



# Effect of Plant Growth Regulators on Growth and Yield of Tomato (*Solanum lycopersicum* L.) Cv. MAHY 701 under Agroclimatic Conditions of Bhubaneswar

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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

Exogenous application of plant growth regulators play a vital role on effectively enhancing plant growth along with crop output. In order to determine the effect of plant growth regulators and the ideal concentration of GA<sub>3</sub> and NAA for improved tomato growth and yield (*Solanum lycopersicum*

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L.) cv. MAHY-701 under Bhubaneswar condition, a field experiment was conducted in Rabi 2022 at Agricultural Research Station, Binjhagiri, Institute of Agricultural Sciences, Siksha "O" Anusandhan (Deemed to be) University, Bhubaneswar, Odisha using plant growth regulators, namely GA<sub>3</sub> and NAA. The experimental design was randomized block design, which consisted of three replications and seven treatments. When compared to the control treatment, all growth, yield, and quality parameters were shown to be significantly better at various concentrations of GA<sub>3</sub> (30, 60, and 90 ppm) and NAA (25, 50, and 75 ppm). The findings of the investigation reinforce the claim that, as compared to the control, tomato growth and yield were considerably affected by both GA<sub>3</sub> and NAA. The results categorically demonstrated that the treatment where the plant was sprayed with GA<sub>3</sub> @ 90 ppm had the highest total soluble solids (4.33°Brix), acidity (0.42%), and shelf life (18.73), as well as the highest number of fruits per plant (42.90), fruit length (6.40cm), fruit diameter (6.80cm), weight of fruit (118.80g), yield per plot (31.70kg), yield per ha. (423.50qt), and other quality attributes. In conclusion, farmers may be suggested to apply GA<sub>3</sub> at 90 ppm and NAA at 50 ppm when raising tomatoes in Bhubaneswar Agroclimatic environments for MAHY-701.

**Keywords:** *Solanum lycopersicum*; tomato; fruit weight; fruit yield; TSS; acidity; plant growth regulators; GA<sub>3</sub>; NAA.

## 1. INTRODUCTION

As a preventive food, vegetables are the most essential part of a balanced diet. India is the world's second-largest producer of vegetables, behind China, and holds a prominent position in this regard. India's diverse agroclimatic conditions allow for the year-round cultivation of a large range of vegetable crops. As a valuable supply of carbohydrates, proteins, vitamins, minerals, element salts, and crude fibers, vegetables are crucial to a balanced diet. A 300g daily intake of vegetables (125g of leafy vegetables, 100g of root and tuber vegetables, and 75g of other vegetables) is what dieticians recommend for an adult to maintain good health. But in India, the average person consumes only 175 g of veggies per day, which is far less than the suggested amount.

Tomato, which places second behind potato among vegetables, is one of the most cultivated and well-liked crops worldwide. Soup, juice, ketchup, puree, paste, and powder are all made with a lot of tomatoes. Tomatoes are widely used in pickles because they are exceptionally high in vitamin C and give food a range of colours and flavours. Green tomatoes are also used in pickles. Because of its abundance in lycopene, in addition to other minerals and vitamins like β-carotene and ascorbic acid, which are antioxidants and support good health, tomatoes perform a vital role in human nutrition. The tomato has a great medicinal significance since its pulp and juice are mildly noticeable, easily digested, promote gastric secretion, detoxify blood, and are believed to have antiseptic properties for the intestines. It is beneficial for

persistent dyspepsia and activates the torpid liver. It is one of the important veggies that maintains the wellness of our intestines and stomach. Within every 100 grams of fruit pulp, tomato fruit contains 93.1 g of water, 1.9 g of protein, 0.1 g of fat, 3.6 g of carbohydrates, 0.6 g of mineral matter, 20 mg of calcium, 36 mg of phosphorus, 0.3 mg of iron, 320 IU of carotene (vitamin A), 2.27 mg of thiamine, 0.4 mg of nicotinic acid, 0.01 mg of riboflavin, and 31 mg of ascorbic acid. It also includes inhibitors linked to pantothenic acid, biotin, vitamin K, folic acid, and biotin.

An organic substance, either manufactured or natural, a growth regulator alters or regulates one or more particular physiological processes in a plant, while it's sites of action and synthesis are distinct. Plant growth regulators include both naturally occurring plant hormones and hormones produced in a lab. In comparison to plants' needs for minerals and vitamins, the concentration of hormones needed for plant response is extremely low. Plant hormones are more widely distributed and not often locally synthesized within the plant. Plant hormones are compounds, not nutrients, that in limited amounts impact and promote the division, growth, and development of cells and tissues.

Gibberellic Acid (GA<sub>3</sub>) and Naphthalene Acetic Acid (NAA) are two growth promoters that are particularly effective at enhancing vegetable crop output and plant growth. One of the key compounds that stimulates cell division and elongation, aiding in the growth and development of several plants, is GA<sub>3</sub>. NAA influences

physiological functions, accelerates fruit ripening, and enhances fruit quality. Numerous chemical and cultural methods are used to boost crop yields. Numerous experts have stressed the use of plant growth regulators to increase the quantity and quality of numerous vegetable crops [1,2]. Nonetheless, the concentration of the plant growth regulator and the timing of administration are the primary determinants of improved crop output and quality. Indole-3-acetic acid (IAA), a significant auxin generated by plants, is an important hormone. Apical dominance, root initiation and development, parthenocarp, inhibition of the abscission layer, and blooming are among the functions of auxin. Essential plant hormones known as cytokinins (CKs) are identified to play an essential part in controlling a number of characteristics of plant growth and development, such as cell division, senescence of leaves, lateral stem and root conformation, stress tolerance etc. The most frequently used growth regulators are GA<sub>3</sub>, NAA, 4 - CPA, 2, 4-D. However, there are significant differences in the crop's improvement based on the type of growth regulators used, concentration, time and method of application.

## 2. MATERIALS AND METHODS

The experiment "Effect of plant growth regulators on growth and yield of tomato (*Solanum lycopersicum* L.)" was conducted at Institution of Agricultural Sciences, Siksha "O" Anusandhan (Deemed to be) University, Bhubaneswar, Situated at 73 km away from the Bay of Bengal at an altitude of 25.5m above mean sea level (MSL). Geographically, it is located at latitude 20.23° North and longitude 85.67° East. The study site is located 25.5 meters above mean sea level (MSL) in latitude 20°25' N and longitude 85°67' E. The distance to the Bay of Bengal is roughly 73 kilometers. Bhubaneswar is located in the Eastern Coastal Plain Agro Ecological Region, which is part of the state's East and South Eastern Coastal Plain Agroclimatic Zone. The cropping season's mean weekly maximum and mean weekly minimum temperatures were found to be 28.37°C and 17.22°C, respectively, based on weather data. During the cropping season, the maximum (95%) relative humidity was observed in the month of February and minimum (47%) was observed in the month of January. The experiment was conducted at its optimum concentration to standardize the best growth regulator for better growth and yield of tomato with seven treatments in RBD (Randomized Block Design) method with three

replications on tomato variety MAHY 701. Seedling of 20-25 days were transplanted during afternoon hours of 16<sup>th</sup> November 2021 at a spacing of 50 x 50cm. A total of 9 treatments using three different concentration of each growth regulator i.e. GA<sub>3</sub> @ 30 ppm, 60 ppm and 90 ppm & NAA @ 25 ppm, 50 ppm, 75 ppm were used in the study. A total fifteen distinguishing parameters namely plant height, plant girth, number of branches, number of leaves, number of flowers per plant, leaf area, number of fruits per plant, fruit length, fruit diameter, fruit weight, yield per plot, yield per hectare, total soluble solids, acidity and shelf life were taken during the experiment procedure.

## 3. RESULTS AND DISCUSSION

### 3.1 Growth Characters

The table showed that the application of GA<sub>3</sub> and NAA resulted in a substantial increase in plant height. The highest plant height of 72.90 cm was observed with the application of GA<sub>3</sub> @ 90 ppm and the next greatest height was 70.50 cm with NAA @ 50 ppm. This may be because developing cells elongate and divide quickly, stimulating RNA and promoting improved growth and development. These findings are consistent with the research conducted by Mehrotra et al. [3] and Rappaport [4]. The application of GA<sub>3</sub> and NAA was shown to result in a considerable rise in the number of branches. 5.80 in with the application of GA<sub>3</sub> @ 90 ppm followed by 5.26 with NAA @ 50 ppm is the maximum number of branches whereas 4.30 branches are the bare minimum that was noted in Control treatment. The number of branches per plant has been found to be strongly impacted by several growth regulators. The notable rise in the number of branches per plant may be attributed to the plant's vegetative development, which is caused by increased cell division and elongation Gupta and Gupta [5]. Rai et al. [6] and these results are in agreement. The application of GA<sub>3</sub> and NAA was found to significantly increase the quantity of leaves. With the application of GA<sub>3</sub> @ 90 ppm had the highest leaves per plant i.e 19.20 followed by NAA @ 50 ppm with 18.70 number of leaves per plant. All concentrations of GA<sub>3</sub> and NAA generally result in more leaves per plant; however, the effect of GA<sub>3</sub> @ 90 ppm was more noticeable than that of other concentrations. This could be as a result of GA<sub>3</sub>'s potential to promote cell elongation and division. The same conclusion has been published by Chauhan et al. [7], Kumar et al. [8], and Prasad et al. [9].

**Table 1. Effect of different concentrations of GA<sub>3</sub> and NAA on vegetative characters of tomato var. MAHY 701**

Sl. No.	Treatment	Plant Height			No. of Branches			No. of Leaves			Plant Girth			Leaf Area	No. of Flowers/Plant
		30D	60D	90D	30D	60D	90D	30D	60D	90D	30D	60D	90D		
1	Control	42.50	65.20	78.10	1.70	4.30	6.36	5.30	17.30	32.90	3.78	4.13	4.30	48.80	57.90
2	GA <sub>3</sub> @ 30 ppm	48.60	68.20	85.20	2.60	5.03	7.13	6.40	17.90	33.70	3.92	4.24	4.45	56.70	58.70
3	GA <sub>3</sub> @ 60 ppm	45.60	65.70	80.40	2.40	4.56	6.50	5.60	17.60	33.10	3.84	4.17	4.34	50.40	58.30
4	GA <sub>3</sub> @ 90 ppm	56.90	72.90	91.30	3.60	5.80	7.73	7.10	19.20	34.60	4.21	4.44	4.64	64.30	61.20
5	NAA @ 25 ppm	46.70	66.40	82.50	2.40	4.80	6.96	5.66	17.70	33.30	3.89	4.24	4.38	54.90	58.60
6	NAA @ 50 ppm	54.20	70.50	89.50	3.40	5.26	7.33	6.90	18.70	34.10	4.02	4.27	4.52	61.20	59.40
7	NAA @ 75 ppm	52.10	69.60	87.80	2.90	4.70	7.16	6.60	18.20	33.90	3.96	4.27	4.49	58.80	59.70
SE(m)±		0.34	0.26	0.29	0.25	0.20	0.24	0.33	0.27	0.28	0.07	0.21	0.31	0.33	0.30
CD		1.07	0.82	0.93	0.79	0.64	0.75	1.04	0.84	0.88	0.22	NS	NS	1.05	0.95

**Table 2. Effect of different concentrations of GA<sub>3</sub> and NAA on Yield characters of tomato var. MAHY 701**

Sl. No.	Treatment	No. of Fruit per Plant	Fruit Length(cm)	Fruit Diameter(cm)	Fruit Weight(g)	Yield per Plot(kg)	Yield per Ha(q/ha)
1	Control	33.80	4.50	4.40	74.60	26.20	350.60
2	GA <sub>3</sub> @ 30 ppm	37.10	5.50	5.90	94.80	29.20	390.20
3	GA <sub>3</sub> @ 60 ppm	34.20	4.80	4.90	80.50	28.60	382.40
4	GA <sub>3</sub> @ 90 ppm	42.90	6.40	6.80	118.80	31.70	423.50
5	NAA @ 25 ppm	35.40	5.30	5.50	85.10	29.10	388.50
6	NAA @ 50 ppm	38.80	6.10	6.50	115.20	31.30	418.60
7	NAA @ 75 ppm	37.50	5.70	6.10	98.60	29.70	396.50
SE(m)±		0.32	0.34	0.20	0.28	0.30	0.30
CD		1.00	1.06	0.64	0.87	0.95	0.95

**Table 3. Effect of different concentrations of GA<sub>3</sub> and NAA on quality parameters of tomato var. MAHY 701**

Sl. No.	Treatment	Total Soluble Solid (degree Brix)	Acidity (%)	Shelf Life(days)
1	Control	3.00	0.33	13.90
2	GA <sub>3</sub> @ 30 ppm	3.83	0.37	16.20
3	GA <sub>3</sub> @ 60 ppm	3.83	0.35	14.40
4	GA <sub>3</sub> @ 90 ppm	4.33	0.42	18.73
5	NAA @ 25 ppm	3.83	0.36	16.20
6	NAA @ 50 ppm	3.16	0.41	15.70
7	NAA @ 75 ppm	2.83	0.39	13.60
SE(m)±		0.37	0.01	0.20
CD		NS	0.05	0.63

Application of GA<sub>3</sub> @ 90 ppm yielded the maximum plant girth, surpassing all other treatments. This could be attributed to the growth stimulating hormones' ability to replenish the natural growth chemicals that are vital for cell division and elongation. The current result corroborated with the findings of Rahman et al. [10] and Bokade et al. [11]. The largest leaf area recorded was 64.30 sq. cm with the application of GA<sub>3</sub> @ 90 ppm and 61.20 sq.cm with NAA @ 50 ppm. The results mentioned above coincided those of Uddain et al. [12]. The data showed that the application of GA<sub>3</sub> and NAA resulted in a substantial rise in the number of blooms per plant. Application of GA<sub>3</sub> @ 90 ppm had the highest number of flowers, measuring 61.20, while NAA @ 75 ppm had the second-greatest number, measuring 59.70 flowers. The number of floral clusters increased by GA<sub>3</sub> treatments could be the cause of this rise. The results mentioned above match those of Uddain et al. [12].

### 3.2 Yield Characters

The use of GA<sub>3</sub> and NAA has been demonstrated to greatly increase the number of fruits. Application of GA<sub>3</sub> @ 90 ppm produced the greatest number of fruits per plant, 42.90. GA<sub>3</sub> @ 90 ppm produced the greatest number of fruits per plant; this may be since those hormones perform a role to encourage pollen germination, fertilization, cell division, and elongation following pollination. The current result corresponded with the findings of Rahman et al. [13] and Kumar et al. [8]. The treatment with GA<sub>3</sub> @ 90 ppm showed the maximum fruit length, and NAA @ 50 ppm showed the next-best results. Since growth-stimulating hormones are known to improve pollen germination, fertilization, and elongation following pollination, GA<sub>3</sub> @ 90 ppm may be more desirable. Siwna (2019) reported on this activity. An further explanation for this could be the increased a build up of carbohydrates as a result of enhanced photosynthesis, which led to the rise in fruit length that Kumar et al. [14] reported. Uddain et al. also reported similar results [12]. The fruit diameter considerably grew after applying GA<sub>3</sub> and NAA, as seen in the Table 2. The maximum fruit diameter 6.80 cm was seen with the application of GA<sub>3</sub> @ 90 ppm and 6.50 cm with NAA @ 50 ppm. Control had the lowest fruit diameter, averaging 4.40 cm. According to Bhosle et al. [2] and Pundir and Yadav [1], the

maximum fruit diameter was measured by GA<sub>3</sub> @ 90 ppm. This may be explained by the increased availability of photosynthetic materials and their effective mobilization in plants, which leads to increased stimulation of fruit growth and ultimately an increase in fruit length. The greatest fruit weight, 118.80g was obtained with the application of GA<sub>3</sub> @ 90ppm followed by the application of NAA @ 50ppm having fruit weight of 115.20g. Fruit weight superiority has been proven by GA<sub>3</sub> @ 90ppm. The observed increase in fruit weight can be due to GA<sub>3</sub>, as its characteristic of cell elongation has facilitated the growth of all vegetative parts, thereby providing more food material for fruit development. Additionally, Kumar et al. [15] reported that plant anabolic processes are other factors leading to the higher fruit weight. GA<sub>3</sub> @ 90 ppm yielded the highest output per plot, measuring 31.70 kg, which was followed by the application of NAA @ 50 ppm averaging 31.30 kg. GA<sub>3</sub> @ 90ppm produced the highest yield per plot and was demonstrated to be superior for all yield attributes; this may help enhance the number of fruits per plant and reduce fruit falling. The advantageous impacts of PGRs on numerous physiological and biochemical processes, as well as enhanced nutrient mobilization in the treated plants. The use of growth regulators might have enhanced tomato yield because of better vegetative development, higher fruit set, and bigger fruits. The highest possible yield per hectare was recorded with the application of GA<sub>3</sub> @ 90 ppm i.e 423.50q which was followed by and 418.60q with NAA @ 50 ppm. The application of GA<sub>3</sub> @ 90 ppm increased the yield because it kept the plant physiologically more active, allowing it to gather enough food stocks for developing flowers and fruits. This increased fruit set subsequently led to a higher yield, as reported by Kumar et al. [15]. These results coincided with what Uddain et al. [12] had discovered.

### 3.3 Quality Characters

The TSS levels were found to vary from 2.83° to 4.33° Brix. Maximum TSS was seen in with the application of GA<sub>3</sub> @ 90 ppm i.e 4.33° Brix and was followed by 3.83° Brix with GA<sub>3</sub> @ 30 ppm .Ali et al. [16], Kumar et al. [8], and Singh et al. [17] all acquired similar results. The findings discovered that the range of acidity values was 0.33% to 0.42%. The treatment with the highest acidity, 0.42% with GA<sub>3</sub> @ 30 ppm, proved to be the most acidic, followed by 0.41% with the application of NAA @ 50 ppm. Shelf life

observations show that it falls around 18.73 and 13.60. The treatment with the application of GA<sub>3</sub> @ 30 ppm had the greatest acidity i.e 18.73, followed NAA @ 25 ppm. The reduction in ripening throughout the storage period may be the cause of the decrease in decay loss following GA<sub>3</sub> treatment. The results of the present research show that the fruits treated with GA<sub>3</sub> had a lesser level of degradation. These results were consistent with the outcomes published by Nirupama et al. [18]. In addition, the outcome agrees with Singh and Patel [19].

#### 4. CONCLUSION

The results of this study suggest that, as compared to the control, tomato growth and yield were significantly impacted by both GA<sub>3</sub> and NAA. The study demonstrated that GA<sub>3</sub> @ 90ppm surpassed the other growth regulator in terms of boosting growth parameters such as plant height, number of branches, and number of leaves, as well as yield features like fruit weight, diameter, and length, as well as yield per hectare and plot. In contrast, NAA at 50 ppm excelled the other growth and yield standards. Therefore, farmers may be suggested to apply GA<sub>3</sub> at 90 ppm and NAA at 50 ppm when raising tomatoes in BBSR Agroclimatic environments for MAHY-701.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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