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Effect of Plant Growth Regulator (GA3 and NAA) on Growth, Yield and Quality of Tomato (*Solanum lycopersicum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A trial was conducted at the Vegetable Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences,Prayagraj (UP) during 2022. This study investigates the "Effect of Plant Growth Regulators (GA_3 and NAA) on growth, yield and quality of Tomato (*Solanum Lycopersicum* L.)." The purpose of the study is to evaluate the plants in terms of various parameters such as plant height, survival percentage, days to first flowering, days to 50% flowering, number of flower clusters per plant, number of fruit set per cluster, number of fruits per plant, fruit weight, fruit yield per plant, fruit yield per hectare, total soluble solids (TSS), ascorbic acid, and benefit-cost ratio. The results of thestudy indicate that the application of increased percentage of NAA and GA3 significantly improvedthe growth and yield tomatoes. The highest fruit yield, fruit weight, TSS, and ascorbic acid contentwere observed in the plants treated with GA_3 @60ppm + NAA @60ppm. The benefit- cost ratio wasalso found to be

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higher in the treated plants compared to the control. Overall, the study suggests thatthe application of GA_3 @60ppm + NAA @60ppm can be an effective and sustainable method for enhancing the growth, yield, and quality of Tomatoes.

Keywords: Tomato; GA3; NAA; TSS.

1. INTRODUCTION

"Tomato, botanically known as *Solanum lycopersicum* L. or *Lycopersicon esculentum* Mill. is one of the most popular and widely grown vegetable crops throughout the world and treated as "protective food" universally. It is rich source of vitamins, vegetable protein and minerals and holds a glorious position among vegetable after the potato and sweet potato. Tomato known as poor man's apple (orange) in India & love of apple in England. Tomato is used as soup, salad, pickles, ketchup, puree, sauces, tomato paste, tomato juice and other products. The pulp and juice of tomato fruit are digestible and a mild aperient, a promoter of gastric secretion and a blood purifier" [1].

"Tomatoes are horticulture crop belongs to the family *Solanaceae* bearing chromosome number 2n=2X=24" (Karpechenko, 1925). "It originated from South America" (Vavilov, 1935). "The tomato plants typically grow to 1–3 meters (3–10 ft) in height and have a weak stem that often sprawls over the ground and vines over other plants. Flowers are generally borne in clusters of 4 to 8 but small fruited types may have 30 to 50 flowers per cluster. Tomato plants are dicots, and grow as a series of branching stems, with a terminal bud at the tip that does the actual growing" (Vavilov, 1935). "Tomato plays a major role in human nutrition, fruit contain 93.1% water, 1.9% protein, 0.3 g fat, 0.7% fibre, 3.6%carbohydrates, 23 calorie, 320 I.U vitamin A., 0.07 mg vitamin B1, 0.01 mg vitamin B2, 31 mg vitamin C, 20 mg calcium, 36 mg phosphorus and 0.8 mg iron. Tomato has valuable vitamins and cholesterol. Approximately 20–50 mg of lycopene per 100g of fruit weight can be obtained from tomato. Tomato is a warm season crop. The best fruit colour and quality is obtained at a temperature range of 21-24°C. Tomato is one of the versatile crop in the world because of its fast and wide climate adaption and it is universally treated as protective food. Tomato contributes to a healthy and well balanced-diet. They are rich in minerals, vitamins, essential amino acids, sugars, dietary fibres and it has many other uses tomato seed contain 24% of oil is used as salad oil and in the manufacture of margarine" [1,2-5].

2. MATERIALS AND METHODS

Soil samples were drawn randomly before commencement of the experiment from each replication of the experimental plots from a depth of 0-30 cm and a composite sample was prepared and analysed for physico- chemical properties of the soil viz. pH, electrical conductivity (EC), organic carbon, available nitrogen, available phosphorus and available potassium. Soil samples were analysed at Krishi Vigyan Kendra, SHUATS, Prayagraj.

During 2022-2023 different combination of plant growth regulator are applied and the observation were recorded at different stage.

3 .TREATMENT COMBINATION

Table 1. Treatment combination

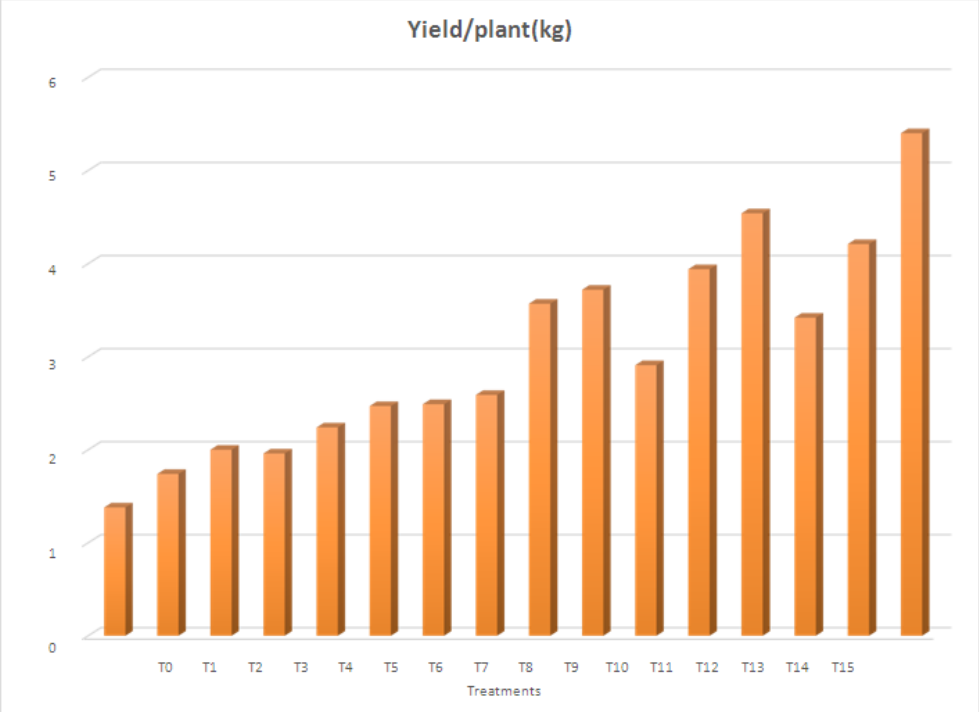
Treatment no.	Treatment details
T0	CONTROL
T1	GA3@20PPM
T2	NAA@20PPM
T3	GA3@40PPM
T4	NAA@40PPM
T5	GA3@60PPM
T6	NAA@60PPM
T7	GA3@20PPM+NAA@20PPM
T8	GA3@20PPM+NAA@40PPM
T9	GA3@20PPM+NAA@60PPM
T10	GA3@40PPM+NAA@20PPM
T11	GA3@40PPM+NAA@40PPM
T12	GA3@40PPM+NAA@60PPM
T13	GA3@60PPM+NAA@20PPM
T14	GA3@60PPM+NAA@40PPM
T15	GA3@60PPM+NAA@60PPM

Table 2. Performance table of different treatment combination PGR (GA3 and NAA) on growth and earliness parameters

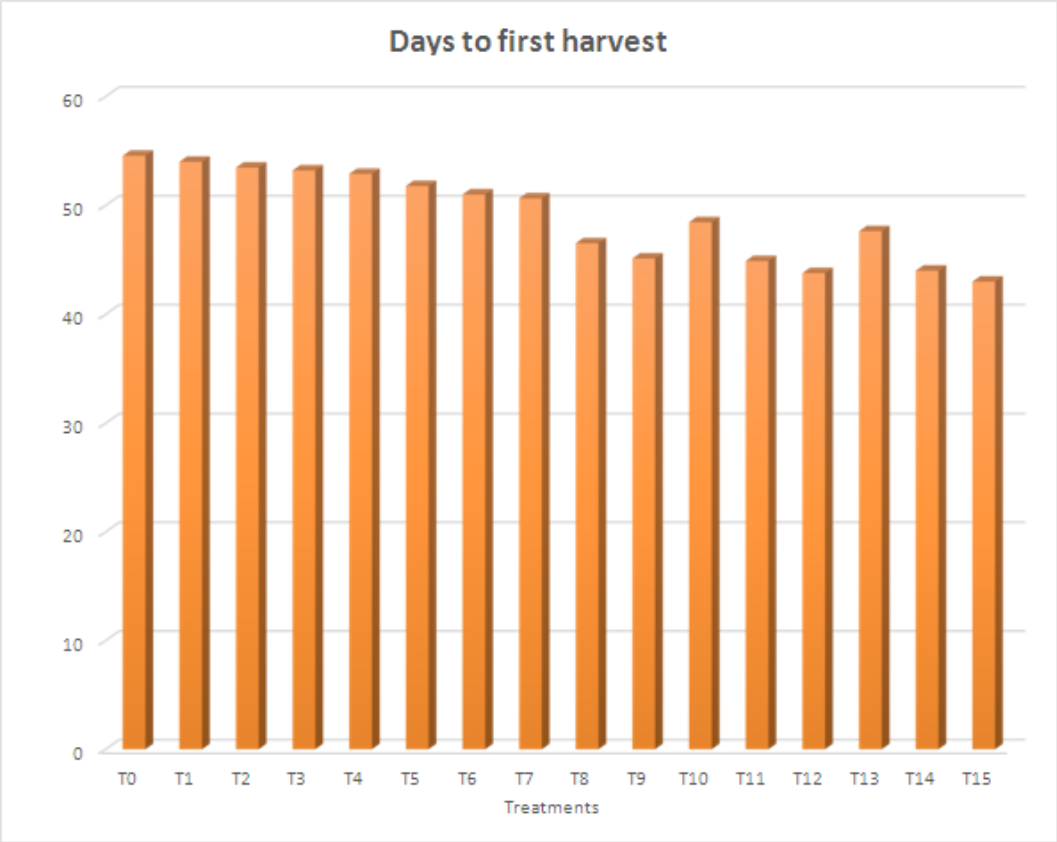
Treatment no.	Treatment details	Plant height 90dat	Survival %	days to 1st floweing	Days to 50% flowering	Days to 1st harvesting
T0	Control	84.67	93	35.76	47.87	54.56
T1	GA3@20PPM	85.32	93.67	35	47	54
T2	NAA@20PPM	86.79	94.11	34.34	46.52	53.47
T3	GA3@40PPM	87.21	94.32	34.56	45.92	53.21
T4	NAA@40PPM	87.97	95	33.89	45.52	52.89
T5	GA3@60PPM	88.78	95.23	33.12	44.32	51.78
T6	NAA@60PPM	90.587	95.54	32.78	44.11	51
T7	GA3@20PPM+NAA@20PPM	92.327	96	32.56	43.56	50.65
T8	GA3@20PPM+NAA@40PPM	95.597	97.21	28.56	40.67	46.52
T9	GA3@20PPM+NAA@60PPM	96.037	97.56	27.76	40.12	45.12
T10	GA3@40PPM+NAA@20PPM	95.157	96.21	30.54	42.56	48.45
T11	GA3@40PPM+NAA@40PPM	96.893	98.32	27.27	40.32	44.89
T12	GA3@40PPM+NAA@60PPM	99.88	99.4	26	37.45	43.78
T13	GA3@60PPM+NAA@20PPM	95.363	96.67	29.87	41.44	47.63
T14	GA3@60PPM+NAA@40PPM	98.917	98.4	26.37	39.36	44
T15	GA3@60PPM+NAA@60PPM	100.253	99.68	25.54	36.21	43
F.test		S	S	S	S	S
S.E(d)		0.74	1.392	1.002	1.002	1.002
C.D 0.05		2.15	2.856	2.057	2.057	2.057
C.V		1.3	1.812	3.841	3.124	2.542

Table 3. Performance table on different treatment combination on PGR (GA_3 and NAA) on yield parameters

Treatment no.	Treatment details.	No.of flower cluster/plant	No. of fruit set	No.of fruit /plant	Average fruit weight(g)	Fruit yield/kg	Fruit yield/ha.	Polar diameter (mm)	Equatorial diameter (mm)
T0	Control	4.87	3.11	15.15	91.22	1.38	30.67	69.51	72.51
T1	GA3@20PPM	5	3.89	19.45	89.34	1.74	38.67	68.71	70.71
T2	NAA@20PPM	6.21	3.65	22.67	88.43	2	44.44	66.21	68.21
T3	GA3@40PPM	5.45	4.1	22.35	87.54	1.96	43.56	64.32	66.32
T4	NAA@40PPM	5.98	4.35	26.01	86.21	2.24	49.78	65.31	67.31
T5	GA3@60PPM	6.11	4.76	29.08	85.11	2.47	54.89	67.56	69.56
T6	NAA@60PPM	6	4.93	29.58	84.12	2.49	55.33	64.12	66.12
T7	GA3@20PPM+NAA@20PPM	6.21	5	31.05	83.32	2.59	57.55	66.34	68.34
T8	GA3@20PPM+NAA@40PPM	7.67	5.79	44.41	80.45	3.57	79.33	61.1	63.1
T9	GA3@20PPM+NAA@60PPM	8	5.81	46.48	80	3.72	82.67	60.23	62.23
T10	GA3@40PPM+NAA@20PPM	6.76	5.23	35.35	82.34	2.91	64.67	65.37	67.37
T11	GA3@40PPM+NAA@40PPM	8.12	6.11	49.61	79.32	3.94	87.55	59.65	61.65
T12	GA3@40PPM+NAA@60PPM	9	6.44	57.96	78.34	4.54	100.89	58.87	60.87
T13	GA3@60PPM+NAA@20PPM	7.54	5.58	42.07	81.34	3.42	76	64.89	66.89
T14	GA3@60PPM+NAA@40PPM	8.43	6.32	53.28	79	4.21	93.55	59.32	61.32
T15	GA3@60PPM+NAA@60PPM	9.89	7	69.03	78	5.4	120	58.98	60.98
F.test		S	S	S	S	S	S	S	S
S.E(d)		0.17	0.436	2.119	1.055	0.185	4.11	1.186	0.641
CD 0.05		0.348	0.15	4.35	2.166	0.379	8.433	2.434	1.316
C.V		2.992	0.213	4.544	1.55	4.715	4.715	2.22	1.157



Graph 1. Effect of foliar application of GA3 and NAA on fruit yield per plant of tomato



Graph 2. Effect of foliar application of GA3 and NAA on Days to 1st harvesting

Fig. 1. Fruit per plant

Fig. 2. Production scenario

4. RESULTS AND DISCUSSION

4.1 Growth Parameters

4.1.1 Plant height (cm) 90DAT

The height of plant significantly varied among different treatment combinations. The maximum plant height (100.25cm) at 90 DAT was observed with T15 (GA_3@60ppm + NAA@60ppm) followed by T12 (GA_3 @40ppm + NAA @60ppm) with 99.88cm. Minimum plant height (84.67cm) was observed in T0 (Control), while the remaining treatments are moderatein their growth habitat [6,7].

4.1.2 Survival percentage

Survival percentage of plant significantly varied among different treatment combinations. Themaximum survival percentage (99.68%) were observed with T15 (GA_3 @60ppm + NAA @60ppm) followed by T12 (GA_3 @40ppm + NAA@60ppm) with 99.40%. Minimum survivalpercentage (93%) was observed in T0 (Control), while the remaining treatments are moderatein their growth habitate [8,9].

4.2 Yield Parameter

4.2.1 Days to 1st flowering

Days to 1st Flowering of plant significantly varied among different treatment combinations.The minimum days to 1st flowering (25.54) were observed with T15 (GA_3 @60ppm + NAA @60ppm) followed by T12 (GA_3 @40ppm + NAA @60ppm) with 26.00. Maximum days to1st flowering (35.76) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat. Similar results have also been reported by Singh and Tiwari (2013), Dixit et al. (2018) and Singh et al. [3].

4.2.2 Days to 50% flowering

Days to 50% flowering of plant significantly varied among different treatment combinations.The minimum days to 50% flowering (36.21) were observed with T15 (GA_3 @60ppm + NAA@60ppm) followed by T12 (GA_3 @40ppm + NAA @60ppm) with 37.45. Maximum days to 50% flowering (47.87) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat. Similar results have also been reported by Singh and Tiwari (2013), Dixit *et al.* (2018) and Singh et al. [3].

4.2.3 Days to first harvesting

Days to 50% flowering of plant significantly varied among different treatment combinations. The minimum days to 50% flowering (43.00) were observed with T15 (GA_3 @60ppm + NAA@60ppm) followed by T12 (GA_3 @40ppm + NAA @60ppm) with 43.78. Maximum days to 50% flowering (54.56) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat. Similar results have also been reported by Singh and Tiwari (2013), Dixit et al. (2018) and Singh et al. [3].

4.2.4 Number of flower clusters per plant

Number of clusters per plant of plant significantly varied among different treatment combinations. The maximum number of clusters per plant (9.89) were observed with T15 (GA_3@60ppm + NAA @60ppm) followed by T12 (GA_3 @40ppm + NAA @60ppm) with 9.00. Minimum number of clusters per plant (4.87) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat. These results are in close conformity with the findings of Basavarajeshwari et al. (2008); Saravaiya et al. (2014); Kumar et al. (2016); Reddy et al. (2018) and Shnain et al. (2021)

4.2.5 Number of fruit set per cluster

Number of fruit set per cluster of plant significantly varied among different treatmentcombinations. The maximum number of fruit set per cluster (7.00) were observed with T15 (GA_3 @60ppm + NAA @60ppm) followed by T12 (GA_3 @40ppm + NAA @60ppm) with 6.44. Minimum number of fruit set per cluster (3.11) was observed in T0 (Control), while theremaining treatments are moderate in their growth habitat. Similar findings were reported by Kazemi et al. (2013); Sivaiah et al. (2013); Pandiyan et al. (2018); Swetha et al. (2018) in tomato.

4.2.6 Number of fruits per plant

Number of fruits per plant of plant significantly varied among different treatment combinations. The maximum number of fruits per plant (69.23) were observed with T15 (GA_3@60ppm + NAA @60ppm) followed by T12 (GA_3 @40ppm + NAA @60ppm) with 57.96. Minimum number of fruits per plant (15.15) was observed in T0 (Control), while theremaining treatments are moderate in their growth habitat. Similar findings were reported by Sathyamurthy et al. (2017); Reddy et al. (2018); Singh et al. [3] in tomato.

4.2.7 Fruit weight (g)

Fruit weight of plant significantly varied among different treatment combinations. Themaximum fruit weight (91.22) was observed with T0 (Control) followed by T1 (GA_3 @20ppm)with 89.34. Minimum fruit weight (78.00) was observed in T15 (GA_3@60ppm+NAA@60ppm), while the remaining treatments are moderate in their growth habitat. PGRs play an important role in improving productivity and quality of Tomato. Added dose of GA3 and NAA increased the vigor of plants, assimilating area, size of fruit, thereby resulting into higher weight of fruit. These results are in close conformity with the findings of Ali et al. (2015); Haleema et al. (2017); Satyamurthy et al. (2017); Pandiyan et al. (2018); Singh et al. [3] and Shnain et al. (2021) as reported in tomato.

4.2.8 Fruit yield per plant (kg)

Fruit yield per plant significantly varied among different treatment combinations. The maximum fruit yield (5.40) was observed with T15 (GA3 @60ppm + NAA @60ppm) followedby T12 (GA_3 @40ppm + NAA @60ppm) with 4.54. Minimum fruit yield per plant (1.38) wasobserved in T0 (Control), while the remaining treatments are moderate in their growth habitat.

PGRs play an important role in improving productivity and quality of Tomato. Added dose of GA3 and NAA increased the vigour of plants, assimilating area, size of fruit, thereby resulting into higher weight of fruit. These results are in close conformity with the findings of Sivaiah et al. (2013); Ali et al. (2015); Haleema et al. (2017); Satyamurthy et al. (2017);Pandiyan et al. (2018); Singh et al. [3] and Shnain et al. (2021) as reported in tomato.

4.2.9 Fruit yield per hectare (tonn/ha)

Fruit yield per hectare significantly varied among different treatment combinations. The maximum fruit yield per hectare (120.00) was observed with T15 (GA_3 @60ppm + NAA @60ppm) followed by T12 (GA_3 @40ppm + NAA @60ppm) with 100.89. Minimum fruit yield per hectare (30.67) was observed in T0 (Control), while the remaining treatments are moderate in their growth habitat [10].

4.2.10 Polar diameter (mm)

Polar diameter significantly varied among different treatment combinations. The maximum fruit girth (69.51) was observed with T0 (Control) followed by T1 (GA_3@20ppm) with 68.71. Minimum polar diameter (58.98) was observed in T15 (GA_3@60ppm+NAA@60ppm), while the remaining treatments are moderate in their growth habitat [11].

4.2.11 Equatorial diameter (mm)

Equatorial diameter significantly varied among different treatment combinations. The maximum equatorial diameter (72.51) was observed T0 (Control) followed by T1 (GA_3@20ppm) with

70.71. Minimum polar diameter (60.98) was observed in T15 (GA_3@60ppm+NAA@60ppm), while the remaining treatments are moderate in their growthhabitat.

5. CONCLUSION

From the above experimental finding, it may be concluded that the treatment, T15 (GA_3 @60ppm + NAA @60ppm) was found to be best in terms of growth, yield and quality. Highestnet return and benefit-cost ratio was found in the same treatments T15 (GA_3 @60ppm + NAA @60ppm).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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