanting (DAT). Treatment with micronutrient mixtures was conducted at 25 and 75 DAT. Higher nutritive content was obtained with the application of both PGRs and micronutrient mixtures than treatment with either PGR or micronutrient mixture. NAA at 75 ppm + Multiplex increased P content by l6.l2 % and iron content by 23.33%. The application of 75 ppm NAA + Humaur increased K content by 13.80% and Ca concentration by 52.38%. The Mg content increased by 43.84% due to the application of 25 ppm NAA + Humaur.

Gupta *et al*. (2001) studied with Tomato (cv. Krishna) plants were treated with IAA (25 ppm at 25 clays alter transplanting, DAT) and NAA (75 ppm at 75 DAT), and supplied with Multiplex (2500 ppm) and Humaur (2000 ppm), in a field experiment conducted during the rabi seasons. The physicochemical characteristics of, fruits were analyzed. Maximum total soluble solid content (5.4%) in mature tomato fruits was recorded from treatments of- NAA and Humaur. Maximum lycopene and carotenoid contents were recorded from NAA and Multiplex. Reducing and non-reducing sugar contents were the highest (4 mg/l00 g and 31.5 mg/100 g) when plants were treated with NAA and Humaur.

Lopez *et al.*, (2001) said that, Naphthalene Acetic Acid (NAA) significantly increased the number of root and root length.

Yadav *et al*. (2001) observed that NAA application increased total soluble solid percentage significantly.

Chung and Chori (2001) stated the foliar application of plant growth regulators affects distribution and accumulation of calcium ($45CaCl_2$) in tomato leaves. All tomato (cv. Sunroad) leaves, except the 7th and 8th or 5th to 8th leaves from the cotyledons, stem apices and the inflorescence, were removed to investigate the effect of plant growth regulators (PGR) on the leaves. The application of GA_3 to either of these leaves resulted in the accumulation of

$45Ca_2$ twice as high in the treated plants as in the plants which were sprayed distilled water (control plants). When 2-(3-chloroplrenoxy) propanoic acid (CPA) was applied onto the upper leaf, than $45Ca_2$ accumulation was higher than in the control plants, whereas there was no difference when CPA was applied onto the lower leaf. IAA or NAA treated leaves showed lower amount $45Ca_2$ than the leaves of control plants, showing more inhibiting effect of NAA, in particular. The present study indicates that the application of various PGR does not interrupt the acropetal movement of calcium ion.

Singh and Lal (2001) conducted a field experiment to determine the effect of plant bioregulators on the growth and yield of tomato cv. Pant T-3. The bioregulator treatments comprised CIPA (10 and 20 ppm); NAA (20 and 40 ppm); 2,4-D (5 and 10 ppm), Alar [daminozide] (50 and 100 ppm); GA_3 (5 and 10 ppm); ethephon (50 and 100 ppm); PPP (paclobutrazol, 5 and 10 ppm); and the control (water, 0 ppm). All the plant bioregulators decreased plant height compared to the control. The number of branches per plant increased with 10 ppm GA_3. All the bio regulators decreased the number of days to fruit maturity compared to the control. The minimum number of days to fruit maturity were found in 10 ppm 2,4-D. The maximum and minimum number of fruits per plant was recorded in 5 ppm GA_3 and 10 ppm 2,4-D, respectively.

Gupta and Gupta (2000) applied the auxins (IAA and NAA) at 25 and 50 days after transplanting (DAT) at 25 ppm and 75 ppm, respectively on tomato cv. Krishna. The two commercial products of micronutrient mixtures (Multiplex and Humaur) were applied at 2500 ppm and 2000 ppm at 25 and 50 DAT, respectively. The maximum plant height at 75 DAT was 82 cm and maximum number of branches (30) at 60 DAT was significantly ($P<0.05$) observed with 75 ppm NAA along with 2000 ppm Humaur. The early flower initiation (28 days) was significantly observed with 25 ppm NAA and Humaur compared to the control. The minimum days for fruit setting in plant were 42 DAT, observed significantly with the treatment of 25 ppm NAA along with Humaur.

Akhtar *et al.* (1997) conducted an experiment to study the effect of different rates of NAA (0, 25, 50, 75 and 100 ppm) on two tomato lines (TM 0111 and TM 0367). Different concentrations of NAA, when sprayed on flower clusters, had significant effects on fruit bearing, individual fruit weight, size and yield per plant and per hectare. The highest yield (11.21 t/ha) was obtained when the plants were sprayed with 25 ppm NAA. The yield reduced gradually as NAA rate increased from 50 to 100 ppm. The effects of plant growth regulators (IAA or NAA at 15, 25 or 50 ppm or GA_3 at 50, 75 or 100 ppm) and methods of plant growth regulator application (presoaking seeds for 24 h before sowing or presoaking seeds + foliar spray 30 days after transplanting) on the quality of tomato fruits were investigated. Plant growth regulators had profound effects on fruit length, weight and sugar: acid ratio. The effects of presoaking seeds + foliar application of plant growth regulators were more profound than presoaking alone.

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

Kar *et al.* (1993) applied IAA, NAA (both at 15, 25 or 50 p.p.m.) or GA_3 (50, 75 or 100 p.p.m.) to tomato cv. Pusa Early Dwarf by presoaking seeds with or without a foliar spray 30 days after transplanting. Plant growth, flowering, fruit retention and yield were evaluated. There was no consistent trend in response with increasing rates of plant growth regulator. Overall, the application as a seed presoak + spray gave the best fruit retention and yield.

Sumiati (1987) carried out an experiment to study the effects of plant growth regulators on flowering and fruit set using 4 tomato cultivars: Gondol, Moneymaker, Intan and Ratna. The plant growth regulator treatments were:

chlorflurenol, 50 ppm; NAA, 50 ppm; IAA, 100 ppm; GA_3, 10 ppm, and control. Flower initiation in Gondol was later than that in Intan, Ratna or Moneymaker. Number of flowers per cluster and per plant were not affected by plant growth regulator application, but were affected by cultivar. Chlorflurenol applied to Intan or Ratna significantly increased number of fruit clusters and number of fruits per plant. Application of IAA to cultivars Gondol, Moneymaker, Intan and Ratna significantly increased fruit diameter and total fruit weight; total fruit weight for cultivars Intan and Ratna were higher than for cultivars Gondol or Moneymaker.

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

2.2 Effect of gibberellic acid (GA_3) on growth and yield of Tomato

Shital *et al.* (2017) stated the application of GA_3 at 50 ppm (G1) recorded the significantly the highest plant height (79.69 cm), highest number of branches per plant (9.39), maximum number of fruit per plant(31.06), maximum length of fruit (4.36 cm), maximum diameter of fruit (4.32 cm), highest seed yield per plant (18.94 g), highest germination percentage (96.25%), highest root length (6.80 cm), highest shoot length (8.76cm), highest root fresh weight (0.81g), highest shoot fresh weight (3.37g), highest root dry weight (0.05mg), highest the shoot dry weight (0.20mg),highest vigour index 1 (length) (789.25), highest vigour index 2 (mass) (22.66).

Ahmad *et al.* (2017) evaluated the influence of different plant growth promoters on growth and yield of JP-27 summer cherry tomato line. Four different growth promoters including control viz. F0= Control (Water), F1= Flora (Nitrobenzene 20% w/w) @ 2.5ml/L, F2= 4-CPA @ 2.5 ml/L and F3= GA_3 @ 200ppm was used in this experiment arranged in a Randomized

Completely Blocked Design (RCBD) with three replications. Maximum plant height, no. of leaves, no. of branches, days to first flower, no. of flowers, no. of fruits, fruit length, single fruit weight, yield/plant and yield/ha (194.5 cm, 28.7, 12.7, 18.0, 48.3, 34.7, 19.9 mm, 20.4 gm, 458.7 gm and 19.0 ton respectively) were found in F3 treatment and maximum fruit diameter (40.7 mm) were found in F2 whereas the minimum (179.7 cm, 13.1, 5.7, 27.3, 36.3, 22.3, 13.5 mm, 33.0 mm, 10.6 gm, 287.9 gm and 13.2 ton respectively) were observed in F0. Thus application of plant growth promoters for improving overall performance of cherry tomato produced in summer can be recommended.

Akand *et al.* (2015) conducted an experiment on tomato crop at Sher-e- Bangla Agricultural University, Dhaka, Bangladesh. The experiment consisted three concentration of GA_3 i.e. 75ppm, 100ppm and 125 ppm. Among the concentration of GA_3 they found highest yield (92.99 t/ha) with GA_3 @ 125 ppm where as the G0 (no GA_3) gave lowest yield (60.46 t/ha).

Rahman *et al*. (2015) carried out an experiment to evaluate influence of different concentrations of GA_3 on biochemical parameters at different growth stages in order to maximize yield of summer tomato var. Binatomato-2. The concentrations of GA_3 were 0, 25, 50, 75 and 100 ppm. 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.

Mazed *et al*. (2014) observed that GA_3 had significant influence on 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.

Ram *et al.* (2014) carried out a field experiment to assess the growth, flowering, fruiting yield and quality traits of Tomato cv. KASHI VISHESH (H-86). The experiment was laid out in randomized block design with three replications for tomato crop 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 and various horticulture characters namely; plant height (cm), number of branches, number flowers per plant, number of clusters per plant, number of fruits per clusters, number of fruits per plant, average fruit length (cm), average fruit diameter (cm), average fruit weight (g), fruit yield per plant (kg), fruit yield per plot (kg), fruit yield per hectare (q), acidity (%) and total soluble solids TSS (0Brix). However, 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.

Kumar *et al*. (2014) conducted an experiment on tomato crop at SHIATS, Allahabad, UP. The experiment consisted of one tomato variety "Golden" and five levels of GA_3 *i.e.* (10, 20, 30, 40 and 50 ppm). The highest plant height (38.17 cm) at 20 DAT, number of leaves (39.51) and fresh fruit weight was found 1.10 kg. Highest yield were estimated for GA_3 @ 50 ppm followed by GA_3 @ 40 ppm.

Kazemi *et al.* (2014) investigated the effect of 2 levels of GA_3 (10-4 and 10-8 mm) and 2 levels of potassium nitrate (6 and 8 mm) spray on growth, leaf NPK – content, University, karaj, Iran. With regard to fruit quality, the application of GA_3 at 10-8 mm and potassium nitate at 8mm increased fruit lycopene content and TSS. They concluded that GA_3 was suitable for increasing vegetative growth and reproductive characteristics of tomato.

Choudhury *et al.* (2013) carried out a field experiment on tomato at Sher-e-Bangla Agricultural University, Dhaka to assess the effect of different plant growth regulators on tomato during summer season. They confined that highest yield (28.40 t ha^{-1}) were found in PGR (4-CPA + GA_3 @ 20 ppm of each), followed by PGR (4- CPA @ 20 ppm) and minimum yield (17.35 t ha^{-1}) obtained with control.

Gelmesa *et al.* (2010) conducted an experiment at Mekassa Agricultural Research center, Ethiopia on tomato. The experiment consisted of two tomato varieties one for processing (Roma VF) and one for fresh market (Fetan), three levels of 2,4-D (0, 5, 10 mg l^{-1}) and 4 levels of GA_3 (0, 10, 15 and 20 mg l^{-1}) were applied. They found increase in fruit length from 5.44 to 6.72 cm at 10 mg l-1 2,4-D combined with 10 mg l^{-1} GA_3. The marketable fruit yield of "Rome-VF was obtained 69.50 t ha^{-1} with 10 mg l^{-1} GA_3 followed by 67.92 t ha^{-1} with 15 mg l^{-1} GA_3.

Serrani *et al*. (2007) investigated the effect of applied gibberellin (GA_3) and auxin on fruit-set and growth in tomato (*Solanum lycopersicum* L.) cv. Micro-Tom. Unpollinated ovaries responded to GA_3 and to different auxins [indol-3-acetic acid, naphthaleneacetic acid, and 2,4-dichlorophenoxyacetic acid (2,4-D)], 2,4-D being the most efficient. Simultaneous application of GA_3 and 2,4-D produced parthenocarpic fruits similar to pollinated fruits, but for the absence of seeds, suggesting that both kinds of hormones are involved in the induction of fruit development upon pollination.

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

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

Nibhavanti *et al*. (2006) carried out an experiment on the effects of gibberellic acid, NAA, 4-CPA and boron at 25 or 50 ppm on the growth and yield of tomato (cv. Dhanshree) during the summer season of 2003. Plant height and number of leaves were greatest with gibberellic acid at 25 and 50 ppm (74.21 cm and 75.33 cm, respectively) and 4-CPA at 50 ppm (72.22 cm). The number of primary branches per plant did not significantly vary among the treatments. Gibberellic acid at 50 ppm resulted in the lowest number of primary branches per plant. The number of fruits per plant (38.86) was highest 50 ppm boron. The highest yields were recorded for boron at 25 and 50 ppm (254.2 and 264.4 quintal/ha).

Bhalekar *et al.* (2006) studied the effects of GA_3, NAA, 4-CPA and boron at 25 or 50 ppm on the growth and yield of tomato (cv. Dhanshree). Plant height was greatest with GA_3 at 25 and 50 ppm (74.21 and 75.33 cm, respectively), and 4-CPA at 50 ppm (72.22 cm). The number of primary branches per plant did not significantly vary among the treatments. GA_3 at 50 ppm resulted in the lowest number of primary branches per plant (69.55). The number of fruits per plant (38.86) was highest 50 ppm boron. The highest yields were recorded for boron at 25 and 50 ppm (254.2 and 264.4 quintal/ha).

Sasaki *et al*. (2005) studied the effect of plant growth regulators on fruit set of tomato (*Lycopersicon esculentum* cv. Momotaro) under high temperature and in a field (Japan) under rain shelter. Tomato plants exposed to high temperature (34/20 degrees C) had reduced fruit set. Treatments of plant growth regulators reduced the fruit set inhibition by high temperature to some extent, especially with mixtures of 4-chlorophenoxyacetic acid (4-CIIA) and gibberellins (GAs). They also reported that tomatoes treated with a mixture of 4-CPA and GA_3 showed increased fruit set, dry matter content of fruit and the numbers of normal fruits were more than the plants treated with 4-CPA alone during summer.

Naeem *et al.*(2006) a pot experiment was performed according to a factorial randomized design at Aligarh to study the effect of 4 levels of gibberellic acid spray (0, 10-8, 10-6 and 10-4 M GA_3) on the growth, leaf-NPK content, yield and quality parameters of 2 tomato cultivars (*Lycopersicon esculentum* Mill.), namely Hyb-SC-3 and Hyb-Himalata. Irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters, especially in the case of Hyb-SC-3.

Kataoka *et al*. (2004) conducted an experiment on the effect of uniconazole on fruit growth in tomato cv. Severianin and reported that uniconazole (30 mg/litre) reduced fruit weight when applied to parthenocarpic fruits at approximately 0, 1 and 2 weeks after anthesis, but had no effect on fruit weight when applied at approximately 3 weeks after anthesis. To determine the antagonism between gibberellic acid (GA_3) and uniconazole in the regulation of fruit growth, flower clusters were treated with uniconazole (5 mg/L) and GA_3 (5 or 50 mg/L). They reported that no notable gibberellin's activity was detected in treated fruits at 3 days to 4 weeks after treatment. The mean fresh weight of fruits at 4 weeks after treatment was lower than that of the control value. The results suggest that endogenous gibberellins in the early phase are important for fruit set and development.

Bhosle *et al.* (2002) found in tomato that the number of flowers per cluster, fruit weight and marketable yield increased with increasing rates of the plant growth regulators. Treatment with GA_3 @ 30 ppm resulted in the tallest plants, whereas treatment with 25 ppm 4-CPA and 45 ppm GA_3 resulted in the highest number of primary branches of tomato cultivars Dhanashree (4.16) and Rajashree (5.38), respectively.The highest marketable yield of Dhanashree and Rajashree resulted from treatment with 4-CPA @ 75 ppm.

Pundir and Yadav (2001) stated that GA_3 sprayed at 25 ppm significantly increased the growth characters yield and yield components and also improved the quality of tomato cv. Punjab Chhuhara.

Martins *et al*. (1999) studied the growth regulators and leaf anatomy in tomato (*Lycopersicon esculenlum* Mill.) cv. Angela Gigante. The plant growth regulators GA_3 (50 mg/L), NAA (100 mg/L), chlormequat (1500 mg/L.) and SADH [daminozide] (3000 mg/L) were applied to greenhouse tomato cv. Angela Gigante plants at the 4-true-leaves stage. Twenty days after treatment, the growth promoters (GA_3 and NAA) increased the number of stomata per square mm on the adaxial epiderrnis and carbon assimilation rate cornpared with untreated controls and decreased the number of epidermal cells on both sides of the leaves. The growth retardants (chlormequat and SADH) increased the thickness of the lacunary parenchyma more than the growth promoters.

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

Gulnaz *et al.* (1999) reported that seeds of tomato treated with to 10 ppm of GA_3 resulted in 36-43% increase in dry weight at 13.11 dSm-1. Gurdev and Saxena (1991) observed that the growth regulators (GA_3 at 10-5 M) increased total dry matter. Application of 10-5 M GA_3 on mustard at 40 or 60 days after sowing significantly increased total dry matter (Khan *et al*. 1998).

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

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

Bima *et al*. (1995) worked with gibberellic acid and found that GA_3 (5-10 ppm) enhanced germination of seeds and induced flowering. NAA and 2,4-D (5-10 ppm) induced early flowering and promote fruit set.

El-Abd *et al*. (1995) studied the effect of plant growth regulators for improving fruit set of tomato. Two tomato cv. Alicante crops were produced in pots in the greenhouse. When the third flower of the second cluster reached anthesis, the cluster was sprayed with IAA, GA_3 or ABA at l0-4, 10-6 or 10-8 M each and ACC at l0-9, 10-10 or 10-11 M. All concentrations of IAA, GA_3 ACC and ABA induced early fruit set compared with controls sprayed with distilled water. For the first of the 2 crops, the highest ABA concentration (l0-5 M) accelerated fruit set, but the other 2 concentrations delayed it. For the second crop, however all ABA treatments accelerated fruit set. ABA applions also retarded red fruit color formation, more so at increasing concentrations. IAA at l0-6 M resulted in the formation of double flowers of total fruits set from treated flowers, 40 % were double. GA_3 led to the formation of leafy clusters, with the number of leaves and dry matter content of leaves increasing with GA_3 concentration. Saleh and Abdul (1980) conducted an experiment with GA_3 (25 or 50 ppm) which was applied 3 times in June or early July. They reported that GA_3 stimulated plant growth. It reduced the total number of flowers per plant, but increased the total yield compared to the control. GA_3 also improve fruit quality.

Singh and Lal (1995) reported the foliar spray of GA_3 (50 ppm) at 50 percent flowering increased the fruit set and seed yield of tomato.

Total dry matter of a crop is the output of net photosynthesis Patel and Saxena (1994) reported that presoaking of seed of gram in varying concentrations of GA_3 showed the best results on dry weights.

Sumati (1987) recorded significant increase in number of fruit per plant in tomato cv. Money maker with spraying of 10 ppm GA_3 against untreated plants. The purpose of applying gibberellins is to optimize yield by modifying growth and development and to enhance the quantitative and qualitative production. Many physiological processes and management practices involved in tomato production, those can effected by gibberellins (GA_3) in order to reduce production cost and increase yield and its quality.

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

Satti and Oebekar (1986) reported that an increase in fruit set of tomato due to application of GA_3 @ 45 ppm at various stages of inflorescence development.

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

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

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

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

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

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

Kanwar *et al.* (1976) recorded significantly increased fruit length (5.15 cm) and weight with spray of GA_3 (30 ppm) at pre-bloom stage in tomato whereas, did not notice any significant increase in fruit length of chilli with GA_3 (10 ppm) sprayed at first flower opening followed by two sprays at interval of 30 days.

Mehta and Mathi (1975) reported that GA_3 treatments at 10 or 25 ppm improved the yield of tomato cv. "Pusa Ruby" irrespective of planting date. GA_3 gave earlier setting and maturity.

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

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

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

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

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

Gain in dry matter per unit assimilatory area per unit time is the NAR. It was established that NAR become higher during vegetative stage and then decline rapidly as season progressed (Kollar *et al*., 1970) possibly due to mutual leaf shading and increase of old leaves which could have lower photosynthetic efficiency (Pandey and Singh, 1978). The NAR was positively correlated with CGR (Majumder *et al.*, 1980).

Mehrotra *et al.* (1970) recorded the significant increase in the plant height (95 cm) with 25 ppm GA_3 spray at flower initiation stage in tomato.

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

Bora and Selman (1969) working with tomato demonstrated that four foliar sprays of GA_3 (0, 5, 50 or 500 ppm) applied at 7, 17, 22, 27 or 370 increased the leaf area, weight and height of tomato plants. The best treatment was 5 ppm GA_3 at 220C.

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

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

Feofanova (1960) observed that the application of growth regulators on tomato plants could produce not only seedless fruits but also could increase the size of the fruits and even could change favorably the form of the fruit trusses. He further that the application could increase total yield of tomato fruits by preventing fruit drop.

Rappaport (1960) noted that GA_3 had no significant effect on fruit weight or size either cool (11 ^{0}C) or warm (23 ^{0}C) night temperatures; but it strikingly Reduced fruit size at an optimal temperature (l7 ^{0}C) and recorded more plant height when GA_3 sprayed at the rate of 20 to 40 mg per litre of water at flower initiation stage in tomato.

Choudhury and Singh (1960) reported the enhanced effect of GA_3 on vegetative growth in tomato by spraying at different concentrations in field condition.Involved in many physiological processes like, controlling flowering, increasing number of branch, number of cluster, enhancing fruit set and size, dry matter content of fruits, increasing earliness, regulating sex expression and to enhance productivity of crop.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from November, 2015 to April, 2016 to study the effect of different levels of NAA and GA_3 on growth and yield of tomato. This chapter includes materials and methods that were used in conducting the experiment and presented below under the following headings:

3.1 Location of the experimental field

The experiment was conducted at Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2015 to April 2016. The location of the experimental site was at 23^0 $46^{'}$ N latitude and 90^0 $22^{'}$ E longitudes with an elevation of 8.24 meter from sea level.

3.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of May to September (Anon., 1988) and scattered rainfall during the rest of the year. Information regarding average monthly temperature as recorded by Meteorological Department of Bangladesh (climate division) during the period of study has been presented in Appendix I.

3.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) with pH 5.8-6.5, ECE-25.28 (Haider, 1991). The analytical data of the soil sample collected from the experimental area were determined from the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.4 Plant materials collection

The tomato variety used in the experiment was "BARI Tomato-14". This is a high yielding indeterminate type variety. The seeds were collected from Olericulture division of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) Joydebpur, Gazipur.

3.5 Raising of seedlings

Tomato seedlings were raised in two seedbeds of 3 m x 1m size. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed and 5 kg well rotten cow dung was mixed with the soil. Five (5) gram of seeds was shown on each seedbed on 3rd November, 2015. After sowing, seeds were covered with light soil. The emergence of the seedlings took place within 6 to 7 days after sowing. Weeding, mulching and irrigation were done as and when required.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:

Factor A: Three levels of NAA (Naphthalene acetic acid)

N_0 = Control (No NAA)
N_1 = 25 ppm NAA
N_2 = 50 ppm NAA

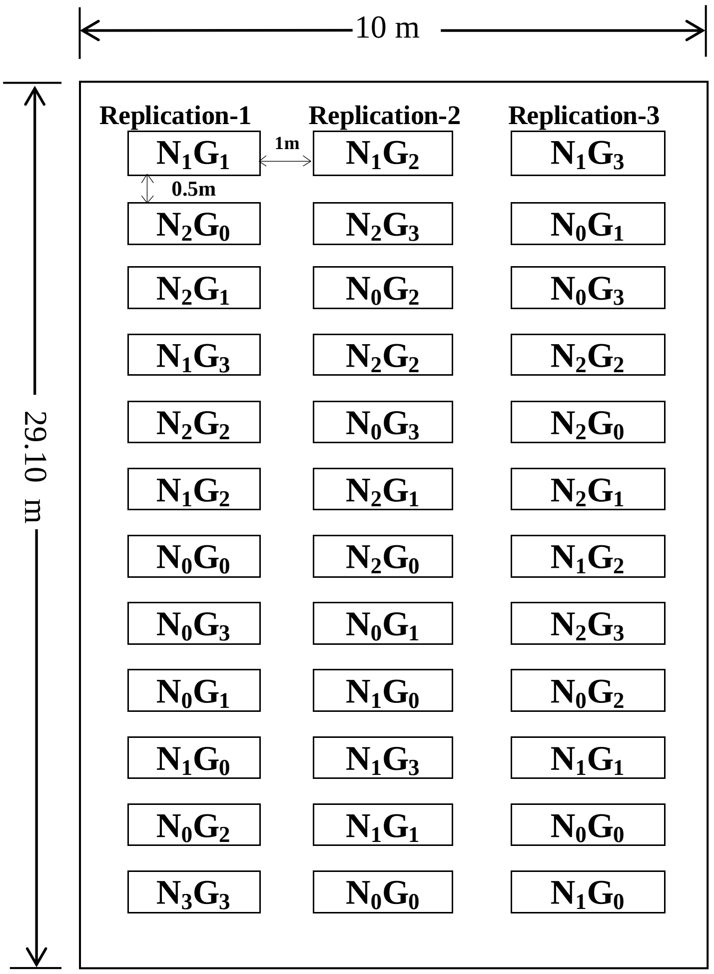
Factor B: Four levels of GA_3 (Gibberellic acid)

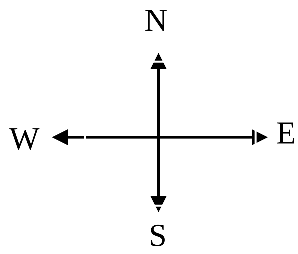
G_0 = Control (No GA_3)
G_1 = 50 ppm GA_3
G_2 = 100 ppm GA_3
G_3 = 150 ppm GA_3

There were altogether 12 treatments combination used in each block.

3.7 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 29.1 m x 10 m was divided into three equal blocks. Each block was consists of 12 plots where 12 treatments were allotted randomly. There were 36 unit plots in the experiment. The size of each plot was 1.8 m x 2 m. The distance between two blocks and two plots were kept 1 m and 0.5 m respectively. A layout of the experiment has been shown in figure 1.





Plot size: 2m x 1.8 m
Spacing: 60 cm x 50 cm
Spacing between plots: 0.50 m
Spacing between replication: 1 m

Factor A : IAA

N_0 : Control (no NAA)
N_1 : 25 ppm NAA
N_2 : 50 ppm NAA

Factor B : GA_3

G_0 : Control (no GA_3)
G_1 : 50 ppm GA_3
G_2 : 100 ppm GA_3
G_3 : 150 ppm GA_3

Fig. 1: Field layout of the experimental plot

3.8 Cultivation procedure

3.8.1 Land preparation

The soil was well prepared and good tilth was ensured for commercial crop production. The land of the experimental field was ploughed with a power tiller on 20 November, 2015. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was made ready. The field layout and design was followed after land preparation.

3.8.2 Manures and fertilizers and its methods of application

Fertilizer	Quantity	Application method
Cow dung	15t/ha	Basal dose
Urea	400kg/ha	20, 30 and 40 DAT
TSP	300 kg/ha	Basal dose
MOP	250 kg/ha	20, 30 and 40 DAT mixed with urea

Rashid (2012).

According to Rashid (2012), the entire amount of cow dung and TSP were applied as basal dose during land preparation. Urea, TSP and MOP were applied at the rate of 400 kg/ha, 300 kg/ha and 250 kg/ha respectively. Urea and MOP were used as top dressing in equal splits at 20, 30 and 40 days after transplanting.

3.8.3 Application and preparation of NAA

The stock solution of 1000 ppm of NAA was made by mixing of 1 g of NAA with small amount of ethanol to dilute and then mixed in 1 litre of distilled water. Then as per requirement of 25 ppm and 50 ppm solution of NAA, 25 and 50 ml of stock solution were mixed with 1 litre of distilled water respectively. Application of NAA was done at 15 days interval and was applied at 25, 40, and 55 days after transplanting.

3.8.4 Application and preparation of GA_3

The stock solution of 1000 ppm of GA_3 was made by mixing of 1 g of GA_3 with small amount of ethanol to dilute and then mixed in 1 litre of distilled water. Then as per requirement of 50 ppm, 100 ppm and 150 ppm solution of $GA_{3,}$ 50, 100 and 150 ml of stock solution were mixed with 1 litre of distilled water respectively. Application of GA_3 was done at 15 days interval and was applied at 20, 35, and 50 days after transplanting.

3.8.5 Transplanting of seedlings

Healthy and uniform 25 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in 05 December, 2015 maintaining a spacing of 60 cm x 50 cm between the rows and plants, respectively. This allowed an accommodation of 12 plants in each plot. The seedbed was watered before uprooting the seedlings from the seedbed so as to minimize damage to the roots. The seedlings were watered after transplanting. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.8.6 Intercultural operations

After transplanting the seedlings, various kinds of intercultural operations were accomplished for better growth and development of the plants, which are as follows:

3.8.6.1 Gap filling

When the seedlings were well established, the soil around the base of each seedling was pulverized. A few gaps filling was done by healthy seedlings of the same stock where initial planted seedling failed to survive.

3.8.6.2 Weeding

Numbers of weeding were accomplished as and whenever necessary to keep the crop free from weeds.

3.8.6.3 Staking

When the plants were well established, staking was given to each plant by rope and plastic wire to keep them erect. Within a few days of staking, as the plants grew up, other cultural operations were carried out.

3.8.6.4 Irrigation

Number of irrigation was given throughout the growing period by garden pipe and watering cane. The first irrigation was given immediate after the transplantation where as other were applied when and when required depending upon the condition of soil.

3.8.6.5 Plant protection

From seedling to harvesting stage i.e. any stage, tomato is very sensitive to diseases and pest. After getting a maturity stage protection measure was taken against diseases and pests. So that, any insect or fungal infection and insect infestation cannot appear in the plant.

3.8.6.6 Insect pests

Bavistin 50 WP and Ripcord 10 EC were applied @ 10 ml/L against the fungal diseases, leaf curl disease and insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly for a week after transplanting to two weeks before first harvesting.

3.9 Harvesting

Fruits were harvested at 7 to 8 days intervals during early ripe stage when they attained slightly red color. Harvesting was started from 10 March, 2016 and was continued up to end of 20 April 2016.

3.10 Data collection

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

3.10.1 Plant height (cm)

The plant height was measured in centimeters from the base of plant to the terminal growth point of main stem on tagged plants was recorded at 10 days interval starting from 20 days of planting up to 60 days to observe the plant height. The average height was computed and expressed in centimeter.

3.10.2 Number of leaves plant^{-1}

The number of leaves per plant was manually counted at 20, 30, 40, 50 and 60 days after transplanting from randomly selected tagged plants. The average of six plants were computed and expressed in average number of leaves per plant.

3.10.3 Number of branches plant^{-1}

The number of branches per plant was manually counted at 50 and 60 days after transplanting from randomly selected tagged plants. The average of six plants were computed and expressed in average number of branch per plant.

3.10.4 Canopy size of the plant (cm)

The canopy size of the plant was manually counted at 50 and 60 days after transplanting from randomly selected tagged plants. The average of six plants were computed and expressed in average canopy size of the plant.

3.10.5 Stem diameter of plant (cm)

The stem diameter of the plant was manually measured by slide calipers at 50 and 60 days after transplanting from tagged plants. The average of six plants were measured and expressed in average stem diameter of the plant

3.10.6 Length of leaf (cm)

The Length of leaf of the plant was manually measured by centimeter scale at 50 and 60 days after transplanting from randomly selected six tagged plants. The length of six tagged leaves were measured and expressed in average Length of leaf of the plant. The tomato plant has the compound leaf. So the higher length of compound leaf can contain the large number of leaflet on the mid rib.

3.10.7 Number of clusters plant^{-1}

The number of clusters was counted at 50 and 60 days after transplanting from the six sample plants and the average number of clusters produced per plant was recorded.

3.10.8 Number of flowers cluster^{-1}

The number of flowers per cluster was counted at 50 and 60 days after transplanting from the six sample plants. From each plant randomly five clusters were selected and counted the number of flowers per cluster to make an average value for one plant. The final average value of number of flowers per cluster was calculated from six averages from six plants.

3.10.9 Number of fruits cluster^{-1}

The number of fruits per cluster was counted at 60 DAT and harvesting time from selected six plants. From each plant randomly five clusters were selected and counted the number of fruits per cluster to make an average value for one plant. The final average value of number of fruits per cluster was calculated from six plants.

3.10.10 Length of fruit (cm)

Among the total number of fruit harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for determine the length of fruit by slide calipers. The length of fruit was calculated by making the average of five fruits from each of the six plants.

3.10.11 Diameter of fruit (cm)

Among the total number of fruits harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for determine the diameter of fruit by slide calipers. The diameter of fruit was calculated by making the average of five fruits from each of the six plants.

3.10.12 Fresh weight of fruit (g)

Among the total number of fruit harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for determine the individual fruit weight in gram. The weight was calculated from total weight of fruits was divided by total number of fruits of every harvest and finally making the average was made from four times harvesting data.

3.10.13 Dry matter content of fruit (%)

After harvesting, randomly selected 100 gram of fruit sample previously sliced in to very thin pieces. The fruits were then dried in the sun for one day and placed in oven maintained at 60 ^{0}C for 72 hrs. The sample was then transferred into desiccators and allowed to cool down to the room temperature. The final weight of the sample was taken. The dry matter was calculation by the following formula:

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

3.10.14 Total Soluble Solid (TSS) of fruit

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

3.10.15 Chlorophyll content in leaf (%)

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

3.10.16 Length of root (cm)

The length of root was manually measured at the time of harvest from randomly selected six plants. The averages root length of six sample plants were considered as root length of plant.

3.10.17 Carbon assimilation rate (%)

The Carbon assimilation rate of the plant was measured by an automatic LC-PRO meter at 50 days after transplanting from six tagged plants. The Carbon assimilation rate of five tagged leaves of each plant was measured and calculated the average Carbon assimilation rate of one plant.

3.10.18 Yield plant^{-1} (kg)

Yield of tomato per plant was recorded as the whole fruit per plant and was expressed in kilogram (kg).It was measured by the following formula:

$$\text{Weight of fruits per plant (Kg)} = \frac{\text{Total weight of fruits in six sample plants}}{6}$$

3.10.19 Yield plot^{-1} (kg)

An electric balance was used to measure the weight of fruits per plot. The total fruit yield of each unit plot measured separately from each sample plant during the harvesting period and was expressed in kilogram (kg).

3.10.20 Yield (t ha^{-1})

It was measured by the following formula:

$$\text{Yield of tomato (t/ha)} = \frac{\text{Fruit yield per unit plot (kg) x 10000}}{\text{Area of unit plot in square meter x 1000}}$$

3.11 Statistical analysis

The recorded data on various parameters were statistically analyzed using MSTAT-C statistical package program. The mean for all the treatments was calculated and analysis of variance for all the characters were performed by F-Difference between treatment means were determined by LSD according to Gomez and Gomez, (1984) at 5% level of significance.

CHAPTER IV

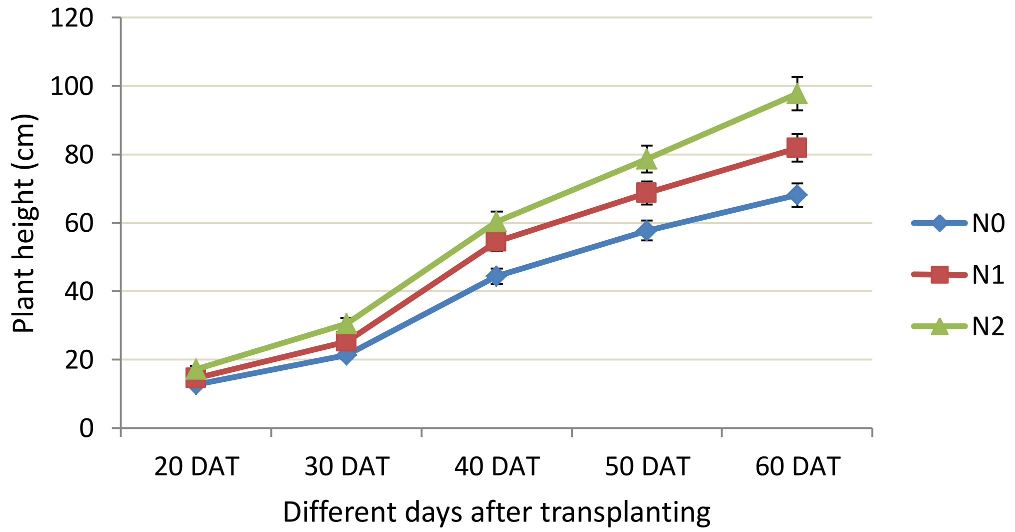
RESULT AND DISCUSSION

The present study was conducted to find the effect of NAA and GA_3 on growth and yield of tomato. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are given in Appendix III-IX. The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following headings:

4.1 Plant height

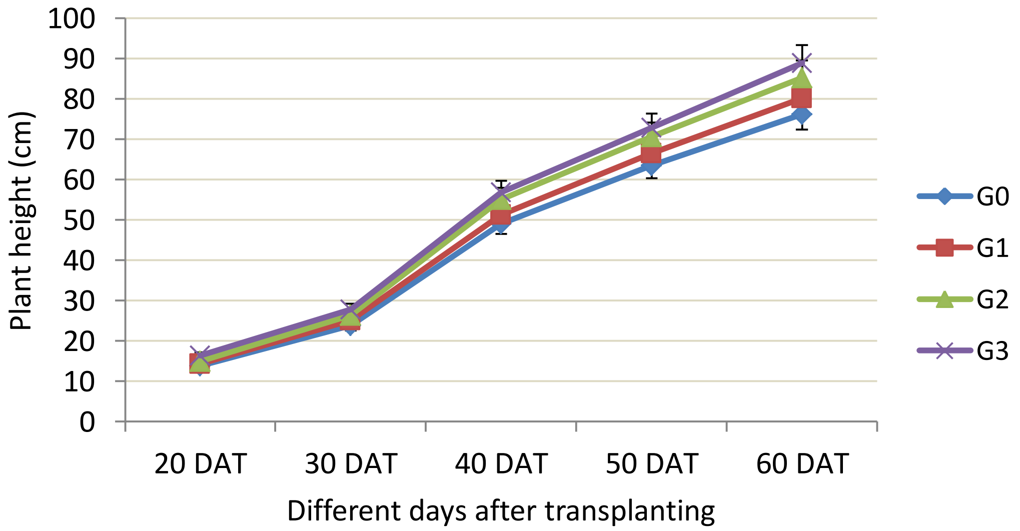
The significant difference was observed due to the application of NAA at 30, 40, 50 and 60 DAT except 20 DAT (Appendix III). At 20, 30, 40, 50 and 60 DAT the maximum plant height (17.25 cm, 30.58 cm, 60.33 cm, 78.58 cm and 97.75 cm) was recorded from N_2 (50 ppm NAA) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum plant height (12.75 cm, 21.33 cm, 44.41 cm, 57.75 cm and 68.08 cm) was recorded from N_0 (control) treatment (Fig 2). Rai *et al*. (2002) conducted an experiment that application of IAA along with Multiplex resulted in highest plant height and yield. Gupta *et al*. (2001) studied with Tomato plants were treated with NAA and supported the results.

Due to the GA_3 application significant difference was observed at 30, 40, 50 and 60 DAT except 20 DAT (Appendix III). At 20, 30, 40, 50 and 60 DAT the maximum plant height (16.33 cm, 27.77 cm, 56.88 cm, 72.77 cm and 88.88 cm) was obtained from G_3 (150 ppm GA_3) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum plant height (13.88 cm, 23.77 cm, 49.00 cm, 63.55 cm and 76.11 cm) was recorded from G_0 (control) treatment (Fig 3). Shital *et al.* (2017) stated the application of GA_3 significantly increases the plant height. Kumar *et al*. (2014) conducted an experiment on tomato and supported the results. Rai *et al.* (2006) conducted an experiment GA_3



N_0: 0 ppm NAA (control), N_1: 25 ppm NAA, N_2: 50 ppm NAA

Fig 2. Effect of NAA on plant height of tomato at different days after transplanting (DAT)



G_0: 0 ppm GA_3 (control), G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, G_3: 150 ppm GA_3

Fig 3. Effect of GA_3 on plant height of tomato at different days after transplanting (DAT)

Table 1. Combined effect of NAA and GA_3 on plant height of tomato at different days after transplanting (DAT)

Treatment	**Plant Height (cm)**				
	20 DAT	**30 DAT**	**40 DAT**	**50 DAT**	**60 DAT**
N_0G_0	12.00 h	19.33 h	37.33 f	52.66 g	60.33 g
N_0G_1	12.66 gh	21.33 gh	42.66 f	57.33 fg	68.00 fg
N_0G_2	13.00 fgh	22.00 g	48.66 e	60.00 ef	71.33 ef
N_0G_3	13.33 fg	22.66 fg	49.00 e	61.00 ef	72.67 ef
N_1G_0	13.66 efg	23.33 fg	51.66 de	64.00 ef	75.33 ef
N_1G_1	14.00 ef	24.33 ef	52.33 cde	65.66 de	77.67 de
N_1G_2	14.66 de	26.33 de	56.00 bcd	72.00 cd	86.67 cd
N_1G_3	15.66 cd	27.33 cd	57.66 bc	73.33 bc	88.00 c
N_2G_0	16.00 bc	28.66 bc	58.00 bc	74.00 bc	92.67 bc
N_2G_1	16.00 bc	29.66 b	58.66 ab	76.33 bc	94.67 bc
N_2G_2	17.00 b	30.66 b	60.66 ab	80.00 ab	97.67 ab
N_2G_3	20.00 a	33.33 a	64.00 a	84.00 a	106.00 a
LSD $_{(0.05)}$	**1.25**	**2.24**	**5.83**	**6.81**	**9.16**
CV %	**5.01**	**5.16**	**6.50**	**5.89**	**6.55**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control)
N_1: 25 ppm NAA
N_2: 50 ppm NAA
G_0: 0 ppm GA_3 (control)
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3

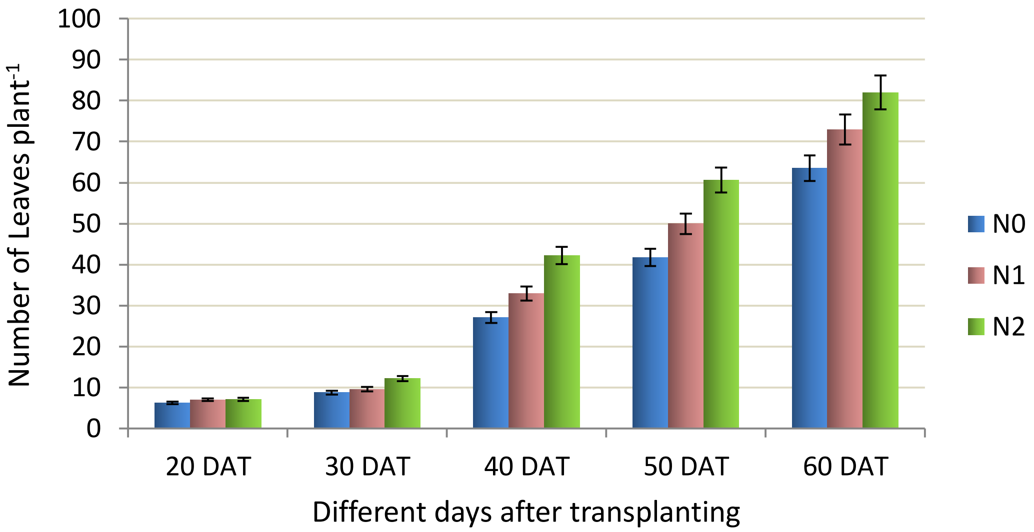
significantly reduced the number of seeds per fruit but increased plant height, plant canopy size and number of branches per plant. Wu *et al.* (1983) sprayed one month old transplanted tomato plants with GA at 1, 10,100 ppm. They reported that GA_3 at 100 ppm increased plant height and leaf area. Mehrotra *et al.* (1970) recorded the significant increase in the plant height (95 cm) with 25 ppm GA_3 spray at flower initiation stage in tomato. Bora and Selman (1969) working with tomato demonstrated that four foliar sprays of GA_3 increased the leaf area, weight and height of tomato plants.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application at 30, 40, 50 and 60 DAT except 20 DAT (Appendix III). At 20, 30, 40, 50 and 60 DAT the maximum plant height (20.00 cm, 33.33 cm, 64.00 cm, 84.00 cm and 106.00 cm) was recorded from N_2G_3 (50 ppm NAA and 150 ppm GA_3) treatment combination. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum plant height (12.00 cm, 19.33 cm, 37.33 cm, 52.66 cm and 60.33 cm) was recorded from N_0G_0 (control) treatment combination (Table 1).

4.2 Number of leaves plant^{-1}

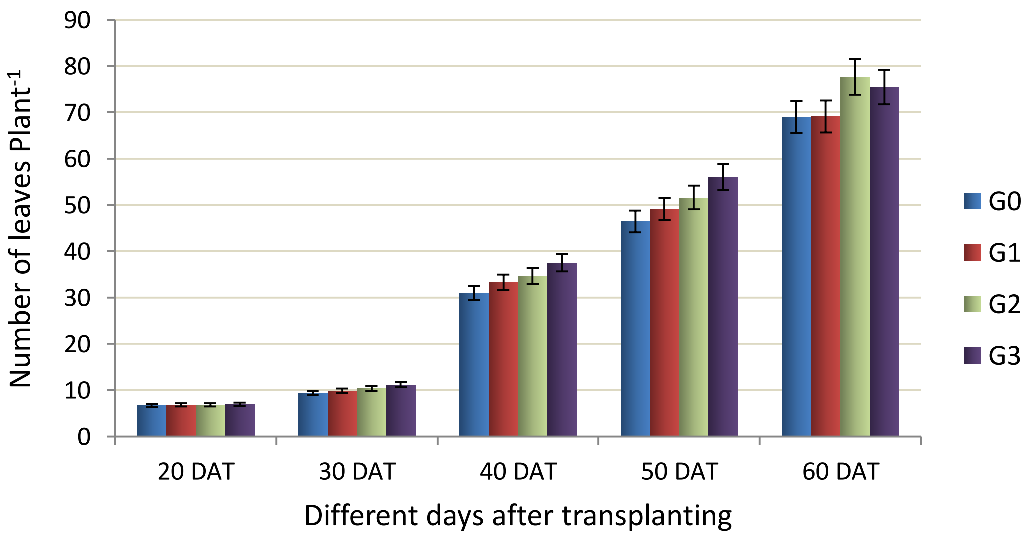
The significant difference was observed due to the application of NAA at 30, 40, 50 and 60 DAT except 20 DAT (Appendix IV). At 20, 30, 40, 50 and 60 DAT the maximum number of leaves per plant (7.08, 12.16, 42.16, 60.58 and 82.00) was recorded from N_2 (50 ppm NAA) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum number of leaves per plant (6.25, 8.75, 27.08, 41.75 and 63.50) was recorded from N_0 (control) treatment (Fig 4). Gupta *et al*. (2001) studied with Tomato plants were treated with NAA and supported the results.

Due to the GA_3 application significant difference was observed at 30, 40, 50 and 60 DAT except 20 DAT (Appendix IV). At 20, 30, 40, 50 and 60 DAT the maximum number of leaves per plant (6.88, 11.11, 37.44, 56.00 and 77.66) was obtained from G_3 (150 ppm GA_3) treatment. On the other hand, at 20, 30, 40, 50 and 60 DAT minimum number of leaves per plant (6.66, 9.33, 30.88, 46.44 and 69.00) was recorded from G_0 (control) treatment (Fig 5). Shital *et al.* (2017) stated the application of GA_3 significantly increases the plant height, highest number of leaves per plant. Choudhury *et al.* (2013) carried out a field experiment on tomato and agreed with the results. Wu *et al.* (1983) sprayed one month old transplanted tomato plants with GA at 1, 10,100 ppm. They reported that GA_3 at 100 ppm increased plant height and leaf area. Bora and Selman (1969) working with tomato demonstrated that four foliar sprays of GA_3 increased the leaf area, weight and height of tomato plants.



N_0: 0 ppm NAA (control), N_1: 25 ppm NAA, N_2: 50 ppm NAA

Fig 4. Effect of NAA on Number of leaves plant^{-1} of tomato at different days after transplanting (DAT)



G_0: 0 ppm GA_3 (control), G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, G_3: 150 ppm GA_3

Fig 5. Effect of GA_3 on Number of leaves plant^{-1} of tomato at different days after transplanting (DAT)

Table 2. Combined effect of NAA and GA_3 on number of leaves $plant^{-1}$ of tomato at different days after transplanting (DAT)

Treatment	Number of leaves $plant^{-1}$				
	20 DAT	**30 DAT**	**40 DAT**	**50 DAT**	**60 DAT**
N_0G_0	6.00 b	8.00 f	24.00 k	38.33 l	58.00 e
N_0G_1	6.33 b	9.00 e	27.33 j	40.66 k	59.33 de
N_0G_2	6.33 b	9.00 e	28.00 j	42.33 j	70.00 cd
N_0G_3	6.33 b	9.00 e	29.00 i	45.66 i	66.66 cde
N_1G_0	7.00 a	9.33 e	30.33 h	47.33 h	72.33 c
N_1G_1	7.00 a	9.33 e	32.33 g	49.33 g	70.33 cd
N_1G_2	7.00 a	9.33 e	33.33 f	50.66 f	75.33 bc
N_1G_3	7.00 a	10.33 d	35.66 e	52.66 e	73.66 c
N_2G_0	7.00 a	10.66 cd	38.33 d	53.66 d	76.66 abc
N_2G_1	7.00 a	11.33 c	40.33 c	57.33 c	77.66 abc
N_2G_2	7.00 a	12.66 b	42.33 b	61.66 b	87.66 a
N_2G_3	7.33 a	14.00 a	47.66 a	69.66 a	86.00 ab
LSD $_{(0.05)}$	**0.48**	**0.67**	**0.77**	**0.82**	**11.88**
CV %	**4.19**	**3.92**	**5.34**	**6.96**	**9.64**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control)
N_1: 25 ppm NAA
N_2: 50 ppm NAA
G_0: 0 ppm GA_3 (control)
G_1: 50 ppm GA_3
G_2: 100 ppm GA_3
G_3: 150 ppm GA_3

The significant difference was observed due to the interaction effect of different NAA and GA_3 application at 30, 40, 50 and 60 DAT except 20 DAT (Appendix IV). At 20, 30, 40, 50 and 60 DAT the maximum number of leaves per plant (7.33, 14.00, 47.66, 69.66 and 87.66) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand at 20, 30, 40, 50 and 60 DAT minimum number of leaves per plant (6.00, 8.00, 24.00, 38.33 and 58.00) was recorded from N_0G_0 (control) treatment combination (Table 2).

4.3 Number of branches plant^{-1}

The significant difference was observed due to the application of NAA (Appendix V). The maximum number of branches per plant (8.83) was obtained from N_2 (50 ppm NAA) treatment and followed by (7.91) N_1 treatment. On the other hand, the minimum number of branches per plant (7.66) was recorded from N_0 (control) treatment (Table 3). Tiwari and Singh (2014) reported that number of branches increased by NAA 40 ppm.

Due to the GA_3 application significant difference was also found (Appendix V). The maximum number of branches per plant (9.11) was obtained from G_3 (150 ppm GA_3) treatment which is statistically similar to G_2 treatment and followed by (8.11) G_1 treatment. On the other hand the minimum number of branches per plant (6.88) was recorded from G_0 (control) treatment (Table 4). Shital *et al.* (2017) stated the application of GA_3 significantly increases the plant height, highest number of branches per plant. Choudhury *et al.* (2013) carried out a field experiment on tomato and agreed with the results. Rai *et al*. (2006) conducted an experiment GA_3 significantly reduced the number of seeds per fruit but increased plant height, plant canopy size and number of branches per plant.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix V). The maximum number of branches per plant (10.00) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination which is statistically similar to N_0G_1, N_0G_2, N_1G_2, N_2G_3 treatment combination. On the other hand, the minimum number of branches per plant (6.00) was recorded from N_0G_0 (control) treatment combination (Table 5).

4.4 Canopy size (cm)

The significant difference was observed due to the application of NAA (Appendix V). The maximum canopy size (107.75 cm) was obtained from N_2 (50 ppm NAA) treatment and followed by (98.08 cm) N_1 treatment. On the other hand, the minimum canopy size (86.67 cm) was recorded from N_0 (control) treatment (Table 3). Kar *et al.* (1993) applied NAA on tomato and agreed with the results.

Due to the GA_3 application significant difference was also found (Appendix V). The maximum canopy size (102.89 cm) was obtained from G_3 (150 ppm GA_3) treatment and followed by (101.00 cm) G_2 treatment. On the other hand the minimum canopy size (90.11) was recorded from G_0 (control) treatment (Table 4). Choudhury *et al.* (2013) carried out a field experiment on tomato and agreed with the results. Rai *et al*. (2006) conducted an experiment GA_3 significantly reduced the number of seeds per fruit but increased plant canopy size and number of branches per plant. Briant (1974) sprayed GA_3 on the growth of leaves of young tomato plants and observed that total leaf weight and area were increased by GA_3. Choudhury and Singh (1960) reported the enhanced effect of GA_3 on vegetative growth in tomato by spraying at different concentrations in field condition.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix V). The maximum canopy size (115.00 cm) was recorded from N_2G_3 (50 ppm NAA and 150 ppm GA_3) treatment combination. On the other hand, the minimum canopy size (72.00 cm) was recorded from N_0G_0 (control) treatment combination (Table 5).

4.5 Stem diameter (cm)

The significant difference was observed due to the application of NAA (Appendix V). The maximum stem diameter (2.61 cm) was obtained from N_2 (50 ppm NAA) treatment and followed by (2.38 cm) N_1 treatment. On the other hand, the minimum stem diameter (2.17 cm) was recorded from N_0 (control) treatment (Table 3). Tiwari and Singh (2014) reported that TSS and pericarp thickness increases by using NAA.

Table 3. Effects of NAA on number of branches plant^{-1}, canopy size, stem diameter and length of leaf of tomato

Treatment	No. of branches plant^{-1}	Canopy size (cm)	Stem diameter (cm)	Length of leaf (cm)
N_0	7.91 b	86.67 c	2.17 c	34.36 c
N_1	7.66 b	98.08 b	2.38 b	40.05 b
N_2	8.83 a	107.75 a	2.61 a	44.79 a
LSD $_{(0.05)}$	**0.74**	**0.55**	**0.01**	**0.40**
CV %	**7.33**	**5.67**	**6.89**	**5.21**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control), N_1: 25 ppm NAA, N_2: 50 ppm NAA

Table 4. Effects of GA_3 on number of branches plant^{-1}, canopy size, stem diameter and length of leaf of tomato

Treatment	No. of branches plant^{-1}	Canopy size (cm)	Stem diameter (cm)	Length of leaf (cm)
G_0	6.88 c	90.11 d	2.28 d	37.39 c
G_1	8.11 b	96.00 c	2.34 c	39.27 b
G_2	8.44 ab	101.00 b	2.43 b	41.07 a
G_3	9.11 a	102.89 a	2.49 a	41.20 a
LSD $_{(0.05)}$	**0.85**	**0.63**	**0.02**	**0.47**
CV %	**7.33**	**5.67**	**6.89**	**5.21**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3 (control), G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, G_3: 150 ppm GA_3

Due to the GA_3 application significant difference was also found (Appendix V). The maximum stem diameter (2.49 cm) was obtained from G_3 (150 ppm GA_3) treatment and followed by (2.43 cm) G_2 treatment. On the other hand the minimum stem diameter (2.28 cm) was recorded from G_0 (control) treatment

(Table 4). Choudhury and Singh (1960) reported the enhanced effect of GA_3 on vegetative growth in tomato by spraying at different concentrations in field condition.

Table 5. Combined effects of NAA and GA_3 on number of branches plant^{-1}, canopy size, stem diameter and length of leaf of tomato

Treatment	No. of branches plant^{-1}	Canopy size (cm)	Stem diameter (cm)	Length of leaf (cm)
N_0G_0	6.00 e	72.00 i	2.00 i	32.50 i
N_0G_1	8.66 abc	85.00 h	2.12 h	34.00 h
N_0G_2	8.66 abc	95.00 g	2.28 g	35.79 fg
N_0G_3	8.33 bc	94.67 g	2.28 g	35.16 g
N_1G_0	6.66 de	96.33 f	2.33 f	36.46 f
N_1G_1	7.33 cde	98.00 e	2.37 e	40.00 e
N_1G_2	8.66 abc	99.00 e	2.40 e	41.44 d
N_1G_3	8.00 bcd	99.00 e	2.44 d	42.33 c
N_2G_0	8.00 bcd	102.00 d	2.53 c	43.22 b
N_2G_1	8.33 bc	105.00 c	2.55 c	43.83 b
N_2G_2	10.00 a	109.00 b	2.62 b	46.00 a
N_2G_3	9.00 ab	115.00 a	2.75 a	46.11 a
LSD $_{(0.05)}$	**1.48**	**1.10**	**0.03**	**0.81**
CV %	**7.33**	**5.67**	**6.89**	**5.21**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control) G_0: 0 ppm GA_3 (control) G_2: 100 ppm GA_3
N_1: 25 ppm NAA G_1: 50 ppm GA_3 G_3: 150 ppm GA_3
N_2: 50 ppm NAA

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix V). The maximum stem diameter (2.75 cm) was recorded from N_2G_3 (50 ppm NAA and 150 ppm GA_3)

treatment combination. On the other hand, the minimum stem diameter (2.00 cm) was recorded from N_0G_0 (control) treatment combination (Table 5).

4.6 Length of leaf (cm)

The significant difference was observed due to the application of NAA (Appendix V). The maximum length of leaf (44.79 cm) was obtained from N_2 (50 ppm NAA) treatment and followed by (40.05 cm) N_1 treatment. On the other hand, the minimum length of leaf (34.36 cm) was recorded from N_0 (control) treatment (Table 3). Akhtar *et al.* (1997) conducted an experiment to study the effect of different rates of NAA and agreed with the results.

Due to the GA_3 application significant difference was also found (Appendix V). The maximum length of leaf (41.20 cm) was obtained from G_3 (150 ppm GA_3) treatment which is statistically identical to G_2 treatment and followed by (39.27 cm) G_1 treatment. On the other hand the minimum length of leaf (37.39) was recorded from G_0 (control) treatment (Table 4). Choudhury and Singh (1960) supported the results.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix V). The maximum length of leaf (46.11 cm) was recorded from N_2G_3 (50 ppm NAA and 150 ppm GA_3) treatment combination which is statistically identical to N_2G_2 treatment combination. On the other hand, the minimum length of leaf (32.50 cm) was recorded from N_0G_0 (control) treatment combination (Table 5).

4.7 Number of clusters plant^{-1}

The significant difference was observed due to the application of NAA (Appendix VI). The maximum number of clusters plant^{-1} (13.25) was recorded from N_2 (50 ppm NAA) treatment and followed by (8.91) N_1 treatment. On the other hand, the minimum number of clusters plant^{-1} (6.58) was recorded from N_0 (control) treatment (Table 6). Kar *et al.* (1993) applied NAA on tomato and agreed with the results.

Due to the GA_3 application significant difference was also found (Appendix VI). The maximum number of clusters plant^{-1} (11.11) was obtained from G_2 (100 ppm GA_3) treatment and followed by (10.00) G_3 treatment. On the other hand the minimum number of clusters plant^{-1} (8.55) was recorded from G_0 (control) treatment (Table 7) which is statistically identical to G_1 treatment.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VI). The maximum number of clusters plant^{-1} (16.00) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the minimum number of clusters plant^{-1} (6.00) was recorded from N_0G_0 (control) treatment combination which is statistically identical to N_0G_1 treatment combination (Table 8).

4.8 Number of flowers cluster^{-1}

The significant difference was observed due to the application of NAA (Appendix VI). The maximum number of flowers cluster^{-1} (7.20) was found from N_2 (50 ppm NAA) treatment and followed by (6.32) N_1 treatment. On the other hand, the minimum number of flowers cluster^{-1} (5.27) was recorded from N_0 (control) treatment (Table 6). Gupta and Gupta (2000) applied the auxins and supported the results. Kar *et al.* (1993) applied NAA on tomato and agreed with the results.

Due to the GA_3 application significant difference was also found (Appendix VI). The maximum number of flowers cluster^{-1} (6.81) was obtained from G_2 (100 ppm GA_3) treatment and followed by (6.34) G_3 treatment. On the other hand the minimum number of flowers cluster^{-1} (5.79) was found from G_0 (control) treatment (Table 7). Bhosle *et al.* (2002) found in tomato that the number of flowers per cluster, fruit weight and marketable yield increased with increasing rates of the plant growth regulators. Singh and Lal (1995) reported the foliar spray of GA_3 (50 ppm) at 50 percent flowering increased the fruit set and seed yield of tomato. Sawhney and Greyson (1972) reported that application of GA_3 non flowering plants of tomato induced multilocular, multicarpellary ovaries which were larger at anthesis than control upon pollination produced fruits which were significantly larger with higher fresh weight.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VI). The maximum number of flowers cluster^{-1} (7.75) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the minimum number of flowers cluster^{-1} (4.75) was recorded from N_0G_0 (control) treatment combination (Table 8).

4.9 Number of fruits cluster^{-1}

The significant difference was observed due to the application of NAA (Appendix VI). The maximum number of fruits cluster^{-1} (7.25) was found from N_2 (50 ppm NAA) treatment and followed by (5.16) N_1 treatment. On the other hand, the minimum number of fruits cluster^{-1} (3.33) was recorded from N_0 (control) treatment (Table 6). Deb *et al.* (2009) found significant response of NAA with respect to number of fruits/plant. Gupta and Gupta (2000) applied the auxins and found the similar results.

Due to the GA_3 application significant difference was also found (Appendix VI). The maximum number of fruits cluster^{-1} (6.00) was obtained from G_2 (100 ppm GA_3) treatment and followed by (5.44) G_3 treatment. On the other hand the minimum number of fruits cluster^{-1} (4.55) was found from G_0 (control) treatment (Table 7). Rahman *et al*. (2015) carried out an experiment and stated that the fruit yield of tomato per plant increased linearly with the increased number of flowers and fruits per plant by usisng GA_3. Groot *et al*. (1987) reported that GA_3 and IAA were indispensable for the development of fertile flowers and for seed germination, but only stimulated in later stages of fruit and seed development. Kaushik *et al*. (1974) carried out an experiment with the application of GA_3 and reported that GA_3 increased the number, weight and dry matter content of fruits per plant at higher concentration.

Table 6. Effect of NAA on number of clusters plant^{-1}, number of flowers cluster^{-1}, number of fruits cluster^{-1} and length of fruit of tomato

Treatment	No. of clusters plant^{-1}	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	Length of fruit (cm)
N_0	6.58 c	5.27 c	3.33 c	4.55 c
N_1	8.91 b	6.32 b	5.16 b	5.19 b
N_2	13.25 a	7.30 a	7.25 a	5.74 a
LSD $_{(0.05)}$	**0.20**	**0.11**	**0.20**	**0.02**
CV %	**6.41**	**6.16**	**4.69**	**5.53**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control), N_1: 25 ppm NAA, N_2: 50 ppm NAA

Table 7. Effect of GA_3 on number of clusters plant^{-1}, number of flowers cluster^{-1}, number of fruits cluster^{-1} and length of fruit of tomato

Treatment	No. of clusters plant^{-1}	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	Length of fruit (cm)
G_0	8.55 c	5.79 d	4.55 d	4.83 d
G_1	8.66 c	6.11 c	5.00 c	4.92 c
G_2	11.11 a	6.81 a	6.00 a	5.67 a
G_3	10.00 b	6.34 b	5.44 b	5.22 b
LSD $_{(0.05)}$	**0.24**	**0.13**	**0.24**	**0.02**
CV %	**6.41**	**6.16**	**4.69**	**5.53**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3 (control), G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, G_3: 150 ppm GA_3

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VI). The maximum number of fruits cluster^{-1} (7.75) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the minimum number of fruits cluster^{-1} (3.00) was recorded from N_0G_0 (control) treatment combination which is statistically identical to N_0G_1 treatment combination (Table 8).

Table 8. Combined effect of NAA and GA_3 on number of clusters plant^{-1} , number of flowers cluster^{-1}, number of fruits cluster^{-1} and length of fruit of tomato

Treatment	No. of clusters plant^{-1}	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	Length of fruit (cm)
N_0G_0	6.00 h	4.75 h	3.00 g	4.00 j
N_0G_1	6.00 h	5.00 g	3.00 g	4.18 i
N_0G_2	7.33 fg	5.86 e	4.00 e	5.03 g
N_0G_3	7.00 g	5.49 f	3.33 fg	4.98 h
N_1G_0	7.66 ef	5.72 ef	3.66 ef	5.06 g
N_1G_1	8.00 e	6.33 d	5.00 d	5.14 f
N_1G_2	10.00 d	6.83 c	6.00 c	5.37 d
N_1G_3	10.00 d	6.40 d	6.00 c	5.20 e
N_2G_0	12.00 c	6.92 c	6.00 c	5.43 c
N_2G_1	12.00 c	7.00 bc	7.00 b	5.45 bc
N_2G_2	16.00 a	7.75 a	7.75 a	6.63 a
N_2G_3	13.00 b	7.15 b	7.00 b	5.48 b
LSD $_{(0.05)}$	**0.41**	**0.22**	**0.41**	**0.04**
CV %	**6.41**	**6.16**	**4.69**	**5.53**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control) G_0: 0 ppm GA_3 (control) G_2: 100 ppm GA_3
N_1: 25 ppm NAA G_1: 50 ppm GA_3 G_3: 150 ppm GA_3
N_2: 50 ppm NAA

4.10 Length of fruit (cm)

The significant difference was observed due to the application of NAA (Appendix VI). The maximum length of fruit (5.74 cm) was found from N_2 (50 ppm NAA) treatment and followed by (5.19 cm) N_1 treatment. On the other hand, the minimum length of fruit (4.55 cm) was recorded from N_0 (control) treatment (Table 6). Desai *et al.* (2012) conducted an experiment on tomato variety GT-3 (Gujarat tomato-3) at JAU, Junagarh, India and found maximum fruit length (7.57 cm) with NAA @ 75 ppm.

Due to the GA_3 application significant difference was also found (Appendix VI). The maximum length of fruit (5.67 cm) was obtained from G_2 (100 ppm GA_3) treatment and followed by (5.22 cm) G_3 treatment. On the other hand the minimum length of fruit (4.83 cm) was found from G_0 (control) treatment (Table 7). Shital *et al.* (2017) stated the application of GA_3 significantly increases the number of fruit per plant, length of fruit, diameter of fruit, highest yield per plant. Ahmad *et al.* (2017) evaluated the influence of different plant growth promoters on growth and yield of tomato and supported the results. Feofanova (1960) observed that the application of growth regulators on tomato plants could produce not only seedless fruits but also could increase the size of the fruits

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VI). The maximum length of fruit (6.63 cm) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the minimum length of fruit (4.00 cm) was recorded from N_0G_0 (control) treatment combination (Table 8).

4.11 Diameter of fruit (cm)

The significant difference was observed due to the application of NAA (Appendix VII). The maximum diameter of fruit (6.62 cm) was found from N_2 (50 ppm NAA) treatment and followed by (6.25 cm) N_1 treatment. On the other hand, the minimum diameter of fruit (5.24 cm) was recorded from N_0 (control) treatment (Table 9). Desai *et al.* (2012) conducted an experiment on tomato and found maximum fruit girth (6.47 cm) and pulp seed ratio with NAA application. Sumiati (1987) carried out an experiment to study the effects of plant growth regulators and said that fruit diameter and total fruit weight significantly increased.

Due to the GA_3 application significant difference was also found (Appendix VII). The maximum diameter of fruit (6.52 cm) was obtained from G_3 (150 ppm GA_3) treatment and followed by (6.16 cm) G_2 treatment which is statistically identical to G_1 treatment. On the other hand the minimum diameter of fruit (5.55 cm) was found from G_0 (control) treatment (Table 10). Shital *et al.* (2017) stated the application of GA_3 significantly increases the number of fruit per plant, length of fruit, diameter of fruit, highest yield per plant. Rappaport (1960) noted that GA_3 had no significant effect on fruit weight or size.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VII). The maximum diameter of fruit (6.90 cm) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination which is statistically similar to N_1G_2, N_2G_0, N_2G_1, N_2G_3 treatment combination. On the other hand, the minimum diameter of fruit (4.33 cm) was recorded from N_0G_0 (control) treatment combination (Table 11).

4.12 Fresh weight of fruit (g)

The significant difference was observed due to the application of NAA (Appendix VII). The maximum fresh weight of fruit (100.50 g) was found from N_2 (50 ppm NAA) treatment and followed by (77.17 g) N_1 treatment. On the other hand, the minimum fresh weight of fruit (55.33 g) was recorded from N_0 (control) treatment (Table 9). Tiwari and Singh (2014) reported that TSS and pericarp thickness increases by using NAA. Deb *et al.* (2009) found significant response of NAA with respect to fruit weight/plant. Sanyal *et al.(*1995) studied that the effects of plant growth regulators and said plant growth regulators had profound effects on fruit length, weight. Sumiati (1987) carried out an experiment to study the effects of plant growth regulators and said that fruit diameter and total fruit weight significantly increased.

Due to the GA_3 application significant difference was also found (Appendix VII). The maximum fresh weight of fruit (88.66 g) was obtained from G_2 (100 ppm GA_3) treatment and followed by (82.77 g) G_3 treatment. On the other hand the minimum fresh weight of fruit (65.55 g) was found from G_0 (control) treatment (Table 10). Bhosle *et al.* (2002) found in tomato that the number of flowers per cluster, fruit weight and marketable yield increased with increasing rates of the plant growth regulators. Kaushik *et al*. (1974) carried out an experiment with the application of GA_3 and reported that GA_3 increased the number, weight and dry matter content of fruits per plant at higher concentration. Feofanova (1960) observed that the application of growth regulators on tomato plants could produce not only seedless fruits but also could increase the weight of the fruits. Rappaport (1960) noted that GA_3 had no significant effect on fruit weight or size.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VII). The maximum fresh weight of fruit (115.00 g) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the minimum fresh weight of fruit (46.00 g) was recorded from N_0G_0 (control) treatment combination (Table 11).

4.13 Dry matter content of fruit (%)

The significant difference was observed due to the application of NAA (Appendix VII). The maximum dry matter content of fruit (13.98 %) was found from N_2 (50 ppm NAA) treatment and followed by (12.42 %) N_1treatment. On the other hand, the minimum dry matter content of fruit (10.76 %) was recorded from N_0 (control) treatment (Table 9). Desai *et al.* (2012) conducted an experiment on tomato and found maximum dry matter content with NAA spray.

Due to the GA_3 application significant difference was also found (Appendix VII). The maximum dry matter content of fruit (13.35 %) was obtained from G_2

(100 ppm GA_3) treatment and followed by (12.57 %) G_3treatment. On the other hand the minimum dry matter content of fruit (11.55 %) was found from G_0 (control) treatment (Table 10). Kaushik *et al.* (1974) carried out an experiment with the application of GA_3 and reported that GA_3 increased the number, weight and dry matter content of fruits per plant at higher concentration.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VII). The maximum dry matter content of fruit (15.37 %) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the minimum dry matter content of fruit (10.00 %) was recorded from N_0G_0 (control) treatment combination (Table 11).

4.14 TSS (Total Soluble Solid) (%)

The significant difference was observed due to the application of NAA (Appendix VII). The maximum TSS of fruit (7.87 %) was found from N_2 (50 ppm NAA) treatment and followed by (7.32 %) N_1treatment. On the other hand, the minimum TSS of fruit (6.68 %) was recorded from N_0 (control) treatment (Table 9). Tiwari and Singh (2014) reported that TSS and pericarp thickness increases by using NAA. Desai *et al.* (2012) conducted an experiment on tomato and found maximum TSS with NAA spray. Singh and Singh (2011) carried out an experiment and supported the results. Yadav *et al.* (2001) observed that NAA application increased total soluble solid percentage significantly.

Due to the GA_3 application significant difference was also found (Appendix VII). The maximum TSS of fruit (7.80 %) was obtained from G_1 (50 ppm GA_3) treatment and followed by (7.35 %) G_3 treatment. On the other hand the minimum TSS of fruit (6.96 %) was found from G_0 (control) treatment (Table 13). Saleh and Abdul (1980) performed an experiment with GA_3 and supported the results.

Table 9. Effect of NAA on diameter of fruit, fresh weight of fruit, dry matter content of fruit and TSS of tomato

Treatment	**Diameter of fruit (cm)**	**Fresh weight of fruit (g)**	**Dry matter content of fruit (%)**	**TSS (%)**
N_0	5.24 c	55.33 c	10.76 c	6.68 c
N_1	6.25 b	77.17 b	12.42 b	7.32 b
N_2	6.62 a	100.50 a	13.98 a	7.87 a
LSD $_{(0.05)}$	**0.24**	**0.20**	**0.25**	**0.02**
CV %	**4.75**	**6.32**	**2.38**	**7.29**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control), N_1: 25 ppm NAA, N_2: 50 ppm NAA

Table 10. Effect of GA_3 on diameter of fruit, fresh weight of fruit, dry matter content of fruit and TSS of tomato

Treatment	**Diameter of fruit (cm)**	**Fresh weight of fruit (g)**	**Dry matter content of fruit (%)**	**TSS (%)**
G_0	5.55 c	65.55 d	11.55 d	6.96 d
G_1	5.92 b	73.66 c	12.07 c	7.80 a
G_2	6.16 b	88.66 a	13.35 a	7.05 c
G_3	6.52 a	82.77 b	12.57 b	7.35 b
LSD $_{(0.05)}$	**0.28**	**0.24**	**0.28**	**0.02**
CV %	**4.75**	**6.32**	**2.38**	**7.29**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3 (control), G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, G_3: 150 ppm GA_3

Table 11. Combined effect of NAA and GA_3 on diameter of fruit, fresh weight of fruit, dry matter content of fruit and TSS of tomato

Treatment	Diameter of fruit (cm)	Fresh weight of fruit (g)	Dry matter content of fruit (%)	TSS (%)
N_0G_0	4.33 f	46.00 i	10.00 h	6.13 j
N_0G_1	4.90 e	52.00 h	10.43 h	6.31 i
N_0G_2	6.26 bc	62.00 f	11.70 f	7.16 g
N_0G_3	5.48 d	61.33 g	10.94 g	7.11 h
N_1G_0	5.88 cd	61.67 fg	11.54 f	7.19 g
N_1G_1	6.33 bc	70.00 e	12.38 e	7.27 f
N_1G_2	6.42 ab	89.00 c	13.00 cd	7.50 d
N_1G_3	6.38 b	88.00 d	12.79 de	7.33 e
N_2G_0	6.45 ab	89.00 c	13.13 cd	7.56 c
N_2G_1	6.53 ab	99.00 b	13.42 c	8.76 a
N_2G_2	6.90 a	115.00 a	15.37 a	7.61 b
N_2G_3	6.63 ab	99.00 b	14.00 b	7.58 bc
LSD $_{(0.05)}$	**0.48**	**0.41**	**0.50**	**0.04**
CV %	**4.75**	**6.32**	**2.38**	**7.29**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control) | G_0: 0 ppm GA_3 (control) | G_2: 100 ppm GA_3
N_1: 25 ppm NAA | G_1: 50 ppm GA_3 | G_3: 150 ppm GA_3
N_2: 50 ppm NAA

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VII). The maximum TSS of fruit (8.76 %) was recorded from N_2G_1 (50 ppm NAA and 50 ppm GA_3) treatment combination. On the other hand, the minimum TSS of fruit (6.13 %) was recorded from N_0G_0 (control) treatment combination (Table 11).

4.15 Chlorophyll content in leaf (%)

The significant difference was observed due to the application of NAA (Appendix VIII). The maximum chlorophyll content in leaf (56.63 %) was found from N_2 (50 ppm NAA) treatment and followed by (51.39 %) N_1 treatment. On the other hand, the minimum chlorophyll content in leaf (47.79 %) was recorded from N_0 (control) treatment (Table 12). Gupta and Gupta (2004) studied and supported the results.

Due to the GA_3 application significant difference was also found (Appendix VIII). The maximum chlorophyll content in leaf (55.86 %) was obtained from G_2 (100 ppm GA_3) treatment and followed by (51.93 %) G_3 treatment. On the other hand the minimum chlorophyll content in leaf (49.35 %) was found from G_0 (control) treatment (Table 13). Saleh and Abdul (1980) performed an experiment with GA_3 and supported the results.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VIII). The maximum chlorophyll content in leaf (64.55 %) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the minimum chlorophyll content in leaf (44.90 %) was recorded from N_0G_0 (control) treatment combination (Table 14).

4.16 Root length of plant (cm)

The significant difference was observed due to the application of NAA (Appendix VIII). The maximum root length of plant (34.75 cm) was obtained from N_2 (50 ppm NAA) treatment and followed by (28.75 cm) N_1 treatment. On the other hand, the minimum root length of plant (24.83 cm) was recorded from N_0 (control) treatment (Table 12). Gad and Atta Ali (2006) observed the best root formation in tomato cuttings by spraying NAA. Lopez *et al.,* (2001) said that, Naphthalene Acetic Acid (NAA) significantly increased the number of root and root length.

Due to the GA_3 application significant difference was also found (Appendix VIII). The maximum root length of plant (31.44 cm) was obtained from G_1 (50 ppm GA_3) treatment followed by (29.66 cm) G_2 treatment. On the other hand the minimum root length of plant (27.55 cm) was recorded from G_0 (control) treatment (Table 13).

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VIII). The maximum root length of plant (37.00 cm) was recorded from N_2G_1 (50 ppm NAA and 50 ppm GA_3) treatment combination. On the other hand, the minimum root length of plant (24.00 cm) was recorded from N_0G_0 (control) treatment combination (Table 14).

4.17 Carbon assimilation rate (%)

The significant difference was observed due to the application of NAA (Appendix VIII). The maximum carbon assimilation rate (10.02 %) was found from N_2 (50 ppm NAA) treatment and followed by (8.21 %) N_1 treatment. On the other hand, the minimum carbon assimilation rate (5.62 %) was recorded from N_0 (control) treatment (Table 12). Kar *et al.* (1993) applied NAA on tomato and agreed with the results.

Due to the GA_3 application significant difference was also found (Appendix VIII). The maximum carbon assimilation rate (9.00 %) was obtained from G_2 (100 ppm GA_3) treatment and followed by (8.58 %) G_1 treatment. On the other hand the minimum carbon assimilation rate (6.41 %) was found from G_0 (control) treatment (Table 13). Pandey and Singh (1983) supported the results. Mehta and Mathi (1975) reported that GA_3 treatments and agreed with the results.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix VIII). The maximum carbon assimilation rate (11.00 %) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination which is statistically identical to N_2G_3 (50 ppm NAA and 150 ppm GA_3) treatment combination. On the other hand, the minimum carbon assimilation rate (3.00 %) was recorded from N_0G_0 (control) treatment combination (Table 14).

Table 12. Effect of NAA on chlorophyll content in leaf, root length and carbon assimilation rate of tomato plant

Treatment	Chlorophyll content in leaf (%)	Root length of plant (cm)	Carbon assimilation rate (%)
N_0	47.79 c	24.83 c	5.62 c
N_1	51.39 b	28.66 b	8.21 b
N_2	56.63 a	34.75 a	10.02 a
LSD $_{(0.05)}$	**0.60**	**0.20**	**0.28**
CV %	**5.37**	**4.26**	**6.84**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control), N_1: 25 ppm NAA, N_2: 50 ppm NAA

Table 13. Effect of GA_3 on chlorophyll content in leaf, root length and carbon assimilation rate of tomato plant

Treatment	Chlorophyll content in leaf (%)	Root length of plant (cm)	Carbon assimilation rate (%)
G_0	49.35 d	27.55 d	6.41 d
G_1	50.61 c	31.44 a	7.82 c
G_2	55.86 a	29.66 b	9.00 a
G_3	51.93 b	29.00 c	8.58 b
LSD $_{(0.05)}$	**0.69**	**0.24**	**0.33**
CV %	**5.37**	**4.26**	**6.84**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3 (control), G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, G_3: 150 ppm GA_3

Table 14. Combined effect of NAA and GA_3 on chlorophyll content in leaf, root length and carbon assimilation rate of tomato plant

Treatment	Chlorophyll content in leaf (%)	Root length of plant (cm)	Carbon assimilation rate (%)
N_0G_0	44.90 i	24.00 j	3.00 h
N_0G_1	46.33 h	25.00 i	5.80 g
N_0G_2	50.93 ef	25.33 hi	7.28 e
N_0G_3	49.01 g	25.00 i	6.43 f
N_1G_0	50.17 fg	25.66 h	7.17 e
N_1G_1	51.40 e	28.00 g	8.27 d
N_1G_2	52.10 de	32.00 e	8.73 cd
N_1G_3	51.90 de	29.00 f	8.70 cd
N_2G_0	53.00 cd	33.00 d	9.08 bc
N_2G_1	54.10 bc	37.00 a	9.39 b
N_2G_2	64.55 a	35.00 b	11.00 a
N_2G_3	54.90 b	34.00 c	10.61 a
LSD $_{(0.05)}$	**1.20**	**0.41**	**0.57**
CV %	**5.37**	**4.26**	**6.84**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control) G_0: 0 ppm GA_3 (control) G_2: 100 ppm GA_3
N_1: 25 ppm NAA G_1: 50 ppm GA_3 G_3: 150 ppm GA_3
N_2: 50 ppm NAA

4.18 Yield plot^{-1} (kg)

The significant difference was observed due to the application of NAA (Appendix IX). The highest yield per plot (28.36 kg) was found from N_2 (50 ppm NAA) treatment and followed by (22.57 kg) N_1 treatment. On the other hand, the lowest yield per plot (18.36 kg) was recorded from N_0 (control) treatment (Table 15). Maurya *et al.* (2013) conducted an experiment and suggested that NAA has beneficial role on yield and quality of tomato. Singh and Lal (2001) conducted a field experiment and found the maximum number of fruits per plant by using NAA.

Due to the GA_3 application significant difference was also found (Appendix IX). The highest yield per plot (24.71 kg) was obtained from G_2 (100 ppm GA_3) treatment and followed by (23.62 kg) G_3 treatment. On the other hand the lowest yield per plot (21.18 kg) was found from G_0 (control) treatment (Table 16). Sumati (1987) recorded that gibberellins (GA_3) in order to reduce production cost and increase yield and its quality.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix IX). The highest yield per plot (30.29 kg) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the lowest yield per plot (16.20 kg) was recorded from N_0G_0 (control) treatment combination (Table 17).

4.19 Yield plant^{-1} (Kg)

The significant difference was observed due to the application of NAA (Appendix IX). The highest yield per plant (2.36 kg) was found from N_2 (50 ppm NAA) treatment and followed by (1.88 kg) N_1 treatment. On the other hand, the lowest yield per plant (1.53 kg) was recorded from N_0 (control) treatment (Table 15). Maurya *et al.* (2013) conducted an experiment and suggested that NAA has beneficial role on yield of tomato. Deb *et al.* (2009) found significant response of NAA with respect to number of fruits/plant, fruit yield. Singh and Lal (2001) conducted a field experiment and found the maximum number of fruits per plant by using NAA. Singh and Upadhaya (1967) studied the effect of IAA and NAA on tomato and reported that the regulators activated growth, increased the fruit set, size and yield of fruit

Due to the GA_3 application significant difference was also found (Appendix IX). The highest yield per plant (2.05 kg) was obtained from G_2 (100 ppm GA_3) treatment and followed by (1.97 kg) G_3 treatment. On the other hand the lowest yield per plant (1.76 kg) was found from G_0 (control) treatment (Table 16).

Shital *et al.* (2017) stated the application of GA_3 significantly increases the number of fruit per plant, length of fruit, diameter of fruit, highest yield per plant.

Table 15. Effect of NAA on yield plot^{-1}, yield plant^{-1} and yield hectare^{-1} of tomato

Treatment	Yield plant^{-1} (kg)	Yield plot^{-1} (kg)	Yield (t ha^{-1})
N_0	1.53 c	18.36 c	51.02 c
N_1	1.88 b	22.57 b	62.71 b
N_2	2.36 a	28.36 a	78.80 a
LSD $_{(0.05)}$	**0.03**	**0.37**	**1.03**
CV %	**7.52**	**5.91**	**6.71**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control), N_1: 25 ppm NAA, N_2: 50 ppm NAA

Table 16. Effect of GA_3 on yield plot^{-1}, yield plant^{-1} and yield hectare^{-1} of tomato

Treatment	Yield plant^{-1} (kg)	Yield plot^{-1} (kg)	Yield (t ha^{-1})
G_0	1.76 d	21.18 d	58.84 d
G_1	1.90 c	22.90 c	63.62 c
G_2	2.05 a	24.71 a	68.64 a
G_3	1.97 b	23.62 b	65.61 b
LSD $_{(0.05)}$	**0.03**	**0.43**	**1.19**
CV %	**7.52**	**5.91**	**6.71**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

G_0: 0 ppm GA_3 (control), G_1: 50 ppm GA_3, G_2: 100 ppm GA_3, G_3: 150 ppm GA_3

Table 17. Combined effect of NAA and GA_3 on yield plot^{-1}, yield plant^{-1} and yield of tomato

Treatment	Yield plant^{-1} (kg)	Yield plot^{-1} (kg)	Yield (t ha^{-1})
N_0G_0	1.35 i	16.20 i	45.00 i
N_0G_1	1.53 h	18.40 h	51.12 h
N_0G_2	1.64 fg	19.76 fg	54.90 fg
N_0G_3	1.59 g	19.11 gh	53.09 gh
N_1G_0	1.69 f	20.30 f	56.41 f
N_1G_1	1.90 e	22.78 e	63.29 e
N_1G_2	2.01 d	24.09 d	66.91 d
N_1G_3	1.93 e	23.13 e	64.25 e
N_2G_0	2.25 c	27.04 c	75.12 c
N_2G_1	2.29 c	27.52 c	76.45 c
N_2G_2	2.52 a	30.29 a	84.13 a
N_2G_3	2.39 b	28.62 b	79.50 b
LSD $_{(0.05)}$	**0.06**	**0.74**	**2.07**
CV %	**7.52**	**5.91**	**6.71**

In a column, means with similar letter (s) are not significantly different by LSD at 5% level of significance.

N_0: 0 ppm NAA (control) G_0: 0 ppm GA_3 (control) G_2: 100 ppm GA_3
N_1: 25 ppm NAA G_1: 50 ppm GA_3 G_3: 150 ppm GA_3
N_2: 50 ppm NAA

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix IX). The highest yield per plant (2.52 kg) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the lowest yield per plant (1.35 kg) was recorded from N_0G_0 (control) treatment combination (Table 17).

4.20 Yield (t ha^{-1})

The significant difference was observed due to the application of NAA (Appendix IX). The highest yield (78.80 ton) was found from N_2 (50 ppm

NAA) treatment and followed by (62.71 ton) N_1 treatment. On the other hand, the lowest yield (51.02 ton) was recorded from N_0 (control) treatment (Table 15). Pargi *et al.* (2014) conducted a pot experiment on tomato and found maximum yield of tomato with NAA @ 50 ppm followed by NAA @ 30 ppm. Verma *et al*. (2014) conducted an experiment to study the effect of varying levels of NAA and he also got the maximum yield per hectare. Singh and Lal (2001) conducted a field experiment and found the maximum number of fruits per plant by using NAA. Sanyal *et al.(*1995) studied that the effects of plant growth regulators and said plant growth regulators had profound effects on fruit length, weight.

Due to the GA_3 application significant difference was also found (Appendix IX). The highest yield per hectare (68.64 ton) was obtained from G_2 (100 ppm GA_3) treatment and followed by (65.61 ton) G_3 treatment. On the other hand the lowest yield per hectare (58.84 ton) was found from G_0 (control) treatment (Table 16). Shital *et al.* (2017) stated the application of GA_3 significantly increases the number of fruit per plant, length of fruit, diameter of fruit, highest yield per plant. Akand *et al.* (2015) conducted an experiment on tomato found highest yield with GA_3 application. Bhosle *et al.* (2002) found in tomato that the number of flowers per cluster, fruit weight and marketable yield increased with increasing rates of the plant growth regulators. Pundir and Yadav (2001) are also agreed with the results. Saleh and Abdul (1980) performed an experiment with GA_3 and stated that the total number of flowers $plant^{-1}$ increased the total yield compared with the control. GA_3 also improved fruit quality.

The significant difference was observed due to the interaction effect of different NAA and GA_3 application (Appendix IX). The highest yield per hectare (84.13 ton) was recorded from N_2G_2 (50 ppm NAA and 100 ppm GA_3) treatment combination. On the other hand, the lowest yield per hectare (45.00 ton) was recorded from N_0G_0 (control) treatment combination (Table 17).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period November, 2015 to April, 2016 to find out the effect of different levels of NAA and GA_3 on growth and yield of tomato. The experiment consisted of two factors: Factor A: Three levels of organic manures. The treatments are N_0: 0 (control), N_1: 25 NAA and N_2: 50 ppm NAA. Factor B: Four levels of GA_3. The treatments are G_0: control (no GA_3); G_1: 50 ppm GA_3; G_2: 100 ppm GA_3 and G_3: 150 ppm GA_3. There were 12 treatment combinations. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and yield contributing characters and yield were recorded to find out the optimum level of NAA and GA_3 concentration on tomato production.

Due the application of NAA, the longest plant height at 60 DAT (97.75), maximum number of leaves plant^{-1} at 60 DAT (82.00), maximum number of branches plant^{-1} (8.83), maximum size of canopy (107.75 cm), maximum size of stem diameter (2.61 cm), maximum length of leaf (44.79 cm), maximum number of clusters plant^{-1} (13.25), maximum number of flowers cluster^{-1} (7.20), maximum number of fruits cluster^{-1} (7.25), maximum length of fruit (5.74 cm), maximum diameter of fruit (6.62 cm), maximum fresh weight of fruit (100.50 g), maximum dry matter content of fruit (13.98 %), maximum TSS of fruit (7.87 %), maximum chlorophyll content in leaf (56.63 %), maximum root length of plant (34.75 cm), maximum carbon assimilation rate (10.02 %), highest yield plot^{-1} at 60 DAT (28.36 kg), highest yield plant^{-1} (2.36 kg), highest yield (78.80 t ha^{-1}) were recorded from the treatment of 50 ppm NAA that is N_2 treatment. On the other hand the shortest plant height at 60 DAT (68.08), minimum number of leaves plant^{-1} at 60 DAT (63.50), minimum number of branches plant^{-1} (7.66), minimum size of canopy (86.67 cm), minimum size of stem diameter (2.17 cm), minimum length of leaf (34.36 cm), minimum number of clusters plant^{-1} (6.58), minimum number of flowers cluster^{-1} (5.27), minimum number of fruits cluster^{-1} (3.33), minimum length of fruit (4.55 cm), minimum diameter of fruit (5.24 cm), minimum fresh weight of fruit (55.33 g), minimum dry matter content of fruit (10.76 %), minimum TSS of fruit (6.68 %), minimum chlorophyll content in leaf (47.79 %), minimum root length of plant (24.83 cm), minimum carbon assimilation rate (5.62 %), lowest yield plot^{-1} at 60 DAT (18.36 kg), lowest yield plant^{-1} (1.53 kg), lowest yield (51.02 t ha^{-1}) were recorded from the treatment of 0 ppm NAA that is N_0 treatment.

For the application of $GA_{3,}$ the longest plant height at 60 DAT (88.88), the maximum number of leaves plant^{-1} at 60 DAT (77.66), maximum number of branches plant^{-1} (9.11), maximum size of canopy (102.89 cm), maximum size of stem diameter (2.49 cm), maximum length of leaf (41.20 cm), maximum diameter of fruit (6.52 cm) were recorded from the treatment of 150 ppm GA_3 that is G_3 treatment. The maximum number of clusters plant^{-1} (11.11), maximum number of flowers cluster^{-1} (6.81), maximum number of fruits cluster^{-1} (6.00), maximum length of fruit (5.67 cm), maximum fresh weight of fruit (88.62 g), maximum dry matter content of fruit (13.35 %), maximum chlorophyll content in leaf (55.86 %), maximum carbon assimilation rate (9.00 %), highest yield plot^{-1} at 60 DAT (24.71 kg), highest yield plant^{-1} (2.50 kg), highest yield (68.64 t ha^{-1}) were recorded from 100 ppm GA_3 that is G_2 treatment. The maximum TSS of fruit (7.80 %), maximum root length of plant (31.44 cm) were recorded from 50 ppm GA_3 that is G_1 treatment. On the other hand the shortest plant height at 60 DAT (76.11), the minimum number of leaves plant^{-1} at 60 DAT (69.00), minimum number of branches plant^{-1} (6.88), minimum size of canopy (90.11 cm), minimum size of stem diameter (2.28 cm), minimum length of leaf (37.39 cm), minimum number of clusters plant^{-1} (8.55), minimum number of flowers cluster^{-1} (5.79), minimum number of fruits cluster^{-1} (4.55), minimum length of fruit (4.83 cm), minimum diameter of fruit

(5.55 cm), minimum fresh weight of fruit (65.55 g), minimum dry matter content of fruit (11.55 %), minimum TSS of fruit (6.96 %), minimum chlorophyll content in leaf (49.35 %), minimum root length of plant (27.55 cm), minimum carbon assimilation rate (6.41 %), lowest yield plot^{-1} at 60 DAT (21.18 kg), lowest yield plant^{-1} (1.76 kg), lowest yield (58.84 t ha^{-1}) were recorded from the treatment of 0 ppm GA_3 that is G_0 treatment.

Due to the interaction effect of different NAA and GA_3 the longest plant height at 60 DAT (106.00), maximum number of leaves plant^{-1} at 60 DAT (87.66), maximum size of canopy (115.00 cm), maximum size of stem diameter (2.75 cm), maximum length of leaf (46.11 cm) were recorded from the treatment of 50 ppm NAA + 150ppm GA_3 that is N_2G_3 treatment. The maximum number of branches plant^{-1} (10.00), maximum number of clusters plant^{-1} (16.00), maximum number of flowers cluster^{-1} (7.75), maximum number of fruits cluster^{-1} (7.75), maximum length of fruit (6.63 cm), maximum diameter of fruit (6.90 cm), maximum fresh weight of fruit (115.00 g), maximum dry matter content of fruit (15.37 %), maximum chlorophyll content in leaf (64.55 %), maximum carbon assimilation rate (11.00 %), highest yield plot^{-1} at 60 DAT (30.29 kg), highest yield plant^{-1} (2.52 kg), highest yield (84.13 t ha^{-1}) were recorded from the treatment of 50 ppm NAA + 100 ppm GA_3 that is N_2G_2 treatment. The maximum TSS of fruit (8.76 %), maximum root length of plant (37.00 cm) were recorded from the treatment of 50 ppm NAA + 50 ppm GA_3 that is N_2G_1 treatment. On the other hand the shortest plant height at 60 DAT (60.33), minimum number of leaves plant^{-1} at 60 DAT (58.00), minimum number of branches plant^{-1} (6.00), minimum size of canopy (72.00 cm), minimum size of stem diameter (2.00 cm), minimum length of leaf (32.50 cm), minimum number of clusters plant^{-1} (6.00), minimum number of flowers cluster^{-1} (4.75), minimum number of fruits cluster^{-1} (3.00), minimum length of fruit (4.00 cm), minimum diameter of fruit (4.33 cm), minimum fresh weight of fruit (46.00 g), minimum dry matter content of fruit (10.00 %), minimum TSS of fruit (6.13 %), minimum chlorophyll content in leaf (44.90 %), minimum root length of plant (24.00 cm), minimum carbon assimilation rate (3.00 %), lowest yield $plot^{-1}$ at 60 DAT (16.20 kg), lowest yield $plant^{-1}$ (1.35 kg), lowest yield (45.00 t ha^{-1}) were recorded from the treatment of 0 ppm NAA + 0 ppm GA_3 that is N_0G_0 treatment.

Considering the findings of the experiment, it can be concluded that -

- The combination 50 ppm NAA + 100 ppm GA_3 treatment combination is the appropriate practice for tomato production.

Further research should be conducted by setting more treatments on NAA and GA_3 to study the maximum growth and yield of tomato at different places of Bangladesh.

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APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2015 to May 2016

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
October,15	29.18	18.26	81	39
November,15	25.82	16.04	78	0
December,15	22.4	13.5	74	0
January,16	24.5	12.4	68	0
February,16	27.1	16.7	67	3
March,16	31.4	19.6	54	11
April, 16	35.3	22.4	51	15
May, 16	38.2	23.2	62	17

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

Appendix II. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

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

B. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix-III. Analysis of variance of data on plant height at different days after transplanting of tomato

Source of variation	Degrees of freedom (df)	Mean square of plant height at				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	2.583	9.25	46.861	114.53	235.08
Factor A (NAA)	2	61.75	258.25*	776.694*	1303.44*	2644.33*
Factor B (GA_3)	3	10.552	26.25*	116.185*	154.77**	284.18**
Interaction (A X B)	6	1.75	1.028*	11.435*	3.96*	15.93**
Error	22	0.553	1.765	11.891	16.19	29.27
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-IV. Analysis of variance of data on number of leaves at different days after transplanting of tomato

Source of variation	Degrees of freedom (df)	Mean square of number of leaves at				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	0.444	1.5833	0.694	13.36	6.36
Factor A (NAA)	2	2.527	38.083*	694.194*	1069.53**	1026.86*
Factor B (GA_3)	3	0.074	5.074*	66.852**	148.30*	176.18*
Interaction (A X B)	6	0.046	1.490*	5.157*	18.71*	16.23*
Error	22	0.080	0.159	0.21	0.24	49.24
** : Significant at 1% level of probability; * : Significant at 5% level of probability						

Appendix-V. Analysis of variance of data on number of branches plant^{-1}, canopy size, stem diameter and Length of leaf of tomato

Source of variation	Degrees of freedom (df)	Mean square of			
		No. of branches plant^{-1}	Canopy size (cm)	Stem diameter (cm)	Length of leaf (cm)
Replication	2	5.861	2.73E^{-27}	1.73E-30	5.05E^{-28}
Factor A (NAA)	2	4.527*	1336.58*	0.583*	327.02*
Factor B (GA_3)	3	7.805*	294.407*	0.073**	28.921*
Interaction (A X B)	6	0.861*	78.213*	9.66E^{-03}**	1.980**
Error	22	0.770	0.424	4.55E^{-04}	0.231
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VI. Analysis of variance of data on number of clusters plant^{-1}, number of flowers cluster^{-1}, number of fruits cluster^{-1} and length of fruit of tomato

Source of variation	Degrees of freedom (df)	Mean square of			
		No. of clusters plant^{-1}	No. of flowers cluster^{-1}	No. of fruits cluster^{-1}	Length of fruit (cm)
Replication	2	3.35E^{-29}	1.30E^{-29}	1.05E^{-29}	7.42E^{-30}
Factor A (NAA)	2	137.333*	11.181*	46.083*	4.309*
Factor B (GA_3)	3	13.213*	1.650**	3.435**	1.3105*
Interaction (A X B)	6	1.851**	0.069*	0.824**	0.322**
Error	22	0.060	0.018	0.060	7.52E^{-04}
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VII. Analysis of variance of data on diameter of fruit, fresh weight of fruit, dry matter content of fruit and TSS of tomato

Source of variation	Degrees of freedom (df)	Mean square of			
		Diameter of fruit (cm)	Fresh weight of fruit (g)	Dry matter content of fruit (%)	TSS (%)
Replication	2	1.48E^{-29}	1.77E^{-27}	5.27E^{-29}	1.59E^{-29}
Factor A (NAA)	2	6.154*	6122.33*	30.956*	4.309*
Factor B (GA_3)	3	1.504*	929.407**	5.275**	1.310*
Interaction (A X B)	6	0.419*	72.626*	0.266**	0.322*
Error	22	0.082	0.060	0.087	7.52E^{-04}
** : Significant at 1% level of probability; * : Significant at 5% level of probability					

Appendix-VIII. Analysis of variance of data on chlorophyll content in leaf, root length and carbon assimilation rate of tomato plant

Source of variation	Degrees of freedom (df)	Mean square of		
		Chlorophyll content in leaf (%)	Root length of plant (cm)	Carbon assimilation rate
Replication	2	7.59E^{-28}	3.03E^{-28}	1.56E^{-29}
Factor A (NAA)	2	237.32*	300.083*	58.458*
Factor B (GA_3)	3	71.435*	23.435*	11.621*
Interaction (A X B)	6	18.983**	3.490**	1.437**
Error	22	0.509	0.060	0.115
** : Significant at 1% level of probability; * : Significant at 5% level of probability				

Appendix-IX. Analysis of variance of data on yield plot^{-1}, yield plant^{-1} and yield hectare^{-1} of tomato

Source of variation	Degrees of freedom (df)	Mean square of		
		Yield plot^{-1} (kg)	Yield plant^{-1} (kg)	Yield hectare^{-1} (t ha^{-1})
Replication	2	1.69E^{-28}	3.01E^{-31}	9.04E^{-28}
Factor A (NAA)	2	302.454*	2.095*	2333*
Factor B (GA_3)	3	19.776**	0.139**	152.381**
Interaction (A X B)	6	0.724**	4.90E^{-03}**	5.597**
Error	22	0.194	1.28E^{-03}	1.503

** : Significant at 1% level of probability; * : Significant at 5% level of probability