**Effect of Plant Growth Regulators on Growth and Yield of Tomato (*Solanum lycopersicum* L.) Cv. MAHY-701 Under Bhubaneswar Condition**

**Abstract**

Exogenous application of plant growth regulators plays a vital role in effectively enhancing plant growth and crop output. To determine the effect of plant growth regulators and the ideal concentration of GA₃ and NAA for improved tomato growth and yield (*Solanum lycopersicum* L.) cv. MAHY-701 under Bhubaneswar conditions, a field experiment was conducted during the Rabi season of 2022 at the Agricultural Research Station, Binjhagiri, Institute of Agricultural Sciences, Siksha "O" Anusandhan (Deemed to be) University, Bhubaneswar, Odisha. The experiment used plant growth regulators, namely GA₃ and NAA, and was designed as a randomized block design with three replications and seven treatments. Compared to the control treatment, all growth, yield, and quality parameters significantly improved at various concentrations of GA₃ (30, 60, and 90 ppm) and NAA (25, 50, and 75 ppm). The investigation findings reinforce the claim that tomato growth and yield were considerably affected by both GA₃ and NAA compared to the control. The results demonstrated that the treatment where the plant was sprayed with GA₃ @ 90 ppm had the highest total soluble solids (4.33°Brix), acidity (0.42%), shelf life (18.73 days), number of fruits per plant (42.90), fruit length (6.40 cm), fruit diameter (6.80 cm), fruit weight (118.80 g), yield per plot (31.70 kg), yield per hectare (423.50 q/ha), and other quality attributes. In conclusion, farmers may be advised to apply GA₃ at 90 ppm and NAA at 50 ppm when cultivating tomatoes in the Bhubaneswar agroclimatic environment for the MAHY-701 variety.

Keywords: *Solanum lycopersicum*, tomato, fruit weight, fruit yield, TSS, acidity, plant growth regulators, GA₃, NAA

 **Introduction**

Vegetables are an essential part of a balanced diet and play a crucial role as preventive foods. India is the world's second-largest producer of vegetables, behind China, and holds a prominent position in this regard. The country's diverse agroclimatic conditions allow for the year-round cultivation of a wide range of vegetable crops. Vegetables are a valuable source of carbohydrates, proteins, vitamins, minerals, element salts, and crude fibers. Dieticians recommend a daily intake of 300g of vegetables for an adult to maintain good health, comprising 125g of leafy vegetables, 100g of root and tuber vegetables, and 75g of other vegetables. However, in India, the average person consumes only 175g of vegetables per day, which is significantly less than the recommended amount.

Tomato, ranking second behind potato among vegetables, is one of the most cultivated and popular crops worldwide. Tomatoes are used in a variety of products, including soup, juice, ketchup, puree, paste, and powder, and they are widely used in pickles. Tomatoes are exceptionally high in vitamin C and provide food with a range of colors and flavors. Green tomatoes are also used in pickles. Tomatoes are rich in lycopene, ß-carotene, and ascorbic acid, which are antioxidants and support good health. The medicinal significance of tomatoes is notable as their pulp and juice are mildly laxative, easily digested, promote gastric secretion, detoxify blood, and have antiseptic properties for the intestines. Tomatoes are beneficial for chronic dyspepsia and stimulate a torpid liver. They are important for maintaining the wellness of the intestines and stomach. Every 100 grams of tomato fruit pulp contains 93.1g of water, 1.9g of protein, 0.1g of fat, 3.6g of carbohydrates, 0.6g of mineral matter, 20mg of calcium, 36mg of phosphorus, 0.3mg of iron, 320 IU of carotene (vitamin A), 2.27mg of thiamine, 0.4mg of nicotinic acid, 0.01mg of riboflavin, and 31mg of ascorbic acid. Tomatoes also contain 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 specific physiological processes in a plant, while its sites of action and synthesis are distinct. Plant growth regulators include both naturally occurring plant hormones and hormones produced in a lab. The concentration of hormones needed for plant response is extremely low compared to plants' needs for minerals and vitamins. Plant hormones are more widely distributed and not often locally synthesized within the plant. They are compounds, not nutrients, that in limited amounts impact and promote the division, growth, and development of cells and tissues.

Gibberellic Acid (GA₃) and Naphthalene Acetic Acid (NAA) are two growth promoters that are particularly effective at enhancing vegetable crop output and plant growth. GA₃ stimulates cell division and elongation, aiding in the growth and development of several plants. NAA influences physiological functions, accelerates fruit ripening, and enhances fruit quality. Numerous chemical and cultural methods are used to boost crop yields. Many experts have stressed the use of plant growth regulators to increase the quantity and quality of various vegetable crops (Pundir and Yadav, 2001; Bhosle et al., 2002). Nonetheless, the concentration of the plant growth regulator and the timing of administration are the primary determinants of improved crop output and quality. The most frequently used growth regulators include GA₃, NAA, 4-CPA, and 2,4-D. However, there are significant differences in crop improvement based on the type of growth regulators used, their concentration, and the timing and method of application.

**Materials and Methods**

The experiment “Effect of Plant Growth Regulators on Growth and Yield of Tomato (*Solanum lycopersicum* L.)” was conducted at the Institute of Agricultural Sciences, Siksha “O” Anusandhan (Deemed to be) University, Bhubaneswar. This location is situated 73 km away from the Bay of Bengal at an altitude of 25.5 meters above mean sea level (MSL), at latitude 20.23° North and longitude 85.67° East. 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.

During the cropping season, the mean weekly maximum and minimum temperatures were 28.37˚C and 17.22˚C, respectively. The maximum relative humidity (95%) was observed in February, while the minimum (47%) was observed in January.

The experiment aimed to standardize the best growth regulator concentration for improved growth and yield of tomatoes, using seven treatments in a Randomized Block Design (RBD) with three replications on the tomato variety MAHY-701. Seedlings of 20-25 days were transplanted during the afternoon hours of November 16, 2021, at a spacing of 50 x 50 cm. A total of nine treatments were applied, using three different concentrations of each growth regulator: GA₃ at 30 ppm, 60 ppm, and 90 ppm, and NAA at 25 ppm, 50 ppm, and 75 ppm.

Fifteen distinguishing parameters were measured during the experiment: 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.

**Results and Discussions**

Growth Characters

The table showed that the application of GA₃ and NAA resulted in a substantial increase in plant height. The highest plant height of 72.90 cm was observed with the application of GA₃ @ 90 ppm, followed by 70.50 cm with NAA @ 50 ppm. This increase in height may be attributed to the rapid elongation and division of developing cells, which stimulate RNA activity and promote improved growth and development. These findings are consistent with research conducted by Mehrotra et al. (1970) and Rappaport (1975).

The application of GA₃ and NAA also resulted in a considerable increase in the number of branches. The maximum number of branches was observed with the application of GA₃ @ 90 ppm (5.80), followed by NAA @ 50 ppm (5.26), whereas the control treatment had the minimum number of branches (4.30). The increase in the number of branches per plant may be due to enhanced vegetative growth caused by increased cell division and elongation, as supported by the findings of Gupta and Gupta (2000) and Rai et al. (2006).

The application of GA₃ and NAA significantly increased the number of leaves. The highest number of leaves per plant was observed with GA₃ @ 90 ppm (19.20), followed by NAA @ 50 ppm (18.70). All concentrations of GA₃ and NAA generally resulted in more leaves per plant, with the effect of GA₃ @ 90 ppm being more pronounced. This increase could be due to GA₃'s ability to promote cell elongation and division, as reported by Chauhan et al. (2017), Kumar et al. (2014), and Prasad et al. (2013).

Application of GA₃ @ 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 essential for cell division and elongation. The current results corroborate the findings of Rahman et al. (2015) and Bokade et al. (2006).

The largest leaf area recorded was 64.30 sq. cm with the application of GA₃ @ 90 ppm and 61.20 sq. cm with NAA @ 50 ppm. These results coincide with those of Uddain et al. (2009).

The data showed that the application of GA₃ and NAA resulted in a substantial rise in the number of blooms per plant. The highest number of flowers was observed with GA₃ @ 90 ppm (61.20), followed by NAA @ 75 ppm (59.70). The increase in the number of floral clusters due to GA₃ treatments could explain this rise. These results are consistent with those of Uddain et al. (2009).

Yield Characters

The use of GA₃ and NAA has been demonstrated to greatly increase the number of fruits. The application of GA₃ @ 90 ppm produced the greatest number of fruits per plant (42.90). This may be due to the hormones' role in encouraging pollen germination, fertilization, cell division, and elongation following pollination. These findings align with those of Rahman et al. (2015) and Kumar et al. (2014).

The treatment with GA₃ @ 90 ppm showed the maximum fruit length, followed by NAA @ 50 ppm. Growth-stimulating hormones are known to improve pollen germination, fertilization, and elongation following pollination, making GA₃ @ 90 ppm more desirable. Siwna (2019) reported similar findings. Another explanation could be the increased accumulation of carbohydrates due to enhanced photosynthesis, leading to the rise in fruit length reported by Kumar et al. (2018). Uddain et al. (2009) also reported similar results.

The fruit diameter considerably grew after applying GA₃ and NAA. The maximum fruit diameter (6.80 cm) was seen with GA₃ @ 90 ppm, followed by NAA @ 50 ppm (6.50 cm). The control had the lowest fruit diameter (4.40 cm). According to Bhosle et al. (2002) and Pundir and Yadav (2001), the maximum fruit diameter was measured with GA₃ @ 90 ppm. This may be due to the increased availability and effective mobilization of photosynthetic materials in plants, leading to increased stimulation of fruit growth and ultimately an increase in fruit length.

The greatest fruit weight (118.80 g) was obtained with the application of GA₃ @ 90 ppm, followed by NAA @ 50 ppm (115.20 g). The observed increase in fruit weight can be attributed to GA₃'s characteristic of cell elongation, facilitating the growth of all vegetative parts and providing more food material for fruit development. Additionally, Kumar et al. (2018) reported that plant anabolic processes also contribute to the higher fruit weight.

GA₃ @ 90 ppm yielded the highest output per plot (31.70 kg), followed by NAA @ 50 ppm (31.30 kg). GA₃ @ 90 ppm produced the highest yield per plot and was superior for all yield attributes. This may help enhance the number of fruits per plant and reduce fruit drop. The beneficial impacts of PGRs on various physiological and biochemical processes, as well as enhanced nutrient mobilization in treated plants, likely contributed to this increase. The highest possible yield per hectare was recorded with GA₃ @ 90 ppm (423.50 q/ha), followed by NAA @ 50 ppm (418.60 q/ha). The application of GA₃ @ 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. (2018). These results coincide with those discovered by Uddain et al. (2009).

Quality Characters

The TSS levels varied from 2.83° to 4.33° Brix. The maximum TSS was seen with the application of GA₃ @ 90 ppm (4.33° Brix), followed by GA₃ @ 30 ppm (3.83° Brix). Similar results were acquired by Ali et al. (2020), Kumar et al. (2014), and Singh et al. (2022).

The acidity values ranged from 0.33% to 0.42%. The highest acidity (0.42%) was observed with GA₃ @ 30 ppm, followed by NAA @ 50 ppm (0.41%).

Shelf life observations ranged from 18.73 to 13.60 days. The treatment with GA₃ @ 30 ppm had the greatest shelf life (18.73 days), followed by NAA @ 25 ppm. The reduction in ripening during storage may account for the decrease in decay loss following GA₃ treatment. The results show that the fruits treated with GA₃ had a lower level of degradation, consistent with the findings of Nirupama et al. (2010). Additionally, the outcome agrees with Singh and Patel (2014).

## Conclusion

The results of this study suggest that, as compared to the control, tomato growth and yield were significantly impacted by both GA₃ and NAA. The study demonstrated that GA₃ @ 90 ppm surpassed the other growth regulators 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, length, and yield per hectare and plot. In contrast, NAA @ 50 ppm also excelled in improving several growth and yield standards. Therefore, farmers may be advised to apply GA₃ @ 90 ppm and NAA @ 50 ppm when raising tomatoes in the Bhubaneswar agroclimatic environment for the MAHY-701 variety.

**Table.1.** Effect of Different Concentrations of GA₃ and NAA on Vegetative Characteristics of Tomato Variety MAHY 701:



**Note: Reconstruct Table No:1 like other two tables.**

**Table.2.** Effect of Different Concentrations of GA₃ and NAA on Yield Characteristics of Tomato Variety 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 | GA₃ @ 30 ppm | 37.10 | 5.50 | 5.90 | 94.80 | 29.20 | 390.20 |
| 3 | GA₃ @ 60 ppm | 34.20 | 4.80 | 4.90 | 80.50 | 28.60 | 382.40 |
| 4 | GA₃ @ 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 GA₃ 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 | GA₃ @ 30 ppm | 3.83 | 0.37 | 16.20 |
| 3 | GA₃ @ 60 ppm | 3.83 | 0.35 | 14.40 |
| 4 | GA₃ @ 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 |

**REFERENCES:**

Ali M R, Quddns A, Tanjila S, Mohamad M R, Asaduzzaman. 2020. Influence of plant growth regulators on growth & yield & quality of tomato grown under high temperature tropics in summer. *International Journal of Vegetable Science,* ***28***(1): 59-75.

Bhosle A B, Khorbhade S B, Sanap P B, Gorad M J. 2002. Effect of plant hormones on growth and yield of summer tomato (*Lycopersicon esculentum* L.). *Orissa J Hort*, **30**(2): 63-65.

Bokade N, Bhalekar M N, Gupta N S, Deshpande A. 2006. Effect of growth regulators on growth and yield of summer tomato. *J. Maharashtra Agric. Univ*, **31**(1): 64-65.

Chauhan S A, Patel N B, Mehta D R, Patel J B, Zalaishita M, Vaja A D. 2017. Effect of plant growth regulators on seed yield and its parameters of tomato (*Lycopersicon esculentum* L.). *Int. J. of Agric. Sci*, **9**(8): 3906-3909.

Gupta P K, Gupta A K. 2000. Efficacy of plant growth regulators (IAA and NAA) and micronutrient mixtures on growth, flowering, fruiting and shelf life of tomato (*Lycopersicon esculentum* L.). *Bioved*, **11**(1/2): 25-29.

Kumar A, Biswas T K, Singh N, Lal E P. 2014. Effect of gibberellic acid on growth, quality and yield of tomato (*Lycopersicon esculentum* L.). *IOSR* *Journal of Agriculture and Veterinary Science*, **7**(7): 2319-2372.

Kumar A, Biswas T K, Singh N, Lal E P. 2014. Effect of gibberellic acid on growth, quality and yield of tomato (*Lycopersicon esculentum* L.). *IOSR* *Journal of Agriculture and Veterinary Science*, **7**(7): 2319-2372.

Kumar A, Biswas T K, Singh N, Lal E P. 2014. Effect of gibberellic acid on growth, quality and yield of tomato (*Lycopersicon esculentum* L.). *IOSR* *Journal of Agriculture and Veterinary Science*, **7**(7): 2319-2372.

Kumar P, Pathak S, Amarnath K S, Teja P V B, Dileep B, Kumar K, Siddique A. 2018. Effect of growth regulator on morpho-physiological attributes of chilli: A case study. *Plant Archives*, **18**(2): 1771-1776.

Kumar S, Singh R, Singh V, Singh M K, Singh A K. 2018. Effect of plant growth regulators on growth, flowering, yield and quality of tomato (*Solanum lycopersicum* L.). *Journal of Pharmacognosy and Phytochemistry*, **7**(1): 41-44.

Mehrotra O, Garg N, Garg RG, Singh I.1970. Growth, fruiting and quality of tomato as influenced by growth regulators. *Progressive Horti*, **2**(1): 57-64.

Nirupama P, Neeta B G, Ramana Rao T V. 2010. Effect of post-harvest treatments on physicochemical characteristics and shelf life of tomato fruits during storage. *American-Eurasian Journal of Agriculture and Env Science,* **9**(5): 470-479.

Prasad R N, Singh S K, Yadav R B, Chaurasia S N S. 2013. Effect of GA₃ and NAA on growth and yield of tomato. *Vegetable* *science*, **40**(2): 195-197.

Pundir J P S, Yadav P K. 2001. Effect of GA₃ and NAA on growth, yield and quality of tomato. *Current* *Agric*, **32**(1&2): 137-138.

Rahman M S, Haque M A, Mostofa M G.2015. Effect of GA3 on biochemical attributes and yield of summer tomato. *Journal of Bioscience and Agriculture Research*, **3**(02): 73-78.

Rahman M, Nahar M A, Sahariar M S, Karim M R. 2015. Plant growth regulators promote growth and yield of summer tomato (*Lycopersicone sculentum* L.). *Progressive Agriculture*, **26**(1): 32-37.

Rai N, Yadav D S, Patel K K, Yadav R K, Asati B S and Chaudey T. 2006. Effect of plant growth regulators on growth, yield and quality of tomato (*Lycopersicon esculentum* L.). *Veg* *Sci*, **33**(2): 180-182.

Rappaport L. 1975. Growth regulating metabolites. *Caif. Agric*, **10**(12): 4-11.

Singh Neha, Biswas K Tarun, Sharma Richa. 2014. Impact of Plant Growth Regulators on Vegetative Characters, Quality and Yield Attributes in Chilli (*Capsicum annuum* L*.*) Cv. G-4. *New Agriculturist Journal*, **25**(2): 227-233.

Singh V, Singh V, Shahi P B, Singh N, Somvanshi S P S. 2022. Impact of Gibberellic Acid on Physiological Yield and Quality Attributes of Tomato (*Lycopersicon esculentum* L.) Underneath Semi-Arid Condition of Eastern U.P. *Biological Forum-An International Journal*, **14**(2): 400-402.

Uddain j, Hossain K M, Akhter, Mostafa G M, Rahman J M. 2009. Effect of Different Plant Growth Regulators on Growth and Yield of Tomato. *International Journal of Sustainable Agriculture*, **1**(3): 58-63.