EFFECT OF PLANT GROWTH REGULATORS ON GROWTH AND YIELD OF TOMATO (*Lycopersicon esculentum Mill.*) VARIETIES

By

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This is to certify that thesis entitled, **"Effect of plant growth regulators on growth and yield of tomato (*Lycopersicon esculentum Mill.*) varieties".** Submitted to the **Department of Horticulture & Postharvest Technology**, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE** in **HORTICULTURE**, embodies the result of a piece of genuine research work carried out by SADIA SHARMIN, Registration No. 07-02575 under my supervision and guidance. No part of the thesis has been submitted for any other degree in any other institutes.

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

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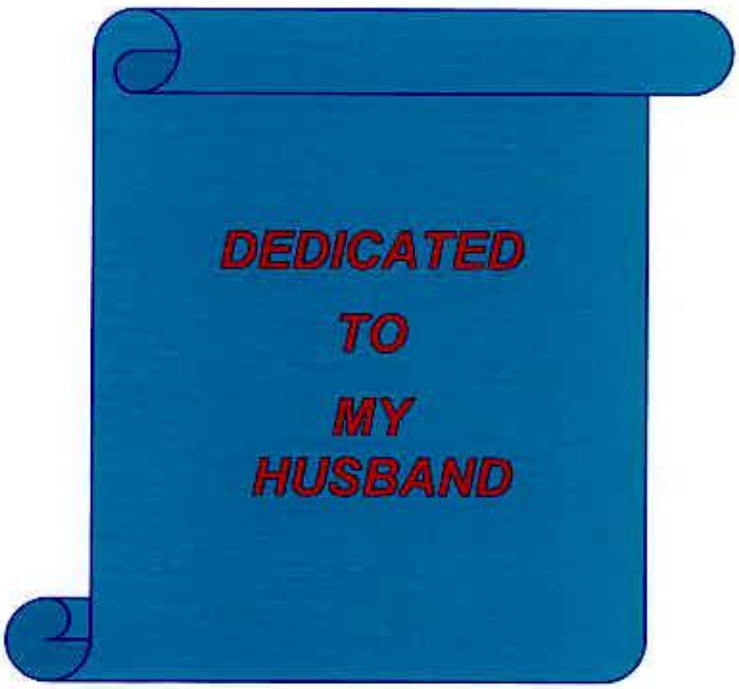
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Abbreviations

Abbreviation	Full Word
BARI	Bangladesh Agricultural Research Institute
BCR	Benefit cost ratio
^{0}C	Degree Celsius
cm	Centimeter
CV	Coefficient of variance
DAT	Days after transplanting
df	Degrees of freedom
DMRT	Duncan's Multiple Range Test
E	East
et al.	And others
^{0}F	Degree Fahrenheit
g	Gram
GA_3	Gibberellic acid
ha	Hectare
HRC	Horticulture Research Centre
IAA	Indole acetic acid
kg	Kilogram
LSD	Least significance difference
m	Meter
N	North
NAA	Naphthalene acetic acid
P^H	Hydrogen ion conc.
t	Ton (1000 kg)

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ABSTRACT

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the month of October 2007 to March 2008 to study the effect of plant growth regulators on growth and yield of tomato. The experiment was laid out in Randomized Complete Block Design with three replications. Three plant growth regulators (G_1 =NAA, G_2 = GA_3 and G_3 =IAA) and three tomato varieties (V_1=BARI Tomato 3, V_2= BARI Tomato 7 and V_3=BARI Tomato 9) were used in this experiment. In case of plant growth regulators the results of the experiment showed that G_3 produced highest number of branches per plant (12.37), number of flower per plant (91.51) and yield (126.6 t/ha). In case of tomato variety highest number of branches per plant (11.81), number of flower per plant (91.66) and yield (99.74 t/ha) produced by V_2. For combined effect V_2G_3 produced highest number of branches per plant (15.23), number of flower per plant (105.2) and yield (151.5 t/ha), which also gave the best economic return (BCR=8.44). It may be concluded that IAA with BARI Tomato 7 produced the best result.

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CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum Mill.*), a member of the family solanaceae is one of the most popular and important vegetable crop grown in Bangladesh during rabi season. It is cultivated in almost all home gardens and also in the field due to its adaptability to wide range of soil and climate (Ahmed, 1976). It ranks next to potato and sweet potato in the world vegetable production and tops the list of canned vegetable (Choudhury, 1979). It has been originated in tropical America (Salunkhe, 1987) which includes Peru, Equador, Bolivia areas of Andes (Kallo, 1986). Tomato is popular as salad in the new state and is used to made soups, juice, ketchup, pickles, sauces, conserved puree, paste, powder and other products (Ahmed, 1976). Tomato is highly nutrious as it contains 94.1% water, 23 calories energy, 1.90 g protein, 1 g calcium, 7 mg magnesium, 1000 IU vitamin A, 31 mg vitamin C, 0.09 mg thiamin, 0.03 mg riboflavin, 0.8 mg niacin per 100 g edible portion (Rashid, 1993).

In Bangladesh, half of the population is under the poverty level and suffering from various health problems. A large number of children under six year of age have clinical sign of vitamin A deficiency and suffering from some degree of exophthalmia. Tomato has high nutritive value especially vitamin A and vitamin C. Therefore, it can be met up some degree of vitamin A and vitamin C requirement and can contribute to solve malnutrition problem.

Yield of this crop in our country is very low compared to that in advanced countries (Sharfuddin and Siddique, 1985). The leading tomato producing countries of the world are China, United States of America, India, Egypt, Turky, Iran, Italy, Mexico, Brazil and Indonesia (FAO, 2007).

Tomato is grown during the winter season. It is one of the vegetables of Bangladesh which is increasing attention of the growers and consumers. Recent statistics shows that tomato was grown in 27 thousand acre of land and annually produces one lakh metric tons (BBS, 2003), which is very low in comparison with that of other countries viz. India (15.67 t/ha), Japan (52.82 t/ha), USA (63.66 t/ha) China (30.39 t/ha) and Egypt (34 t/ha) (FAO, 2007). The reasons behind such low yield are lack of high yielding varieties, poor crop management and improved technologies.

A large number of tomato varieties are grown which are of exotic origin and were developed long before. Most of them lost their potentiality due to genetic deterioration and disease contamination. Hence in order to improve the present situation of tomato production, it is essential to promote better varieties to the growers of the country. Recently, the Bangladesh Agricultural Research Institute developed some varieties with good yield contributing characters.

In Bangladesh, tomato is cultivated only in winter season. There is considerable interest in extending the cultivation of tomato over a longer period. However, high temperature before and after the short winter season inhibits the flower and fruit development. Use of plant growth regulators viz. gibberellin and auxin has been reported to be very effective to overcome the problems of flower and fruit development in tomato (Adlakha and Verma, 1965; Groot *et al.*, 1987). GA_3, particularly, is known to promote fruit development in pollinated ovaries that undergoes dormancy due to high temperature (Johnson and Liverman, 1957). Fruit set in tomato can be increased by applying plant growth regulators to compensate the deficiency of natural growth substances required for its development (Singh and Choudhury, 1966). Fruit set in tomato was successfully improved by application of NAA (Mukherji and Roy, 1966 and Kallo, 1986).

It is commonly known that the tomato production in the late growing season in Bangladesh is different due to rise in atmospheric temperature. Therefore, it was thought that the use of growth regulators viz. NAA, GA_3 and IAA might be effective in promoting the fruit set that will eventually lead to enhanced increasing yield of tomato even in higher temperature that prevails in the later part of the growing season under Bangladesh condition. Infact the use of growth regulators improved the production of tomato including other vegetables respect of better growth and quality which ultimately lead general interest among scientist and farmers for commercial application of these substances.

Considering the above mentioned facts the present investigation was under taken with the following objectives:

1. To study the effect of NAA, GA_3 and IAA on growth and yield of tomato;
2. To observe the yield potential of three tomato varieties developed by Bangladesh Agricultural Research Institute;
3. To find out the interaction effects of different varieties and plant growth regulators on yield and yield contributing characters of tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato is an important vegetable crop and has received much attention of the researchers throughout the world. Different varieties and growth regulators have marked effects on tomato production. Various investigations have been carried out in this line. Some of the available research works have been reviewed here.

2.1 Effect of variety on growth and yield attributes of tomato

An experiment was conducted with four tomato varieties (BARI Tomato 4, BARI Tomato 5, BARI Tomato 7 and BARI Tomato 8) to study the yield performance at the Horticultural farm, BAU, Mymensingh during the winter season and observed that the variety BARI Tomato 7 produced the highest yield (57.02 t/ha) and BARI Tomato 5 produced the lowest yield (51.38 t/ha). He also reported that highest plant height was observed in BARI Tomato 7 (Hossain, 2001).

From an experiment Tododrov *et al.* (2001) developed a new determinate tomato variety at the Institute of Gardening and Canning in Plovdiv with orange-colored fruits, elongated-cylindrical, 2-3 locular, weighting 50-75 g on average and with beta-carotene content (2.60%). This variety has been bred through continuous individual selection up to F_{12} from the cross 11/1-85 x K-549. Neven is suitable for mechanical harvesting and is intended for processing into juices and pastes including many dietary foods and those for children.

An experiment was conducted with two winter (Ratan and Bahar) and three summer (BINA Tomato 2, BINA Tomato 3 and E-6) varieties of tomato to

study the yield performance at the Horticultural farm, BAU, Mymensingh. It was found that the highest yield/plant was obtained from BINA Tomato 2 (1.74 kg) followed by BINA Tomato 3 (1.67 kg). But the yields of these varieties were statistically similar to each other (Khalid, 1999).

Xu *et al.* (1999) reported that tomato (*Lycopersicon esculentum*) variety Puhong No. 2 was bred from the reciprocal cross Great Red 402 X Xiaojixin. It is characterized by strong vigor, late maturity, good adaptability, red fruits, and fruit weights of 150-180 g and yields of 4000 kg /666.7 m^2 [6 kg/m^2]. They also reported that it is particularly suitable for cultivation in open fields in spring and is extensively cultivated in Sichuan, Chongqin, Jiangsu, Zhejiang, Fujian, Yunnan, Anhui, Hunan, Shannxi, Shanghai and other regions.

Zhang (1998) studied (*Lycopersicon esculentum*) variety Xinfan 5 was developed from the cross Zhongshu 6 and line 0307, containing a non-ripening gene. It has a determinate habit. Fruits are dark red and round and weight on average 140-160 g. Their thick skin and flesh make them storable and resistant to cracking. When fruits were stored for 70-90 days under room conditions, 70% remained unspoilt.

Ajlouni *et al.* (1996) carried out a field trial in Jordan in 1993 to study the yield of 13 local and introduced open pollinated cultivars and to compare the yield to that of 3 common hybrids (Maisara 898 F_1 and GS12 F_1) in relation to seasonal distribution of marketable and unmarketable yields and fruit number. The cultivars varied in their marketable yield during the harvesting period (10 weeks from 22 June, 1993). The results indicated that the cultivars Rio Grande, Nagina and T_2 improved were superior to the hybrids.

An experiment was carried out at Wooster, USA with the hybrid processing tomato Ohio OX 38 in 1992 and 1993. It was observed that the yields of this variety were higher (70.3 and 80.4 t/ha, respectively) compared to other cultivars (Berry *et al.*, 1995).

Singh *et al.* (1999) conducted an experiment where five tomato varieties were grown under different fertility levels (0, 150, 200 and 250 kg N/ha). Half of this was applied at transplanting time and the second half as two top dressings at 45 days after transplanting and after first fruit picking. Information on 6 yield components was recorded. They observed that plant height, number of leaves, number of first orders laterals, percentage fruit set, fruit weight and yield were increased with increasing N level. They also reported that Ajanta gave the best yield.

Singh *et al.* (1994) evaluated the performance of tomato varieties (Akra Vikas, LE79, BT12, BT14, Punjab Chhuhara, BWRI and Pusa Ruby). They observed that BT12 produced the tallest plants and BT14 the shortest (mean value of 75.90 and 62.52 cm respectively). They also reported that Akra Vikas had the highest fruits weight (54.87 g). Akra Vikas gave the highest mean yield (157.55 q/ha) and BT14 the lowest (119.79 q/ha).

Choudhury *et al.* (1993) developed a dwarf bushy plant (Pusa Gaurav) with moderate foliage cover and smooth, elliptical fruits, 4 X 3.5 cm in diameter. The ripe fruits are firm and have a thick (0.6 cm) flesh and 2 well-filled locules that allow easy transportation. They reported that the absence of a neck constriction, high total soluble solids (6%) and good storage quality at room temperature makes the cultivar very suitable for processing. It can be grown at 15-20°C in loam or sand-loam soil that produces more than 2 crops per year under congenial temperatures. Fruits are ready to harvest 85-88 days after

sowing and yields varied from 35 to 49 t/ha dependent upon the location, versus a standard control at 25-45 t/ha. Pusa Gaurav has been tested since 1977, entered as SI152, and has been recently released by the Indian Agricultural Research Institute.

Wu *et al.* (1991) conducted an experiment with Red Rose was selected through six generations from a hybrid fruit acquired in Hong Kong. They observed that the plants are determinate and the fruits are oval, bright red, about 70 g in weight and of uniform size with firm flesh. The flesh is 0.6-0.7 cm thick and low in water content. The fruits are resistant to bursting and cracking can withstand 6.7 kg/cm^2 pressure when ripe and show excellent transport quality. After being transported 100 km, the ripe fruits can be stored for >20 days. Red Rose has excellent taste and is the predominant export tomato variety of Guangdong Province, China.

Stamova *et al.* (1989) carried out an experiment with Emona indeterminate large-fruited variety of hybrid origin was bred in Bulgaria for fresh consumption. The fruits, with a mean weight of 180 g, are almost spherical and have many locules and a good flavor. Yields exceed 10 t/ha in many areas. Emona is resistant to tobacco mosaic tobamovirus, Verticillium and Fusarium wilts and Stemphylium. It is intended for early field production.

Kallo (1989) worked with some tomato varieties (Pusa Early Dwarf, HS 102, Hiser Arun and Punjab Chhuhara). He reported that HS102 and Punjab Chhuhara were fit for summer cultivation, and for getting early fruits Pusa Early Dwarf and Hiser Arun were suitable.

Stamova *et al.* (1988) reported that tomato variety Stela bred in Bulgaria; this vigorous determinate variety had almost spherical fruits which are firm, resistant to cracking and deep red in colour, with a mean weight of 90-120 g and a soluble solids content of 5.6-6%. Stela is resistant to Verticillium and Fusarium wilts and to high daytime temperatures. It is an early variety with uniform ripening and is suitable for mechanical harvesting. It gives high yields and is intended for processing (mainly for concentrates) but can be consumed fresh.

Ahmed *et al.* (1986) assessed eight F-7 line of tomato at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh. They observed that all the lines had shown no difference in plant height and fruit size. In contrast, fruit number had shown significant difference among the varieties. The line 0014-60-3-9-1-0 gave the highest yield of fruits (56.9 t/ha), followed by 0013-52-10-27-32-0 (50 t/ha).

Sarker and Hoque (1980) carried out an investigation during the period from October, 1977 to March, 1978, to compare the yielding ability and to asses the distinguishing external morphological characters of seven tomato varieties (Master No.2, Ramulas, Roma.Rambo, Marmande, Bigo and World Champion). They reported that highest yield obtaining from Rambo (28.28 t/ha) followed by Bigo (24.63 t/ha), World Champion (23.38 t/ha), Master No. 2 (21.98 t/ha), Roma (21.03 t/ha) and Ramula (20.21 t/ha).

Thomas *et al.* (1979) conducted an experiment in India with some recently introduced pear-shaped tomato varieties to study the yield and fruit characters. They reported that Dwarf Money Maker was the highest yielder (50 t/ha) and having the longest fruiting period (50 days). They also reported that V.687 and Pare-5 also gave higher yield than Roma, Punjab Chhuhara and Gamed.

In India, Prasad *et al.* (1977) carried out an experiment with 8 varieties of tomato. They observed that the highest yield was obtained from Kalyanpur Angurlate followed by Kalyanpur T_1 and Sioux. The Kalyanpur T_1 had the largest fruit.

Hoque *et al.* (1975) found that for Bangladesh, Oxheart, Sinkurihara, L-7, Marglobe and Bulgaria were the promising tomato varieties. They conducted a yield trial in 1969-70 with the above varieties of tomato at the vegetable division of Agricultural Research Institute, Dhaka. The experiment was repeated in 1971-72. They observed that in both years, the varieties Oxheart and Sinkurihara were found to be similar and significant higher yielder than the others.

Ali *et al.* (1974) found that the plants of Oxheart variety were 190.8 cm in height and yielded 426.6 md/acre. In the above study they observed that the plants took 23 days for flowering.

Norman (1974) carried out an experiment to observe the performance of 13 varieties of tomato in Ghana. He found significant difference between cultivars in plant height, fruit maturity yield and quality. He also stated that in the dry season, Floradel, Ace VF, Floralon, Piacenza 0164, Red colour and Ife no. 1 were found to be high yielder and appeared promising.

A performance trail of six varieties of tomato conducted at the Bangladesh Agricultural Research Institute, joydebpur by Hossain and Ahmed (1973) and they observed that, cv. Sanmarzano was the highest yielder (28.98 t/ha), followed by Oxheart, Roma, Bulgaria, USA and Anabik. They also observed that Oxheart produced the longest fruits with the average weight of 87 g followed by Bulgaria, Roma, USA, Anabik and Sanmarzano.

In an experiment, Gomes *et al.* (1970) in Brazil found that the variety Floradel was slightly superior to the other varieties, namely, Maca, Cqui and Manalucie as regards to yield and number of fruits.

2.2 Effect of Plant Growth Regulators on growth and yield contributing characters of tomato

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

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 was 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 (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).

Dhanasekaran *et al.* (2005) reported the effects of humic acid extracted from Neyveli lignite on the growth and yield of tomato (cv. PKM-1). The treatments

applied to foliage at 30 and 50 days after transplanting consisted of humic acid (0.3% solution), 50 ppm NAA, micronutrient mixture, humic acid + NAA, humic acid + nutrient mixture, NAA + micronutrient mixture, and humic acid + NAA + nutrient mixture. They reported that the application of humic acid either alone or in combination with NAA and/or nutrient mixture significantly improved the yield of tomato. The combined application of humic acid with NAA and nutrient mixture resulted in the superior yield and quality.

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 P1 (25 ppm IAA) x M2 (Humaur) interaction was better in increasing the plant growth at 75 DAT. The number of branches was significantly 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). Application of 25 ppm IAA and 2000 ppm Humaur was significantly increased the tomato yield. 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.

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 treatment with mixtures of 4-chlorophenoxyacetic acid (4-CPA) and gibberellins (GAs). They also reported that tomatoes treated with a mixture of 4-CPA and GAs showed increased fruit set and the numbers of normal fruits were more than the plants treated with 4-CPA alone during summer.

Djanaguiraman *et al.* (2004) conducted an experiment where the plants were sprayed with four different concentrations of Nitrophenols (ATONIK) at flowering and fruit setting stage. Observations were recorded in the flowers and developing fruits. Application of nitrophenols significantly increased the activity of antioxidant enzymes namely superoxide dismutase (SOD), catalase (CAT), peroxidase (POX) and auxin content coupled with decreased activity of polyphenol oxidase [catechol oxidase] (PPO) and IAA oxidase (IAAO) enzymes over the control significantly. Among the concentrations experimented, application of nitrophenols at 0.4% during fruit set stage was found to be the most effective in recording high antioxidant enzymes activity and auxin level which was reflected in an increased number of fruit clusters per plant, fertility coefficient and yield of tomato.

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 Allahabad, 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.

Gupta *et al.* (2003) observed the response of plant growth regulators and micronutrient mixtures on fruit size, colour and yield of tomato (*Lycopersicon esculentum, Mill*). An experiment was conducted for two years (1997-99) in Uttar Pradesh, India, to determine the effect of growth regulators (25 ppm IAA and 75 ppm NAA) at 25 and 50 days after transplanting (DAT) and/or micronutrient mixtures (2500 ppm Multiplex and 2000 ppm Humaur) at 25 and 50 DAT, respectively, on tomato cv. Krishna (F_1 hybrid). Among all treatments, the largest fruit size (6.67 cm diameter), most attractive ripe fruit color (Phantom, 2L-12) and the highest yield (63.61 t/ha) were observed with 75 ppm NAA + Multiplex micronutrient mixture at the maturity stage during 1998-99. The highest dry matter (2.7%) and ash content (1.0%) were obtained upon treatment with 75 ppm NAA + Humaur micronutrient mixture.

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) and uniconazole in the regulation of fruit growth, flower clusters were treated with uniconazole (5 mg/L) and GA (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.

Reddy *et al.* (2004) reported the effect of foliar application of enriched humic substances on the growth, yield and quality of tomato cv. S-22. The treatments

comprised: control; humic acid + NAA + nutrient mixture; polycarboxylic acid + NAA + nutrient mixture; penshibao; and spic cytozyme. They reported that polycarboxylic acid + NAA + nutrient mixture gave maximum plant height in 60 days, number of flowers per plant, fruit set percentage, number of fruits per plant, fruit weight, fruit volume, fruit density, yield per plant, stover yield and contents of total soluble solids, reducing sugars, total sugars, titratable acidity and ascorbic acid. It also gave the earliest number of days taken for ripening.

Singh *et al.* (2003) stated that the effects of 2,4-D, beta naphthoxyacetic acid [2-naphthoxyacetic acid] and IAA (1, 10 or 100 ppm), applied as either as seed treatment or plant spray, on the growth and yield of tomato cv. Pusa Ruby were studied in Kanpur, Uttar Pradesh, India. Seed germination varied from 8.2 to 40.2% during the initial evaluation. Flowering was initially observed in treated plants at 77-87 days after sowing. 2,4-D at all concentrations resulted in earlier flowering, whereas 1 ppm BNOA and all concentrations of IAA delayed flowering. Plants treated with 100 ppm BNOA exhibited the greatest seed germination and fruit set, and the lowest number of days to flowering. BNOA applied at 100 ppm as seed treatment gave the earliest fruit ripening (earlier than the control by 15 days).

Bhosle *et al.* (2002) reported the effects of NAA (25, 50 and 75 ppm), gibberellic acid (15, 30 and 45 ppm) and 4-CPA (25, 50 and 75 ppm) on the growth and yield of tomato cultivars Dhanashree and Rajashree during the summer of 1997. They reported that the number of flowers per cluster, fruit weight and marketable yield increased with increasing rates of the plant growth regulators. Treatment with 30 ppm gibberellic acid resulted in the tallest plants, where as treatment with 25 ppm 4-CPA and 45 ppm gibberellic acid resulted in

the highest number of primary branches of Dhanashree (4.16) and Rajashree (5.38), respectively. The highest marketable yield of Dhanashree and Rajashree was also found from treatment with 75 ppm 4-CPA.

Gupta *et al.* (2002)[a] conducted an experiment on the effect of IAA and NAA (25 and 75 ppm, respectively, at 25 and 50 days after transplanting) and the micronutrients mixtures Multiplex and Humaur (2500 and 2000 ppm, respectively), on the tomato cultivar Krishna was evaluated in Karnataka, India during 1997-98 and 1998-99. The application of auxins and micronutrients significantly improved the fruit size, dry matter, ash content and yield of tomato. The greatest fruit size and yield were obtained with 75 ppm NAA + Multiplex; while the highest dry matter and ash content were recorded for 75 ppm NAA + Humaur.

Gupta *et al.* (2002)[b] conducted an experiment to observed the effect of the plant growth regulators (PGRs) IAA and NAA (25 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 16.12% and iron content by 23.33%. The application of 75 ppm NAA+Humaur increased K content by 23.80% and Ca concentration by 52.38%. The Mg content increased by 43.84% due to the application of 25 ppm NAA+Humaur.

Singh *et al.* (2002) investigated to examine the effects of p-chlorophenoxyacetic 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. DVRT-2 during 1999-2000 under the cold climatic conditions (10-12 degrees C). Spraying PCPA at 50 ppm to the flower clusters significantly improved the fruit set per cluster compared with the control, but increasing the concentration to 100 and 150 ppm had no significant effect on fruit set. 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. PCPA at 50 ppm gave a non-significant increase in average fruit weight, whereas 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).

A field experiment was conducted 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.

Application of IAA at 75 ppm along with Multiplex at 2500 ppm resulted in the 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 was 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 (Rai *et al.*, 2002).

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. NAA application increased total soluble solids percentage significantly. Application of 2,4-D at 5 ppm also increased the yield, but retarded the growth attributes and yield at higher concentration.

Gupta *et al.* (2001) studied with Tomato (cv. Krishna) plants were treated with IAA (25 ppm at 25 days after 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/100 g and 31.5 mg/100 g) when plants were treated with NAA and Humaur.

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 with distilled water (control plants). When 2-(3-chlorophenoxy) 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 of $45Ca_2$ 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.

Rodrigues *et al.* (2001) conducted an experiment on the effects of plant growth regulators (NAA and parachlorophenoxyacetic acid at 10 and 50 ppm, respectively) and pollination on 8 flower truss sequences (1st and 2nd, 3rd and 4th, 5th and 6th, 7th and 8th, 9th and 10th, 11th and 12th, 13th and 14th, and 15th and 16th) on the performance of tomato cv. Rajashree were investigated in Maharashtra, India. The mean polar diameter, equatorial diameter, fruit weight, fruit set percentage, number of seeds per fruit and seed yield were the highest on initial truss sequences. Spraying with 10 ppm NAA followed by pollination on initial trusses resulted in the highest number of fruits (45.63) and seed yield (0.58 g per plant).

Sun *et al.* (2000) reported the role of growth regulators on cold water for irrigation reduces stem elongation of plug-grown tomato seedlings. The effect

of growth regulators (abscisic acid, gibberellic acid (GA), paclobutrazol, ethephon, IAA and silver thiosulfate) and cold water irrigation at different temperatures (5, 15, 25, 35, 45 and 55 ^{0}C) on the reduction of stem elongation of plug-grown tomato seedlings was investigated. Paclobutrazol, ethephon and GA reduced the stem length of the tomatoes at several water temperatures. Cold water irrigation with the addition of 1.8 ppm GA or irrigation at room temperature could promote stem elongation. Irrigation at room temperature with the addition of 10 ppm paclobutrazol (GAs biosynthesis inhibitor) or cold water irrigation could inhibit stem elongation. The reduction in stem elongation in plug-grown tomato seedlings was due to the relationship of GAs metabolism and sensitivity.

Martins *et al.* (1999) studied the growth regulators and leaf anatomy in tomato (*Lycopersicon esculentum 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 epidermis compared 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.

El-Habbasha *et al* (1999) studied the response of tomato plants to foliar spray with some growth regulators under late summer conditions. Field experiments were carried out with tomato (cv. Castelrock) over two growing seasons (1993-94) at Shalakan, Egypt. The effects of GA_3, IAA, TPA (tolylphthalamic acid)

and 4-CPA (each at 2 different concentrations) on fruit yield and quality were investigated. Many of the treatments significantly increased fruit set percentage and total fruit yield, but also the percentages of puffy and parthenocarpic fruits, compared with controls.

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

Akhtar *et al.* (1996) carried out an experiment on the effect of different rates of NAA (0, 25, 50, 75 and 100 ppm) on two tomato lines (TM0111 and TM0367). 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. Vitamin C content was highest (14.87 mg/100 g) in the fruits when sprayed with 100 ppm NAA. The tomato line TM0111 had maximum TSS at 25 ppm NAA (4.8%). However, vitamin C increased with the higher rates of NAA (50-100 ppm) but TSS (%) showed the reverse trend.

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

second cluster was sprayed with IAA, GA_3 or ABA at 10-4, 10-6 or 10-8 M each and ACC at 10-9, 10-10 or 10-11 M. All concentrations of IAA, GA_3, ACC and ABA induced early fruit set compared with controls sprayed with distilled water. For the first of the 2 crops, the highest ABA concentration (10-5 M) accelerated fruit set, but the other 2 concentrations delayed it. For the second crop, however, all ABA treatments accelerated fruit set. ABA applications also retarded red fruit colour formation, more so at increasing concentrations. IAA at 10-6 M resulted in the formation of double flowers. Of the total fruits set from treated flowers, 40% were double. GA_3 led to the formation of leafy clusters, with the number of leaves formed increasing with GA_3 concentration.

Fiume and Parisi (1994) reported that NAA treatment produced the highest fruit yields (113.38 t/ha), and advanced early fruit production.

In trials with the cultivars Pusa Ruby and Italian Red Pear, seedling roots were dipped in NAA solution at 0.25-1.25 ppm for 12 h on 29 Oct. before transplanting by Balyan (1988). Treatment with 0.25 ppm NAA induced earlier flowering, improved fruit set, advanced ripening and increased the yield from 2.7 to 3.02 kg/plant; higher NAA concentrations decreased the yield. Of the 2 cultivars, Pusa Ruby yielded more than twice as much as Italian Red Pear.

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

Sumiati (1987) reported that tomato cultivars, Gondol, Meneymaker, Intan and Ratan sprayed with 1000 ppm chlorflurenol, 100 ppm IAA, 50 ppm NAA or 10 ppm, GA_3 or left untreated, compared with controls, fruit setting was hastened

by 4-5 days in all cultivars following treatment with 100 ppm IAA or 10 ppm GA_3.

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.

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

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

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

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 improved fruit quality.

Younis and Tigani (1977) carried out an experiment with NAA application on tomato cv. John Moran plants. They observed that when NAA was applied to

field grown tomato plants, 2 applications of NAA at 10 ppm increased fruit set significantly.

Mehta and Mathi (1975) reported that treatments with NAA at 0.1 or 0.2 ppm improved the yield of tomato irrespective of planting date. Maximum fruit set, early and total yield, fruit number and weight were obtained in response to 2, 4-D at 5 ppm followed by NAA at 0.2 ppm. He also reported that GA treatments at 10 or 25 ppm improved the yield of tomato cv. Pusa Ruby irrespective of planting date. GA gave earlier setting and maturity.

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 and weight 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.

Kaushik *et al.* (1974) reported that 1 ppm of NAA increased the number and weight of fruits per plant significantly. The application of NAA at 100 ppm markedly reduced fruit number and yield.

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.

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

Singh and Upadhayaya (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.

Mukherji and Roy (1966) found that application of NAA had protected the flower and premature fruit drop and increased the size of fruit.

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

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

Leopold (1964) observed that with the increase in concentration of auxin there was a comparable increase in percentage of fruit set.

Gustafson (1960) worked with different concentration of GA and observed that when 35 and 70 ppm GA were sprayed to the flowers and flower buds of the first three clusters, percentage of fruits set increased but there was a decrease in the total weight. When only the first cluster was sprayed, the number of fruit

set and the total weight per cluster was increased, but this response did not occur in subsequent clusters.

Feofanova (1960) observed that the application of growth regulators 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 reported that the application could increase total yield of tomato fruits by preventing fruit drop.

Rappaport (1960) noted that GA had no significant effect on fruit weight or size either at cool (11°C) or warm (23°C) night temperatures; but it strikingly reduced fruit size at an optimal temperature (17°C).

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

Singh (1957) found minimum growth of tomato seedlings when treated with 0.1 ppm NAA at the time of transplanting.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The present experiment was conducted at Horticulture Farm in Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh. The experiment was carried out during *rabi* season (1st October, 2007 to March 10, 2008). It was located in 24.09^0 N latitude and 90.26^0 E longitudes. The altitude of the location was 8 m from the sea level (The Meteorological Department of Bangladesh, Agargoan, Dhaka).

3.2 Climate

The experimental area was situated in the sub-tropical climatic zone, which was characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Details of weather data in respect of temperature (^{o}C), rainfall (cm) and relative humidity (%) for the study period were collected from The Meteorological Department of Bangladesh, Agargoan, Dhaka (Appendix I).

3.3 Soil

The experimental site was located in Modhupur Tract (Agro Ecological Zone-28) and it was medium high land with adequate irrigation facilities. The soil was having a texture of sandy loam with pH 5.6. Physical and chemical properties of soil in the experimental field of Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka were given in Appendix II and Appendix III.

3.4 Materials used for the experiment

Three tomato varieties viz. BARI Tomato 3, BARI Tomato 7 (Apurba), BARI Tomato 9 (Lalima) were used as experimental materials in the research work. The variety BARI Tomato 7 is indeterminate type, BARI Tomato 3 is semi indeterminate type and BARI Tomato 9 is determinate type. The seeds of the experimental materials were collected from the Horticultural Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gajipur.

3.5 Plant growth regulators

Three plant growth regulators viz. Naphthalene Acetic Acid (NAA), Gibberellic Acid (GA_3) and Indole Acetic Acid (IAA) were sprayed in different times. NAA (25 PPM) was sprayed 15 days before flower initiation in three times at 15 days interval. GA_3 (35 PPM) was sprayed before flower initiation in three times at 15 days interval and IAA (25 PPM) was sprayed before flowering stage in two times at 35 days interval.

3.6 Seed bed preparation

Seed bed was prepared on 1 October 2007 for raising seedlings of tomato and the size of the seedbed was 3m × 1m. For making seedbed, the soil was well ploughed. Weeds, stubbles and dead roots were removed from the seedbed. Cow dung was applied to the prepared seedbed at the rate of 10 t/ha. The soil was treated by Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworms.

3.7 Seed Treatment

Seeds were treated by Vitavax-200 @ 5g/1kg seeds to protect some seed borne diseases such as leaf spot, blight, anthracnose, etc.

3.8 Seed sowing

Seeds were sown on 7 October, 2007 in the seedbed. Sowing was done thinly in lines spaced at 5 cm distance. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light watering by water can. Thereafter the beds were covered with polythene to maintain required temperature and moisture.

3.9 Raising of seedlings

Light watering and weeding were done several times. No chemical fertilizers were applied for raising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 30 days old seedlings were transplanted into the experimental field on 7 November 2007.

3.10 Design of the experiment:

A. Design

The field experiment was conducted by Randomized Complete Block Design (RCBD) with three replications. The study consisted of two factors viz. three levels of plant growth regulators and three varieties of tomato.

Factor A. three levels of plant growth regulators:

G_0 = Control (No plant growth regulator application)

G_1 = NAA (Naphthalene acetic acid), 25 ppm.

G_2 = GA_3 (Gibberellic acid), 35 ppm.

G_3 = IAA (Indole acetic acid), 25 ppm.

Factor B. Three varieties:

V_1=BARI Tomato 3

V_2= BARI Tomato 7

V_3 =BARI Tomato 9

Therefore the twelve treatment combinations were given below:

T_1	V_1G_0	T_7	V_2G_2
T_2	V_1G_1	T_8	V_2G_3
T_3	V_1G_2	T_9	V_3G_0
T_4	V_1G_3	T_{10}	V_3G_1
T_5	V_2G_0	T_{11}	V_3G_2
T_6	V_2G_1	T_{12}	V_3G_3

B. Layout of the experiment

The experimental area was first divided into three blocks. Each block was divided into 12 plots for the treatment combinations. Therefore, the total numbers of plots were 36. Thereafter 12 treatment combinations were assigned randomly to each block as per design of the experiment. The size of the unit plot was 3.2 m × 1.2 m. A distance of 50 cm between the plots and 100 cm between the blocks was kept. The plants were spaced 60 cm × 40 cm on beds. Each unit plot contains two rows accommodating 14 plants.

3.11 Land preparation

The soils of the experimental area was first opened on 1 November 2007 by a disc plough to open direct sunshine to kill soil born pathogens and soil inhabitant insects. Then the land was prepared by several ploughing and cross ploughing with a power tiller followed by laddering to bring a good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. The weeds, crop residues and stables were removed from the field. The basal dose of manure and fertilizers were applied at the finally ploughing. The plots were prepared according to design and layout of the experiment. The soil of the

plot was treated by Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworm.

3.12 Application of manure and fertilizers

Manure and fertilizers were applied according to Rashid (1993) given below:

Name of fertilizers and manure	Amount
Cow dung	10 t/ha
Urea	250 kg/ha
TSP	175 kg/ha
MP	150 kg/ha

Half dose of total cow dung and half dose of TSP were broadcasted and incorporated during final land preparation. The remaining dose of cowdung and TSP were applied in hills prior to seedling transplanting. Urea and MP were applied in two equal installments. The first installment was applied after 20-25 days after transplanting (DAT) and second installment was applied after 40-45 days after transplanting (DAT) as ring method followed by irrigation.

3.13 Transplanting

The seedbeds were watered before uprooting the seedlings to minimize the root damage. At the time of uprooting, care was taken so that root damage became minimum. Healthy and 30 days-old seedlings were transplanted at the spacing of 60 cm × 40 cm in experimental plots on 10 November 2007. Planting was done in the afternoon and light irrigation was given immediately after transplanting for better establishment.

3.14 Intercultural operation

Gap filling

Very few seedlings were damaged after transplanting and these were replaced by the new seedlings from the same stock.

Weeding

The experimental field was kept under careful observation. Weeding was done on the 30th November, 25th December and 15th January, 2008.

Earthing up

Earthing up was done after 30 days after transplanting to protect the plant against lodging.

Irrigation

Irrigations were given by observing the soil moisture condition of the experimental area in once a week.

Staking

Staking was provided with bamboo sticks. It helped the plant to keep erect and protect the plant against lodging.

Insects and diseases management

Diathane M45 was applied two times at 15 days interval @ 2 g/L in water to control late blight disease. Admire 200SL was applied to control the vector of virus disease of tomato plant. Virus infected plants were removed from the field as soon as the disease appeared in the field.

3.15 Harvesting

Harvesting was done at 4 days interval during early ripen stage and ripen stage. Harvesting was started at 15 January and was completed by 10 March 2008.

3.16 Collection of data

The following data were recorded from the tomato plants during the study period.

Plant height (cm): Five plants were randomly selected from each plot to measure the plant height and average plant height was measured in centimeter (cm). Plant height was measured from base to the tip of the longest leaf at 40 and 60 days after transplanting (DAT). A meter scale was used to measure the plant height.

Number of branch: Branches were counted in each of selected plant at 60 day after transplanting and there average was taken.

Stem diameter: Diameter of the stem was measured at 40 and 60 days after transplanting. The diameter of the stem was measured at the lower portion of five selected plants from each plot with a slide calipers and the average was taken and expressed in cm.

Number of leaves: The number of leaves was counted in five selected plants from each plot and their average was taken.

Days to 50% flowering: It was estimated as the number of days required from sowing to first flower opening of the 50% plants of each replication.

No. of flower cluster/plant: Flower clusters were counted in every five plant and their average was taken.

No. of flower /cluster: flower of each five cluster were counted in every plant and their average was taken.

No. of flower /plant: The average value of the total number of flower per plant from the five selected plant were counted.

No. of fruit /cluster: Fruit of each cluster were counted in every five selected plant and their average was taken.

No. of fruit /plant: The average value of the total number of fruit per plant harvested at different dates from the five selected plant were counted.

Fruit length: Fruit length was measured from the neck of fruit to the bottom of the same by using slide calipers of five fruits randomly selected from each of the plot.

Fruit diameter: Fruit diameter was measured along the equatorial part of the same five represented fruit by distal slide calipers and their average was taken.

Fruit weight: Based on five represented fruits individual fruit weight in gram was taken.

Yield per plant: The yield per plant was calculated by averaging the fruit yield of five plants from each plot.

Yield per hectare: The yield per hectare was calculated out from per plot yield data and their average was taken.

Brix (%): A hand refractrometer was used to record the percentage of brix. The value was the average of five representative fully ripened fruits.

3.17 Statistical analysis:

The recorded data on different parameters were statistically analyzed with the help of "MSTAT" programme. The treatment means were separated by Duncan's Multiple Range Test (DMRT) [Gomez and Gomez (1984)] at 5% level of significance for interpretation of the results.

Plate 1. Experimental field

Plate 2. Plant growth regulators application on the flower cluster of tomato plants

BARI Tomato 3

BARI Tomato 7

BARI Tomato 9

Plate 3. Fruited tomato plants of different varieties used.

BARI Tomato 3

BARI Tomato 7

BARI Tomato 9

Plate 4. Freshly harvested fruits of three tomato varieties

BARI Tomato 3	BARI Tomato 9	BARI Tomato 7

Plate 5. A comparative study of three varieties

CHAPTER IV

RESULTS AND DISCUSSION

The results of different parameters obtained from the present study were presented in tables 1 to 13. The summaries of analysis of variance for different parameters are presented in appendix IV. Results are discussed chronologically as below:

4.1 Plant height

Plant height was recorded at 40 and 60 days after transplanting (DAT). Plant height differed significantly among different varieties. The variety BARI Tomato 7 produced the highest plant height (46.47 cm) which was statistically similar to that of the variety BARI Tomato 3 and the variety BARI Tomato 9 produced the shortest plant height (36.58 cm) at 40 days after transplanting (Table 1). At 60 days after transplanting the highest plant height (88.90 cm) produced from the variety BARI Tomato 7 which was statistically similar to that of the variety BARI Tomato 3 and the variety BARI Tomato 9 produced the shortest plant height (74.97 cm). Similar trend of the result on tomato was reported by Hossain (2001).

There were significant variations due to the effect of plant growth regulators in respect of plant height at different days after transplanting (Table 2). The Indole Acetic Acid (IAA) produced significantly highest plant height (47.72 cm) at 40 days after transplanting which was statistically similar to the Gibberellic Acid treatment (43.23 cm). The shortest plant height (35.77 cm) was obtained from controlled treatment in case of three varieties at 40 days after transplanting. At 60 days after transplanting the highest plant height

(92.55 cm) produced from Indole Acetic Acid (IAA) treatment which was statistically similar to the Gibberellic Acid treatment (85.39 cm) and the shortest plant height (71.24 cm) was obtained from controlled treatment in case of three varieties.

The interaction effect of variety and plant growth regulators in respect of plant height was found significant at different days after transplanting. The highest plant height (53 cm) was observed in V_2G_3 treatment which was statistically similar to the V_1G_3 and V_2G_2 treatments and the lowest plant height was found in case of controlled treatment at 40 days after transplanting (Table 3). At 60 days after transplanting the highest plant height (99.53 cm) was observed in V_2G_3 treatment which was statistically similar to the V_1G_3 and V_2G_2 treatments and the lowest plant height was found in case of controlled treatment.

4.2 Number of branches per plant

The number of branches per plant differed significantly among the three varieties of tomato at 60 days after transplanting (Table 1). The number of branches per plant varied from 7.97 to 11.81. The variety BARI Tomato 7 produced the highest number of branches per plant (11.81) which was significantly differed from the other two varieties. The lowest number of branches was recorded from the variety BARI Tomato 3 (7.97). The variation might be due to the varietals characteristics. This finding coincided with that of Afrin (2002).

Significant variations in respect of number of branches per plant were recorded due to the effect of plant growth regulators at different days after

transplanting. The Indole Acetic Acid produced significantly highest number of branches per plant (12.37) at 60 days after transplanting (Table 2). Singh *et al.* (2005) also reported that the number of branches per plant was significantly and highly increased by the application of Indole Acetic Acid. The lowest number of branches per plant (7.23) was found from controlled treatment in case of three varieties.

Significant variations in respect of number of branches per plant were found due to the combined effect of variety and plant growth regulators at 60 days after transplanting (Table 3). The highest number of branch per plant (15.23) was observed in V_2G_3 treatment at 60 days after transplanting which was statistically different from other treatments. The lowest number of branches per plant was found in case of controlled treatment.

4.3 Number of leaves per plant

Number of leaves per plant was counted at 60 days after transplanting. The variety BARI Tomato 7 produced significantly highest number of leaves per plant (76.80) and the variety BARI Tomato 3 produced the lowest number of leaves per plant (45.65) at 60 days after transplanting (Table 1). The variation may be due to varietals characteristics.

A marked variation was found among different plant growth regulators application in respect of number of leaves per plant at 60 days after transplanting. The Indole Acetic Acid (IAA) produced significantly higher number of leaves per plant (72.16) than Naphthalene Acetic Acid (55.66) and Gibberellic Acid treatment (63.83) at 60 days after transplanting (Table 2). The lowest number of leaves per plant (48.17) was found from controlled treatment at 60 days after transplanting.

Significant variations were observed in case of number of leaves per plant due to the combined effect of variety and plant growth regulators at 60 days after transplanting. Number of leaves per plant increased progressively with the variety and plant growth regulators at 60 days after transplanting. The highest number of leaves per plant (90.47) was observed in V_2G_3 treatment which was significantly different from other treatment (Table 3). The control treatment gave the lowest number of leaves per plant.

Table 1. Effect of varieties on different Plant characteristics in tomato

Treatments	Plant height (cm) at		Number of branches at 60 DAT	Number of leaves at 60 DAT	Stem diameter (cm) at	
	40 DAT	60 DAT			40 DAT	60 DAT
V_1	41.85ab	81.74ab	7.97c	45.65c	0.72b	1.06ab
V_2	46.47a	88.90a	11.81a	76.80a	0.89a	1.12a
V_3	36.58b	74.97b	9.16b	57.41b	0.82a	0.97b
CV (%)	10.40	7.02	6.22	7.69	7.11	8.18
$LSD_{(.05)}$	6.35	8.43	0.88	6.76	0.08	0.12

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. V_1= BARI Tomato 3, V_2= BARI Tomato 7 and V_3= BARI Tomato 9.

4.4 Stem diameter

The variation among different varieties at 40 and 60 days after transplanting in respect of stem diameter were found to be significant (Table 1). The variety BARI Tomato 7 significantly produced highest stem diameter (0.89 cm), which was statistically similar to that of BARI Tomato 9 variety (0.82 cm) and the variety BARI Tomato 3 produced lowest stem diameter (0.72 cm) at 40 days after transplanting. At 60 days after transplanting the variety BARI Tomato 7

significantly produced highest stem diameter (1.12 cm), which was statistically similar to that of BARI Tomato 3 variety (1.06 cm) and the variety BARI Tomato 9 produced lowest stem diameter (0.97 cm). The variation may be due to varietals performance.

There were significant variations in stem diameter per plant due to different growth regulators at different days after transplanting. The Indole Acetic Acid (IAA) produced significantly highest stem diameter (0.92 cm) per plant (Table 2) which was statistically similar to the Gibberellic Acid (GA_3) treatment at 40 days after transplanting. The lowest stem diameter was found from controlled treatment in case of three varieties. At 60 days after transplanting the highest stem diameter (1.22 cm) per plant produced from Indole Acetic Acid (IAA) which was statistically similar to the Gibberellic Acid (GA_3) treatment. The lowest stem diameter was found in case of controlled treatment. This variation may be due to the stimulation of the meristematic tissue, resulting higher cell division, cell enlargement and cell differentiation by IAA.

Significant variations were found in respect of stem diameter due to combined effect of variety and plant growth regulators at different day's interval (Table 3). The highest stem diameter (1 cm) was observed in the V_2G_3 treatment which was statistically similar to the V_2G_2 and V_3G_3 treatments and the lowest stem diameter was found in case of controlled treatment at 40 days after transplanting. At 60 days after transplanting the highest stem diameter (1.35 cm) was observed in the V_2G_3 treatment which was statistically similar to the V_1G_3 treatment and the lowest stem diameter was found in case of controlled treatment or without any plant growth regulators application of three varieties.

Table 2. Effect of plant growth regulators on different plant characteristics in tomato

Treatments	Plant height (cm) at		Number of branches at 60 DAT	Number of leaves at 60 DAT	Stem diameter (cm) at	
	40 DAT	60 DAT			40 DAT	60 DAT
G_0	35.77b	71.24c	7.23d	48.17c	0.71c	0.91c
G_1	39.81b	78.29bc	8.46c	55.66c	0.76bc	0.98bc
G_2	43.23ab	85.39ab	10.53b	63.83b	0.84ab	1.09ab
G_3	47.72a	92.55a	12.37a	72.16a	0.92a	1.22a
CV (%)	10.40	7.02	6.22	7.69	7.11	8.18
$LSD_{(.05)}$	7.33	9.73	1.02	7.81	0.09	0.14

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. G_0= control, G_1= NAA, G_2= GA_3 and G_3= IAA.

4.5 Days to 50% flowering

Days required to 50 % flowering were recorded under field condition of three varieties of tomato. Significant variations were found in case of days required to 50 % flowering. All variety varied from 43 days to 50.75 days (Fig. 1). The minimum days were required by the variety BARI Tomato 7 (43 days) that was statistically similar to that of the variety BARI Tomato 9 (46.5 days). The maximum days were required by the variety BARI Tomato 3 (50.75 days). High temperature probably interrupted the process of flowering (Ahmed, 2002). Aung (1976); Charles and Harris (1972) and Kuo *et al.* (1979) also reported that flower formation is affected by temperature stress.

Table 3. Combined effects of varieties and plant growth regulators on different plant characteristics in tomato

Treatments	Plant height (cm) at		Number of branches/ plant at 60 DAT	Number of leaves/ plant at 60 DAT	Stem diameter (cm) at	
	40 DAT	60 DAT			40 DAT	60 DAT
V_1G_0	36.8cde	71.11de	6.96g	34.2i	0.65f	0.91d
V_1G_1	40bcd	78.21cd	7.2fg	42.77h	0.69ef	1.01cd
V_1G_2	43.2bcd	85.21bc	8.2ef	50.2fgh	0.75cdef	1.11bc
V_1G_3	47.4ab	92.43ab	9.53d	55.43ef	0.80cd	1.21ab
V_2G_0	40.1bcd	78.35 cd	8.5e	66.63cd	0.77cde	0.95d
V_2G_1	44bc	85.29 bc	10.1d	71.67c	0.83c	1.04cd
V_2G_2	48ab	92.42 ab	13.4b	80.43b	0.94ab	1.15bc
V_2G_3	53a	99.53 a	15.23a	90.47a	1a	1.35a
V_3G_0	30.4e	64.25 e	6.23g	45.67gh	0.72def	0.88d
V_3G_1	35.4de	71.38de	8.1ef	52.53fg	0.78cde	0.90d
V_3G_2	38.2cde	78.54 cd	10d	60.87de	0.85bc	1.01cd
V_3G_3	42.27bcd	85.71 bc	12.33c	70.57c	0.94ab	1.12bc
CV %	10.40	7.02	6.22	7.69	7.11	8.18
$LSD_{(.05)}$	7.33	9.73	1.02	7.81	0.09	0.14

Mean in a column having different letter(s) differed significantly at 0.05 level of probability.

V_1=BARI Tomato 3

V_2= BARI Tomato 7

V_3= BARI Tomato 9

Go=Control

G_1= NAA

G_2= GA_3

G_3=IAA

Days required to 50% flowering significantly affected by the different plant growth regulators (Fig. 2). The minimum days were required by the application of Indole Acetic Acid (39.33 days) which was statistically similar to Gibberellic Acid (44 days). The maximum days (53.67 days) were required by the controlled treatment or without any plant growth regulator application, which was statistically similar to the application of Naphthalene Acetic Acid (50 days).

Number of days to 50% flowering was significantly affected by combined effect of variety and plant growth regulators application (Fig. 3). The maximum days were required from the V_1G_0 treatment which was statistically similar to V_1G_1, V_3G_0 treatments and the minimum days were required from the V_2G_3 treatment.

4.6 Number of flower cluster per plant

Significant variation was observed among different varieties in respect of number of flower cluster per plant (Table 4). The maximum number of flower cluster per plant (12.52) was produced by the variety BARI Tomato 7 and the minimum number of flower cluster per plant (8.73) was produced by the variety BARI Tomato 3 which was statistically similar to that of the variety BARI Tomato 9 (9.96). The number of flower cluster per plant is an important character, which has got the significant role to determine the yield of tomato. The production of flower cluster per plant might be affected by the different cultivars. Aung (1976) and Stevens (1979) reported that an extent of decreased number of flower cluster depends on cultivars.

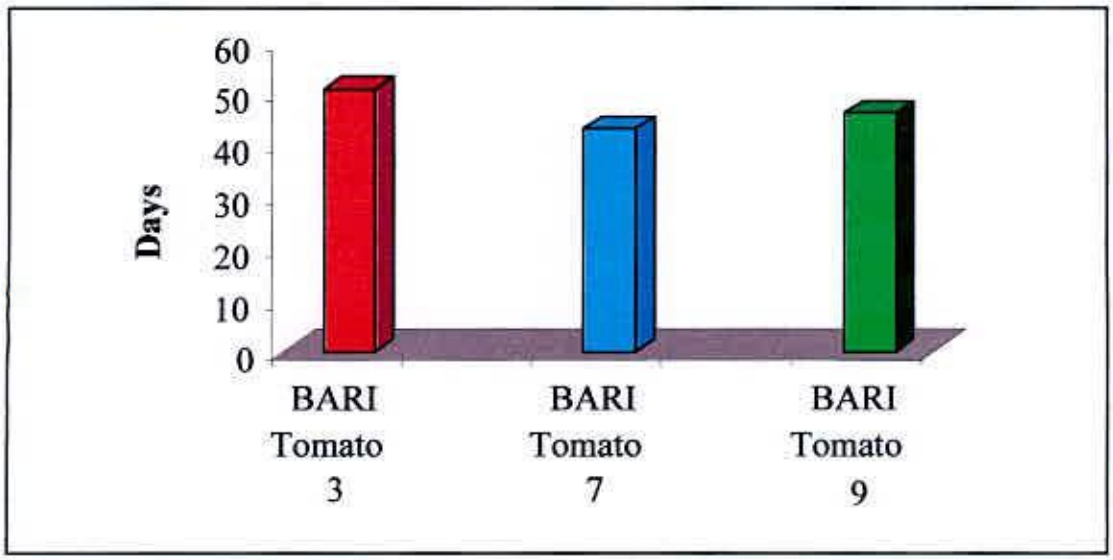

Figure 1. Effect of varieties on days to 50% flowering in tomato

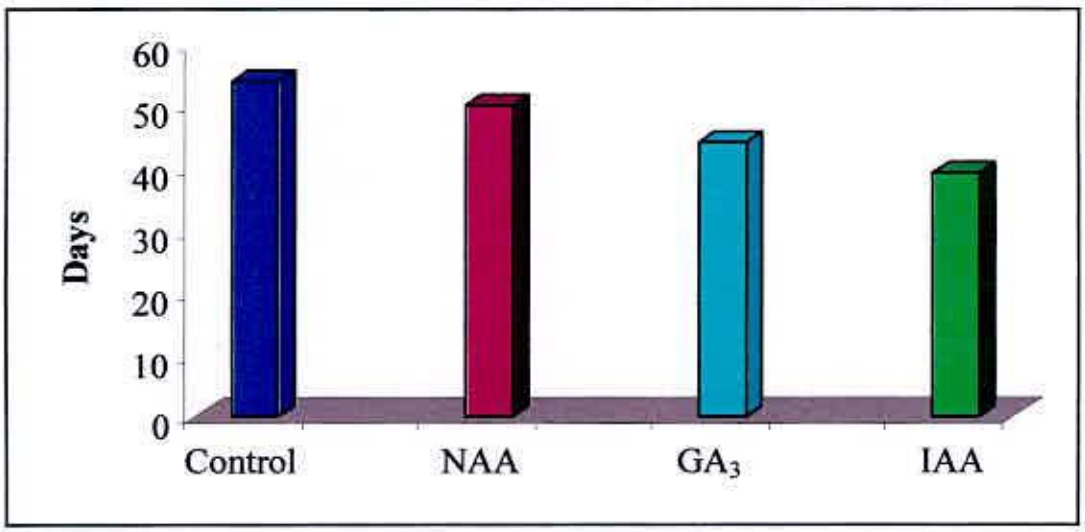

Figure 2. Effect of plant growth regulators on days to 50% flowering in tomato

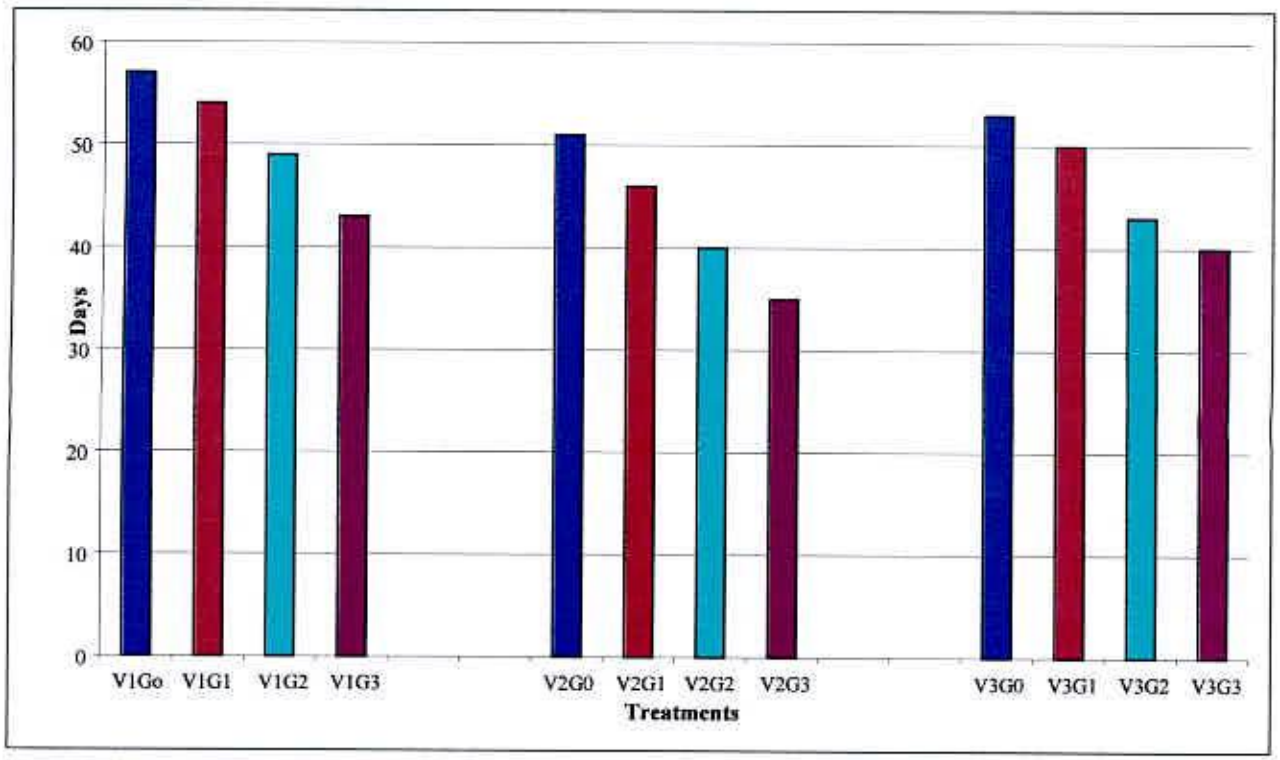

Fig. 3. Combined effects of varieties and plant growth regulators on days to 50% flowering in tomato

V_1=BARI Tomato 3

V_2= BARI Tomato 7

V_3= BARI Tomato 9

G_0=Control

G_1=NAA

G_2=GA_3

G_3=IAA

A marked variation was found among different plant growth regulators application in terms of number of flower cluster per plant (Table 5). The maximum flower cluster per plant were produced by the application of IAA (13.50) and the minimum flower cluster per plant (8.34) were produced by the controlled treatment or without any plant growth regulator application,

Highly significant variations were observed in respect of number of flower cluster per plant due to combined effect of variety and plant growth regulators application (Table 6). The maximum flower cluster per plant (16.8) was observed in V_2G_3 treatment and the minimum flower cluster per plant (7.5) was observed in V_1G_1 treatment.

4.7 Number of flower per cluster

Significant variation was observed among different varieties in respect of number of flower per cluster of tomato plant (Table 4). The maximum number of flower per cluster (6.47) was produced by the variety BARI Tomato 7 and the minimum number of flower per cluster (3.97) was produced by the variety BARI Tomato 3. The variation may be due to varietals performance. This finding coincided with Afrin (2002).

Highly significant variations were observed among different plant growth regulators application in respect of number of flower per cluster (Table 5). The maximum number of flower per cluster (6.33) was produced by the application of IAA and the minimum number of flower per cluster (3.82) was produced by the controlled treatment or without application of any plant growth regulator application.

Marked variations were found due to the combined effect of variety and plant growth regulators application in respect of number of flower per cluster (Table 6). The maximum number of flower per cluster (7.8) was observed in V_2G_3 treatment and the minimum number of flower per cluster was observed in V_1G_0 treatment (3.06) which was statistically similar with V_1G_1 and V_3G_0 treatments.

4.8 Number of flower per plant

The effect of variety on number of flowers per plant was recorded in the variety BARI Tomato 7 (91.66) which was statistically different from other two varieties (Table 4). The minimum number of flower per plant was recorded in the variety BARI Tomato 3 (64.55). The variation may be due to its varietals characteristics.

The effect of plant growth regulators on number of flower per plant was significant (Table 5). The maximum number of flower per plant (91.51) was produced by the application of IAA and the minimum number of flower per plant (64.97) was produced by the controlled treatment or without any plant growth regulator application. NAA and GA_3 produced intermediate number of flower per plant (73.02 and 81.67 respectively).

Significant variations were found in respect of number of flower per plant due to the combined effect of variety and plant growth regulators application (Table 6). The maximum number of flower per plant (105.2) was observed in V_2G_3 treatment and the minimum number of flower per plant was observed in V_1G_0 treatment (52.2), which was statistically similar to V_1G_1, V_1G_2 and V_3G_0 treatments.

4.9 Number of fruit per cluster

The effect of variety on number of fruits per cluster was significant. The maximum number of fruit per cluster (5.2) was produced by the variety BARI Tomato 7, which was statistically similar to the variety BARI Tomato 9 (4.38). The minimum number of fruit per cluster (3.55) was recorded in the variety BARI Tomato 3 (Table 7). The variation may be due to its varietals characteristics.

Table 4. Effect of varieties on floral characteristics in tomato

Treatments	Flower cluster/ plant	No. of flower/ cluster	No. of flower/ plant
V_1	8.73b	3.97c	64.55c
V_2	12.52a	6.47a	91.66a
V_3	9.96b	4.7b	77.17b
CV (%)	13.94	6.30	5.59
$LSD_{(.05)}$	2.12	0.47	6.37

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. V_1= BARI Tomato 3, V_2= BARI Tomato 7 and V_3= BARI Tomato 9.

Table 5. Effect of plant growth regulators on floral characteristics in tomato

Treatments	No. of flower cluster/plant	No. of flower/ cluster	No. of flower/ plant
G_0	8.34b	3.82d	64.97d
G_1	9.10b	4.63c	73.02c
G_2	10.67b	5.4b	81.67b
G_3	13.50a	6.33a	91.51a
CV (%)	13.94	6.30	5.59
$LSD_{(.05)}$	2.46	0.54	7.36

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. G_0= control, G_1= NAA, G_2= GA_3 and G_3= IAA.

Table 6. Combined effects of varieties and plant growth regulators on flower characteristics in tomato

Treatments	Flower cluster/ plant	No. of flower/ cluster	No. of flower/ plant
V_1G_0	8.5de	3.067f	52.2h
V_1G_1	7.5e	3.5f	59.9g
V_1G_2	8.4de	4.2e	67.3fg
V_1G_3	10.5d	5.1d	78.8d
V_2G_0	8.9de	4.9d	77.37de
V_2G_1	10.9cd	6.2c	88.27bc
V_2G_2	13.5b	7b	95.77b
V_2G_3	16.8a	7.8a	105.2a
V_3G_0	7.62e	3.5f	65.33fg
V_3G_1	8.9de	4.2e	70.9ef
V_3G_2	10.1de	5d	81.93cd
V_3G_3	13.2bc	6.1c	90.5b
CV (%)	13.94	6.30	5.59
$LSD_{(.05)}$	2.46	0.54	7.36

Mean in a column having different letter(s) differed significantly at 0.05 level of probability.

V_1=BARI Tomato 3

V_2= BARI Tomato 7

V_3= BARI Tomato 9

G_0=Control

G_1=NAA

G_2=GA_3

G_3=IAA

Highly significant variations were observed in respect of number of fruit per cluster due to the effect of different plant growth regulators application (Table 8). The maximum number of fruit per cluster (5.23) was found by the application of IAA which was statistically similar to GA_3 application (4.73). The minimum number of fruit per cluster (3.43) was found by the controlled treatment or without any plant growth regulator application which was statistically similar to NAA application (4.1).

Number of fruit per cluster was differed significantly due to the combined effect of variety and plant growth regulators application (Table 9). The maximum number of fruit per cluster (6.1) was observed in V_2G_3 treatment which was statistically similar to V_2G_2 and V_3G_3 treatments. The minimum number of fruit per cluster was observed in V_1G_0 treatment (2.7) which was statistically similar to V_1G_1, V_1G_2, V_2G_0, V_3G_0 and V_3G_1 treatments.

4.10 Number of fruit per plant

A marked variation among the varieties was observed in number of fruit per plant. The maximum number of fruits per plant (36.13) was produced by the variety BARI Tomato 9, which was statistically different from other varieties (Table 7). The minimum number of fruit per plant (18.52) was recorded in variety BARI Tomato 7. The marked variation among the varieties in terms of number of fruit per plant was possibly due to the genetically potentiality of the varieties. The present findings agree with the report of Bhangu and Singh (1993).

Significant variations were observed in respect of number of fruit per plant due to the effect of different plant growth regulators (Table 8). The maximum number of fruit per plant (29.96) was recorded by the application

of IAA and the minimum number of fruit per plant (21.12) was recorded by the controlled treatment or without any plant growth regulator application. NAA and GA_3 produced intermediate number of fruit per plant (23.28 and 25.58, respectively).

Highly significant variations were found due to the combined effect of variety and plant growth regulators application in respect of number of fruit per plant (Table 9). The maximum number of fruit per plant (40.50) was observed in V_3G_3 treatment which was statistically similar with V_3G_2 treatment (38.28) and the minimum number of fruit per plant was observed in V_2G_0 treatment (14.13) which was statistically similar to V_1G_0, V_1G_1, V_1G_2, V_2G_1 and V_2G_2 treatments.

4.11 Fruit weight

The weight of individual fruit was significantly affected by different varieties (Table 7). The highest fruit weight (129.2 g) was obtained from the variety BARI Tomato 7 which was statistically different from other varieties. The lowest fruit weight (56.28 g) was obtained from the variety BARI Tomato 9. The wide variation among the varieties in respect of individual fruit weight was due to the varietals characteristic. Varietals influence on individual fruit weight was also reported by Bhangu and Singh (1993).

Fruit weight varied significantly due to the effect of different plant growth regulators application (Table 8). The highest fruit weight (111.1 g) was recorded by the application of IAA. The lowest fruit weight (78.17 g) was recorded by the controlled treatment, which was statistically similar to NAA application (86.39 g).

A marked variation was found in respect of fruit weight due to the combined effect of variety and plant growth regulators application (Table 9). The highest fruit weight (150.5 g) was observed in V_2G_3 treatment and the lowest fruit weight was observed in V_3G_0 treatment (42.43 g) which was statistically similar to V_3G_1, V_3G_2 and V_3G_3 treatments.

4.12 Fruit length

There was no significant variation observed in respect of fruit length (Table 10). The highest fruit length (5.48 cm) was produced by the variety BARI Tomato 7 which was statistically similar to the variety BARI Tomato 9 (4.80 cm) and the variety BARI Tomato 3 (4.16 cm).

Significant variations were observed in respect of fruit length due to the effect of different plant growth regulators (Table 11). The longest fruit length (5.68 cm) was recorded by the application of IAA which was statistically similar to NAA (4.58 cm) and GA_3 (5.15 cm) application. Singh and Upadhayaya (1967) also reported that the application of IAA and other plant growth regulators increased fruit size of tomato. The shortest fruit length (3.85 cm) was recorded by the controlled treatment.

The combined effect of variety and plant growth regulators on fruit length was significant (Table 12). The highest fruit length (6.53 cm) was observed in V_2G_3 treatment which was statistically similar to V_2G_2, V_2G_1, V_1G_3, V_3G_2 and V_3G_3 treatments. The lowest fruit length was observed in V_1G_0 treatment (3.37 cm) which was statistically similar to V_1G_1, V_1G_2, V_2G_0, V_3G_0, and V_3G_1 treatments.

Table 7. Effect of varieties on yield contributing characteristics in tomato

Treatments	No. of fruit/ cluster	No. of fruit/ plant	Fruit weight (g)
V_1	3.55b	20.31b	95.43b
V_2	5.2a	18.52b	129.2a
V_3	4.38ab	36.13a	56.28c
CV (%)	13.20	17.64	6.45
$LSD_{(.05)}$	0.85	6.46	8.85

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. V_1= BARI Tomato 3, V_2= BARI Tomato 7 and V_3= BARI Tomato 9.

Table 8. Effect of plant growth regulators on yield contributing characteristics in tomato

Treatments	No. of fruit/ cluster	No. of fruit/ plant	Fruit weight (g)
G_0	3.43c	21.12b	78.17c
G_1	4.1bc	23.28ab	86.39c
G_2	4.73ab	25.58ab	98.89b
G_3	5.23a	29.96a	111.1a
CV (%)	13.20	17.64	6.45
$LSD_{(.05)}$	0.98	7.47	10.22

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. G_0= control, G_1= NAA, G_2= GA_3 and G_3= IAA.

Table 9. Combined effects of varieties and plant growth regulators on yield contributing characteristics in tomato

Treatments	No. of fruit/ cluster	No. of fruit/ plant	Fruit weight (g)
V_1G_0	2.7h	18.83def	81.57e
V_1G_1	3.2gh	18.15def	87.27e
V_1G_2	3.9efg	20.17def	100.4d
V_1G_3	4.4cdef	24.1cde	112.5c
V_2G_0	4.1defg	14.13f	110.5cd
V_2G_1	5bcd	16.37ef	120.2c
V_2G_2	5.6ab	18.30def	135.6b
V_2G_3	6.1a	25.28cd	150.5a
V_3G_0	3.5fgh	30.40bc	42.43h
V_3G_1	4.1defg	35.33ab	51.67gh
V_3G_2	4.7bcde	38.28a	60.7fg
V_3G_3	5.2abc	40.50a	70.33f
CV (%)	13.20	17.64	6.45
$LSD_{(.05)}$	0.98	7.47	10.22

Mean in a column having different letter(s) differed significantly at 0.05 level of probability.

V_1=BARI Tomato 3

V_2= BARI Tomato 7

V_3= BARI Tomato 9

G_0=Control

G_1=NAA

G_2=GA_3

G_3=IAA

4.13 Fruit diameter

Fruit diameter of three variety differed significantly (Table 10). The ranges of fruit diameter were 3.84 to 7.34 cm. The highest fruit diameter (7.34 cm) was obtained from the variety BARI Tomato 7 and the lowest fruit diameter (3.84 cm) was obtained from the variety BARI Tomato 9 which was statistically similar to the variety BARI Tomato 3 (5.31 cm). The variation may be due to genetical. Varietals influence on fruit diameter was reported by Bhangu and Singh (1993).

The effect of different plant growth regulators on fruit diameter was found significant. The longest fruit diameter (6.59 cm) was recorded by the application of IAA which was statistically similar to NAA (5.05 cm) and GA_3 (5.90 cm) application (Table 11). The shortest fruit diameter (4.45 cm) was recorded by the controlled treatment.

Significant variation was found in respect of fruit diameter due to the combined effect of variety and plant growth regulators application (Table 12). The highest fruit diameter (8.94 cm) was observed in V_2G_3 treatment which was statistically similar to V_2G_2 treatment. The lowest fruit diameter was observed in V_3G_0 treatment (3.25 cm) which was statistically similar to V_3G_0, V_3G_1, V_3G_2, V_3G_3, V_1G_1 and V_1G_0 treatments.

4.14 Brix (%)

Insignificant variations were found in case of brix percentage among three varieties of tomato. The results showed the range from 3.6% to 4.28% (Table 10). The highest brix percentage was found in the variety BARI tomato 9 (4.28%) and the lowest brix percentage was found in the variety BARI tomato 3 (3.6%).

Brix percentage was found insignificant by the application of plant growth regulators. The highest brix percentage was found in IAA application (4.6 %) and the lowest brix percentage (3.7%) was found in controlled treatments (Table 11).

Insignificant variation was found in respect of brix percentage due to the combined effect of variety and plant growth regulators application. The highest brix percentage was found in V_2G_3 treatment (5%) and the lowest brix percentage (3.2%) was found in V_1G_2 treatment (Table 12).

4.15 Yield per plant

Yield per plant was significantly influenced by different varieties. The highest yield per plant (2452 g) was obtained from the variety BARI tomato 7, which was statistically different from other varieties. The lowest yield per plant (1889 g) was recorded from the variety BARI tomato 3 (Fig. 4) .This differences may be due to varietals performance. Hossain (2001) also reported that the variety BARI tomato 7 produced the highest yield.

Plant growth regulators were significantly increases the yield of tomato. The highest yield per plant was obtained from IAA (3119 g) where as the lowest yield per plant (1363 g) was recorded from control or without any plant growth regulators (Fig. 5). Chhonker and Singh (1959) recorded increase in yield of tomato by treatments with growth substances which were corresponding with the present research work. The yield of tomato per plant was obtained 2275 g and 1791 g from GA_3 and from NAA respectively.

Table 10. Effect of varieties on fruit characteristics in tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)	Brix (%)
V_1	4.16a	5.31b	3.6a
V_2	5.48a	7.34a	4.25a
V_3	4.80a	3.84b	4.28a
CV (%)	18.14	20.96	14.28
$LSD_{(.05)}$	1.28	1.69	0.85

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. V_1= BARI Tomato 3, V_2= BARI Tomato 7 and V_3= BARI Tomato 9.

Table 11. Effect of plant growth regulators on fruit characteristics in tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)	Brix (%)
G_0	3.851b	4.45b	3.73a
G_1	4.58ab	5.05ab	4.06a
G_2	5.15ab	5.90ab	3.76a
G_3	5.68a	6.59a	4.6a
CV (%)	18.14	20.96	14.28
$LSD_{(.05)}$	1.48	1.95	0.98

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. G_0= control, G_1= NAA, G_2= GA_3 and G_3= IAA.

Table 12. Combined effects of varieties and plant growth regulators on fruit characteristics in tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)	Brix%
V_1G_0	3.37d	4.2def	3.4c
V_1G_1	4cd	5.01cdef	3.8bc
V_1G_2	4.31cd	5.78bcde	3.2c
V_1G_3	4.96abcd	6.28bcd	4abc
V_2G_0	4.11cd	5.92bcde	3.8bc
V_2G_1	5.21abc	6.62bc	4.2abc
V_2G_2	6.08ab	7.88ab	4abc
V_2G_3	6.53a	8.94a	5a
V_3G_0	4.07cd	3.25f	4abc
V_3G_1	4.52bcd	3.52f	4.2abc
V_3G_2	5.07abc	4.06ef	4.1abc
V_3G_3	5.57abc	4.56cdef	4.8ab
CV (%)	18.14	20.96	14.28
$LSD_{.05}$	1.48	1.95	0.98

Mean in a column having different letter(s) differed significantly at 0.05 level of probability.

V_1=BARI Tomato 3

V_2= BARI Tomato 7

V_3= BARI Tomato 9

G_0=Control

G_1=NAA

G_2=GA_3

G_3=IAA

Yield per plant was significantly influenced by the combined effect of variety and plant growth regulators (Fig. 6). The highest yield of tomato (3802 g) was found in V_2G_3 treatment and the lowest yield of tomato was obtained from controlled treatments incase of three varieties.

4.16 Yield per hectare

The yield of tomato fruits per plot was converted into per hectare and has been expressed in tons. Yield per hectare was significantly influenced by different varieties. The highest yield per hectare (99.74 t) was obtained from the variety BARI tomato 7, which was statistically different from other varieties. The lowest yield per hectare (77.81 t) was recorded from the variety BARI tomato 3 (Fig. 7). This difference may be due to varietals performance. Hossain (2001) also reported that the variety BARI tomato 7 produced the highest yield.

Yield per hectare of tomato was also varied significantly by different plant growth regulators. The highest yield was obtained from IAA (126.6 t/ha) where as the lowest yield (56.8 t/ha) was recorded from control or without any plant growth regulator application (Fig. 8). Rai *et al.* (2002) also reported that application of IAA resulted in the highest yield of tomato. The yield of tomato was 93.16 t/ha obtained from the GA_3 and 73.9 t/ha from NAA.

Highly significant variations in respect of yield of tomato were recorded due to the combined effect of variety and plant growth regulators (Figure 9). The highest yield of tomato (151.5 t/ha) was found in V_2G_3 treatment and the lowest yield of tomato was obtained in case of three varieties without any plant growth regulator application. El-Haabbashs *et al.* (1999) also reported that fruit

growth regulator application. El-Haabbashs *et al.* (1999) also reported that fruit yield was significantly increased by plant growth regulators application compared to control treatments.

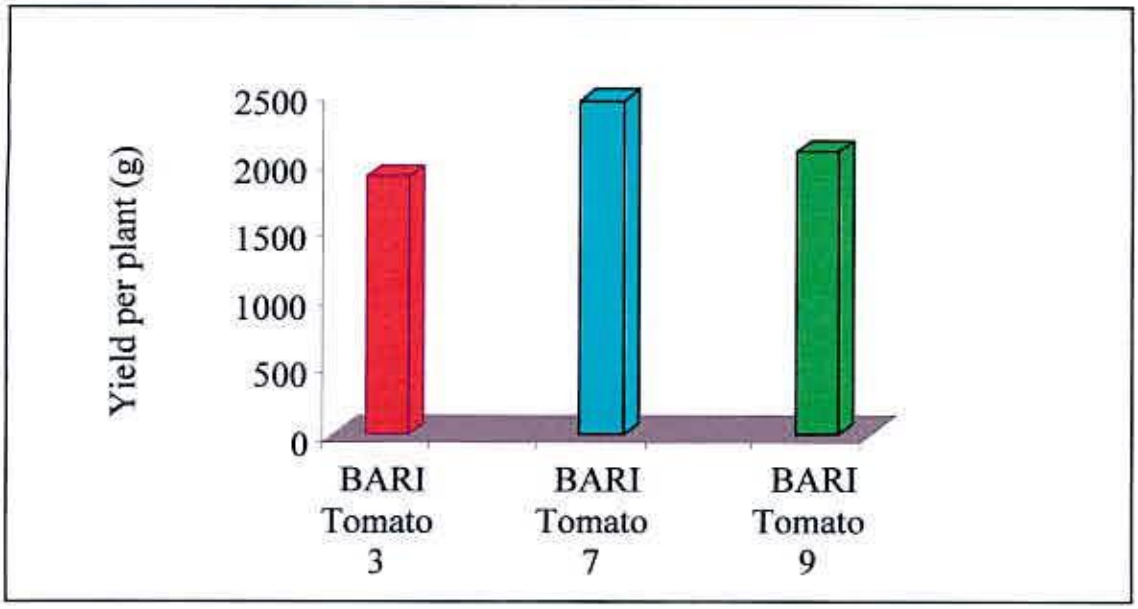

Figure 4. Effect of varieties on yield (g) per plant in tomato

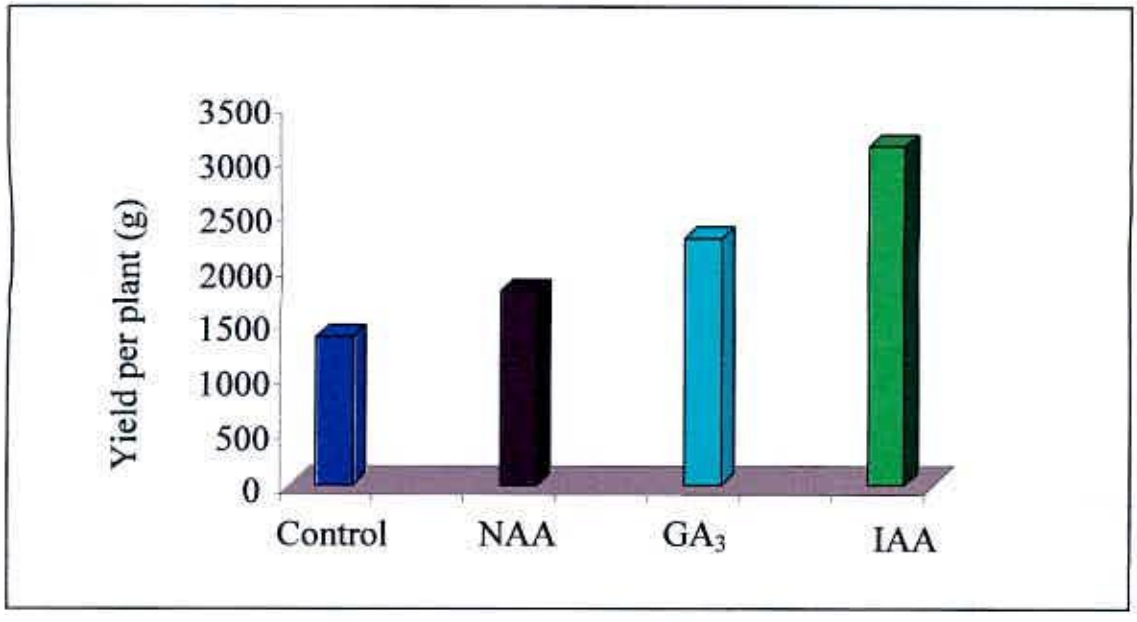

Figure 5. Effect of plant growth regulators on yield per plant in tomato

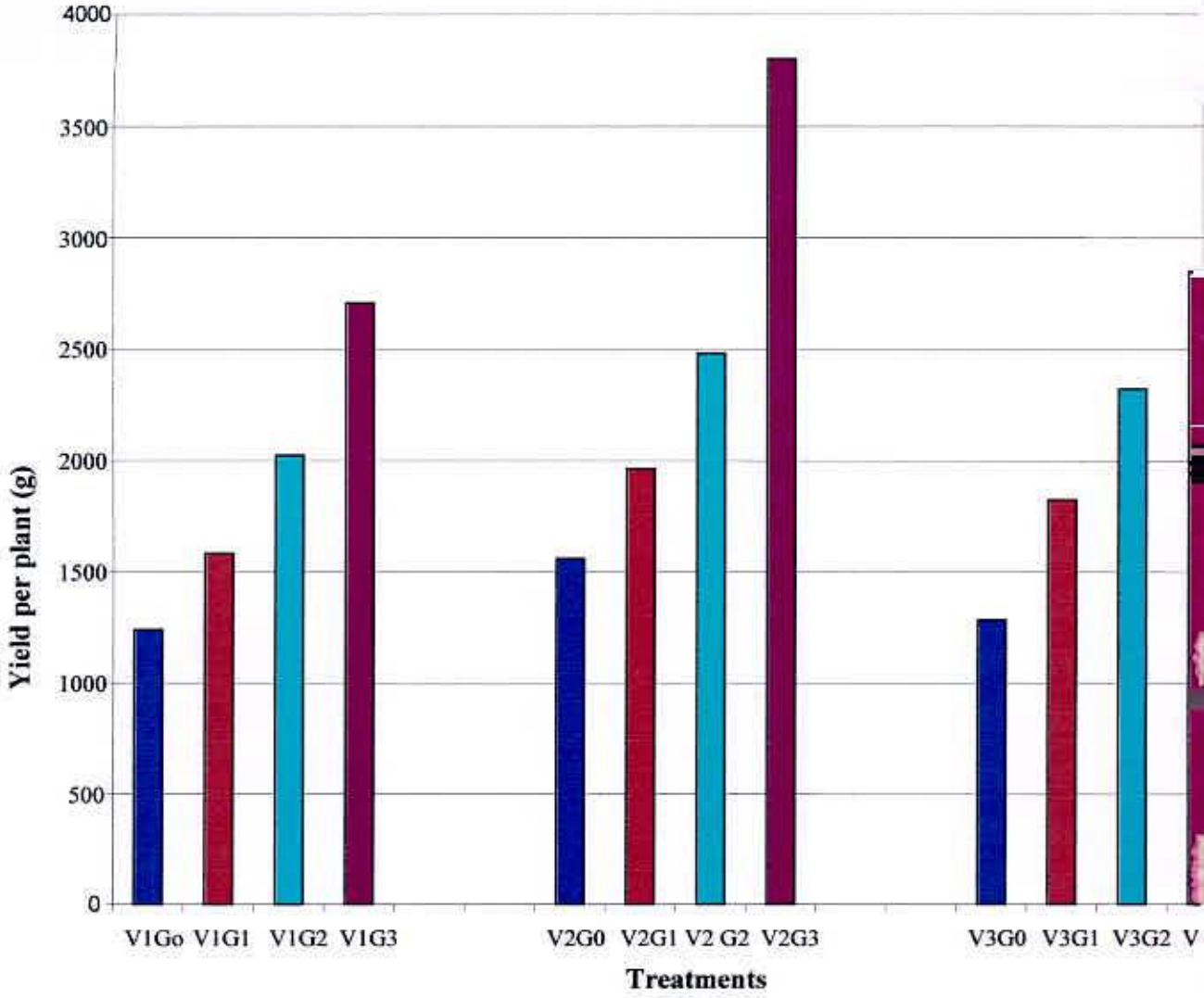

Figure 6. Combined effects of variety and plant growth regulators on yield per plant in tomato

V_1=BARI Tomato 3

V_2= BARI Tomato 7

V_3= BARI Tomato 9

Go=Control

G_1=NAA

G_2=GA_3

G_3=IAA

4.17 Economic analysis

Input costs for land preparation, seed cost, NAA, GA_3, IAA, fertilizer, intercultural operation, irrigation and man power required for all the operations from sowing to harvesting of tomato were recorded for unit plot and converted into hectare. Prices of tomato were considered in Farmgate market rate basis during harvesting time. The economic analysis was done to find out the gross return, net return and the benefit cost ratio in tomato cultivation as influenced by variety and plant growth regulators. The details of economic analysis have been presented in Appendix V.

The total cost of production ranged between Tk. 211812 to Tk. 215352/ha. The variation in cost of production was noticed due to different treatment combinations comprising different variety and plant growth regulators. The highest cost of production (Tk. 215352/ha) was involved in the treatment combination of IAA with the variety BARI Tomato 7 (Table 13).

The highest gross return (Tk. 1212000/ha) was found from the treatment combination of BARI Tomato 7 with IAA application and the lowest gross return (Tk. 419600) was obtained from the combination of BARI Tomato 3 without any plant growth regulator application.

BARI Tomato 7 with IAA application gave the highest net return (Tk. 996648) and the lowest net return (Tk. 207788) was obtained from the treatment combination of BARI Tomato 3 without any plant growth regulator application.

The highest benefit cost ratio (5.62) was obtained from the treatment combination of BARI Tomato 7 with IAA application and the lowest benefit cost ratio (1.98) was obtained from the combination of BARI Tomato 3 without any plant growth regulator application.

The highest benefit cost ratio (5.62) was obtained from the treatment combination of BARI Tomato 7 with IAA application and the lowest benefit cost ratio (1.98) was obtained from the combination of BARI Tomato 3 without any plant growth regulator application.

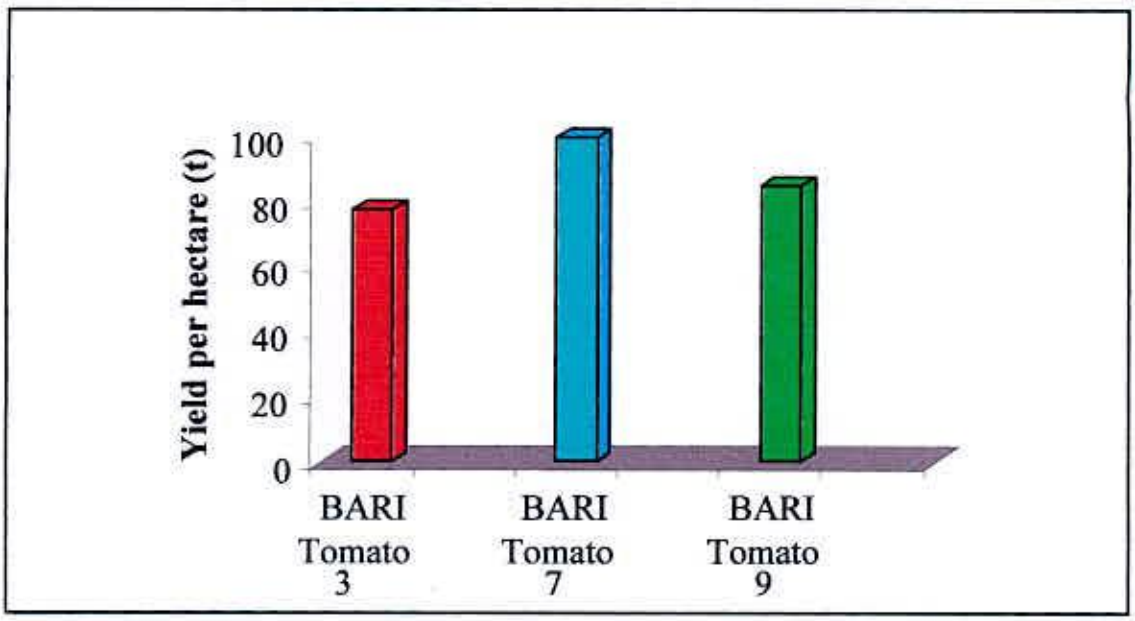

Figure 7. Effect of varieties on yield (t) per hectare in tomato

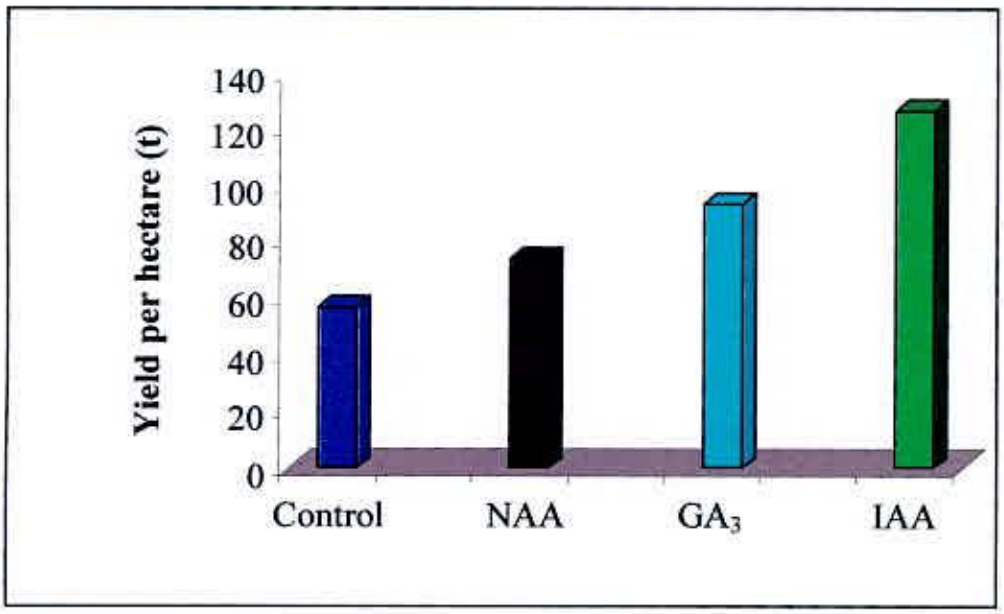

Figure 8. Effect of plant growth regulators on yield per hectare in tomato

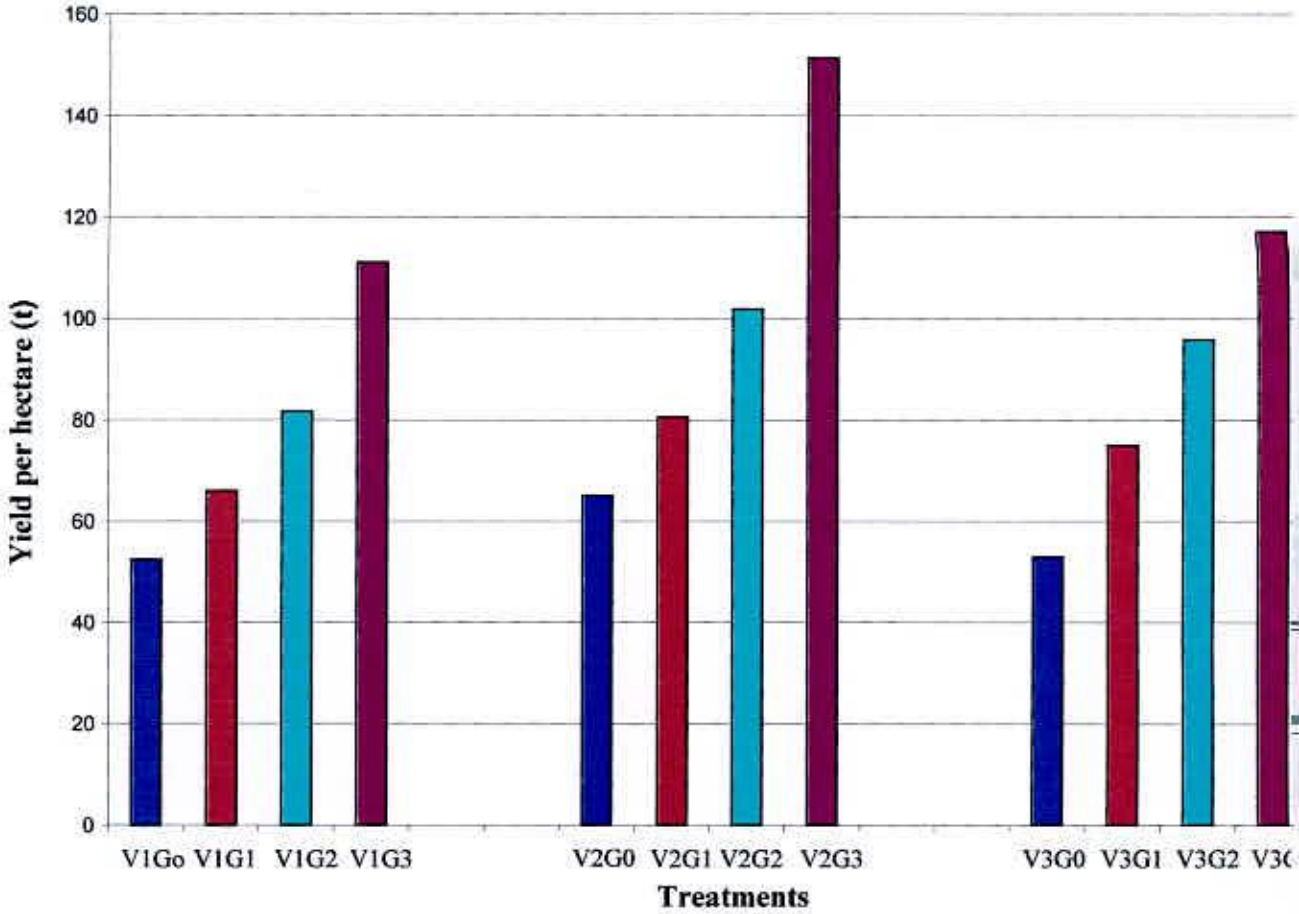

Figure 9. Combined effects of varieties and plant growth regulators on yield per hectare in tomato

V_1=BARI Tomato 3

V_2= BARI Tomato 7

V_3= BARI Tomato 9

G_0=Control

G_1=NAA

G_2=GA_3

G_3=IAA

Table 13. Cost and return in tomato production as influenced by variety and plant growth regulators

Treatments	Cost of production (Tk./ha)	Yield of Tomato (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
V_1G_0	211812	52.45	419600	207788	1.98
V_1G_1	214172	66.03	528240	314068	2.46
V_1G_2	214762	81.77	654160	439398	3.04
V_1G_3	215352	111	888000	672648	4.12
V_2G_0	211812	65.02	520160	308348	2.45
V_2G_1	214172	80.66	645280	431108	3.01
V_2G_2	214762	101.8	814400	599638	3.79
V_2G_3	215352	151.5	1212000	996648	5.62
V_3G_0	211812	52.93	423440	211628	1.99
V_3G_1	214172	75.02	600160	385988	2.80
V_3G_2	214762	95.93	767440	552678	3.57
V_3G_3	215352	117.2	937600	722248	4.35

V_1=BARI Tomato 3

V_2= BARI Tomato 7

V_3= BARI Tomato 9

G_0=Control

G_1=NAA

G_2=GA_3

G_3=IAA

Market price of tomato @ Tk. 8000/ton

Gross return = Total yield (t/ha) × Tk. 8000

Net return = Gross return - Total cost of production

Benefit Cost Ratio (BCR) = Gross return/Total cost of production

On the basis of economic point of view, it was apparent from the result that, the combination of BARI Tomato 7 with IAA application was profitable than the rest of the treatment combinations. This treatment combination showing the highest net return (Tk. 996848) and the highest cost benefit ratio (5.62).

CHAPTER V

SUMMARY AND CONCLUSION

The present piece of research work was conducted at the Horticulture field of the Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from 1st October, 2007 to 10 March, 2008 to investigate the effects of plant growth regulators on growth and yield of tomato (*Lycopersicon esculentum Mill.*) varieties. Three plant growth regulators (NAA, GA_3 and IAA) and three varieties (BARI Tomato 3, BARI Tomato 7 and BARI Tomato 9) were studied for this purpose. The two factor experiment consisting of 12 treatments combinations were laid out in Randomized Complete Block Design (RCBD) with three replications. The size of each unit plot was 3.2 m × 1.2 m and 14 plants were accommodated in each plot following a spacing of 60 cm × 40 cm. Seedlings of tomato varieties were transplanted in the field on 7 November 2007. The seedlings were treated with NAA, GA_3 and IAA at 25, 35 and 25 ppm respectively at different times. The crop was harvested periodically. From each plot, five plants were randomly selected to record data on yield and yield contributing characters. Observation were made on plant height, number of branches per plant, number of leaves per plant, stem diameter, days to 50% flowering, number of flower cluster per plant, number of flower per cluster, number of flower per plant, number of fruit per plant, fruit length, fruit diameter, fruit weight, brix percentage, fruit yield per plant and fruit yield per hectare. The collected data were analyzed and the differences between the means were evaluated by the least significant difference (LSD) test, at 5% and 1% level of probability. The cost and economic returns as influenced by different treatments were also analyzed. The results of the experiment have summarized as below:

The results of the experiment revealed that plant growth regulator (PGRs) had positive influence on all parameters except fruit length, fruit diameter and brix percentage. The maximum plant height, number of branches per plant, number of leaves per plant, stem diameter, number of flower per plant, number of fruit per plant, individual fruit weight and yield were found from IAA than NAA and GA_3. The highest yield (126.6 t/ha) was obtained from IAA application than NAA (73.90 t/ha) and GA_3 (93.16 t/ha) application.

The results of the experiment also revealed that all the parameters studied were significantly influenced by the variety except fruit length and brix percentage. Out of all varieties, BARI Tomato 7 produced the tallest plant (88.90 cm), maximum number of branches (11.81), number of leaves (76.80), stem diameter (1.12 cm), number of flower cluster per plant (12.52), number of flower per cluster (6.47), number of flower per plant (91.66), fruit length (5.48 cm), fruit diameter (7.34 cm) and the maximum weight of individual fruit (129.2 g) while BARI Tomato 9 produced the maximum number of fruits per plant (36.13). For days to 50% flowering among the varieties BARI Tomato 7 took minimum duration (43 days) for flowering. The highest fruit yield per plant (2452 g) and per hectare (99.74 t) was produced by BARI Tomato 7 than the variety BARI Tomato 3 (77.81 t) and the variety BARI Tomato 9 (85.28 t). The different varieties exhibited marked variation in yield of tomato. In respect of yield and yield contributing characters the variety BARI Tomato 7 performed the best.

The interaction effect of variety and plant growth regulators had significant influences on all characteristics except brix percentage. The highest yield (151.5 t/ha) was obtained from BARI Tomato 7 with IAA application. Economic analysis also showed that the BARI Tomato 7 with IAA treatment

combination was economically profitable over all other treatment combinations and the highest cost benefit ratio of (5.62) was obtained from that treatment.

From the above observations it can be concluded that the variety BARI Tomato 7 responded better with IAA application compared to BARI Tomato 3 and BARI Tomato 9. However, further investigation in this line of work is suggested to confirm this result before recommendation.

CHAPTER VI

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APPENDICES

Appendix I. Monthly Air temperature, Rainfall and Relative Humidity of the experimental site during the study (1st October, 2007 to March 10, 2008).

Year	Month	Average* air temperature (°C)			Total** Rainfall (mm)	Average* Relative humidity (%)
		Maximum	Minimum	Mean		
2007	October	30.5	24.3	27.4	417	80
	November	29.7	20.1	24.9	5	65
	December	26.9	15.8	21.35	0	68
2008	January	24.6	12.5	18.7	0	66
	February	27.1	16.8	21.95	0	64
	March	31.5	19.6	25.55	160	47

* Monthly Average ** Monthly Total

Source: The Meteorological Department (Weather and Climate division) of Bangladesh, Agargaon, Dhaka.

Appendix II. Physical properties of soil in the experimental field

Properties	Analytical data
Soil texture	Sandy loam
Sand (%)	30.65
Silt (%)	38.19
Clay (%)	31.16
Soil Type	Shallow Red Brown Terrace soil
Soil Series	Tejgoan

Source: Soil Resource Development Institute, Farmgate, Dhaka.

Appendix III. Chemical properties of soil in the experimental field

Properties	Analytical data
Soil pH	5.6
Total N (%)	0.078
Available P (ppm)	0.0015
Available K (ppm)	0.0053
Organic matter (%)	0.88
C : N ratio	12 : 1

Source: Soil Resource Development Institute, Farmgate, Dhaka.

Appendix IV. Analysis of variance of the data on growth and yield of tomato as influenced by variety and plant growth regulators (PGRs)

Source of variation	Degrees of freedom	Mean square					
		Plant height (cm) at		Number of branches at 60 DAT	Number of leaves at 60 DAT	Stem diameter (cm) at	
		40 DAT	60 DAT			40 DAT	60 DAT
Replication	2	468.75	1638.93	57.0	1550.43	0.16	0.21
Factor A (Variety)	2	294.45**	582.0**	48.19**	2969.24**	0.09**	0.07*
Factor B (Plant growth regulators)	3	232.11**	757.31**	46.20**	964.04**	0.07**	0.17**
Interaction (A×B)	6	1.67**	0.01**	3.24**	6.45**	0.002**	0.004*
Error	22	18.752	33.03	0.361	21.2777	0.003	0.007

** Significant at 0.01 level of probability;

* Significant at 0.05 level of probability

Appendix IV. (Cont'd.)

Source of variation	Degrees of freedom	Mean square				
		Day to 50% flowering	Flower cluster/ plant	Number of flower/ cluster	No. of flower/ plant	No. of fruit/ cluster
Replication	2	1408.33	23.493	14.301	1512.007	0.333
Factor A (Variety)	2	180.75**	45.107**	19.960**	2208.10**	8.167**
Factor B (Plant growth regulators)	3	362.917**	46.817**	10.351**	1171.40**	5.482**
Interaction (A×B)	6	2.417**	5.042**	0.171**	5.04**	0.028*
Error	22	8.333	2.102	0.101	18.88	0.333

** Significant at 0.01 level of probability;

* Significant at 0.05 level of probability

Appendix IV. (Cont'd.)

Source of variation	Degrees of freedom	Mean square				
		No. of fruit/ plant	Individual fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Brix (%)
Replication	2	19.534	1889.08	0.711	1.37	0.333
Factor A (Variety)	2	1126.609**	15975.94**	5.235	36.92**	1.757*
Factor B (Plant growth regulators)	3	128.79**	1873.215**	5.587*	7.977**	1.449**
Interaction (A×B)	6	9.629*	27.322**	0.209*	0.465*	0.084
Error	22	19.436	36.453	0.764	1.330	0.333

** Significant at 0.01 level of probability;

* Significant at 0.05 level of probability

Appendix IV. (Cont'd.)

Source of variation	Degrees of freedom	Mean square	
		Yield/ plant (g)	Yield/ha (t)
Replication	2	23589.61	42.049
Factor A (Variety)	2	991083.117**	1492.092**
Factor B(Plant growth regulators)	3	5108428.4**	8057.532**
Interaction (A×B)	6	145159.52**	189.477**
Error	22	23666.42	79.866

** Significant at 0.01 level of probability;

* Significant at 0.05 level of probability

Appendix V. Production cost of tomato per hectare

A. Input cost

a. Material cost (Tk. /ha)

Treatment (s)	Seed Cost (Tk.)	Cost of PGRs (Tk.)	Manure and fertilizers MP (Tk.)				Insecticide & Fungicides (Tk.)	Sticks (Tk.)	Sub Total (Tk
			Cow dung	Urea	TSP	MP			
V_1G_0	3000	0.00	20000	4000	7000	4400	6000	25000	6940
V_1G_1	3000	2000	20000	4000	7000	4400	6000	25000	7140
V_1G_2	3000	2500	20000	4000	7000	4400	6000	25000	7190
V_1G_3	3000	3000	20000	4000	7000	4400	6000	25000	7240
V_2G_0	3000	0.00	20000	4000	7000	4400	6000	25000	6940
V_2G_1	3000	2000	20000	4000	7000	4400	6000	25000	7140
V_2G_2	3000	2500	20000	4000	7000	4400	6000	25000	7190
V_2G_3	3000	3000	20000	4000	7000	4400	6000	25000	7240
V_3G_0	3000	0.00	20000	4000	7000	4400	6000	25000	6940
V_3G_1	3000	2000	20000	4000	7000	4400	6000	25000	7140
V_3G_2	3000	2500	20000	4000	7000	4400	6000	25000	7190
V_3G_3	3000	3000	20000	4000	7000	4400	6000	25000	7240

V_1=BARI Tomato 3 G_0=Control G_3=IAA

V_2= BARI Tomato 7 G_1=NAA

V_3= BARI Tomato 9 G_2=GA_3

Cowdung @ Tk. 60 / mon
Urea @ Tk. 28 / kg
TSP @ Tk. 80 / kg
MP @ Tk. 63 / kg

Appendix V. (Cont'd.)

b. non material cost (Tk. /ha)

Treatment (s)	Labour cost (Tk.)	Ploughing cost (Tk.)	Watering cost (Tk.)	Cost for bird driving (Tk.)	Cost for harvesting & marketing (Tk.)	Sub Total (Tk.)	Total input cost (Material + non material) (Tk.)
V_1G_0	17000	12000	3000	3000	9000	44000	113400
V_1G_1	17000	12000	3000	3000	9000	44000	115400
V_1G_2	17000	12000	3000	3000	9000	44000	115900
V_1G_3	17000	12000	3000	3000	9000	44000	116400
V_2G_0	17000	12000	3000	3000	9000	44000	113400
V_2G_1	17000	12000	3000	3000	9000	44000	115400
V_2G_2	17000	12000	3000	3000	9000	44000	115900
V_2G_3	17000	12000	3000	3000	9000	44000	116400
V_3G_0	17000	12000	3000	3000	9000	44000	113400
V_3G_1	17000	12000	3000	3000	9000	44000	115400
V_3G_2	17000	12000	3000	3000	9000	44000	115900
V_3G_3	17000	12000	3000	3000	9000	44000	116400

V_1=BARI Tomato 3 G_0=Control G_3=IAA

V_2= BARI Tomato 7 G_1=NAA

V_3= BARI Tomato 9 G_2=GA_3

Labour cost=Tk. 100/day

Appendix V. (Cont'd.)

B. Overhead cost (Tk. /ha)

Treatments	Cost of lease of land for 6 months (13% of value of land Tk. 6,00000/year	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 months (Tk. 13% of cost/year)	Sub total	Total cost of production (Input cost+ Overhead cost)
V_1G_0	78000	5670	14742	98412	21812
V_1G_1	78000	5770	15002	98772	214172
V_1G_2	78000	5795	15067	98862	214762
V_1G_3	78000	5820	15132	98952	215352
V_2G_0	78000	5670	14742	98412	21812
V_2G_1	78000	5770	15002	98772	214172
V_2G_2	78000	5795	15067	98862	214762
V_2G_3	78000	5820	15132	98952	215352
V_3G_0	78000	5670	14742	98412	21812
V_3G_1	78000	5770	15002	98772	214172
V_3G_2	78000	5795	15067	98862	214762
V_3G_3	78000	5820	15132	98952	215352

V_1=BARI Tomato 3 G_0=Control G_3=IAA

V_2= BARI Tomato 7 G_1=NAA

V_3= BARI Tomato 9 G_2=GA_3

Appendix VI. Effect of varieties on days to 50% flowering in tomato

Treatments	50% flowering (Days)
V_1	50.75a
V_2	43b
V_3	46b
CV (%)	6.17
$LSD_{(0.05)}$	4.233

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. V1= BARI Tomato 3, V2= BARI Tomato 7 and V3= BARI Tomato 9.

Appendix VII. Effect of plant growth regulators on days to 50% flowering in tomato

Treatments	50% flowering (Days)
G_0	53.67a
G_1	50a
G_2	44b
G_3	39.33b
CV (%)	6.17
$LSD_{(0.05)}$	4.888

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. G0= control, G1= NAA, G2= GA3 and G3= IAA.

Appendix VIII. Combined effects of varieties and plant growth regulators on days to 50% flowering in tomato

Treatments	50% flowering (Days)
V_1G_0	57a
V_1G_1	54ab
V_1G_2	49bc
V_1G_3	43de
V_2G_0	51bc
V_2G_1	46cd
V_2G_2	40ef
V_2G_3	35f
V_3G_0	53ab
V_3G_1	50bc
V_3G_2	43de
V_3G_3	40ef
CV(%)	6.17
$LSD_{(0.05)}$	4.888

Mean in a column having different letter(s) differed significantly at 0.05 level of probability.

V1=BARI Tomato 3 Go=Control G3=IAA

V2= BARI Tomato 7 G1=NAA

V3= BARI Tomato G2=GA_3

Appendix IX. Effect of varieties on yield in tomato

Treatments	Yield /plant(g)	Yield/ha(t)
V_1	1889b	77.81b
V_2	2452a	99.74a
V_3	2070b	85.28b
CV (%)	7.20	10.20
$LSD_{(0.05)}$	225.6	13.11

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. V1= BARI Tomato 3, V2= BARI Tomato 7 and V3= BARI Tomato 9.

Appendix X. Effect of plant growth regulators on yield in tomato

Treatments	Yield /plant(g)	Yield/ha(t)
G_0	1363	56.80d
G_1	1791	73.90c
G_2	2275	93.16b
G_3	3119	126.6a
CV (%)	7.20	10.20
$LSD_{(0.05)}$	260.5	15.13

Mean in a column having different letter(s) differed significantly at 0.05 level of probability. G0= control, G1= NAA, G2= GA3 and G3= IAA.

Appendix XI. Combined effects of variety and plant growth regulators on yield in tomato

Treatments	Yield/plant (g)	Yield/ha (t)
V_1G_0	1242g	52.45g
V_1G_1	1583f	66.03efg
V_1G_2	2023e	81.77de
V_1G_3	2708bc	111bc
V_2G_0	1560f	65.02fg
V_2G_1	1965e	80.66def
V_2G_2	2481cd	101.8bc
V_2G_3	3802a	151.5a
V_3G_0	1286g	52.93g
V_3G_1	1825ef	75.02ef
V_3G_2	2321d	95.93cd
V_3G_3	2848b	117.2b
CV (%)	7.20	10.20
$LSD_{(0.05)}$	260.5	15.13

Mean in a column having different letter(s) differed significantly at 0.05 level of probability.

V1=BARI Tomato 3 Go=Control G3=IAA

V2= BARI Tomato 7 G1=NAA

V3= BARI Tomato $G_2=GA_3$