**Original Research Article**

**Modulation of** **Growth Dynamics and Yield Performance under Influence of Exogenous Plant Growth Regulators in Tomato (*Solanum lycopersicum* L.)**

**Abstract**

The experiment was conducted during the rabi season of 2024–2025 at United University, Prayagraj, to assess the effects of plant growth regulators (PGRs) on tomato cultivar ‘NDT-1’. The randomized block design included 13 treatments: four concentrations (25, 50, 75, and 100 ppm) each of GA₃, auxins, and kinetin, plus a control, replicated thrice. Results showed that GA₃ at 75 ppm (T₃) was most effective, significantly reducing days to first flowering (39.54 days) and 50% flowering (40.58 days), while enhancing plant height (101.35 cm), primary branches (7.14), flower clusters (10.98), yield (2.68 kg/plant), and fruit quality (TSS 6.23 °Brix, ascorbic acid 26.58 mg/100 g, lycopene 6.23 mg/100 g). Kinetin at 25 ppm (T₉) and auxin at 100 ppm (T₈) also improved some parameters. These findings underscore the potential of GA₃ at 75 ppm for boosting tomato growth, yield, and quality under these conditions. Future work could explore synergistic PGR effects and integrated nutrient management for enhanced productivity.

**Keywords-** Gibberellic acid, Auxin, Kinetin, Plant growth regulators, Growth dynamics, Yield, Fruit quality.

**1.0 Introduction**

Tomato (*Solanum lycopersicum* L.), a member of the Solanaceae family, is a widely cultivated horticultural crop valued both for its culinary versatility and nutritional benefits. Originating from tropical America—particularly the Andean regions of Bolivia, Ecuador, and Peru—tomato is now globally recognized as one of the most important vegetable crops. It ranks just below sweet potatoes and potatoes in terms of vegetable production and is predominantly grown in tropical and subtropical regions (Mahesti *et al*., 2025; Tanim *et al*., 2025). According to the first advance estimate by the Department of Agriculture & Farmers Welfare (2025), the total area under tomato cultivation in India is approximately 853,000 hectares, yielding a total production of about 21.55 million metric tonnes.

Tomatoes are nutritionally rich, containing essential minerals and vitamins at both the green and ripe stages. They provide 13 mg of calcium, 27 mg of phosphorus, 0.5 mg of iron, and 244 mg of potassium per 100 grams. Notably, Vitamin A content increases from 270 I.U. in green tomatoes to 900 I.U. in ripe ones, while Niacin (Vitamin B3) and ascorbic acid (Vitamin C) also show a modest increase during ripening (Sainju *et al.,* 2003; Sohrabi *et al.,* 2025). These nutritional attributes make tomato not only a dietary staple but also a valuable crop for addressing nutritional security.

To enhance tomato productivity and fruit quality, the application of Plant Growth Regulators (PGRs) has gained significant attention in modern agriculture. PGRs play a vital role in manipulating physiological processes such as fruit set, fruit development, and overall plant growth. Among these, gibberellic acid (GA) is well-documented for its role in promoting seed germination, stem elongation, flowering, and fruit enlargement, with its concentration peaking during early fruit development (Wu *et al.,* 2024). Additionally, GA biosynthesis inhibitors are employed to regulate plant architecture and reproductive timing (Shohat *et al.,* 2021).

Other important PGRs include auxins and cytokinins, which have critical roles in plant development. Auxins are central to flower initiation, sex expression, fruit development, and parthenocarpy. They also facilitate cell elongation and differentiation, especially in vascular tissues (Alam *et al.,* 2020). Cytokinins, on the other hand, are crucial for promoting cell division, delaying leaf senescence, and enhancing lateral growth. They also contribute to stress resilience and mediate nutrient signaling pathways within the plant system (Dawood *et al.,* 2022). The strategic application of these hormones has proven effective in improving tomato yield and quality under varying environmental and agronomic conditions (Gomasta *et al.,* 2025).

Keeping these points in view, the present research has been planned to investigate the effects of selected plant growth regulators on the growth, yield, and quality attributes of tomato. This study aims to contribute to a better understanding of how different PGRs can be effectively utilized to enhance tomato production and meet the growing demand for high-quality horticultural produce.

**2.0 Materials and Methods**

The experiment was conducted during the rabi season of 2024–2025 at the Agricultural Research Farm of United University, Jhalwa, Prayagraj, Uttar Pradesh (211012), India. The primary objective was to evaluate the effect of different plant growth regulators on the vegetative and reproductive attributes of the tomato cultivar ‘NDT-1’.

The experimental layout followed a Randomized Block Design (RBD) comprising 13 treatments with three replications each. The treatments included four concentrations of gibberellic acid (GA₃): 25 ppm (T1), 50 ppm (T2), 75 ppm (T3), and 100 ppm (T4); four concentrations of auxin: 25 ppm (T5), 50 ppm (T6), 75 ppm (T7), and 100 ppm (T8); and four concentrations of kinetin: 25 ppm (T9), 50 ppm (T10), 75 ppm (T11), and 100 ppm (T12). A control treatment without any plant growth regulator was also included (T13).

The nursery was sown on 15 September 2024, and seedlings were transplanted on 12 October 2024, with a planting distance of 45 cm × 60 cm. During field preparation, 3.5 quintals of well-rotted farmyard manure were incorporated into the soil. The recommended dose of fertilizers (NPK) was applied at rates of 250 kg/ha of nitrogen, 200 kg/ha of phosphorus, and 150 kg/ha of potassium in two split doses. The full dose of nitrogen and half doses of phosphorus and potassium were applied as a basal application at the time of transplanting, while the remaining half doses of phosphorus and potassium were applied 45 days after transplanting.

Data were collected from ten randomly selected plants from each plot for the following parameters: days to first flowering, days to 50% flowering, plant height (cm), number of primary branches per plant, number of flower clusters per plant, total number of fruits per plant, fruit length (cm), fruit diameter (cm), average fruit weight (g), yield per plant (kg), total soluble solids (°Brix), pH, ascorbic acid content (mg/100g), and lycopene content (mg/100g). The collected data were analyzed using SPSS software (version 30).

**3.0 Results and Discussion**

**3.1 Days to First Flowering**

The earliest initiation of flowering was observed with GA₃ at 75 ppm (T₃), which recorded the lowest value of 39.54 days. This was significantly earlier than the control treatment (T₁₃), which exhibited the highest value of 52.63 days. Treatments T₂ (43.56 days), T₉ (41.87 days), and T₁ (47.54 days) were statistically at par with T₃ and also promoted early flowering. The results are in agreement with Poudel *et al*., 2020 & Singh *et al*., 2021.

**3.2 Days to 50% Flowering**

The least number of days to reach 50% flowering was also recorded in T₃ (40.58 days), indicating enhanced synchronization in flowering. In contrast, the control treatment (T₁₃) took the maximum time at 54.45 days. Treatments such as T₂ (44.58 days), T₉ (42.78 days), and T₁ (49.54 days) were found to be statistically similar to T₃. The result is in support with Singh *et al*., 2024.

**3.3 Plant Height (cm)**

The highest plant height was recorded in T₃ (101.35 cm), followed by T₂ (97.25 cm), T₉ (98.87 cm), and T₅ (99.36 cm), all of which were statistically at par. The shortest plants were observed in the control (T₁₃), which recorded the lowest value of 90.18 cm. Similar findings was also reported by Choudhury *et al*., 2013.

**Table 1-** Analyzed data set of different parameters for designed treatments.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Days to first flowering** | **Days to 50 % flowering** | **Plant height (cm)** | **Primary branches per plant** | **Number of flower cluster per plant** | **Total number of fruits per plant**  | **Fruit length (cm)** |
| T1 (GA3@ 25ppm) | 47.54 | 49.54 | 95.35 | 5.65 | 7.65 | 25.83 | 3.83 |
| T2 (GA3@ 50ppm) | 43.56 | 44.58 | 97.25 | 4.89 | 8.68 | 30.80 | 5.10 |
| T3 (GA3@ 75ppm) | 39.54 | 40.58 | 101.35 | 7.14 | 10.98 | 27.10 | 4.70 |
| T4 (GA3@ 100ppm) | 48.24 | 50.17 | 94.87 | 6.42 | 8.48 | 25.64 | 3.89 |
| T5 (Auxin@ 25ppm) | 45.67 | 48.61 | 99.36 | 4.35 | 7.42 | 26.50 | 4.66 |
| T6 (Auxin@ 50ppm) | 48.65 | 49.71 | 90.82 | 5.54 | 9.12 | 26.50 | 3.66 |
| T7 (Auxin@ 75ppm) | 48.37 | 51.65 | 91.98 | 5.40 | 8.18 | 25.66 | 3.66 |
| T8 (Auxin@ 100ppm) | 50.64 | 52.35 | 93.64 | 5.95 | 9.58 | 26.54 | 4.18 |
| T9 (Kinetin@25ppm) | 41.87 | 42.78 | 98.87 | 6.58 | 8.56 | 25.80 | 4.20 |
| T10 (Kinetin@ 50ppm) | 49.71 | 51.84 | 96.65 | 4.38 | 7.69 | 26.03 | 3.86 |
| T11 (Kinetin @75ppm) | 52.62 | 53.41 | 94.68 | 6.48 | 6.54 | 26.16 | 3.93 |
| T12 (Kinetin @100ppm) | 48.69 | 50.48 | 93.54 | 5.69 | 7.54 | 25.19 | 3.25 |
| T13 (Control) | 52.63 | 54.45 | 90.18 | 4.12 | 7.35 | 22.93 | 3.36 |
| SED | 0.68 | 0.63 | 0.78 | 0.41 | 0.19 | 1.56 | 0.085 |
| CD (0.05) | 3.54 | 2.54 | 3.61 | 0.21 | 0.57 | 3.98 | 0.29 |

**Table-2** Analyzed data set of different parameters for designed treatments.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Fruit diameter (cm)** | **Average Fruit weight (g)** | **Yield per plant (kg)** | **TSS (0Brix)** | **pH** | **Ascorbic acid (mg/100g)** | **Lycopene (mg/100g)** |
| T1 (GA3@ 25ppm) | 3.33 | 73.18 | 1.89 | 6.08 | 4.08 | 22.58 | 5.54 |
| T2 (GA3@ 50ppm) | 4.93 | 69.81 | 2.15 | 6.05 | 4.05 | 22.82 | 4.15 |
| T3 (GA3@ 75ppm) | 3.90 | 98.90 | 2.68 | 6.23 | 4.14 | 26.58 | 6.23 |
| T4 (GA3@ 100ppm) | 3.58 | 85.03 | 2.18 | 5.89 | 4.08 | 21.54 | 4.25 |
| T5 (Auxin@ 25ppm) | 4.30 | 83.02 | 2.20 | 5.73 | 4.06 | 23.64 | 4.13 |
| T6 (Auxin@ 50ppm) | 3.96 | 66.42 | 1.76 | 5.68 | 4.11 | 24.23 | 5.74 |
| T7 (Auxin@ 75ppm) | 3.36 | 69.37 | 1.78 | 5.25 | 3.97 | 25.73 | 3.69 |
| T8 (Auxin@ 100ppm) | 2.89 | 95.71 | 2.54 | 5.81 | 3.68 | 26.05 | 5.89 |
| T9 (Kinetin@25ppm) | 4.13 | 78.69 | 2.03 | 5.40 | 4.12 | 24.63 | 4.52 |
| T10 (Kinetin@ 50ppm) | 3.83 | 71.46 | 1.86 | 5.47 | 3.93 | 21.75 | 3.54 |
| T11 (Kinetin @75ppm) | 3.33 | 62.31 | 1.63 | 5.07 | 4.03 | 23.04 | 5.89 |
| T12 (Kinetin @100ppm) | 4.12 | 76.23 | 1.92 | 4.98 | 3.56 | 24.23 | 3.69 |
| T13 (Control) | 3.16 | 70.22 | 1.61 | 4.58 | 3.48 | 21.34 | 3.49 |
| SED | 0.075 | 0.42 | 0.11 | 0.04 | 0.05 | 0.33 | 0.12 |
| CD (0.05) | 0.24 | 2.09 | 0.38 | 0.21 | 0.17 | 1.05 | 0.69 |

**3.4 Primary Branches per Plant**

GA₃ at 75 ppm (T₃) resulted in the highest number of primary branches per plant (7.14), whereas the control had the least (4.12). Treatments T₉ (6.58), T₄ (6.42), and T₁₁ (6.48) were also statistically at par with T₃ and demonstrated significant branching. The results are in agreement with Tiwari and Singh, 2014 and Manish *et al*., 2024.

**3.5 Number of Flower Clusters per Plant**

The maximum number of flower clusters per plant was recorded in T₃ (10.98), followed by T₈ (9.58), T₆ (9.12), and T₇ (8.18), which were all statistically comparable. The minimum value was noted in T₁₁ (6.54). Similar result was reported by Uddain *et al*., 2009.

**3.6 Total Number of Fruits per Plant**

Although the highest number of fruits per plant was recorded in T₂ (30.80), T₃ showed a high value of 27.10 fruits, comparable to T₅ (26.50) and T₆ (26.50). The control exhibited the lowest fruit count with only 22.93 fruits per plant. The results are in agreement with Poudel *et al*., 2020 & Ahmed *et al*., 2021.

**Graph-1** Multiline graph for comparative visualization for all parameters

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**3.7 Fruit Length (cm)**

T₂ produced fruits with the greatest length (5.10 cm), followed closely by T₅ (4.66 cm), T₃ (4.70 cm), and T₈ (4.18 cm). The smallest fruit length (3.25 cm) was recorded in T₁₂. The similar result was also reported by Singh *et al*., 2024 & Manish *et al*., 2024.

**3.8 Fruit Diameter (cm)**

The highest fruit diameter was observed in T₂ (4.93 cm), with T₅ (4.30 cm), T₉ (4.13 cm), and T₃ (3.90 cm) also showing considerable girth. The lowest diameter (2.89 cm) was found in T₈. The results are in agreement with Tiwari and Singh, 2014 and Manish *et al*., 2024.

**3.9 Average Fruit Weight (g)**

T₃ recorded the highest average fruit weight (98.90 g), followed by T₈ (95.71 g), T₄ (85.03 g), and T₅ (83.02 g), which were all statistically at par. The lowest fruit weight was recorded in T₁₁ (62.31 g). The result is in Chartort with Poudel *et al*., 2020

**3.10 Yield per Plant (kg)**

The maximum yield per plant was observed in T₃ (2.68 kg), followed by T₈ (2.54 kg), T₄ (2.18 kg), and T₂ (2.15 kg). The minimum yield was recorded in the control (T₁₃) at 1.61 kg per plant. Similar findings were reported by Tiwari and Singh, 2014 & Singh *et al*., 2024.

**3.11 Total Soluble Solids (°Brix)**

The highest TSS value was recorded in T₃ (6.23 °Brix), followed by T₁ (6.08 °Brix), T₂ (6.05 °Brix), and T₈ (5.81 °Brix), all of which were statistically at par. The control treatment had the lowest TSS (4.58 °Brix). Similar result was also reported by Ali *et al*., 2022, Singh *et al*., 2024. & Poonia *et al*., 2024.

**3.12 pH**

The highest fruit pH was recorded in T₃ (4.14), followed by T₉ (4.12), T₁ (4.08), and T₄ (4.08). The lowest pH was observed in the control (3.48), indicating comparatively higher acidity. Similar result was reported by Uddain *et al*., 2009.

**3.13 Ascorbic Acid Content (mg/100g)**

T₃ also recorded the highest ascorbic acid content (26.58 mg/100g), followed by T₈ (26.05 mg/100g), T₇ (25.73 mg/100g), and T₆ (24.23 mg/100g), while the control exhibited the lowest value (21.34 mg/100g). The results are in agreement with Poonia *et al*., 2024.

**3.14 Lycopene Content (mg/100g)**

The lycopene content was highest in T₃ (6.23 mg/100g), followed by T₈ (5.89 mg/100g), T₆ (5.74 mg/100g), and T₁ (5.54 mg/100g), with the control recording the lowest content (3.49 mg/100g). Similar result was reported by Uddain *et al*., 2009.

**4.0 Conclusion**

Overall, GA₃ application at 75 ppm (T₃) was the most effective treatment in promoting early flowering, vigorous vegetative growth, higher fruit set, improved fruit size and weight, and enhanced yield and quality attributes. This confirms the role of GA₃ as a potent growth regulator that can be employed to improve crop productivity and fruit quality under the given experimental conditions. Future studies could focus on the combined use of GA₃ with other growth regulators or nutrient management strategies to further optimize crop performance.

**5.0 References**

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