Effect of plant growth regulators on the growth, yield and quality of tomato (*Solanum lycopersicum* L.)

ABSTRACT

The present investigation entitled **Effect of plant growth regulators on the growth, yield and quality of tomato** (*Solanum lycopersicum* Cv. TMTH-234) was carried out at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during Kharif in- 2022-23. The experiment was laid out in a randomized block design with 19 treatments and three replications. Different plant growth regulators (PGRs) (NAA, GA_3, and IAA), were used in different combinations and doses. Among the various treatments significant results were showen by T_{18} (GA_3@90ppm + NAA@45ppm) best in terms of plant height (123.93 cm), days to first flowering (42.3 DAT), days to 50% flowering (49.83 DAT), days to the first harvest (85.63 DAT), number of flower cluster per plant (7.87), fruit set per cluster (8.07), polar diameter (63.13 mm), equatorial diameter (63.33 mm) , number of fruit per plant (17.27), individual fruit weight (112.63 g), average weight of 10 fruit (1126.33 g), average fruit yield per plant (1.95 Kg), total yield per plant (5.84 Kg), fruit yield per hectare (216.3 t), TSS (6.07°Brix) and ascorbic acid (20.3 mg/100g).

Keywords: *NAA,* GA_3 *, IAA, PGRs, TMTH-234.*

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae. It is a herbaceous perennial typically cultivated as an annual. It has sprawling stems, compound leaves, and yellow, star-shaped flowers. The fruit, a false fruit or berry, varies in shape, size, and color. Tomato plants have a fibrous root system, and their growth habits can be determinate or indeterminate. They follow a seasonal lifecycle and are treasured for their culinary versatility and nutritional value. It is a good source of vitamin A and vitamin C and minerals like calcium, potassium etc.**.** It also contains organic acids like citric acid, malic acid and acetic acid which are found in fresh tomato fruit. It promotes gastric secretion, acts as a blood purifier and works as an intestinal antiseptic. The nutritional value of red tomatoes (raw) per 100 g contains 18 kcal energy, 4.0 g carbohydrates, 2.6 g sugars, 1.0 g dietary fiber, 0.2 g fat, 1.0 g protein, 95 g water, 13 mg vitamin C. The antioxidant compounds present in tomatoes are lycopene, β carotene and ascorbic acid which protect against cancer and heart diseases **(Zhang *et al*.,2009).** (PGRs) are extensively used in horticultural crops to enhance plant growth and improve yield with increased fruit number, fruit set and size. PGRs help in both vegetative and reproductive growth. Although plant growth regulators have great potential for growth improvement, their application has to be planned sensibly in terms of optimal concentration, stage of application, species specificity and seasons.

2. MATERIALS AND METHODS

The present investigation was done to study the impact of combined application and sole application of plant growth regulators on the growth, yield and quality of tomatoes (*S. lycopersicum*). The investigation was carried out

at Horticultural Research Farm (HRF), Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during *Kharif* season in 2022. The experiment was conducted in factorial randomized block design with 19 treatments in three replications viz. **T0**: Control, **T1**:(NAA@20ppm), **T2**:(NAA@45ppm), **T3**:(IAA@30ppm), **T4**:(IAA@45ppm), **T5**:(GA3@60ppm), **T6**:(GA3@90ppm), **T7**:(NAA@30ppm+IAA@30ppm), **T8**:(NAA@30ppm+IAA@45ppm), **T9**:(NAA@45ppm+IAA@30ppm), **T10**:(NAA@45ppm+IAA@45ppm), **T11**:(IAA@30ppm+GA3@60ppm), **T12**:(IAA@30ppm+GA3@90ppm), **T13**:(IAA@45ppm+GA3@60ppm), **T14**:(IAA@45ppm+GA3@90ppm), **T15**:(GA3@60ppm+NAA@30ppm), **T16**:(GA3@60ppm+NAA@45ppm), **T17**:(GA3@90ppm+NAA@30ppm), **T18**:(GA3@90ppm+NAA@45ppm) with tomato hybrid TMTH-234 (Trimurti plant science pvt. Ltd.). The crop was transplanted with the spacing of 60cm X 45cm (RxP) The observation of randomly five selected plants from each plot was measured in cm by a 100 cm scale from ground level to tip of the shoot at 90 DAT stage. Observation were recorded at different stages of growth periods and studied for growth parameters like plant height (cm), days to first flowering, days to 50% flowering, days to first harvest, number of flower cluster per plant, fruit set per cluster, polar diameter (mm), equatorial diameter (mm), number of fruits per plant, individual fruit weight (g), average weight of 10 fruits (g), average fruit yield per plant (Kg), total yield per plant (Kg), fruit yield per hectare (tha^{-1}), T.S.S.(°Brix) and ascorbic acid (mg/100g).

3. RESULTS AND DISSCUSSIONS

3.1. Growth Parameters

3.1.1. Plant Height for 30 DAT, 60 DAT, 90 DAT and harvest (cm)

Analysis of plants showed a significant effect on plant height at 30, 60 and 90 DAT and harvest (cm). The maximum plant height (13.93 cm) at harvest stage was observed with treatment T_{18} (GA_3@90ppm + NAA@45ppm) and the minimum plant height (99.47 cm) was observed in T_0 (control) (Table:01). The foliar application and soil drenching have improved the soil physical and chemical properties and leading to the adequate supply of nutrients to the plants which promoted the maximum vegetative growth while the minimum plant growth was due to non-availability of nutrients. Similar findings were reported by **Meena *et al.* (2008) and Kumar *et al.* (2014).**

3.2. Earliness parameters

3.2.1. Days to first flowering (DAT), days to 50% flowering (DAT) and days to first harvest (DAT)

Analysis of the plants shows a significant effect on days to first flowering, days to 50% flowering and days to first harvest. Minimum days to first flowering, days to 50% flowering and days to first harvest was observed in T_{18} (GA_3@90ppm + NAA@45ppm) with 42.3 DAT, 49.83 DAT and 85.63 DAT respectively. While the maximum days to first flowering, days to 50% flowering and days to first harvest were recorded for T_0 (Control) with 52.6, 60.13 and 95.63 respectively (Table:02). This is due to the reaction of plants to bio-stimulant treatments depend on the flowering biology of the cultivars, particularly proportions of different flower phenotypes and their fertility. More intensive flower setting was elicited either by improved plant growth through seaweed extract application or by endogenous components, especially cytokinins, which enhance nutrient partitioning in vegetative plant organs and increase the transport to assimilate to the growing fruits. A similar

effect was observed for these findings are in conforming with the reports of **Tewari *et al.*,(2001) *and* Shital *et al.*, (2017).**

3.2.2. Number of flower clusters per plant and fruit set per cluster

A maximum number of flower clusters per plant was observed in T_{18} (GA_3@90ppm + NAA@45ppm) with 7.87 and 8.07 respectively while the minimum number of flower clusters per plant was recorded under T_0 (Control) with 1.27 and 2.07 respectively, shown in (Table:02). PGRs promote the initiation and development of flowers. Auxins, gibberellins, and ethylene-releasing compounds enhanced the flowering process in tomatoes. By influencing hormonal balance and signaling pathways, these PGRs facilitate flower bud formation and subsequent cluster development. Increased flower clusters often lead to a higher fruit set. By promoting flower cluster development and enhancing flower fertility, PGRs increase the number of fruits produced per plant. Similar findings were reported **by Bhosle *et al*., (2002) and Uddain *et al*., (2009).**

3.3. Yield parameters

3.3.1.Polar diameter (mm) and equatorial diameter (mm)

Maximum polar diameter and equatorial diameter were observed in T_{18} (GA_3@90ppm + NAA@45ppm) with 63.13mm and 63.33mm respectively While the minimum polar diameter and equatorial diameter were recorded under T_0 (Control) with 52.2 and 52.3 respectively (Table:03) The effects of (PGRs) on the polar and equatorial diameter of tomatoes can vary depending on factors such as the type of PGR used, concentration, timing, and tomato cultivar. PGRs like gibberellins can promote cell expansion and elongation, potentially leading to an increase in both polar and equatorial fruit diameter. PGRs involved in fruit setting and development, such as auxins can influence hormonal balances and signaling pathways that impact fruit growth. Similar findings were reported in **Prasad *et al*., (2013) and Ranjeet *et al*., (2014).**

3.3.2. Number of fruits per plant

A maximum number of fruits per plant was observed in T_{18} (GA_3@90ppm + NAA@45ppm) with 17.27 while the minimum number of fruits per plant was recorded under T_0 (Control) with 3.47 are shown in Table:03. PGRs played a role in optimizing pollination and fertilization processes in tomatoes. They can influence floral traits, attract pollinators, and enhance pollen viability and germination. By improving these aspects, PGRs can enhance the successful pollination and fertilization of flowers, leading to an increased number of fruits. Similar findings were recorded by **Naeem *et al*., (2001) and Yadav *et al*, (2001).**

3.3.3. Individual fruit weight (g) and Average weight of 10 fruits (g)

Maximum individual fruit weight and average weight of 10 fruits was observed in T_{18} (GA_3@90ppm + NAA@45ppm) with 112.63g and 1126.33g respectively while the minimum was recorded under T_0 (Control) with 90.4 g and 904g respectively(Table:03). PGRs promote cell division and elongation, leading to larger fruit size potentially increasing fruit weight. Similar findings were recorded by **Ujjwal *et al*., (2018) and Roy *et al*., (2011).**

3.3.4. Average fruit yield per plant (Kg), Total fruit yield per plant (Kg) and Fruit yield per hectare (t)

Maximum average fruit yield per plant was observed in T_{18} (GA_3@90ppm + NAA@45ppm) with 1.95Kg, 5.84Kg and 216.3t respectively while minimum was

recorded T_0 (Control) with 0.32 Kg, 0.95Kg and 35.18t respectively (Table:04). Gibberellic acid (GA3) promotes fruit set and vegetative growth, potentially increasing yield. Auxins improve fruit set and growth, contributing to higher yields. Ethylene-releasing compounds aid in uniform ripening, potentially boosting overall yield. Similar findings were reported in **Meena *et al*., (2008), Prasad *et al*., (2013) and Yadav *et al*., (2001).**

3.4. Qualitative parameters

3.4.1. Total Soluble Solid (^{0}Brix) and Ascorbic acid (mg/100g)

Maximum Total Soluble Solid was observed in T_{18} (GA_3@90ppm + NAA@45ppm) and ascorbic acid with 6.07 ^{0}Brix and 20.3 respectively while Total Soluble Solid was recorded under T_0 (Control) with 1.03 ^{0}Brix and 12.37 respectively (Table:04). The use of Plant Growth Regulators (PGRs) significantly impacted the quality of tomato fruits. It has the potential to influence various attributes that contribute to the overall fruit quality. By promoting cell division and elongation, certain PGRs like gibberellins can result in larger tomato fruits. This can be advantageous for specific tomato varieties or market preferences that prioritize larger-sized fruits. PGRs also influenced fruit color development and ripening. Ethylene-releasing PGRs play a crucial role in accelerating the ripening process and improving fruit color. This can lead to more visually appealing tomatoes, enhancing their marketability and consumer appeal. Similar findings were reported by **Naeem *et al*., (2008), Tomar *et al*., (2017) and Ranjeet *et al*., (2014).**

4. CONCLUSION

It is concluded that T_{18} (GA_3@90ppm + NAA@45ppm) was best in terms of plant height, days to first flowering, days to 50% flowering, days to first harvest, number of flower cluster per plant, fruit set per cluster, polar diameter, equatorial diameter, number of fruits per plant, individual fruit weight, the average weight of 10 fruits, the average fruit yield per plant, total yield per plant, fruit yield per hectare, TSS and ascorbic acid.

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TABLE 1: Plant height (cm) at 30 DAT, 60 DAT, 90 DAT and at harvest.

Treatment Notation	Treatment Details	Plant height [30 DAT]	Plant height [60 DAT]	Plant height [90 DAT]	Plant height [At Harvest]
T_0	CONTROL	30.87	60.37	90.80	99.47
T_1	NAA@30 ppm	34.20	62.50	92.93	101.60
T_2	NAA@45 ppm	32.00	61.50	91.93	100.60
T_3	IAA @30 ppm	34.47	63.23	93.67	102.33
T_4	IAA@45 ppm	36.00	63.87	94.30	102.97
T_5	GA_3@ 60 ppm	36.27	64.77	95.20	103.87
T_6	GA_3@90 ppm	36.60	65.87	96.30	104.97
T_7	NAA@30ppm + IAA@30ppm	37.33	67.50	97.93	106.60
T_8	NAA@30ppm + IAA@45ppm	37.40	68.90	99.33	108.00
T_9	NAA@45ppm + IAA@30ppm	37.73	69.77	100.20	108.87
T_{10}	NAA@45ppm + IAA@45ppm	37.80	71.93	102.37	111.03
T_{11}	IAA@30ppm +GA_3@60ppm	38.00	73.33	103.77	112.43
T_{12}	IAA@30ppm +GA_3@90ppm	38.87	77.33	107.77	116.43
T_{13}	IAA@45ppm +GA_3@60ppm	38.80	75.77	106.20	114.87
T_{14}	IAA@45ppm +GA_3@90ppm	38.20	74.53	104.97	113.63
T_{15}	GA_3@60ppm + NAA@30ppm	39.07	78.40	108.83	117.50
T_{16}	GA_3@60ppm + NAA@45ppm	39.50	80.37	110.80	119.47
T_{17}	GA_3@90ppm + NAA@30ppm	39.07	82.67	113.10	121.77
T_{18}	GA_3@90ppm + NAA@45ppm	42.13	84.83	115.27	123.93
F- TEST		**S**	**S**	**S**	**S**
S.E. (d) ±		**1.29**	**0.25**	**0.27**	**0.26**
C.D. $_{0.05}$		**2.63**	**0.51**	**0.53**	**0.52**
C.V.		**4.27**	**0.43**	**0.31**	**0.28**

TABLE 2: Days to first flowering (DAT), days to 50% flowering (DAT), days to first harvest (DAT), number of flower cluster per plant and fruit set per cluster.

Treatment Notation	Treatment Details	Days to first flowering	Days to 50% flowering	Days to first harvest	Number of flower cluster per plant	Fruit set per cluster
T_0	CONTROL	52.60	60.13	95.93	1.27	2.07
T_1	NAA@30 ppm	51.00	58.53	94.33	2.53	2.87
T_2	NAA@45 ppm	51.77	59.30	95.10	2.13	2.50
T_3	IAA @30 ppm	50.23	57.77	93.57	2.87	3.13
T_4	IAA@45 ppm	49.67	57.20	93.00	3.13	3.43
T_5	GA_3@ 60 ppm	49.13	56.67	92.47	3.47	3.77
T_6	GA_3@90 ppm	48.57	56.10	91.90	3.80	4.13
T_7	NAA@30ppm + IAA@30ppm	48.07	55.60	91.40	4.13	4.57
T_8	NAA@30ppm + IAA@45ppm	47.53	55.07	90.87	4.43	4.80
T_9	NAA@45ppm + IAA@30ppm	47.13	54.67	90.47	4.87	5.13
T_{10}	NAA@45ppm + IAA@45ppm	46.67	54.20	90.00	5.40	5.53
T_{11}	IAA@30ppm +GA_3@60ppm	46.13	53.67	89.47	5.73	5.80
T_{12}	IAA@30ppm +GA_3@90ppm	44.73	52.27	88.07	6.77	6.73
T_{13}	IAA@45ppm +GA_3@60ppm	45.3	52.83	88.63	6.43	6.40
T_{14}	IAA@45ppm +GA_3@90ppm	45.73	53.27	89.07	6.07	6.13
T_{15}	GA_3@60ppm + NAA@30ppm	44.37	51.90	87.70	7.13	7.13
T_{16}	GA_3@60ppm + NAA@45ppm	43.63	51.17	86.97	7.40	7.43
T_{17}	GA_3@90ppm + NAA@30ppm	43.00	50.53	86.33	7.53	7.67
T_{18}	GA_3@90ppm + NAA@45ppm	42.30	49.83	85.63	7.87	8.07
F- TEST		**S**	**S**	**S**	**S**	**S**
S.E. (d) ±		**0.13**	**0.15**	**0.15**	**0.07**	**0.06**
C.D. $_{0.05}$		**0.26**	**0.26**	**0.27**	**0.14**	**0.12**
C.V.		**0.33**	**0.29**	**0.18**	**1.69**	**1.45**

TABLE 3: Polar diameter (mm), Equatorial diameter (mm), Number of fruits per plant, Individual fruit weight (g) and Average weight of 10 fruits (g)

Treatment Notation	Treatment Details	Polar Diameter	Equatorial Diameter	Number of fruits per plant	Individual fruit weight	Average weight of 10 fruits
T_0	CONTROL	52.20	52.20	3.47	90.40	904.00
T_1	NAA@30 ppm	54.53	54.53	5.33	93.20	932.00
T_2	NAA@45 ppm	53.63	53.63	4.70	92.37	923.67
T_3	IAA @30 ppm	54.87	54.87	5.73	94.13	941.33
T_4	IAA@45 ppm	55.33	55.33	6.33	95.20	952.00
T_5	GA_3@ 60 ppm	55.73	55.73	6.87	96.23	962.33
T_6	GA_3@90 ppm	56.13	56.13	7.43	98.07	980.67
T_7	NAA@30ppm + IAA@30ppm	56.80	56.80	8.27	98.60	986.00
T_8	NAA@30ppm + IAA@45ppm	57.13	57.13	8.93	99.37	993.67
T_9	NAA@45ppm + IAA@30ppm	57.53	57.53	9.73	99.87	998.67
T_{10}	NAA@45ppm + IAA@45ppm	58.13	58.13	10.40	100.47	1004.67
T_{11}	IAA@30ppm +GA_3@60ppm	58.60	58.60	11.20	101.33	1013.33
T_{12}	IAA@30ppm +GA_3@90ppm	61.13	60.93	14.33	105.13	1051.33
T_{13}	IAA@45ppm +GA_3@60ppm	60.60	60.30	13.07	103.47	1034.67
T_{14}	IAA@45ppm +GA_3@90ppm	60.13	59.13	12.10	102.57	1025.67
T_{15}	GA_3@60ppm + NAA@30ppm	61.53	61.53	15.20	107.57	1075.67
T_{16}	GA_3@60ppm + NAA@45ppm	62.13	62.13	15.93	108.50	1085.00
T_{17}	GA_3@90ppm + NAA@30ppm	62.53	62.53	16.70	110.07	1100.67
T_{18}	GA_3@90ppm + NAA@45ppm	63.13	63.33	17.27	112.63	1126.33
F- TEST		**S**	**S**	**S**	**S**	**S**
S.E. (d) ±		**0.08**	**0.09**	**0.13**	**0.08**	**0.13**
C.D. $_{0.05}$		**0.16**	**0.19**	**0.26**	**0.16**	**0.27**
C.V.		**0.14**	**0.16**	**1.51**	**0.14**	**0.16**

TABLE 4: Average fruit yield per plant (Kg), Total fruit yield per plant (Kg), Fruit yield per hectare (t), Total Soluble Solid (^{0}Brix) and Ascorbic acid (mg/100g).

Treatment Notation	Treatment Details	Average fruit yield per plant	Total fruit yield per plant	Fruit yield per hectare	Total Soluble Solid	Ascorbic acid
T_0	CONTROL	0.32	0.95	35.18	1.03	12.37
T_1	NAA@30 ppm	0.50	1.49	55.19	1.57	13.37
T_2	NAA@45 ppm	0.43	1.29	47.78	1.33	12.87
T_3	IAA @30 ppm	0.54	1.63	60.37	1.77	13.73
T_4	IAA@45 ppm	0.60	1.81	67.04	2.07	14.13
T_5	GA_3@ 60 ppm	0.66	1.98	73.33	2.20	14.57
T_6	GA_3@90 ppm	0.73	2.20	81.48	2.47	14.87
T_7	NAA@30ppm + IAA@30ppm	0.82	2.45	90.74	2.87	15.47
T_8	NAA@30ppm + IAA@45ppm	0.89	2.66	98.52	3.30	15.87
T_9	NAA@45ppm + IAA@30ppm	0.97	2.92	108.15	3.63	16.27
T_{10}	NAA@45ppm + IAA@45ppm	1.05	3.14	116.30	3.80	16.67
T_{11}	IAA@30ppm +GA_3@60ppm	1.14	3.41	126.30	4.07	17.13
T_{12}	IAA@30ppm +GA_3@90ppm	1.51	4.52	167.41	4.73	18.33
T_{13}	IAA@45ppm +GA_3@60ppm	1.35	4.06	150.37	4.47	17.87
T_{14}	IAA@45ppm +GA_3@90ppm	1.24	3.72	137.78	4.23	17.53
T_{15}	GA_3@60ppm + NAA@30ppm	1.63	4.90	181.48	5.13	18.87
T_{16}	GA_3@60ppm + NAA@45ppm	1.73	5.19	192.22	5.43	19.30
T_{17}	GA_3@90ppm + NAA@30ppm	1.84	5.52	204.45	5.63	19.63
T_{18}	GA_3@90ppm + NAA@45ppm	1.95	5.84	216.30	6.07	20.30
F- TEST		S	S	S	**S**	**S**
S.E. (d) ±		0.01	0.04	1.47	**0.05**	**0.08**
C.D. $_{0.05}$		0.03	0.08	2.99	**0.11**	**0.17**
C.V.		1.55	1.55	1.55	**1.87**	**0.61**