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RESEARCH ARTICLE

GROWTH AND YIELD OF TOMATO AS INFLUENCED BY GA_3 AND PRUNING

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ABSTRACT

An experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period from October 2012 to March 2013 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 (117.30 cm), maximum number of leaves/plant (75.30) and highest yield (29.03 t/ha) were recorded from GA_3 spray at 120 ppm. 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.

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 (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). 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). 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. 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

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following objectives:t o study the effect of different GA_3 doses on growth and yield of tomatot ,o determine the optimum level of pruning in order to achieve higher yieldt and o find out the suitable combination of GA_3 doses and level of pruning for ensuring the maximum yield of tomato.

MATERIALS AND METHODS

The field experiment was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka -1207, Bangladesh during the period from October 2012 to March 2013 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 23.74^0 N latitude and 90.35^0 E longitudes with an elevation of 8.45 meter from the sea level. 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 tomato variety "BARI Tomato-14" was collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Tomato seedlings were raised in the seedbed situated on a relatively high land at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. The experiment consisted of two factors as One factor was four viz $_3$levels of doses of GA., G_0 = 0 ppm, G_1 = 80 ppm, G_2 = 100 ppm and G_3 = 120 ppmand secand factor was three pruning levels viz.,P = $_1$one stem pruning,P = $_2$two stem pruning and P = $_3$three stem pruning. The experiment was laid out in a Randomized Complete Block Design (RCBD) having two factors with three replications. An area of 31.5 m x 11.2 m was divided into three equal blocks. There were 36 unit plots altogether in the experiment. The size of each plot was 2 m x 1.8 m and maintaining a spacing of 60 cm x 40 cm between the rows and plants. The distance between two blocks and two plots were l m and 0.5 m respectively. 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 (2012). Application of GA3 was done at 20 and 30 days after transplanting as per treatment. Fruits were harvested at 3 days interval during early ripe stage when they developed slightly red color. Harvesting was started from 15 February, 2013 and was continued up to 30 April, 2013.

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. 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).

RESULTS AND DISCUSSION

Plant height

Plant height varied significantly at different days after transplanting (DAT) for different doses of 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. 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 (Figure 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.

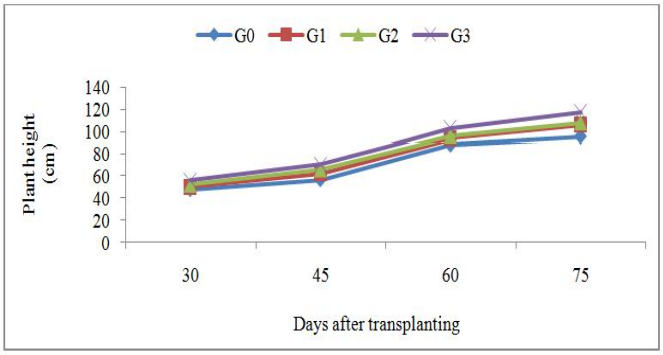

Fig ure1. Effect of GA_3 on plant height of tomato

Due to pruning plant height showed significant variation at different days after transplanting (DAT). 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 (Figure 2).

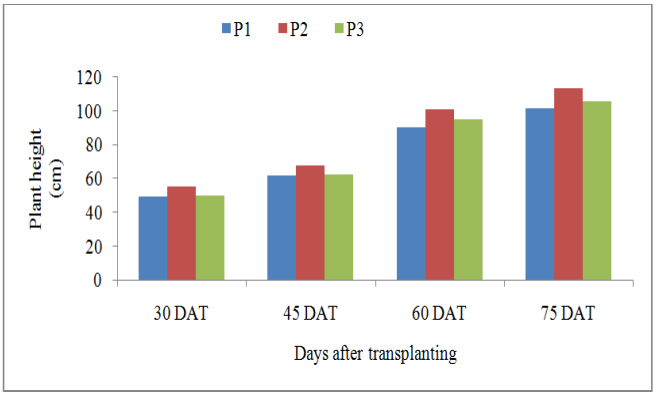

Figure 2. Effect of pruning on plant height of tomato

The variation was found due to combined effect of GA_3 application and pruning on plant height at different DAT (Table 1). At 75 DAT, G_3P_2 showed the longest plant height (125.00 cm) which was followed by G_1P_2, G_2P_2 and G_3P_3, where as the minimum (90.00 cm) was recorded from the combination of G_0P_1 which was statistically similar to G_0P_3.

Number of leaves per plant

Number of leaves per plant varied significantly at different DAT for different doses of GA_3. 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 (Figure 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.
During pruning, 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 (Figure 4).

Table 1. 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	46.33 d	54.23 e	82.33 g	90.00 f	24.67 g	50.67 g	39.80 d	46.60 e
G_0P_2	50.00 cd	59.33 d	94.67 cd	102.00 e	26.33 e-g	55.00 f	51.65 bc	59.15 c
G_0P_3	47.17 d	56.97 de	88.67 f	95.00 f	25.00 fg	51.33 g	48.62 c	55.75 d
G_1P_1	47.67 d	60.00 cd	89.33 ef	100.30 e	27.00 d-g	57.67 e	47.23 c	49.11 e
G_1P_2	53.33 bc	66.67 b	99.00 bc	113.30 b	29.00 cd	63.67 bc	59.08 b	61.65 c
G_1P_3	49.27 cd	59.83 cd	94.00 c-e	104.30 de	27.30 d-f	60.67 d	56.05 b	58.25 c
G_2P_1	50.33 cd	64.50 bc	92.67 d-f	102.70 e	28.50 c-e	61.00 d	54.32 bc	57.61 cd
G_2P_2	56.33 b	69.00 b	101.7 b	114.00 b	30.33 bc	65.00 b	66.17 a	70.15 a
G_2P_3	49.33 cd	64.67 bc	95.33 cd	108.00 cd	28.50 c-e	62.00 cd	63.14 ab	66.75 b
G_3P_1	53.00 bc	68.33 b	97.33 b-d	112.30 bc	31.67 b	64.00 bc	57.33 b	60.61 c
G_3P_2	61.00 a	76.00 a	108.7 a	125.00 a	34.67 a	68.67 a	69.18 a	73.15 a
G_3P_3	53.33 bc	67.00 b	102.3 b	114.7 b	30.67 bc	63.67 bc	66.15 a	69.75 a
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

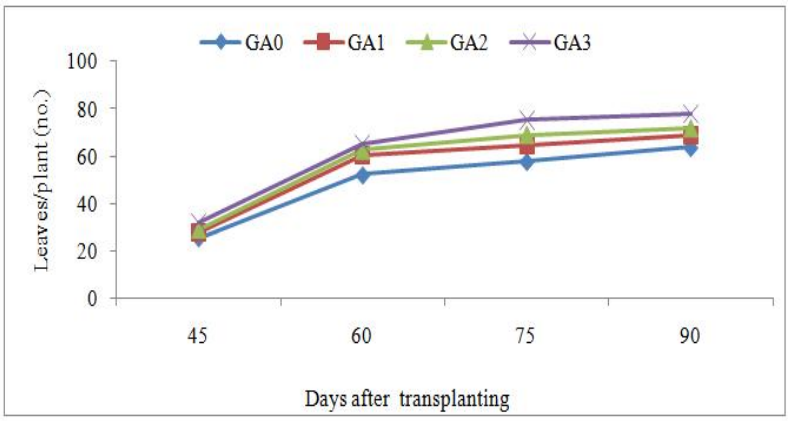

Figure 3. Effect of GA_3 on leaves per plant of tomato

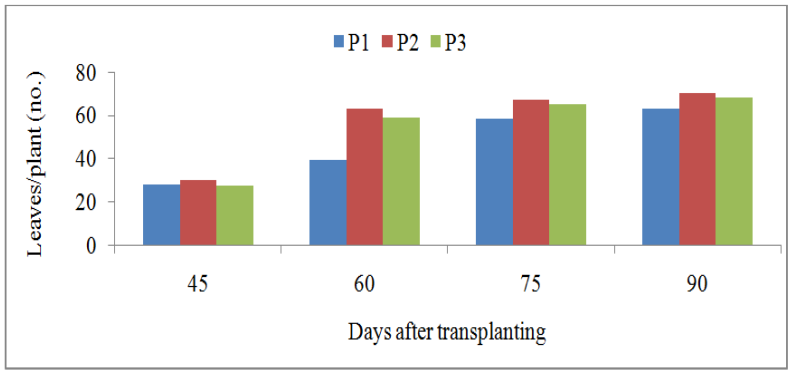

Figure 4. Effect of pruning on leaves per plant of tomato

The variation was found due to combined effect of GA_3 application and pruning on number of leaves per plant at different DAT (Table 1). 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.

Number of branches per plant

Number branches per plant showed significant variation due to application of different concentration of GA_3. 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). Tomar and Ramgiry (1997) reported that 45 ppm GA_3 resulted in the highest number of primary branches per plant. Different pruning levels showed significant variation on number of branches per plant. 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. 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 2).

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

Treatments	Branches/ plant	Number of clusters/ plant	Flowers/ plant	Fruits/ plant
Effect of GA_3				
G_0	8.00 d	9.67 c	108.20 d	18.13 d
G_1	9.39 c	10.78 b	115.00 c	19.15 c
G_2	10.89 b	11.56 b	121.20 b	21.05 b
G_3	12.22 a	13.56 a	133.40 a	25.10 a
LSD $_{(0.05)}$	0.67	0.84	5.436	1.01
Effect of pruning				
P_1	8.96 c	10.50 b	110.30 c	15.92 c
P_2	11.00 a	12.83 a	129.80 a	20.01 a
P_3	10.42 b	10.83 b	118.40 b	17.05 b
LSD $_{(0.05)}$	0.58	0.72	4.65	7.77
Interaction effect of GA_3 × Pruning				
G_0P_1	7.33 g	9.00 g	100.00 g	17.02 h
G_0P_2	8.33 fg	10.67 d-f	118.00 cd	19.07 ef
G_0P_3	8.33 fg	9.33 fg	106.70 fg	17.59 gh
G_1P_1	8.50 f	9.67 e-g	106.70 fg	17.53 gh
G_1P_2	9.67 e	12.00 b-d	124.70 bc	19.58 e-g
G_1P_3	10.00 de	10.67 d-f	113.70 de	18.10 fg
G_2P_1	9.67 e	11.00 c-e	111.00 ef	18.48 bc
G_2P_2	12.00 bc	13.00 b	131.70 b	20.53 de
G_2P_3	11.00 cd	10.67 d-f	121.00 cd	19.05 cd
G_3P_1	10.33 de	12.33 bc	123.30 bc	20.51 a
G_3P_2	14.00 a	15.67 a	144.70 a	22.55 b
G_3P_3	12.33 b	12.67 b	132.30 b	21.07
LSD $_{(0.05)}$	1.163	1.457	9.416	0.06
CV (%)	6.78	7.55	4.65	7.77

Number of cluster per plant

Number of fruit clusters per plant showed significant variation due to application of GA_3. 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). Different levels of pruning showed significant variation on fruit clusters per plant. 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. 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 2).

Number of flowers per plant

Number of flowers per plant showed significant variation due to application of different concentration of GA_3. 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). Different pruning levels showed significant variation on flowers per plant. 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. 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 2).

Number of fruits per plant

Number of fruits per plant showed significant variation on different doses of GA_3. 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). 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. 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. 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 2).

Diameter of fruit

Fruit diameter varied significantly for different doses of GA_3. 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 3). Different levels of pruning showed significant variation on diameter of fruit. 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 3).

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

Treatments	Fruit diameter (cm)	Yield/ plot (kg)	Yield/ ha (ton)
Effect of GA_3			
G_0	4.43 d	8.28 d	23.01 d
G_1	4.78 c	8.86 c	24.62 c
G_2	5.02 b	9.41 b	26.12 b
G_3	5.59 a	10.45 a	29.03 a
LSD $_{(0.05)}$	0.138	0.461	1.278
Effect of pruning			
P_1	4.77 c	8.48 c	23.56 c
P_2	5.16 a	10.12 a	28.11 a
P_3	4.94 b	9.15 b	25.42 b
LSD $_{(0.05)}$	0.120	0.399	1.107
Interaction effect of GA_3 × Pruning			
G_0P_1	4.37 g	7.64 g	21.22 g
G_0P_2	4.57 fg	9.06 c-e	25.16 c-e
G_0P_3	4.37 g	8.16 fg	22.65 fg
G_1P_1	4.60 fg	8.17 fg	22.68 fg
G_1P_2	4.97 de	9.67 bc	26.85 bc
G_1P_3	4.77 ef	8.76 d-f	24.32 d-f
G_2P_1	4.87 e	8.58 ef	23.83 ef
G_2P_2	5.20 cd	10.28 b	28.54 b
G_2P_3	5.00 c-e	9.36 c-e	25.99 c-e
G_3P_1	5.23 c	9.55 b-d	26.52 b-d
G_3P_2	5.90 a	11.48 a	31.89 a
G_3P_3	5.63 b	10.33 b	28.70 b
LSD $_{(0.05)}$	0.239	0.798	2.214
CV (%)	2.82	5.09	5.09

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 3).

Yield per plot

Yield per plot varied significantly influenced by the application of for different concentration of GA_3. 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 3). 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. 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 3). Muhammad and Singh (2007) reported that mean fruit weight was significantly higher in three stem and two stem pruned plants than unpruned plants. 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 3).

Yield per hectare

Yield per hectare varied significantly for different doses of GA_3. 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 3). 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. 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 3). Ece and Darakci (2007) reported that single stem application should be implemented for higher yield in tomato. The variation was found due to combined effect of GA_3 and pruning on yield per hectare. The maximum yield per hectare (31.89 ton) was recorded from the treatment combination of G_3P_2 which was followed by G_3P_3 (28.70 ton) and G_2P_2 (28.54 ton), while the treatment combination of G_0P_1 gave the minimum (21.22 ton) yield per hectare (Table 3). Khan *et al*. (2006) reported that irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters.

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 GA_3 showed predictable role on yield contributing characters of tomato plant and yield was increased with the increasing levels of GA_3. The combined effect of 120 ppm GA_3 and 2 stem pruning contributed the maximum yield. So, further higher levels of GA_3 may be used for obtaining more yields.

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