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Effect of plant growth regulators on yield attributes and quality trait of tomato (*Lycopersicon esculentum* Mill.)

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Abstract
An experiment was conducted at Horticulture Garden, Department of Horticulture, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur in the year 2016- 2017. The experiment was laid out in Randomized Block Design with ten treatments in each replication consisting of three levels of each growth regulator i.e. GA3 at 10, 20, 30 ppm, NAA at 20, 30, 40 ppm and 2,4-D at 2.5, 5.0, 7.5 ppm. The observations were recorded for five characters viz., diameter of fruit (cm), length of fruit per plant (cm), weight of fruit per plant (g), total soluble solid (brix), weight of 100 seed per fruit. The results showed that the use of GA3, NAA and 2,4-D at specific concentration (GA3 at 30 ppm, NAA at 30 ppm and 2,4-D at 5 ppm) in combination considerably increased the weight of fruit and significantly increased increases length of fruit (312 cm).

Keywords: Plant growth regulator, Gibberellins, NAA, 2,4-D, tomato

Introduction
Tomato (*Lycopersicon esculentum* Mill.) is commercially important throughout the world both for fresh fruit market and for the processed food industries. India occupies a prime position in vegetable production and is the second largest producer of vegetable next to China, however the production of tomato in India is about 18 million tonnes from an area of 0.8 million hectares. The production level of tomato in the country is next to potato. Suitable climatic conditions are available for the production of tomato as it can be grown in a wide range of climate. Tomato is one of the most highly praised vegetables consumed widely and it is a major source of vitamins and minerals. It is one of the most popular salad vegetables and is taken with great relish. The fruit contains protein, mineral matter, Vitamin A, thiamine, nicotinic acid, riboflavin and ascorbic acid. Plant growth regulators (PGR) play a major role in the growth and development of plant and its various parts. The specific quantities of PGR in the plants are directly responsible for the promotion, inhibition or otherwise modification in the physiological processes. It is obvious that the growth is directly related to the yield. Gibberellins promote shoot growth by accelerating the cell elongation and cell division in the sub apical meristem region which increases the length of internodes. Gibberellin regulates the mitotic activity of the sub apical meristem. Physiological effects of the gibberellins are; stem elongation: It increases the length of internodes, parthenocarpic fruit: GA induces parthenocarpic development in tomato, it increases the size of leaves and fruits. It increases the cell division and cell size.GA_3 significantly reduces the number of seeds per fruit The higher concentrations of NAA inhibit growth and exert toxic effects on the plants so, optimum concentrations are required to determine the beneficial effects of NAA. The positive effects of NAA have been observed mainly in cell elongation, improvement of phototropism, apical formation, respiration and flower bud initiation. Gibberellins promote shoot growth by accelerate in cell elongation and cell division in the sub apical meristem region which increases the length of internodes and also regulates the mitotic activity of the sub apical meristem. Several synthetic plant growth regulators were tested to determine whether they could be use in solving this problem of high temperature for tomato production.

Materials and Methods
The experiment was conducted during the Rabi season of 2016-17 at Horticulture Garden, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur.

The location is subjected to extreme of weather conditions. Geographically, Kanpur is situated in the alluvial belt of Gangatic plains of central U.P. The experiment was laid out in Randomized Block Design with three replications with 3 replications on tomato variety 'Azad T-6'.. Seedlings were transplanted in November, 2016, at the spacing of 60 x 40 cm. A total of 9 treatments using three different concentration of each growth regulator viz., 2,4-D @ 2.5 ppm, 5.0 ppm and 7.5 ppm GA3 @ 10 ppm, 20 ppm, 30 ppm and NAA @ 20 ppm, 30 ppm and 40 ppm were performed in the study.

The climate of region is subtropical with maximum temperature ranging from 23 °C to 4 5°C in summer, minimum temperature ranging from 5.5 °C to 13 °C in winter and relative humidity ranging from 45-55% in different season of the year. The experiment was laid out in Randomized Block Design with three replications on tomato variety 'Azad T-6'. Seedlings were transplanted in November, 2016 at a spacing of 60 x 40 cm. A total of 9 treatments using three different concentration of each growth regulator viz., 2, 4-D @ 2.5 ppm, 5.0 ppm and 7.5 ppm GA3 @ 10 ppm, 20 ppm, 30 ppm and NAA @ 20 ppm, 30 ppm and 40 ppm were used in the study. A total of five distinguishing parameters namely, weight of of tomato fruit, length of fruit, weight of 100 seeds, fruit diameter and total soluble solid were taken during the experiment procedure. Statistical analysis of the data was done by using Analysis of Variance (ANOVA) technique and difference among treatment means were compared by using Duncan's Multiple Range (DMR) test at 5% level of probability (Steel *et al*., 1997).

Result and Discussion

1. Fruit length per plant (cm)

The data recorded at different concentrations of GA_3, NAA and 2,4-D on fruit length per plant (cm) data have been presented in Table-1. The data on fruit length presented in Table-1 showed that concentrations of various growth regulators have significantly affected the average fruit length. A maximum fruit length of 5.28 cm was recorded at 30 ppm GA_3. Its lower concentrations i.e. 20 ppm and 10 ppm producing 4.45 and 4.15 fruits per plant proved significantly less effective than 30 ppm respectively. Control revealed 3.58 cm long fruit. Treatments GA_3 10 ppm (4.15 cm) and GA_3 20 ppm (4.45 cm) did not differed significantly in fruit length. Application of NAA 40 ppm showed significantly longer fruits (4.31 cm) when compared to NAA 30 ppm concentration (4.12 cm). NAA 30 ppm and NAA 20 ppm treatments were found to be non-significant in this regard. 2,4-D at 5.0 ppm induced fruit length of 4.25 cm which was significantly greater than 2,4-D at 7.5 ppm (3.34 cm) but it was statistically at par over control and its 2.5 ppm concentration (3.85 cm).

2. Fruit weight per plant (g)

Observation with respect of different concentration of GA_3, NAA and 2,4-D on fruit weight per plant (g) were recorded. It is obvious from the mean values showed in Table-1. The data given in Table-1 showed that the average fruit weight was observed at progressive increase with increasing levels of GA_3 applications. Significantly maximum average fruit weight (134.80 g) was recorded at GA_3 30 ppm, followed by the GA_3 20 ppm (124.31 g) while the minimum value was recorded under control (42.10 g). Both of the above GA3 concentration did not differ significantly with each other. NAA influenced significantly fruit weight per plant over control. The maximum fruit weight (86.28 g) express with 30 ppm of NAA spray the minimum was observed (42.10 g) with control. NAA 20 ppm and 40 ppm concentration showing 81.23 and 83.26 g fruit weight per plant did not vary significantly when compared in between 5.0 ppm treatment produced 69.58 g fruit weight per plant followed by its 2.5 ppm and 7.5 ppm concentration revealing 65.38 and 65.43 g fruit weight per plant. These treatments of 2,4-D being significantly over control (42.10 g) did not show significant differences when compared among themselves. The increasing fruit weight as result of GA_3 application has also been obtained by Uddain and Hossain (2009) [20].

3. Weight of 100 seed (mg)

The data on weight of 100 seed of tomato presented in the table 1. A close perusal of the data clearly indicated that different treatment of plant growth regulator increased the seed weight of the tomato fruit.Treatment 2,4-D at 5.0 ppm produced 312 mg/seed followed by 7.5 ppm and 2.5 ppm. A comparison of seed production influenced by growth regulators that seed production (weight) was minimum under control. Treatment of 2,4-D approved more effective followed by NAA and GA3 treatments. The plants under control gave the poorest values. Joshi & Dimri (2001) [11] and Thapa *et al*., (2003) also represented similar results in seed production of chillies.

Table 1: Effect of different concentration of GA3, NAA and 2,4-D on fruit weight, fruit length per plant and weight of 100 seed.

S.N	Symbol	Treatment	Fruits weight (g)	Length of fruit/plant (cm)	Weight of 100 seeds
1	T_0	Control	42.10	249	249
2	T_1	GA_3 10 ppm	115.12	262	262
3	T_2	GA_3 20 ppm	124.31	268	268
4	T_3	GA_3 30 ppm	134.80	259	259
5	T_4	NAA 20ppm	81.23	275	275
6	T_5	NAA 30 ppm	86.28	279	279
7	T_6	NAA 40 ppm	83.26	272	272
8	T_7	2,4-D 2.5 ppm	65.38	281	281
9	T_8	2,4-D 5.0 ppm	69.58	312	312
10	T_9	2,4-D 7.5 ppm	68.43	292	292
		SE (d)	6.07	14.2441	14.2441
		CD at 5%	12.76	29.9360	29.9360

Table 2: Effect of different concentration of GA3, NAA and 2,4-D on fruit diameter (cm), Total soluble solid (Brix).

S.N.	Treatment	Fruit diameter(cm)	Total soluble solid
1	Control	42.44	5.25
2	GA3 10 ppm	96.85	5.25
3	GA3 20 ppm	112.45	5.25
4	GA3 30 ppm	124.22	5.20
5	NAA 20 ppm	68.06	5.37
6	NAA 30 ppm	79.50	5.40
7	NAA 40 ppm	75.01	5.39
8	2,4-D 2.5 ppm	54.96	5.39
9	2,4-D 5.0 ppm	62.40	5.62
10	2,4-D 7.5 ppm	58.83	5.58
	SE (d)	0.64	0.118
	CD	2.35	0.249

4. T.S.S (%)

The total solule solid were estimated with the help of a hand refractometer. It is obvious from the data presented in table 2. Treatment 2,4-D 5.0 ppm (5 mg/lit water) showed Maximum TSS (5.62) of fruit. Statistical analysis indicated that treatment T8 highest TSS which is significantly superior over the rest treatment. It is obvious from Table 2.That T8 recorded maximum TSS content as compare to all the treatment barring T0, T1, T2 and T3.Plants under control gave the TSS value. When the effect of all the three growth regulators was examined 2,4-D was noted to be more effective followed by NAA and GA3. The results are in agreement of finding reported by Meena *et al.,* (2008) [15], Rai *et al*., (2006) [18], Pundir & Yadav (2001) on tomato.

5. Fruit diameter (cm).

The data recorded on different concentration of GA_3, NAA and 2,4-D on fruit diameter (cm) were recorded in Table-2. The data clearly showed that fruit diameter (124.22 cm) was influenced significantly by all the growth regulators trial.The application of GA_3 at 30ppm. Proved superior over control (42.44) and its other concentrations i.e. GA_3 at 10 ppm (96.85 cm) and at 20 ppm GA_3 (112.45). It was also indicated that the various growth regulators with their different concentrations revealed significantly greater average fruit diameter. In this regard NAA 30 ppm treatments produced maximum 79.50 cm diameter of fruit followed by NAA 20 ppm and NAA 40 ppm showing 68.06 and 75.01 cm diameter which were significantly differed when compared to control and NAA concentration of 20 ppm and 40 ppm. 2,4-D also proved effective and it was found that maximum (62.40 cm) diameter of fruits were noted with application of 2,4-D at 5.0 ppm followed by 7.5 ppm (60.83 cm) and 2. 5 ppm concentration (54.96 cm), these values were significantly greater over control. Diameter of fruits when compared within 2,4-D treatments it was found that all treatments being superior to control did not differ statistically among themselves.

Conclusion

The effect of various hormones on tomato indicated that GA3, NAA and 2,4-D at specific concentrations (GA3 at 30 ppm, NAA at 30 ppm and 2,4-D at 5 ppm) considerably increase the weight of fruit and length of fruit. GA3 significantly reduced the number of seeds per fruit but it increased the diameter of fruit. 2,4- D significantly number of seeds per fruits, but it enhanced the, TSS Hence, it can be concluded that the combined doses of GA3, NAA and 2,4-D at specific concentrations (GA3 at 30 ppm, NAA at 30 ppm and 2,4-D at 5 ppm) could be used to improve the quality and yield attributing characters of tomato. Seed weight (100 seed weight) of tomato was recorded highest under @5.0 ppm (312 mg) followed by @ 7.5 ppm (292 mg) agaist lowest under control (249 mg).

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