**Effect of plant growth regulators on growth, yield and quality attributes of brinjal (*Solanum melongena* L.) cv. Kalptaru**

**Abstract**

The present investigation was carried out at Agricultural Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur (Rajasthan) to study the Effect of plant growth regulators on growth, yield and quality attributes of Brinjal (*Solanum melongena* L.) cv. Kalptaru during *kharif* season of the year 2023-24. The experiment was laid down in RBD which consisted 10 treatment combinations viz; T1- Control (Water Spray), T2- NAA (25 PPM), T3- NAA (50 PPM), T4- NAA (100 PPM), T5- GA3 (50 PPM), T6- GA3 (100 PPM), T7- GA3 (200 PPM), T8- 2, 4-D (2 PPM), T9- 2, 4-D (4 PPM), T10-2, 4-D (6 PPM) and treatments were replicated three times. The results showed that treatment T6 (GA3 at 100 PPM) had a significant positive impact on various vegetative growth and quality parameters, while treatment T5 (GA3 at 50 PPM) significantly enhanced yield parameters. Additionally, the highest benefit-cost ratio (2.84) was observed with treatment T5, whereas the lowest benefit-cost ratio (1.21) was recorded in the control (T1).

**Keywords:** NAA, 2,4-D, GA3 and Benefit-Cost Ration.

**1. Introduction**

 “Brinjal or eggplant (*Solanum melongena* L.) (2n=2x=24) of the family Solanaceae is one of the important and popular vegetable crops grown in India and other parts of the world. Various sizes, shapes, colours and forms of cultivated as well as the wild type of brinjal are found in India, white type brinjal fruits is said to be good for diabetic patients. Brinjal is a versatile vegetable, often referred to as a "poor man's crop" due to its adaptability to various agro-climatic regions and its ability to be grown year-round” (DBT, 2014). “Though it is a perennial plant, it is typically cultivated as an annual crop for commercial purposes. It is an important vegetable due to its nutritive value, consisting of minerals like iron, phosphorus, calcium and vitamins like A, B and C. Unripe fruits are used primarily as a vegetable in the country. It is also used as raw material in pickle-making and dehydration industries and is an excellent remedy for those suffering from liver complaints” (Shukla and Naik, 1993). It is used in Ayurvedic medicine for curing diabetes and also as a good appetizer. It is a good aphrodisiac, cardiotonic, laxative, mutant and reliever of inflammation.

 “In India, Brinjal is cultivated in an area of about 0.729 million hectares with the production of 12.68 million tonnes and a productivity of 17.41 metric tonnes per hectare” (NHB, 2024). “However, Brinjal is producing almost all state and West Bengal is the largest producer of Brinjal followed by Maharashtra and Bihar. In Rajasthan, Brinjal is cultivated under 5,138 ha area with 23,356 metric tonnes of production” (DOH, 2024) and Jaipur, Sirohi, Sikar, Tonk producing districts.

 “Use of PGRs may increase the productivity of brinjal in terms of quality and quantity and thereby increase the market price and profitability. The plant growth hormones classified into different categories like Auxin, Gibberellins, Cytokinin, etc. are involved with the physiological activities in plants. Among the plant growth regulators used in present experiment, NAA and 2, 4-D relates to auxins group and GA3 to the group of gibberellins” (Singh *et al.*, 2021). NAA (Naphthalene acetic acid) is a synthetic plant hormone which is used in plant tissue culture, promotes growth and also adds to induce root formation in various plants. NAA is widely used in horticulture for various purposes. The foliar spray of Napthalene Acetic Acid (NAA) induces higher physiological efficiency including photosynthetic ability of plants. It leads to better growth and yield of several agronomic crops without substantial increase in the cost of production. Nehara *et al.,* (2006) observed that “NAA increases ethylene formation in plants, which facilitates the efficient translocation of photosynthesis from source to sink. Gibberellic acid increases the plant height, weight Gibberellins stimulate cell division and elongation and seed germinations too Gibberellic acid is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant” (Rafeekher *et al.,* 2002)

 In the present study we are concerned with chemical *i.e*. growth regulators GA3, NAA and 2, 4-D. The growth regulators available are often inadequate in the plants. The specific quantities in the plants are directly responsible for the promotion, inhibition or otherwise modification in the physiological processes. It is obvious that the growth is directly related to the yield.

**2. Material &Methods**

 Field experiment was conducted at the experimental farm, Department of Horticulture, School of Agriculture, Suresh Gyan Vihar University, Jaipur (Rajasthan), during the kharif season of 2023. The experiment was laid out in Randomized Block Design with three replications and 10 treatments. Treatment combinations were, viz; T1- Control (Water Spray), T2- NAA (25 PPM), T3- NAA (50 PPM), T4- NAA (100 PPM), T5- GA3 (50 PPM), T6- GA3 (100 PPM), T7- GA3 (200 PPM), T8- 2, 4-D (2 PPM), T9- 2, 4-D (4 PPM), T10-2, 4-D (6 PPM). The plot size was 3 m × 3 m and the spacing followed was 60 × 60 cm to keep 25 plants per plot for each treatment. The land was brought to a fine tilth through tillage and ploughing. Bunds and irrigation channels were maintained properly. Different intercultural practices like gap filling, staking, irrigating, weeding, etc. were performed as per crop requirements. The five plants of each plot were randomly selected and tagged. The data were recorded for various growth, yield and quality parameters in brinjal during the course of investigation subjected to statistical analysis by using factorial RBD for analysis of variance (ANOVA) as suggested by online opstat software by Sheoran *et al.,* (1998).

**3. Results & Discussion**

**3.1 Growth parameters**

 The data showed that the adoption of different treatments of growth regulators had produced a significant effect on plant height of brinjal (Table 1). The maximum plant height at 30, 60 and 90 days after transplanting (35.25 cm, 51.17 cm and 76.62 cm cm) was noted in treatment T6-(GA3-100 PPM) followed by T3– (NAA 50 PPM) (32.20 cm, 49.45 cm and 74.32 cm) while the minimum plant height at 30, 60 and 90 days after sowing (18.73 cm, 36.61 cm and 53.48 cm) was recorded from treatment T1- Control (Water Spray). These results are closely confined with the findings of (Sahu and Choudhary, 2022) and (Mukharjee and Datta, 1962) in brinjal crop.

 The maximum number of branches per plant (8.33) at 30 DAT was recorded in the treatment T3-NAA 50 ppm, followed by treatment T6 (GA3 100 PPM) with 7.33. The maximum number of branches per plant at 60 and 90 days after transplanting (16.00 and 20.00) was noted in treatment T6-(GA3-100 PPM) followed by T3 – (NAA 50 PPM) (14.33 and 18.33) while the minimum number of branches per plant at 30, 60 and 90 days after sowing (4.00, 8.67 and 10.33) was recorded from treatment T1- Control (Water Spray). These results are closely confined with the findings of Netam and Sharma (2014) in brinjal.

 The maximum number of leaves per plant (21.33) at 30 DAT was recorded in the treatment T3-NAA 50 ppm, followed by treatment T6 (GA3-100 PPM) with 21.00. The maximum number of leaves per plant at 60 and 90 days after transplanting (45.67 and 73.33) was noted in treatment T6-(GA3-100 PPM) followed by T3 – (NAA 50 PPM) (42.33 and 68.67) while the minimum number of leaves per plant at 60 and 90 days after sowing (28.33 and 48.33) was recorded from treatment T1- Control (Water Spray).

 The data presented in Table 1 clearly marked out that different treatment caused significant response on number of days to 50% flowering. The minimum number of days to 50% flowering (37.33 days) was recorded with the application of T6- GA3 100 PPM followed by T3- NAA 50 PPM (39.33). The maximum (48.67) number of days to 50% flowering was found under the treatment T1- Control (Water Spray). Similarly minimum days to 50% flowering result reported by Arivazhangan *et al*., (2018).

 The data accumulated on number of flowers per plant due to influence of various plant growth regulators have been displayed in Table clearly indicated that the maximum number of flowers per plant (26.67) was recorded with the application of T5-GA3 (50 PPM) followed by T3-NAA (50 PPM) (25.67). The minimum (14.33) number of flowers per plant was found under the treatment T1 (control). Similar result of maximum number of flowers per plant with treatment GA3 50 ppm reported by Kropi *et al.,* (2018).

**3.2 Yield Attributing Parameters**

 The data accumulated on number of fruits per plant due to influence of various levels of plant growth regulators have been displayed in Table 1 clearly indicated that the maximum number of fruits per plant (21.33) was recorded with the application of T5- GA3 50 PPM followed by T3- NAA 50 PPM (20.67). The minimum (11.33) number of fruits per plant was found under the treatment T1 (control). Similar result of maximum number of fruits per plant with treatment GA3 50ppm reported by Shukla *et al.,* (1997) and Meena *et al.,* (2005) in brinjal crop.

 The maximum fruits length (9.83 cm) was recorded with the application of T6- GA3 100 PPM followed by T5- GA3 50 PPM (9.34 cm). The minimum (6.08) fruit length was found under the treatment T1 (control). The maximum fruits girth (17.49 cm) was recorded with the application of T5- GA3 50 PPM followed by T6- GA3 100 PPM (16.78 cm). The minimum (11.68 cm) fruit girth was found under the treatment T1 (control). The maximum fruits weight (67.61 g) was recorded with the application of T5- GA3 50 PPM closely followed by T6- GA3 100 PPM (67.60 g). The minimum (42.93 g) fruit weight was found under the treatment T1 (control). Similar findings have been reported by Sharma (2006) and Meena *et al*., (2005) in brinjal crop.

**3.3 Yield Parameters**

 The data recorded towards fruit yield per plant (kg) due to influence of plant growth regulators have been displayed in Table 2 clearly marked out that different treatment caused significant response on fruit yield per plant (kg). The maximum fruit yield per plant (1.397 kg) was recorded with the application of application of T5- GA3 50 PPM closely followed by T6- GA3 100 PPM (1.260 kg). The minimum (0.486 kg) fruit yield per plant was found under the treatment T1 (control). The maximum fruit yield per plot (34.92kg) was recorded with the application of application of T5- GA3 50 PPM closely followed by T6- GA3 100 PPM (31.50 kg). The minimum (12.15 kg) fruit yield per plot was found under the treatment T1 (control). The maximum fruit yield per hectare (388.00q) was recorded with the application of application of T5- GA3 50 PPM followed by T6- GA3 100 PPM (315.22q). The minimum (135.00 q) fruit yield per hectare was found under the treatment T1 (control). “It happens because NAA increases ethylene formation in plants, which facilitates the efficient translocation of photosynthesis from source to sink. Gibberellic acid increases the plant height, weight Gibberellins stimulate cell division and elongation and seed germinations too Gibberellic acid is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant” (Rafeekher *et al.* 2002) and (Sahu and Choudhary, 2022).

# 3.4 Fruit Quality Parameter

 The highest ascorbic acid content (15.01 mg/100g) was observed with the application of T6-GA3 100 PPM, followed closely by T3-NAA 50 PPM (14.47 mg/100g). The lowest ascorbic acid content (7.59 mg/100g) was recorded under T1 (control). Similarly, the maximum total soluble solids (TSS) value (5.61 °Brix) was achieved with the application of T6-GA₃ 100 PPM, followed by T6-NAA 50 PPM (5.46 °Brix). The minimum TSS (3.27 °Brix) was noted in T1 (control). “This might be due to the application of growth promotive substances increased the plant height and such effect was due to increased photosynthetic activity, enhancement in the mobilization of photosynthates, rapid increase in sugars, there by changing in the membrane permeability” (Shukla *et al.,* 1997).

#### 3.5 Economic Parameters

 Gross return quantifies the total revenue generated from brinjal sales, providing an overall measure of financial income. Net return, on the other hand, deducts production costs from the gross return, reflecting the actual profit obtained from brinjal production. It helps growers assess the profitability and economic viability of their cultivation practices. BC ratio compares the benefits (gross returns) to the costs incurred in brinjal production, indicating the profitability and efficiency of the investment. These measurements assist growers in evaluating the financial performance of their brinjal crops, making informed decisions regarding resource allocation, cost management, and assessing the economic feasibility of brinjal cultivation.

 The data in Table 2 clearly shows that the application of different Growth regulators treatments significantly affects the net return of brinjal fruit production in Jaipur, Rajasthan. The maximum net return (₹.3, 27,376/ha) from brinjal production was recorded in T5-GA3 50PPM treatment followed by (₹.2, 83,018/ha) in T3- NAA 50 PPM. Whereas, the minimum net return (₹. 31,486 /ha) was recorded in Control (T1). Hence, the application 50 PPM GA3 treatment was found the best treatment for maximum net return per hectare. The highest B: C ratio (2.84) was recorded under application of GA3 50 PPM treatment followed by (2.64) in T3- NAA 50 PPM. Whereas, the lowest B: C ratio (1.21) was recorded under Control treatment. Hence, the application GA3 50 PPM was found the best treatment to get highest benefit: cost in brinjal production.

 “Use of PGRs may increase the productivity of brinjal in terms of quality and quantity and thereby increase the market price and profitability. The plant growth hormones classified into different categories like Auxin, Gibberellins, Cytokinin, etc. are involved with the physiological activities in plants. Among the plant growth regulators used in present experiment, NAA and 2, 4-D relates to auxins group and GA3 to the group of gibberellins. NAA (Naphthalene acetic acid) is a synthetic plant hormone which is used in plant tissue culture, promotes growth and also adds to induce root formation in various plants. NAA is widely used in horticulture for various purposes. The foliar spray of Napthalene Acetic Acid (NAA) induces higher physiological efficiency including photosynthetic ability of plants. It leads to better growth and yield of several agronomic crops without substantial increase in the cost of production” (Nehara *et al*., 2006) and (Meena *et al.,* 2005).

**4. Conclusions**

 In present investigation that the application of GA3 at 50 PPM significantly enhances growth, yield, and quality attributes of brinjal compared to other treatments and the control. This treatment resulted in the highest fruit yield, net returns and benefit-cost ratio, making it the most economically viable option. GA3 at 100 PPM and NAA at 50 PPM also showed notable improvements in plant height, branching, flowering, and fruit quality. The findings highlight that the use of plant growth regulators, particularly GA3 at 50 PPM, can optimize brinjal production and profitability, making it a recommended practice for growers.

**Authors’ contribution**

 Conceptualization and designing of the research work (NT, DCM); Execution of field/lab experiments and data collection (NT, DCM, MKB); Analysis of data and interpretation (DCM, NKV, MKB); Preparation of manuscript (MMS, DCM).

**Disclaimer (Artificial Intelligence)**

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

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**Table 1. Effect of Plant growth regulators on** **plant height (cm), number of branches per plant, Number of Leaves per Plant, Days to 50 % Flowering, number of flowers per plant and number of fruits per plant of brinjal**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Plant Height (cm)** | **No. of branches per plant** | **Number of Leaves per Plant** | **Days to 50 % Flowering** | **Number of flowers per plant** | **Number of fruits per plant** |
| **30DAT** | **60 DAT** | **90 DAT** | **30DAT** | **60 DAT** | **90 DAT** | **30DAT** | **60 DAT** | **90 DAT** |
| T1-Control (Water Spray) | 18.73 | 36.61 | 53.48 | 4.00 | 8.67 | 10.33 | 12.00 | 28.33 | 48.33 | 48.67 | 14.33 | 11.33 |
| T2-NAA (25 PPM) | 21.86 | 42.31 | 67.17 | 5.33 | 12.33 | 14.00 | 16.33 | 36.33 | 58.33 | 44.67 | 18.67 | 14.67 |
| T3-NAA (50 PPM) | 32.20 | 49.45 | 74.32 | 8.33 | 14.33 | 18.33 | 21.33 | 42.33 | 68.67 | 39.33 | 25.67 | 20.67 |
| T4-NAA (100 PPM) | 25.61 | 41.52 | 66.57 | 6.33 | 13.33 | 11.67 | 19.33 | 36.00 | 65.33 | 41.67 | 21.00 | 17.00 |
| T5-GA3 (50 PPM) | 21.35 | 40.92 | 64.64 | 6.67 | 10.00 | 16.00 | 16.00 | 35.33 | 61.00 | 45.00 | 26.67 | 21.33 |
| T6-GA3 (100 PPM) | 35.25 | 89+ | 76.62 | 7.33 | 16.00 | 20.00 | 21.00 | 45.67 | 73.33 | 37.33 | 22.33 | 18.33 |
| T7-GA3 (200 PPM) | 28.81 | 42.70 | 68.98 | 7.33 | 14.33 | 17.67 | 20.33 | 37.67 | 64.00 | 41.33 | 21.67 | 17.33 |
| T8-2, 4-D (2 PPM) | 27.96 | 41.67 | 68.73 | 4.33 | 10.33 | 16.33 | 16.33 | 35.33 | 59.67 | 42.00 | 23.33 | 19.67 |
| T9-2, 4-D (4 PPM) | 29.25 | 43.42 | 71.11 | 5.67 | 11.33 | 18.00 | 18.33 | 36.33 | 66.33 | 41.67 | 20.33 | 16.33 |
| T10-2, 4-D (6 PPM) | 31.25 | 46.09 | 72.43 | 5.67 | 12.00 | 19.00 | 19.33 | 38.00 | 68.33 | 41.00 | 22.67 | 18.33 |
| S.Em (±) | 2.40 | 4.09 | 5.90 | 1.01 | 1.12 | 5.33 | 1.83 | 3.59 | 5.85 | 3.67 | 3.84 | 4.51 |
| CD at 5% | 0.80 | 1.36 | 1.99 | 0.33 | 0.37 | 1.78 | 0.61 | 1.21 | 1.95 | 1.27 | 1.15 | 1.50 |

**Table 2. Effect of plant growth regulators on Fruit length (cm), Fruit girth (cm), Fruit weight (g), Fruit Yield per plant (kg), Fruit Yield per plot (kg), Fruit Yield per hectare (q/ha), Ascorbic Acid (mg/100g), TSS (oBrix) and B:C Ratio of brinjal.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Fruit length (cm)** | **Fruit girth (cm)** | **Fruit weight (g)** | **Fruit Yield per plant (kg)** | **Fruit Yield per plot (kg)** | **Fruit Yield per hectare (q/ha)** | **Ascorbic Acid (mg/100g)** | **TSS (oBrix)** | **B:C Ratio** |
| T1-Control (Water Spray) | 6.08 | 11.68 | 42.93 | 0.486 | 12.15 | 135.00 | 7.59 | 3.27 | 1.21 |
| T2-NAA (25 PPM) | 7.04 | 14.66 | 64.67 | 0.948 | 23.70 | 263.33 | 9.51 | 3.29 | 2.17 |
| T3-NAA (50 PPM) | 9.00 | 16.54 | 67.61 | 1.135 | 25.37 | 350.00 | 14.47 | 5.46 | 2.64 |
| T4-NAA (100 PPM) | 8.40 | 15.90 | 59.11 | 1.015 | 28.37 | 281.88 | 11.41 | 4.82 | 2.16 |
| T5-GA3 (50 PPM) | 9.34 | 17.49 | 67.61 | 1.397 | 34.92 | 388.00 | 10.92 | 4.37 | 2.84 |
| T6-GA3 (100 PPM) | 9.83 | 16.78 | 67.53 | 1.260 | 31.50 | 315.22 | 15.01 | 5.61 | 2.16 |
| T7-GA3 (200 PPM) | 8.89 | 15.08 | 53.77 | 0.931 | 23.27 | 258.55 | 12.33 | 4.64 | 1.67 |
| T8-2, 4-D (2 PPM) | 8.39 | 16.20 | 55.43 | 1.091 | 27.27 | 303.00 | 10.82 | 4.37 | 2.60 |
| T9-2, 4-D (4 PPM) | 9.02 | 16.26 | 54.12 | 0.883 | 22.07 | 252.22 | 12.49 | 4.19 | 2.02 |
| T10-2, 4-D (6 PPM) | 9.01 | 16.41 | 57.49 | 1.053 | 26.32 | 292.44 | 14.68 | 4.81 | 2.14 |
| S.Em (±) | 1.28 | 1.39 | 5.45 | 0.17 | 3.23 | 28.43 | 3.16 | 1.20 |  |
| CD at 5% | 0.42 | 0.46 | 1.82 | 0.06 | 0.97 | 9.13 | 1.03 | 0.34 |  |