GROWTH AND YIELD OF TOMATO AS INFLUENCED BY GA_3 AND PRUNING

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A Thesis
Submitted to the Department of Horticulture,
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in partial fulfillment of the requirements
for the degree
of

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IN
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All praises to Almighty and Kindfull trust on to "Omnipotent Creator" for his never-ended blessing, it is a great pleasure to express profound thankfulness to my respected parents, who entiled much hardship inspiring for prosecuting my studies, thereby receiving proper education.

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*I express my sincere respect to the Chairman, **Prof. Dr. Md. Ismail Hossain** and all the teachers of Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for providing the facilities to conduct the experiment and for their valuable advice and sympathetic consideration in connection with the study.*

I would like to thank all of my roommates and friends who helped me in my research work and with technical support to prepare this thesis paper.

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June, 2011 ***The Author***

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
HRC	=	Horticulture Research Centre
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Murate of Potash
RCBD	=	Randomized complete block design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance

DEPARTMENT OF HORTICULTURE

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Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/HORT/.......... Date: ....

CERTIFICATE

This is to certify that the thesis entitled “Growth and Yield of Tomato as Influenced by GA_3 and Pruning” **submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of** MASTER OF SCIENCE **in** HORTICULTURE, **embodies the result of a piece of *bona fide* research work carried out by** MD. AL-AMIN JUEL, **Registration No.**: 05-01627 **under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.**

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

Dated: June, 2011

Dhaka, Bangladesh

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By

MD. AL-AMIN JUEL

ABSTRACT

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2010 to March 2011 to find out the effect of GA_3 and pruning on the growth and yield of tomato. The experiment consisted of three doses of GA_3 such as 80, 100 and 120 ppm with control; three different pruning levels such as 1, 2 and 3 stem pruning. The experiment was laid out in a RCBD with three replications. Both GA_3 and pruning had significant influence on growth and yield contributing characters of tomato. At 75 DAT, the highest plant height (117.30cm), maximum number of leaves/plant (75.30) and highest yield (29.03 t/ha) were recorded from GA_3 spray at 120 ppm. At 75 DAT, the highest plant height (113.60 cm), maximum leaves per plant (67.00) and yield (28.11 t/ha) were recorded from 2 stem pruning. The combined effect of 120 ppm GA_3 and 2 stem pruning performed the highest yield (31.89 t/ha) and lowest from G_0P_1. So, 120 ppm GA_3 with 2 stem pruning may be used for higher yield of tomato.

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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 *et al.*, 1987) which includes Peru, Ecuador, Bolivia areas of Andes (Kallo, 1986). Tomato is popular as salad in the new state and is used to make soup, juice, ketchup, pickle, sauce, conserved puree, paste, powder and other products (Ahmed, 1976). Tomato is highly nutritious 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, 1983). Tomato has high nutritive value especially vitamin A and vitamin C. Therefore, it can be meet up some degree of vitamin A and vitamin C requirement and can contribute to solve malnutrition problem.

GA_3 is known to promote fruit development in pollinated ovaries that undergo 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). Therefore, it is necessary to find out the effective dose of growth regulators, viz. GA_3 in promoting the fruit set that will eventually lead to enhance increasing yield of tomato even in higher temperature that prevails in the later part of the growing season under Bangladesh condition.

Pruning and training in tomato plants are practiced in certain areas of the United States, especially in some parts of the southern states and in few other regions (Thompson and Kelly, 1957). Majority of the tomato growers of Bangladesh have little knowledge about the advantage of pruning in tomato production. Usually the farmers of Bangladesh cultivate tomato without pruning and even they do not maintain proper plant density.

In Bangladesh, the statistics shows that tomato was grown in 19643 hectares of land and the total production was approximately 143,058 metric tons during the year 2007-2008 (BBS, 2008), which is very low in comparison to other countries namely, India (15.67 t/ha), Japan (52.82 t/ha) and USA (63.66 t/ha) (FAO, 1995). The yield of tomato in our country is not satisfactory in comparison to its requirement (Aditya *et al.,* 1999). The low yield of tomato in Bangladesh, however, is not an indication of low yielding ability of this crop, but of the fact that low yielding variety, poor crop management practices and lack of improved technologies.

Generally, tomato is cultivated in winter season in Bangladesh. 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).

Tomato plant can be severely pruned without affecting the yield (Patil *et al.,* 1973). Proper pruning method gives the best quality and early fruit in tomato (Lopez and Chan, 1974). Although pruning needs extra cost, the practice could increase the economic return by increasing yields and improvement of the quality of fruits (Davis and Ester, 1993).

Plant growth regulator (GA_3) and proper pruning method are important factors for successful tomato production. The combined effect of these production practices have not been defined clearly and the information in this respect is meager in Bangladesh. The present study was undertaken in view of the following objectives:

I. To study the effect of different GA_3 doses on growth and yield of tomato.

II. To determine the optimum level of pruning in order to achieve higher yield.

III. To find out the suitable combination of GA_3 doses and level of pruning for ensuring the maximum yield of tomato.

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CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most important vegetable crops grown under field and greenhouse condition, which received much attention of the researchers throughout the world. Among various research works, investigations have been made in various parts of the world to determine the suitable pruning level and optimum dose of growth regulator GA_3 have marked effects on tomato production. Various investigations have been carried out for its successful cultivation. However, the combined effects of these production practices have not been defined clearly. In Bangladesh, there is a little studies on the influence of pruning or GA_3 on the growth and yield of tomato. The relevant literature on tomato and some other related crops available in this connection have been reviewed here to the present study.

2.1 Literature on GA_3

Vegetable growth regulators are capable of controlling the reproductive development, from flower differentiation until the last stages in fruit development. In particular, fruit set and development stage depends on the endogenous content of this substance, being possible to manipulate the beginning of fruit development by external application of hormones. We have previously evaluated the fruit set and development process in tomato cultivation in the greenhouse in response to the application of beta -NOA and GA_3 in fixed doses. Differential sensitivity was observed depending on the genotype and regulator type. Studies were conducted to establish the optimum dose and moment for the application of beta -NOA and

GA_3 as ways to improve the fruit set and development of parthenocarpic fruits. Regulator types beta -NOA and GA_3 in variable doses and application dates were considered as factors. Using unpollinated ovaries as an experimental system, it was possible to conclude that the application of 40 ppm of beta -NOA at 7 days post-anthesis would offer the best advantages from a performance point of view and a lower physiologic impact, not altering the period of fruit development (Aguero *et al*., 2007).

The effect of applied gibberellin (GA_3) and auxin on fruit-set and growth has been investigated by Serrani *et al*. (2007) in tomato (*Solanum lycopersicum* L.) cv Micro-Tom. It was found that to prevent competition between developing fruits only one fruit per truss should be left on the plant. Unpollinated ovaries responded to GA_3 and to different auxins [indol-3-acetic acid, naphthaleneacetic acid, and 2,4-dichlorophenoxyacetic acid (2,4-D)], 2,4-D being the most efficient. Simultaneous application of GA_3 and 2,4-D produced parthenocarpic fruits similar to pollinated fruits, but for the absence of seeds, suggesting that both kinds of hormones are involved in the induction of fruit development upon pollination. It is concluded that Micro-Tom constitutes a convenient model system, compared to tall cultivars, to investigate the hormonal regulation of fruit development in tomato.

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

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.

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.

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.

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 °C) on the reduction of stein elongation of plug-grown tomato seedlings was investigated. Paclobutrazol, ethephon and GA reduced the stem length of the tomatoes at several water temperatures. Cold water irrigation with the addition of 1.8 ppm GA or irrigation at room temperature could promote stem elongation. Irrigation at room temperature with the addition of 10 ppm paclobutrazol (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.

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.

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. GA_3 led to the formation of leafy clusters, with the number of leaves formed increasing with GA_3 concentration.

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 GA3 .

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.

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.
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 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.

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.

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.

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.

Rappaport (1960) noted that GA had no significant effect on fruit weight or size either at cool (11°C) or warm (23^{0}C) night temperatures; but it strikingly reduced fruit size at an optimal temperature (17°C).

2.2 Literature on pruning

Ece and Darakci (2007) investigated relationships between number of stem and yield for some indeterminate tomato varieties. Two different stem applications (single and double-stem) and ten different indeterminate tomato varieties were used. Experiments were carried out at randomized blocks split plots experimental design with three replications during the years 2004-2005. Stem applications were applied in main blocks and varieties were applied in sub-plots. Plant total yield (kg per plant), total number of fruit per plant (number per plant), marketable plant weight (g) and marketable yield (t per ha) were taken into consideration. Correlation and path analysis were carried out between marketable yield and the other plant characteristics. It was observed that plant total yield and number of fruit per plant had significant and positive effects but number of stem had negative effects on marketable yield of tomato. Then, it was concluded that varieties with higher total yield, total number of fruit and adaptation capability should be selected and single stem application should be implemented for higher and quality marketable yield in tomato.

Replicated field trials were carried out by Muhammad and Singh (2007) at the Usmanu Danfodiyo University Fadama Teaching and Research Farm, Sokoto, during 2004/05 and 2005/06 dry seasons, to examine the effects of training and pruning on growth and yield of tomato (*Lycopersicon lycopersicum* Mill.) variety Roma VFN. Treatments consisted of factorial combination of two levels of training (staked and unstaked) and three levels pruning (three-stem, two-stem and unpruned) and three levels of intra-row spacing (20, 40 and 60 cm) laid out in a split-plot design replicated three times, with training allocated to the main plots and pruning intra-row spacing to the sub-plots. Results of training and pruning are presented in this paper. Results revealed that mean fruit length and diameter in the first trial, fruit weight in both trials and the two trials combined, total fresh fruit yield in the first trial and combined and percentage marketable yield in the first trial and the combined were significantly ($p<0.05$) higher in the tomato plants that were staked. Results on pruning showed that mean fruit length, diameter and weight in both trials were significantly higher in three-stem and two-stem pruned plants than unpruned plants. Similarly, three-stem pruned plant produced the highest total fresh fruit yield in both trials. Significant training x pruning interactions recorded, showed that the highest percentage marketable yield was at staked and pruned (both three and two-stem) plants; while two-stem with staking or no staking produced the highest mean fruit weight.

The effects of spacing (45 x 30, S_1; 60 x 30, S_2; 90 x 30, S_3; and 120 x 30 cm, S_4) and training system (single leader, T_1; double leader, T_2; and triple stem, T_3) on the performance of tomato (cv. Naveen-2000) were studied by Thakur *et al*, (2005) in Nauni, Solan, Himachal Pradesh, India, during 1997-98. T_1 resulted in the lowest number of days to first picking (72.10), and greatest fruit weight (84.27

g) and plant height (247.25 cm). The number of fruits per plant (19.57), yield per plant (1.20 kg) and yield/ha (505.80 quintal) were greatest under T_2. The highest ascorbic acid content (31.34 mg/100 g) and TSS [total soluble solids] (4.29 degrees Brix) were recorded for the unpruned control. S4 registered the lowest number of days to first picking (72.92), and greatest fruit weight (79.56 g), whereas S_3 recorded the highest number of fruits per plant (20.67) and yield per plant (1.25 quintal). Plant height was greatest under S_1 (205.50 cm) and S_2 (205.00 cm). The ascorbic acid content was highest under S_1 (31.15 mg/100 g). S_3 and S_4 gave the highest TSS (4.15 and 4.33 degrees Brix). T_3 + S_2 recorded the highest number of fruits per cluster (3.87). The number of fruits per plant was highest for plants under T_2 + S_2 (22.43) and unpruned plants under S_3 (23.60). Yield per plant (1.35 kg) and per hectare (675.0 quintal), net return (201 503.45 rupees) and cost benefit ratio (1:2.94) were highest under T_2 + S_2. T_1 + S_4 gave the tallest plants (256.0 cm). Fruits of unpruned plants under S_1 had the highest ascorbic acid content (32.42 mg/100 g). TSS was highest for unpruned plants under S_3 (4.37 degrees Brix) and S_4 (4.76 degrees Brix). [1 quintal=100 kg].

Balraj and Mahesh (2005) carried out an experiment under greenhouse condition where seedlings of cherry tomato were raised in August 2002 in soilless media under greenhouse conditions and 30-day-old seedlings were transplanted on 1 September 2002 at 3 plant spacing (60 x 30, 60 x 60 and 60 x 90 cm) under drip fertigation system. Training of plants was performed in two systems, i.e. single main stem on each plant and two main stems on each plant. Plants of all treatments were trained and pruned regularly by removing the lateral branches from the leaf axils. Harvesting of fruits was started from the second week of November 2002 and continued up to the end of June 2003. A significant difference was observed between different treatments for number of fruit trusses per plant, average fruit weight and fruit yield of cherry tomato, but plant height was not influenced significantly by the different levels of plant spacing, stem pruning and training. The highest number of fruit-bearing trusses (30.33/plant) was recorded under the widest spacing with two main stems on each plant, while the greatest average fruit weight (10.1 g/fruit) was recorded when the crop was planted at the widest spacing with single main stem on each plant. Although, the highest fruit yield per plant (5.1 kg/plant) was obtained from plants with two main stems on each plant adjusted at the widest spacing, the highest fruit yield per ha (912.0 q/ha) was obtained when the cherry tomato plants with two main stems were grown at the closest spacing for long duration under semi-controlled greenhouse conditions of Delhi (India).

Davis and Ester (1993) found that early season yields were the highest using early pruning (when lateral shoots were 5-10 cm long) or delayed pruning (when lateral shoots were 30- 60 cm long) opposed to no pruning and in row spacing of 46 cm. Total season yields/hectare of pruning plants increased as in row spacing decreased. For unpruned plants, however, total season yields were high at all spacing. Total season yields were lower from delayed pruning plants than from unpruned plants. Unpruned plants produced low yields of fruits >72 mm diameter but their total yield was greater than those of pruning plants. Net return hectare $^{-l}$ was highest when i) plants spaced closely in row spacing were pruned early or ii) plants were spaced 46-76 cm apart and either pruned early or not prune.

Going through the above reviews, it is concluded that the different levels of GA_3 and stem pruning are important considering growth and yield. The literature reveals that the effects of different levels of GA_3 and stem pruning have not been studied well for the production of tomato under Bangladesh condition.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experiment, characteristics of soil, climate, materials used, land preparation, manuring and fertilizing, transplanting and gap filling, stalking, after care, harvesting and collection of data.

3.1 Location of the experiment field:

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka -1207 during the period from October 2010 to March 2011 to find out the effect of different concentration of GA_3 as plant growth regulator and pruning on the growth and yield of tomato. The location of the experimental site was at $23^0 74^{/\ N}$ latitude and $90^0 35^{/\ E}$ longitude with an elevation of 8.45 meter from the sea level.

3.2 Climate of the experimental area:

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

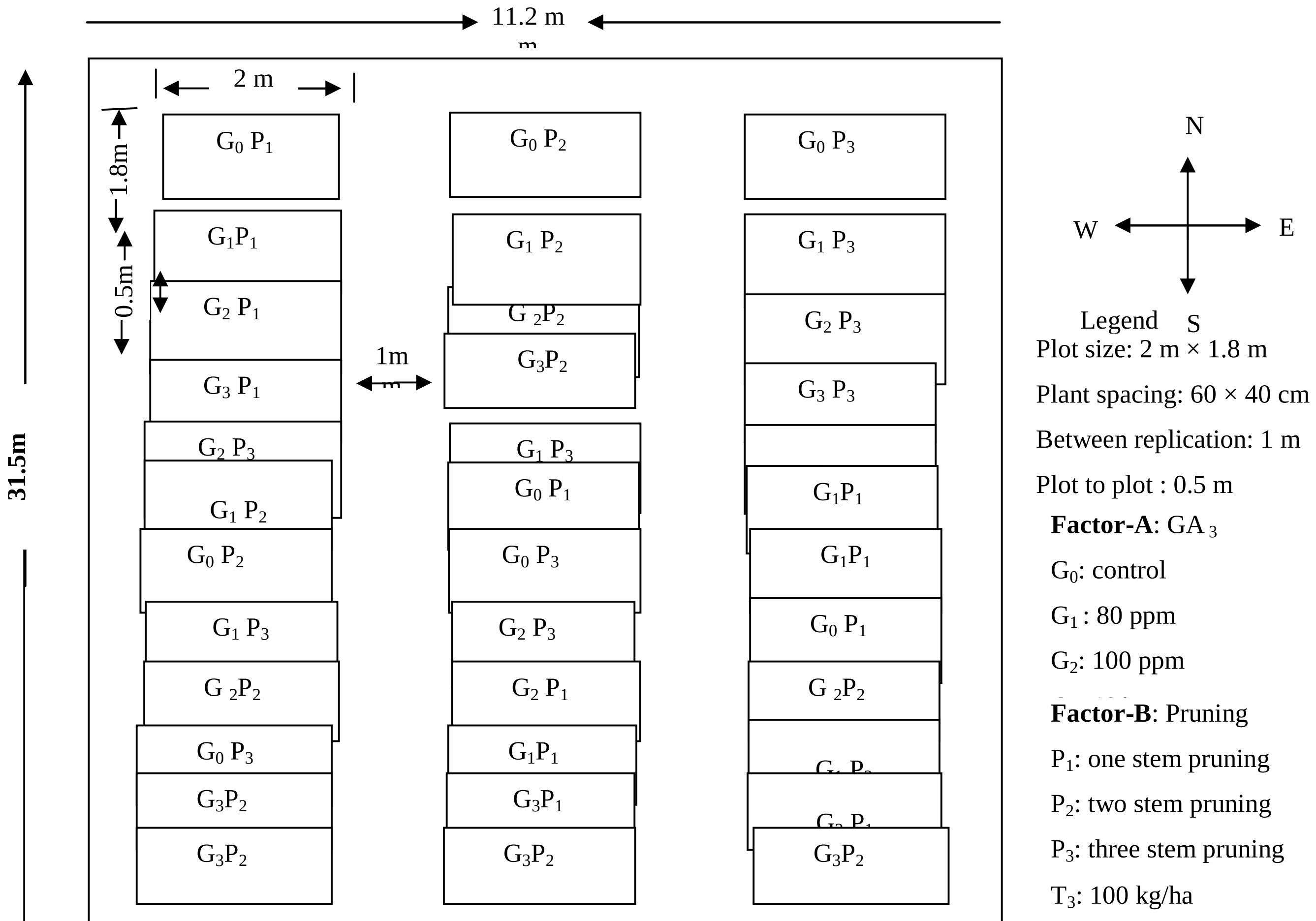

Fig. Layout of the experimental field

3.3 Soil of the experimental field:

Soil of the study site was silty clay loam in texture. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, ECE 25.28. The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources and Development Institute (SRDI), Soil Testing Laboratory, Farmgate, Dhaka and have been presented in Appendix II.

3.4 Plant materials used:

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

3.5 Raising of seedlings:

Tomato seedlings were raised in the seedbed situated on a relatively high land at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the seedbed was 3 m x l m. The soil was well prepared with the help of spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and 5 kg well rotten cowdung was applied during seedbed preparation. The seeds were sown on 25 October, 2010 and after sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg/ha around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place within 5 to 6 days after sowing. Necessary shading by banana leaves was provided over the seedbed to protect the young seedlings from scorching sun or heavy rain. Weeding, mulching and irrigation were done from time to time as and when required and no chemical fertilizer was used in the seedbed.

3.6 Treatments of the experiment:

The experiment consisted of two factors as follows:-

Factor A: It included four different doses of GA_3 (Gibberellic Acid) which are mentioned below with alphabetic symbol.

Doses of GA_3	**Alphabetic symbol**
0 ppm	**G_0**
80 ppm	**G_1**
100 ppm	**G_2**
120 ppm	**G_3**

Factor B: It consisted of three pruning levels which are mentioned below with alphabetic symbol.

Pruning levels	Alphabetic symbol
One stem pruning	**P_1**
Two stem pruning	**P_2**
Three stem pruning	**P_3**

Total 12 treatment combinations were as follows:

G_0P_1 G_0P_2 G_0P_3 G_1P_1 G_1P_2 G_1P_3 G_2P_1 G_2P_2 G_2P_3 G_3P_1 G_3P_2 G_3P_3

3.7 Design of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) having two factors with three replications. The treatment combinations were accommodated randomly in the unit plots.

3.8 Layout of the experiment

An area of 31.5 m x 11.2 m was divided into three equal blocks. Each block consisted of 12 plots where 12 treatments were allotted randomly. There were 36 unit plots altogether in the experiment. The size of each plot was 2 m x 1.8 m. The distance between two blocks and two plots were l m and 0.5 m respectively.

3.9 Cultivation procedure:

3.9.1 Land preparation:

The soil was well prepared and good tilth was ensured for tomato crop production. The land of the experimental field was ploughed with a power tiller. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed. Finally, the unit plots were prepared as 15 cm raised beds. Fifteen pits were made in each plot with in row-to-row and plant to plant spacing of 60 cm X 40 cm.

3.9.2 Manuring and Fertilizing:

Manure and fertilizers such as cowdung, urea, triple super phosphate (TSP) and muriate of potash (MOP) were applied in the experimental field as per recommendation of BARI (2004).

Manure / Fertilizer	Dose per hectare	Applied during land preparation (%)	Applied in pit a week before transplanting (%)	Applied as top-dressing in rows	
				1st installment at 30 DAT (%)	2nd installment at 60 DAT (%)
Cowdung	**10 t**	**100**	**-**	**-**	**-**
Urea	**550 kg**	**-**	**33.33**	**33.33**	**33.33**
TSP	**450 kg**	**100**	**-**	**-**	**-**
MOP	**250 kg**	**-**	**33.33**	**33.33**	**33.33**

The entire amount of cowdung and TSP were applied as basal during land preparation. Urea and MOP were used as pit placement and top dressing in two equal installments. First and second installments were done at 30 and 60 days after transplanting.

3.9.3 Transplanting of seedlings

Healthy and uniform 35 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 30 December, 2010 maintaining a spacing of 60 cm x 40 cm between the rows and plants, respectively. This allowed an accommodation of 15 plants in each plot. The seedbed was watered before uprooting the seedlings from the seedbed so as to minimize damage to the roots. The seedlings were watered after transplanting.

Shading was provided using banana leaf sheath for three days to protect the seedling from the hot sun and removed after seedlings were established. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.9.4 Preparation of GA_3

GA_3 in different concentrations of 0, 80, 100 and 120 ppm were prepared following the procedure mentioned below and spraying was done during the noon using hand sprayer. 80 ppm solution of GA_3 was prepared by dissolving 80 mg of it with distilled water then distilled water was added to make the volume 1 litre 80 ppm solution in a same way 100 and 120 ppm concentration were made. An adhesive Tween-20 @0.1% was added to each solution (Roy *et al*. 1991). Control plot were treated only with distilled water.

3.9.5 Intercultural operations:

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

3.9.5.1 Gap filling:

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

3.9.5.2 Weeding and mulching:

Weeding was done whenever it was necessary. Mulching was also done to help in soil moisture conservation.

3.9.5.3 Stalking and pruning:

When the plants were well established, stalking was given to each plant by bamboo sticks to keep them erect. Within a few days of stalking, as the plants grew up, the first pruning was done when the plant gave three branches and it was observed at 35 days after transplanting. The second pruning was done at 45 days after transplanting.

3.9.5.4 Application of GA_3

Application of GA3 was done at 20 and 30 days after transplanting as per treatment.

3.9.5.5 Irrigation:

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

3.9.4.5 Plant protection:

Insect pests: Melathion 57 EC was applied @ 2 ml/l of water against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly after transplanting and stopped before second week of first harvest. Furadan lO G was also applied during final land preparation as soil insecticide.

Disease: During foggy weather precautionary measure against disease attack of tomato was taken by spraying Diathane M-45 fortnightly @ 2 g/l of water, at the early vegetative stage. Ridomil gold was also applied @ 2 g/l of water against blight disease of tomato.

3.9.4.6 Harvesting:

Fruits were harvested at 3 days interval during early ripe stage when they developed slightly red color. Harvesting was started from 15 February, 2011 and was continued up to 30 April, 2011.

3.10 Parameters assessed:

Five plants were selected at random and uprooted carefully at the time of collecting data of root from each plot and mean data on the following parameters were recorded:-

Plant height

Number of leaves per plant

Number of branches per plant

Number of clusters per plant

Number of flowers per plant

Number of fruits per plant

Length of fruit

Diameter of fruit

Dry matter content of leaves

Dry matter content of fruits

Yield per plot

Yield per hectare

3.11 Data collection:

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

Plant height:

Plant height at 30, 45, 60, 75 and 90 DAT was measured from sample plants in centimeter from the ground level to the tip of the longest stem and the mean value for each treatment was calculated. Plant height was also recorded at 15 days interval starting from 30 days of transplanting upto 90 days to observe the growth rate of plants.

Number of leaves per plant:

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

Number of branches per plant:

The number of branches of the sample plants was counted at 45 and 60 DAT and the average number of branches produced per plant was recorded.

Number of clusters per plant:

The number of fruit clusters was counted from the sample plants and the average number of clusters borne per plant was recorded at the time of final harvest.

Number of flowers per plant:

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

Number of fruits per plant:

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

Length of fruit:

The length of fruit was measured with slide-calipers from the neck to the bottom of 10 selected marketable fruits from each plot and their average was taken in cm as the length of fruit.

Fruit diameter:

Diameter of fruit was measured at the middle portion of 10 selected marketable fruit from each plot with slide-calipers and their average was taken in cm as the diameter of fruit.

Dry matter content of leaves:

Dry matter content of leaves was measured after last harvesting harvesting from randomly selected 100 g of leaf samples previously sliced into very thin pieces were put into envelop and placed in oven at 60°C for 72 hrs. The sample was then transferred into desiccators and allowed to cool down to the room temperature. The final weight of each sample was taken. The dry matter was calculated by the following formula:

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

Dry matter content of fruits

Immediately after harvest, a sample of 100 g fruits was taken randomly and cut into small pieces. The small pieces were sun dried for 3 days and then oven dried for 72 hours at 70 to 80 °C taken into envelope until constant weight. The sample was then transferred into desiccators and allowed to cool down to the room temperature. The final weight of each sample was taken. The dry matter content of sample was calculated by the following formula:

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

Yield per plot:

A balance was used to record the harvested fruits from 5 randomly selected plants and expressed in kilogram. It was measured by the following formula:

Yield per plot = Yield of single plant x 15

Yield per hectare:

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

3.12 Statistical analysis:

The data in respect of growth and yield components were statistically analyzed to find out the significance of the experimental results. The means of all the treatments were calculated and the analysis of variance for each of the characters under study was performed by F test. The difference among the treatment means was evaluated by Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The present study was conducted to find out the effect of GA_3 and pruning on growth and yield of tomato. Data on different growth and yield contributing characters were recorded to find out the optimum dose of GA_3 and optimum pruning type for "BARI Tomato-14". The analysis of variance (ANOVA) of the data on different growth and yield components are given in Appendix III-IV. The results have been presented and discussed, and possible interpretations have been drawn under the following headings.

4.1 Plant height

Plant height varied significantly at different days after transplanting (DAT) for different doses of GA_3 (Appendix III). At 30 DAT, the maximum plant height (55.78 cm) was obtained from G_3 (120 ppm GA_3), while the minimum (47.83 cm) was recorded from G_0 (0 ppm GA_3). The maximum plant height (70.44 cm) was found from G_3 and the minimum (56.84 cm) was obtained from G_0 at 45 DAT (Fig. 1). At 60 DAT, the maximum plant height (102.80 cm) was obtained for G_3 (120 ppm GA_3), while the minimum (88.56 cm) was recorded for G_0 (0 ppm GA_3). The maximum plant height (117.30 cm) was observed in G_3 and the minimum (95.67 cm) was found from G_0 at 75 DAT (Fig. 1). The effect of GA_3 application on plant height was best at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm (Fig. 1). Rai *et al*. (2006) and Nibhabanti *et al*. (2006) observed that GA_3 increased plant height at 25 and 50 ppm. Wu *et al*. (1983) reported that GA_3 at 100 ppm increased plant height.

Due to pruning plant height showed significant variation at different days after transplanting (DAT) (Appendix III). The maximum plant height (55.17 cm) was observed in P_2 (2 stem pruning) and the minimum (49.33 cm) was found from P_1 (1 stem pruning) which was statistically similar to P_3 (3 stem pruning) at 30 DAT. At 45 DAT, the maximum plant height (67.75 cm) was obtained for P_2, while the minimum (61.77 cm) was recorded for $P_{1,}$ which was statistically similar to P_3 (62.12 cm) (Fig. 2). The maximum plant height (101.00 cm) was observed for P_2 (2 stem pruning) and the minimum (90.42 cm) was found for P_1 at 60 DAT (Fig. 2). At 75 DAT the maximum plant height (113.60 cm) was obtained for P_2, while the minimum (101.30 cm) was recorded for P_1 (Fig. 2).

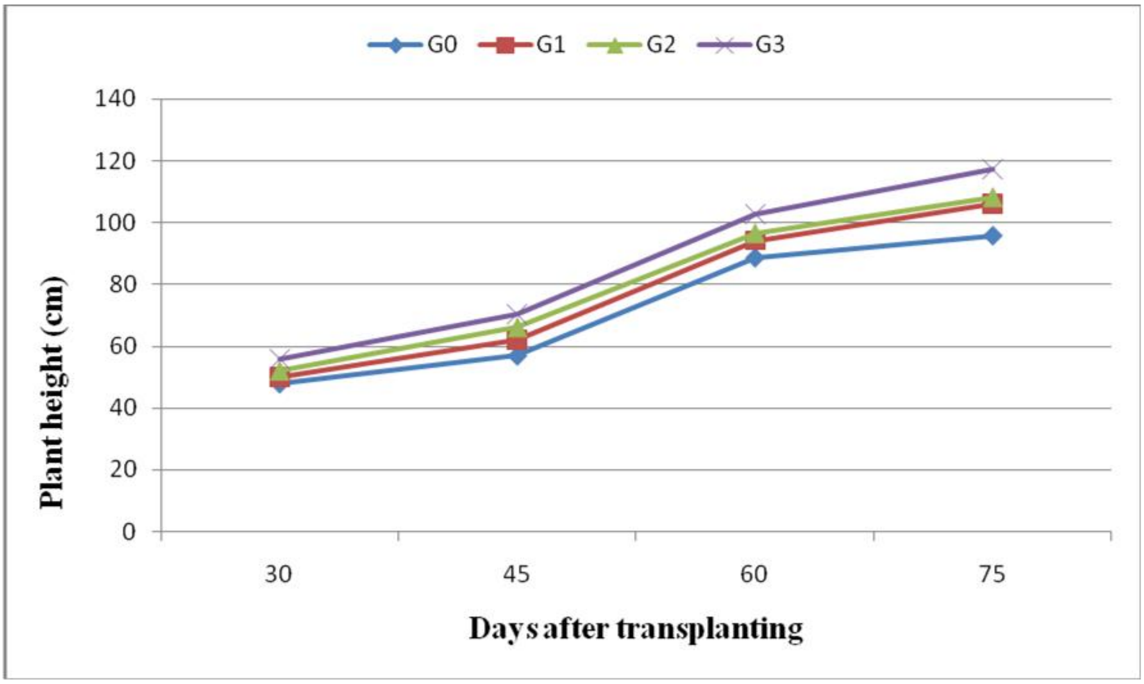

Fig.1. Effect of GA_3 on plant height of tomato

The variation was found due to combined effect of GA_3 application and pruning on plant height at different DAT. The maximum plant height (61.00 cm) was recorded from the treatment combination G_3P_2 (2 stem pruning with GA_3 application at 120 ppm), while the treatment combination of G_0P_1 (1 stem pruning with no GA_3 application) gave the minimum (46.33 cm) plant height, which was statistically similar to G_1P_1, G_0P_2, $G_0P_{3,}$ G_1P_3, G_2P_3 and G_2P_1 (Table 1) at 30 DAT. At 45 DAT the treatment combination of G_3P_2 produced the tallest (76.00 cm) plant where as the shortest plant (54.23 cm) was performed by the treatment of combination $G_0P_{1.}$ The maximum plant height (108.70 cm) was obtained from the treatment combination of G_3P_2 (2 stem pruning with GA_3 application at 120 ppm), while the treatment combination of G_0P_1 (1 stem pruning with no GA_3 application) gave the minimum (82.33 cm) plant height (Table 1) at 60 DAT. At 75 DAT, G_3P_2 showed the longest (125.00 cm) plant height which was followed by G_1P_2, G_2P_2 and $G_3P_{3,}$ where as the minimum plant height (90.00 cm) was recorded from the combination of G_0P_1 which was statistically similar to $G_0P_{3.}$ From the results it was found that both GA_3 application and pruning favored plant growth which was ensured by maximum plant height.

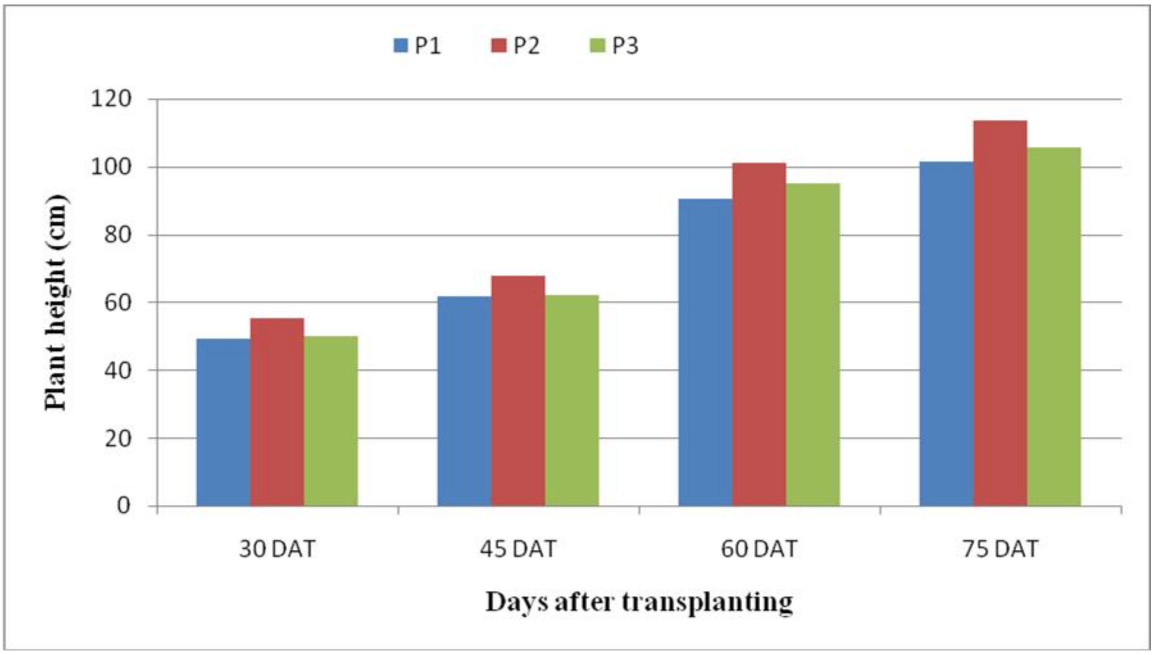

Fig.2. Effect of pruning on plant height of tomato

4.2 Number of leaves per plant

Number of leaves per plant varied significantly at different days after transplanting (DAT) for different doses of GA_3 (Appendix III). At 45 DAT, the maximum number of leaves per plant (32.33) was obtained from G_3 (120 ppm GA_3), while the minimum (25.33) was recorded from G_0 (0 ppm GA_3). The maximum number of leaves per plant (65.44) was counted from G_3 and the minimum (52.33) was found from G_0 at 60 DAT. On the other hand the maximum number of leaves per plant (75.30) was counted from G_3 and the minimum (58) was found from G_0 at 75 DAT. At 90 DAT, the maximum number of leaves per plant (78) was obtained from G_3 and minimum number (64) was found from $G_{0.}$

The effect of GA_3 application on number of leaves per plant was comparatively best at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm (Fig. 3). Rai *et al*. (2006) and Nibhabanti *et al*. (2006) observed that GA_3 increased number of branches per plant at 25 and 50 ppm. Wu *et al*. (1983) reported that GA_3 at 100 ppm increased leaf area.

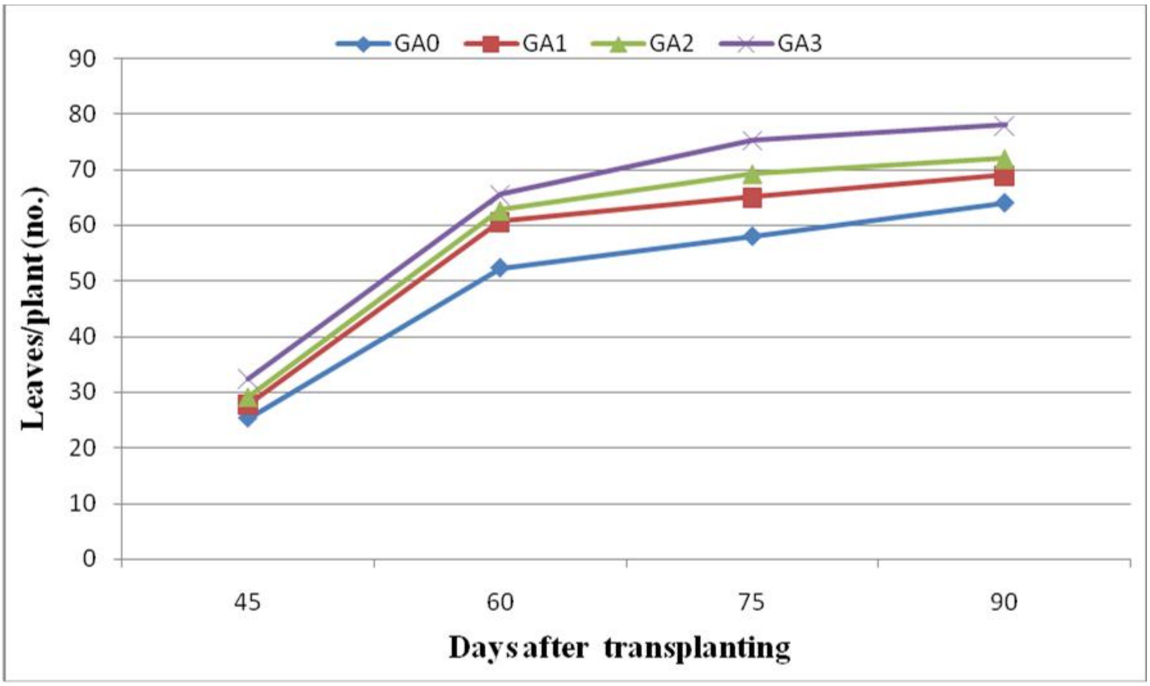

Fig.3. Effect of GA_3 on leaves per plant of tomato

Due to pruning showed significant variation on number of leaves per plant at 45 and 60 days after transplanting (DAT) (Appendix III). The highest number of leaves per plant (30.08) was observed for P_2 (2 stem pruning) and the lowest number (27.87) was found for P_3 (3 stem pruning) at 45 DAT (Fig. 4). At 60 DAT the maximum leaves per plant (63.08) was obtained for P_2, while the minimum (58.33) was recorded for P_1 which was statistically similar to P_3 (Fig. 4). The highest number of leaves per plant (63.07) was observed for P_2 (2 stem pruning) and the lowest number (39.37) was found for P_3 (3 stem pruning) at 75 DAT. On the other hand, maximum number of leaves (70.01) found from P_2 and minimum (63.00) from P_1 at 90 DAT.

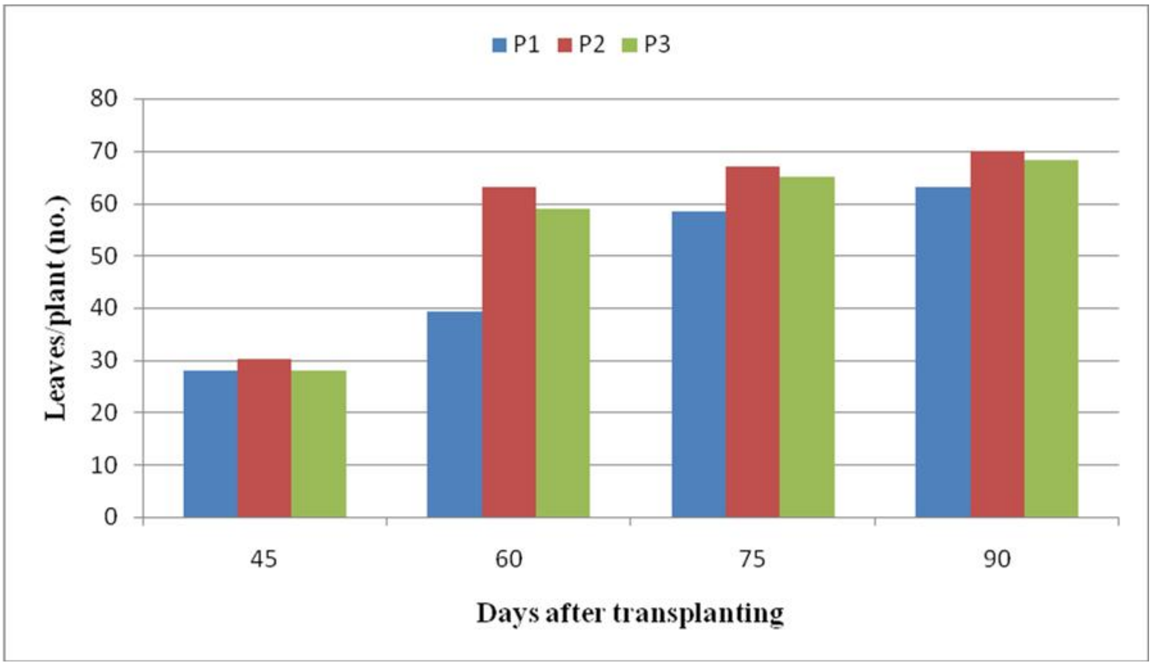

Figure.4. Effect of pruning on leaves per plant of tomato

The variation was found due to combined effect of GA_3 application and pruning on number of leaves per plant at different DAT. The maximum number of leaves per plant (34.67) was obtained from the treatment combination G_3P_2 (2 stem pruning with GA_3 application at 120 ppm), while the treatment combination G_0P_1 (single stem pruning with no GA_3 application) gave the minimum (24.67) number of leaves per plant, which was statistically similar to G_0P_3, G_0P_2 and G_1P_1 at 45 DAT (Table 1). At 60 DAT, the treatment combination of G_3P_2 gave the maximum (68.67) number of leaves plant, whereas the minimum number of leaves per plant (50.67) was recorded from G_0P_1 which was statistically similar to G_0P_3. At 75 DAT, maximum number of leaves per was obtained from G_3P_2 and minimum number (39.80) was found from G_0P_1. Again at 90 DAT, G_3P_2 produced highest number of leaves (73.15) and G_0P_1 gave lowest number of leaves (46.60) per plant. From the results it was found that both GA_3 application and pruning favored plant growth which was ensured by maximum number of leaves per plant.

Table1. Combined effect of GA_3 and pruning on different plant characteristics of tomato

Treatments	Plant height (cm) at				Leaves/ plant at			
	30 DAT	**45 DAT**	**60 DAT**	**75 DAT**	**45 DAT**	**60 DAT**	75 DAT	90 DAT
G_0P_1	**46.33d**	**54.23e**	**82.33g**	**90.00f**	**24.67g**	**50.67g**	39.80d	46.60e
G_0P_2	**50.00cd**	**59.33d**	**94.67cd**	**102.00e**	**26.33efg**	**55.00f**	51.65bc	59.15c
G_0P_3	**47.17d**	**56.97de**	**88.67f**	**95.00f**	**25.00fg**	**51.33g**	48.62c	55.75d
G_1P_1	**47.67d**	**60.00cd**	**89.33ef**	**100.30e**	**27.00defg**	**57.67e**	47.23c	49.11e
G_1P_2	**53.33bc**	**66.67b**	**99.00bc**	**113.30b**	**29.00cd**	**63.67bc**	59.08b	61.65c
G_1P_3	**49.27cd**	**59.83cd**	**94.00cde**	**104.30de**	**27.30def**	**60.67d**	56.05b	58.25c
G_2P_1	**50.33cd**	**64.50bc**	**92.67def**	**102.70e**	**28.50cde**	**61.00d**	54.32bc	57.61cd
G_2P_2	**56.33b**	**69.00b**	**101.7b**	**114.00b**	**30.33bc**	**65.00b**	66.17a	70.15a
G_2P_3	**49.33cd**	**64.67bc**	**95.33cd**	**108.00cd**	**28.50cde**	**62.00cd**	63.14ab	66.75b
G_3P_1	**53.00bc**	**68.33b**	**97.33bcd**	**112.30bc**	**31.67b**	**64.00bc**	57.33b	60.61c
G_3P_2	**61.00a**	**76.00a**	**108.7a**	**125.00a**	**34.67a**	**68.67a**	69.18a	73.15a
G_3P_3	**53.33bc**	**67.00b**	**102.3b**	**114.7b**	**30.67bc**	**63.67bc**	66.15a	69.75a
LSD $_{(0.05)}$	**4.205**	**5.011**	**5.120**	**5.043**	**2.381**	**2.291**	4.21	3.25
CV (%)	**4.83**	**4.63**	**3.17**	**2.79**	**4.91**	**2.24**	6.79	6. 97

4.3 Number of branches per plant

Number branches per plant showed significant variation due to application of different concentration of GA_3 (Appendix IV). The maximum number of branches/plant (12.22) was obtained from G_3 (120 ppm GA_3), while the minimum (8.00) was recorded for G_0 (0 ppm GA_3) (Table 2). The effect of GA_3 application on number of branches per plant was most effective at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm. Tomar and Ramgiry (1997) reported that 45 ppm GA_3 resulted in the highest number of primary brances per plant.

Different pruning levels showed significant variation on number of branches per plant (Appendix III). The highest number of branches per plant (11.00) was found from P_2 which was followed by P_3 (10.42) and the lowest number (8.96) was found for P_1 (Table 2).

The variation was found due to combined effect of GA_3 application and pruning on number of branches per plant (Appendix III). The maximum number of branches per plant (14.00) was recorded from the treatment combination of G_3P_2, while the treatment combination of G_0P_1 gave the lowest (7.33) number of branches per plant, (Table 3). From the results it was found that both GA_3 application and pruning favored the plant growth which was ensured by highest number of branches per plant.

4.4 Number of cluster per plant

Number of fruit clusters per plant showed significant variation due to application of GA_3 (Appendix IV). The maximum number of fruit clusters per plant (13.56) was obtained from G_3 (120 ppm GA_3) which was followed by G_2 (11.56) while the minimum (9.67) was recorded from G_0 (0 ppm GA_3) (Table 2). The effect of GA_3 application on fruit clusters per plant was most effective at the concentration of 80 ppm which was followed by 60, 40 and 0 ppm.

Different levels of pruning showed significant variation on fruit clusters per plant (Appendix IV). The highest number of clusters per plant (12.83) was observed in P_2 and the lowest (10.50) was found for P_1 which was statistically similar to P_3 (Table 2). Balraj and Mahesh (2005) reported that highest number of fruit bearing trusses was recorded under condition of two main stems on each plant.

The variation was found due to combined effect of GA_3 application and pruning on clusters per plant (Appendix IV). The maximum clusters per plant (15.67) was recorded from the treatment combination of G_3P_2, while the treatment combination of G_0P_1 gave the lowest (9.00) number of clusters per plant, which was statistically similar to G_0P_3 and G_1P_1 (Table 3). From the results it was found that both GA_3 (120 ppm) application and pruning (2 stem) favored the highest number of clusters per plant.

4.5 Number of flowers per plant

Number of flowers per plant showed significant variation due to application of different concentration of GA_3 (Appendix IV). The maximum number of flowers per plant (133.40) was obtained from G_3 (120 ppm GA_3) which was followed by G_2 (121.20), while the minimum (108.20) was recorded from G_0 (0 ppm GA_3) (Table 2). The effect of GA_3 application on flowers per plant was most effective at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm.

Different pruning levels showed significant variation on flowers per plant (Appendix IV). The highest number of flowers per plant (129.80) was counted from P_2 which was followed by P_3 (118.40) and the lowest number (110.30) was recorded from P_1 (Table 2).

The variation was found due to combined effect of GA_3 application and pruning on flowers per plant (Appendix IV). The maximum flowers per plant (144.70) was recorded from the treatment combination of G_3P_2 which was followed by G_2P_2 and G_3P_3, while the treatment combination of G_0P_1 gave the lowest (100.00) number of flowers per plant which was statistically similar to G_0P_3 and G_1P_1 (Table 3). From the results it was found that both GA_3 application and pruning favored flower bearing which ensured more yield.

4.6 Number of fruits per plant

Number of fruits per plant showed significant variation on different doses of GA_3 (Appendix IV). The maximum number of fruits per plant (25.10) was obtained for G_3 (120 ppm GA_3), while the minimum (18.13) was recorded for G_0 (0 ppm GA_3) (Table 2). The effect of GA_3 application on fruits per plant was most effective at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm. Tomar and Ramgiry (1997) found that plants treated with GA_3 showed significantly greater number of fruits per plant than untreated controls. Kaushik *et al*. (1974) reported that GA_3 at 100 ppm increased the number and weight of fruits.

Different levels of pruning showed significant variation on fruits per plant (Appendix IV). The highest number of fruits per plant (17.05) was observed for P_2 (two stem pruning) and the lowest number (15.92) was found for P_1 (single stem pruning) (Table 2). Thakur *et al.* (2005) reported that number of fruits per plant was greatest in double leader pruning.

The variation was found due to combined effect of GA_3 application and pruning on fruits/plant (Appendix IV). The maximum fruits per plant (22.55) was recorded from the treatment combination of G_3P_2, while the treatment combination of G_0P_1 gave the lowest (38.33) number of fruits per plant (Table 3). From the results it was found that both GA_3 and pruning favored fruit setting which ensured the higher yield.

4.7 Length of fruit

Application of different concentration of GA_3 showed significant variation on fruit length (Appendix IV). The maximum fruit length (6.18 cm) was obtained from G_3 (120 ppm GA_3) which was followed by G_2 (5.54 cm), while the minimum (5.06 cm) was recorded from G_0 (0 ppm GA_3) (Table 2). The effect of GA_3 application on fruit length was most effective at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm. Adlakha and Verma (1965) reported that GA_3 at 100 ppm could appreciably increase fruit size.

Different levels of pruning showed significant variation on fruit length (Appendix IV). The maximum fruit length (5.78 cm) was recorded from P_2 which was followed by P_3 (5.48 cm) and the minimum (5.31 cm) was found for P_1 (Table 2).

Muhammad and Singh (2007) reported that mean fruit length was significantly higher in three stem and two stem pruned plants than unprimed plants.

The variation was found due to combined effect of GA_3 application and pruning on fruit length. The maximum fruit length (6.50 cm) was recorded from treatment combination G_3P_2 which was followed by G_3P_3, while the treatment combination G_0P_1 gave the minimum (4.93 cm) fruit length, which was statistically similar to G_0P_3 and G_1P_1 (Table 3). From the results it was found that both GA_3 application and pruning favored fruit length which ensured maximum yield.

Table 2. Effect of GA_3 and effect of pruning on different yield contributing characteristics of tomato

Effect of GA_3					
Treatments	**Branches/ plant**	**Number of clusters/ plant**	**Flowers/ plant**	**Fruits/ plant**	**Fruit length (cm)**
G_0	8.00d	9.67c	108.20d	18.13d	5.06d
G_1	9.39c	10.78b	115.00c	19.15c	5.30c
G_2	10.89b	11.56b	121.20b	21.05b	5.54b
G_3	12.22a	13.56a	133.40a	25.10a	6.18a
LSD $_{(0.05)}$	0.67	0.84	5.436	1.01	0.18
Effect of pruning					
P_1	8.96c	10.50b	110.30c	15.92c	5.31c
P_2	11.00a	12.83a	129.80a	20.01a	5.78a
P_3	10.42b	10.83b	118.40b	17.05b	5.48b
LSD $_{(0.05)}$	0.58	0.72	4.65	7.77	0.156
CV (%)	6.78	7.55	4.708	1.73	3.35

Table 3. Combined effect of GA_3 and pruning on different yield contributing characteristics of tomato

Treatments	Branches/ plant	Number of clusters/ plant	Flowers/ plant	Fruits/ plant	Fruit length (cm)
G_0P_1	7.33g	9.00g	100.00g	17.02h	4.93h
G_0P_2	8.33fg	10.67def	118.00cd	19.07ef	5.27efg
G_0P_3	8.33fg	9.33fg	106.70fg	17.59gh	4.97gh
G_1P_1	8.50f	9.67efg	106.70fg	17.53gh	5.07fgh
G_1P_2	9.67e	12.00bcd	124.70bc	19.58efg	5.57de
G_1P_3	10.00de	10.67def	113.70de	18.10fg	5.27efg
G_2P_1	9.67e	11.00cde	111.00ef	18.48bc	5.33ef
G_2P_2	12.00bc	13.00b	131.70b	20.53de	5.77cd
G_2P_3	11.00cd	10.67def	121.00cd	19.05cd	5.53de
G_3P_1	10.33de	12.33bc	123.30bc	20.51a	5.90bc
G_3P_2	14.00a	15.67a	144.70a	22.55b	6.50a
G_3P_3	12.33b	12.67b	132.30b	21.07	6.13b
LSD $_{(0.05)}$	1.163	1.457	9.416	0.06	0.312
CV (%)	6.78	7.55	4.65	7.77	3.35

4.8 **Diameter of fruit**

Fruit diameter varied significantly for different doses of GA_3 (Appendix IV). The maximum diameter of fruit (5.59 cm) was obtained from G_3 (120 ppm GA_3) which was followed by G_2 (5.02 cm), while the minimum (4.43 cm) was recorded for G_0 (0 ppm GA_3) (Table 4). The effect of GA_3 application on fruit diameter was most effective at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm.

Different levels of pruning showed significant variation on diameter of fruit (Appendix IV). The maximum diameter of fruit (5.16 cm) was observed in P_2 which was followed by P_3 (4.94 cm) and the minimum (4.77cm) was found for P_1 (Table 4). Muhammad and Singh (2007) reported that mean fruit diameter was significantly higher in three stem and two stem pruned plants than unprimed plants.

Due to combined effect of GA_3 application and pruning showed significant variation on fruit diameter. The maximum fruit diameter (5.90 cm) was recorded from treatment combination of G_3P_2 which was followed by G_3P_3 (5.63 cm), while the treatment combination G_0P_1 gave the minimum (4.37 cm) fruit diameter which was statistically similar to G_0P_2, G_0P_3 and G_1P_1 (Table 5).

4.9 Dry matter content of leaves

Dry matter content varied significantly in different parts of plant for different doses of GA_3 (Appendix III). In leaf the maximum dry matter content (15.65%) was obtained for G_3 (120 ppm GA_3), while the minimum (8.45%) was recorded for G_0 (0 ppm GA_3) which was statistically similar to G_1 (19.02%) (Table 4).

Different pruning levels showed significant variation on dry matter content in different parts of plant (Appendix III). The maximum dry matter content (22.31%) was observed in P_2 (two stem pruning) and the minimum (19.15%) was found for P_1 (single stem pruning) in leaf (Table 4).

The variation was found due to combined effect of GA_3 application and pruning on dry matter content in different parts of tomato plant (Appendix III). The maximum dry matter content (25.67%) was recorded from treatment combination G_3P_2 (double stem pruning with GA_3 spray at 30 ppm), while the treatment combination G_0P_1 gave the minimum (16.27%) dry matter content (Table 5) in leaf.

4.10 Dry matter content of fruit

Dry matter content varied significantly in different parts of plant for different doses of GA_3 (Appendix III). The maximum dry matter content (4.67%) was observed for G_3 and the minimum (2.84%) was found for G_0 in fruit (Table 4). The effect of GA_3 application on dry matter content was most effective at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm.

Different pruning levels showed significant variation on dry matter content in fruit of tomato (Appendix III). In fruit the maximum dry matter content (4.08%) was obtained for S_3, while the minimum (3.42%) was recorded for P_1 (Table 4).

The variation was found due to combined effect of GA_3 application and pruning on dry matter content of tomato (Appendix III). In fruit the treatment combination G_3P_2 gave the maximum (5.13%) dry matter content, where as the minimum dry matter content (2.67%) was observed for the combination G_0P_1 (Table 5).

4.11 Yield per plot

Yield per plant varied significantly influenced by the application of for different concentration of GA_3 (Appendix IV). The highest yield per plot (10.45 kg) was obtained from G_3 (120 ppm GA_3) which was followed by G_2 (9.41 kg), while the lowest (8.28 kg) was recorded from G_0 (Table 4). The best effect of GA_3 application on yield per plant was at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm. Tomar and Ramgiry (1997) found that plants treated with GA_3 showed significantly greater yield per plot than untreated controls. Hossain (1974) found a gradual increase in the yield per plot with higher concentration (80 ppm) of GA_3.

Due to pruning yield per plant showed significant variation on yield per plot (Appendix IV). The highest yield per plot (10.12 kg) was observed in P_2 (double stem pruning) and the lowest (8.48 kg) was found fromP_1 (single stem pruning) (Table 4). Muhammad and Singh (2007) reported that mean fruit weight was significantly higher in three stem and two stem pruned plants than unpruned plants. Thakur *et al.* (2005) reported yield per plant was greatest in double leader pruning. Balraj and Mahesh (2005) reported that highest yield/plant was recorded under condition of two main stems on each plant.The variation was found due to combined effect of GA_3 and pruning on yield per plant. The maximum yield per plant (11.48 kg) was recorded from the treatment combination of G_3P_2 which was followed by G_3P_3 (10.33 kg) and G_2P_2 (10.28 kg), while the treatment combination of G_0P_1 gave the minimum (7.64 kg) yield per plot (Table 5). From the results it was found that both GA_3 and pruning favored yield/plant which ensured the highest yield.

4.12 Yield/ hectare

Yield per hectare varied significantly for different doses of GA_3 (Appendix IV). The highest Yield per hectare (29.03 ton) was obtained from G_3 (80 ppm GA_3) which was followed by G_2 (26.12 ton), while the lowest (23.01 ton) was recorded from G_0 (Table 4). The best effect of GA_3 application on yield per hectare was at the concentration of 120 ppm which was followed by 100, 80 and 0 ppm. Tomar and Ramgiry (1997) found that plants treated with GA_3 showed significantly greater yield per plant than untreated controls. Hossain (1974) found a gradual increase in the yield per plant with higher concentration (120 ppm) of $GA_{3.}$

Due to pruning yield per hectare showed significant variation (Appendix IV). The highest yield per hectare (28.11 ton) was observed in P_2 (double stem pruning) and the lowest (23.56 ton) was found from P_1 (single stem pruning) (Table 4). Ece and Darakci (2007) reported that single stem application should be implemented for higher yield in tomato. Thakur *et al.* (2005) reported yield per hectare was greatest in double leader pruning. Balraj and Mahesh (2005) reported that highest yield/ha were recorded under condition of two main stems on each plant.

The variation was found due to combined effect of GA_3 and pruning on yield per hectare. The maximum yield per hectare (31.89 t) was recorded from the treatment combination of G_3P_2 which was followed by G_3P_3 (28.70 t) and G_2P_2 (28.54 t), while the treatment combination of G_0P_1 gave the minimum (21.22 ton) yield per hectare (Table 5). Khan *et al*. (2006) reported that irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters.

Table 4. Effect of GA_3 and effect of pruning on different yield contributing characteristics of tomato

Effect of GA_3					
Treatments	**Fruit diameter (cm)**	Dry matter content of leaves(%)	Dry matter content of fruit(%)	**Yield/ plot (kg)**	**Yield/ ha (ton)**
G_0	4.43d	8.45c	6.62d	8.28d	23.01d
G_1	4.78c	9.00c	7.84c	8.86c	24.62c
G_2	5.02b	13.74b	9.05b	9.41b	26.12b
G_3	5.59a	15.65a	11.85a	10.45a	29.03a
LSD $_{(0.05)}$	0.138	1.52	1.07	0.461	1.278
Effect of pruning					
P_1	4.77c	9.66c	7.04c	8.48c	23.56c
P_2	5.16a	13.23a	11.09a	10.12a	28.11a
P_3	4.94b	10.13b	9.08b	9.15b	25.42b
LSD $_{(0.05)}$	0.120	6.52	7.88	0.399	1.107
CV (%)	2.82	1.3	1.96	5.09	5.09

Table 5. Combined effect of GA_3 and pruning on different yield contributing characteristics of tomato

Treatments	Fruit diameter (cm)	Dry matter content In Leaf (%)	Dry matter content in Fruit (%)	Yield/ plot (kg)	Yield/ ha (ton)
G_0P_1	4.37g	9.02i	9.02i	7.64g	21.22g
G_0P_2	4.57fg	10.84e	10.84e	9.06cde	25.16cde
G_0P_3	4.37g	9.79f	9.79f	8.16fg	22.65fg
G_1P_1	4.60fg	9.33h	9.33h	8.17fg	22.68fg
G_1P_2	4.97de	11.11f	11.11f	9.67bc	26.85bc
G_1P_3	4.77ef	10.06g	10.06g	8.76def	24.32def
G_2P_1	4.87e	11.70e	11.70e	8.58ef	23.83ef
G_2P_2	5.20cd	13.47c	13.47c	10.28b	28.54b
G_2P_3	5.00cde	12.48d	12.48d	9.36cde	25.99cde
G_3P_1	5.23c	12.65d	12.65d	9.55bcd	26.52bcd
G_3P_2	5.90a	14.44a	14.44a	11.48a	31.89a
G_3P_3	5.63b	13.39b	13.39b	10.33b	28.70b
LSD $_{(0.05)}$	0.239	0.016	0.016	0.798	2.214
CV (%)	2.82	6.52	6.52	5.09	5.09

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2010 to March 2011 to find out the effect of GA_3 and pruning on the growth and yield of tomato. The experiment consisted of two factors; Factor A: Different doses of GA_3 such as G_0: Control, G_1: 80 ppm G_2: 100 ppm and G_3: 120 ppm; Factor B: Different pruning levels such as P_I: single stem pruning, P_2: double stem pruning and P_3: triple stem pruning. Data on different growth and yield contributing characters were recorded.

The maximum (117.30 cm) plant height was obtained from G_3 and the minimum (95.67 cm) was recorded from G_0 at 75 DAT. At 60 DAT the maximum (65.44) number of leaves per plant was counted from G_3 and the minimum (52.33) was recorded from G_0. The maximum (12.22) number of branches per plant was recorded from G_3 and the minimum (8.00) was recorded from G_0. The maximum (13.56) number of clusters per plant was recorded from G_3 and the minimum (9.67) was recorded from G_0. The maximum (133.40) number of flowers per plant was recorded from G_3 and the minimum (108.20) was recorded from G_0. The maximum (25.10) number of fruits per plant was counted from G_3 and the minimum (18.13) was recorded from G_0. The maximum (15.65%) dry matter content of leaves was recorded from G_3 and the minimum (8.45%) was recorded from G_0. The maximum (11.85%) dry matter content of fruits was recorded from G_3 and the minimum (6.62%) was recorded from G_0. The maximum (6.18 cm) fruit length was recorded from G_3 and the minimum (5.06 cm) was recorded from G_0. The maximum (5.59 cm) fruit diameter was recorded from G_3 and the minimum (4.43 cm) was obtained from G_0. The maximum (10.45 kg) yield per plot was recorded from G_3 and the minimum (8.28 kg) was recorded from G_0. The maximum (29.03 ton) yield per hectare was recorded from G_3 and the minimum (23.01 ton) was found from G_0.

The maximum (113.60 cm) plant height was recorded from P_2 and the minimum (101.30 cm) was recorded from P_1 at 60 DAT. At 60 DAT the maximum (63.08) number of leaves per plant was recorded from P_2 and the minimum (58.33) was recorded from P_1. The maximum (11.00) number of branches per plant was obtaned from P_2 and the minimum (8.96) was recorded from P_1. The maximum (12.83) number of clusters per plant was recorded from P_2 and the minimum (10.50) was recorded from P_1. The maximum (129.80) number of flowers per plant was recorded from P_2 and the minimum (110.30) was recorded from P_1. The maximum (20.01) number of fruits per plant was recorded from P_2 and the minimum (15.92) was recorded from P_1. The maximum (13.23%) dry matter content of leaves was recorded from P_2 and the minimum (9.66%) was recorded from P_1. The maximum (11.09%) dry matter content of fruits was recorded from P_2 and the minimum (7.04%) was recorded from P_1. The maximum (5.78 cm) fruit length was recorded from P_2 and the minimum (5.31 cm) was recorded from P_1. The maximum (5.16 cm) fruit diameter was recorded from P_2 and the minimum (4.77 cm) was recorded from P_1. The maximum (10.12 kg) yield per plot was recorded from P_2 and the minimum (8.48 kg) was recorded from P_1. The maximum (28.11 t) yield per hectare was recorded from P_2 and the minimum (23.56 ton) was obtained from P_1.

The maximum (125.00 cm) plant height was recorded from the treatment combination of G_3P_2 and the minimum (82.33 cm) was recorded from G_0P_1 at 75 DAT. At 60 DAT the maximum (68.67) number of leaves per plant was recorded from the treatment combination of G_3P_2 and the minimum (50.67) was recorded from G_0P_1. The maximum (14.00) number of branches per plant was recorded from the treatment combination of G_3P_2 and the minimum (7.33) was recorded from G_0P_1. The maximum (15.67) number of clusters per plant was recorded from G_3P_2 and the minimum (9.00) was recorded from G_0P_1. The maximum (144.70) number of flowers per plant was recorded from the treatment combination of G_3P_2 and the minimum (100.00) was recorded from

G_0P_1. The maximum (57.67) number of fruits per plant was recorded from G_3P_2 and the minimum (38.33) was recorded from the treatment combination G_0P_1. The maximum (14.44%) dry matter content of leaves was recorded from G_3P_2 and the minimum (9.02%) was recorded from the treatment combination of G_0P_1. The maximum (11.47%) dry matter content of fruits was recorded from the treatment combination of G_3P_2 and the minimum (6.83%) was recorded from the treatment combination of G_0P_1. The maximum (6.50 cm) fruit length was recorded from the treatment combination G_3P_2 and the minimum (4.93 cm) was recorded from G_0P_1. The maximum (5.90 cm) fruit diameter was recorded from the treatment combination of G_3P_2 and the minimum (4.37 cm) was recorded from G_0P_1. The maximum (11.48 kg) yield per plot was recorded from the treatment combination of G_3P_2 and the minimum (7.64 kg) was recorded from G_0P_1. The maximum (31.89 t) yield per hectare was recorded from the treatment combination of G_3P_2 and the minimum (21.22 ton) was performed by the treatment combination of G_0P_1.

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

1. It may be noted further higher concentration of GA3 may be used for ensuring the maximum yield in future.
2. Considering the levels or pruning, when two stems were pruned the plants performed the highest yield . In that case three or more branches may be pruned for future trial for more confirmation in final recommendation.

Conclusion:

The result of the present study revealed that different combination of GA_3 and different levels of pruning play an important role on the growth and yield contributing characters of tomato. It is noted that GA_3 exerted marked effect over the control. On the other hand pruning, such as 2 stem pruning helped to increase the yield of tomato. From the experiment, it was found that different concentration of GA3 showed predictable role on yield contributing characters of tomato plant and yield was increased with the increasing levels of GA3. The combined effect of 120 ppm GA3 and 2 stem pruning contributed the maximum yield. So, further higher levels of GA3 may be used for obtaining more yield.

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Appendices

Appendix I. Monthly average record of air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from October 2010 to April 2011.

Month	Air temperature (ºc)	Relative	Total	Sunshine

	Maximum	Minimum	humidity (%)	rainfall (mm)	(hr)
October, 2010	31.6	23.8	78	172.3	5.2
November, 2010	29.6	19.2	77	34.4	5.7
December, 2010	26.4	14.1	69	12.8	5.5
January, 2011	25.4	12.7	68	7.7	5.6
February, 2011	28.1	15.5	68	28.9	5.5
March, 2011	32.5	20.4	64	65.8	5.2
April, 2011	33.7	23.6	69	165.3	4.9

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargoan, Dhaka - 1212

Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agro-ecological Zone	Madhupur Tract
p^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka

Appendix III. Analysis of variance of the data for different plant characteristics

Sources of variation	Degrees of freedom	Mean sc					
		Plant height (cm) at				Leaves/ plant at	
		30 DAT	45 DAT	60 DAT	75 DAT	45 DAT	60 DAT
Replication	2	90.040	32.00	1.750	72.44	0.87	35.19
GA_3 (A)	3	101.88**	300.77**	312.70**	712.69**	76.67**	287.00**
Pruning (B)	2	126.58**	135.31**	337.58**	465.52**	18.87**	74.36**
Interaction (A X B)	6	4.84	6.70	2.50	3.08	1.10	1.80
Error	22	6.16	8.75	9.144	8.86	1.97	1.83

Appendix IV. Analysis of variance of the data for different yield contributing characteristics

Sources of variation	Degrees of freedom	Mean square				
		Branches/ plant	clusters/ plant	Fruit length (cm)	Fruit diameter (cm)	Flowers plant
Replication	2	0.896	8.528	0.317	0.081	1722.52
GA_3 (A)	3	30.118**	24.185**	2.092**	2.130**	1034.546
Pruning (B)	2	13.271**	19.111**	0.671**	0.462**	1150.778
Interaction (A X B)	6	1.271*	0.741	0.012	0.034	3.074
Error	22	0.472	0.740	0.034	0.020	30.922

*-significant at 5% level and **-significant at 1% level.