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Response of different plant growth regulators on growth and yield of bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) under Chhattisgarh plains

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Abstract
An experiment was conducted during the summer season of 2024-25 to study the response of different growth regulators on bottle gourd cv. Arka bahar with three growth regulators at different concentrations: Ethrel (100, 200, and 300 ppm), GA_3 (25, 50, and 75 ppm), CCC (100, 200, and 300 ppm). Water was used as a control. The growth regulator was sprayed at the 2-4 leaf stage. All treatments were replicated three times in a randomized block design, keeping the plot size 5.7m x 2.5m. Foliage application of T_3 GA_3 (75 ppm) was found beneficial for vine length (7.75 m), node at first male flower (8.3), no. of male flower/plant (67.1), days to first appear male flower (40.8) whereas T_5 Ethrel 200 ppm was found most effective in terms of node at first female flower (11.7), no. of female flower/plant (15.5), days to first appear female flower (45.2), sex ratio (2.60), average fruit length (43.2 cm), average fruit diameter (8.6 cm), average fruit weight (856.3 g), Number of fruit per plant (13.11), fruit yield per plant (11.2 kg), fruit yield per plot (67.33), fruit yield per hectare (47.25). Overall results revealed that the application of ethrel at 200 ppm proved to be more beneficial for various growth and yield traits in bottle gourd.

Keywords: Plant growth regulators, sex expression, Ethrel, GA_3, CCC, fruit yield

Introduction

Bottle gourd (*Lagenaria siceraria*) belongs to the family of Cucurbitaceae, having a chromosome no. 2n = 22. Bottle gourd originated in Tropical Africa and was domesticated in Asia and Africa. It is commonly known as calabash gourd, white flower gourd plant, Lauki, Kadu, ghiya, or doodhi (Sabu *et al*., 2022) [10].

The total production of bottle gourd in India for the year 2023-24 was 3.77 megatonnes. Bihar is the top bottle gourd-producing state in India, with a production of 0.65 megatonnes for the years 2023-24. Other top bottle gourd-producing states in India include Madhya Pradesh, Uttar Pradesh, Punjab, Gujarat, and Haryana. (Anonymous, 2024) [3] Chhattisgarh is in the eighth position in bottle gourd production in India. Chhattisgarh has a total production of 234.15 kilotonnes of bottle gourd in 2023-24 over an area of 132.4 km², contributing 6.19% to India's total bottle gourd production. The main bottle gourd-producing regions are Raipur, Bilaspur, and Durg. (Anonymous, 2024) [3].

Fruits at the tender stage are used as a cooked vegetable and for the preparation of sweets (e.g., kheer, petha, burfi, and halwa), kofta, pickles, and raita. As a vegetable, it is easily digestible. It is rich in vitamin B and a source of minerals, viz., P, Ca, and Fe. The fruit is the main source of nutrients, including potassium (174 mg), calcium (30 mg), phosphorus (15 mg), magnesium (13 mg), sodium (2 mg), zinc (0.81 mg), and iron (0.23 mg).

Bottle gourd is an annual, vigorous, running, or climbing vine with large leaves and a lush appearance. It is a fast-growing plant that starts to flower just two months after sowing (Singh *et al*., 2020) [12]. They are white in color and attractive, up to 10 cm in diameter, with spreading petals. The ovary is inferior, having the shape of a future fruit. Anthers are borne on short filaments, which are grouped at the center of the flower. The stigma is short, thickened, and branched. In the bottle gourd, several male flowers are produced before the appearance of the first female flower. The important stages of this crop are flowering, fruiting, and yield.

Due to its nature, its male and female flowers appear in different nodes and exist on the same plant (Desai *et al*., 2011) [4].

"Hormone" is the Greek word that derives from "hormao," which means "to stimulate." Currently, plant growth regulators are applied to control many physiological processes, including flowering and fruiting (Sharm *et al*., 1998) [11]. Ethrel is commonly applied to promote the development of female flowers in cucurbits. It helps reduce stem elongation, enhances female flower production, and consequently increases the number of fruits per vine. GA_3 is responsible for increasing the internode length, inducing and promoting male flowering, and stimulating protein synthesis. Growth regulators can increase fruit yield by suppressing the number of male flowers on the main vine and increasing the number of female flowers on side branches. Chlormequat chloride (CCC), commercially known as Cycoceal, is a widely used plant growth regulator in bottle gourd (*Lagenaria siceraria*) for managing excessive vegetative growth and enhancing yield parameters.

Materials and Methods

A field experiment was conducted during the summer season of 2024-25 at Instructional Farm Khudmudi, College of Horticulture and Research Station, Mahatma Gandhi University of Horticulture & Forestry, Durg (C.G.). The present investigation was carried out with a popular and high-yielding variety of bottle gourd, cv. Arka Bahar. This variety has been developed at IIHR, Bangalore. Fruits are straight, devoid of crook neck, medium-sized, and each fruit weighs about 1 kg. Fruits are very good for cooking and have good keeping quality. The experiment was laid out in a randomized block design with three replications. The recommended dose of fertilizers was applied at 100:50:50 N:P:K kg/ha.

The field experiment was laid out in a randomized block design with ten treatments and three replications. The treatment consists of three levels of plant growth regulators: Ethrel (100, 200, and 300 ppm), GA3 (25, 50, and 75 ppm), and CCC (100, 200, and 300 ppm), along with T_0—water spray. The plot size was 5.7 m x 2.5 m with 2.5 m x 0.9 m spacing between rows and plants. Two successive sprays of growth regulators were done at 2-4 leaf stages on the crop plants. Various cultural operations, right from the beginning till the end of experimentation, have been performed successfully as per recommendations. Randomly selected and labeled plants in each treatment were used for recording observations with respect to growth, flowering, yield, and quality attributes. Statistical analysis of variance was performed on the data collected throughout the experiment. The observations were recorded for vine length (m), node number to first male and female flower, days to appearance of first male and female flower, total number of male and female flowers per vine, fruit diameter (cm), fruit length (cm), fruit weight (g), number of fruits per vine, fruit yield per plant (kg), and fruit yield per hectare (t/ha). The significance of the treatments was determined using the 'F' test at a level of significance of 5%.

Results and Discussion

Growth parameter

Vine Length (m)

A significant effect of foliar application of plant growth regulators on vine length was observed. The treatment T_3 (GA_3 75 ppm) recorded the maximum vine length (7.75 m), which was statistically at par with T_2 (GA_3 50 ppm) at 7.43 m and T_1 (GA_3 25 ppm) at 7.18 m. In contrast, the minimum vine length (4.77 m) was observed in treatment T_0 (control). The increased vine length in GA3 was due to a mechanism that stimulates auxin production, cell division, and cell elongation; increases plant height; and extends the growth of the shoot, which enhances the vegetative growth of the plant. Similar results were observed by Anayat *et al*. (2020) [2] and Aishwarya K. *et al*. (2019) [1].

Node at first male and female flower

The node number on which the first male flower appeared was earlier under the treatment T_3 (GA_3 75 ppm), i.e., 8.3, as compared to the control, i.e., 11.3. The treatment T_3 (GA_3 75 ppm) was found to be statistically at par with T_1 (GA_3 25 ppm) at 8.7 and T_2 (GA_3 50 ppm) at 9.1, and the node number on which the first female flower appeared was earlier under the treatment T_5 (Ethrel 200 ppm), i.e., 10.3, as compared to the control, i.e., 15.1. The treatment T_3 (Ethrel 200 ppm) was found to be statistically at par with T_4 (Ethrel 100 ppm) at 11.8 and T_6 (Ethrel 200 ppm) at 11.7.

Days to first appearance of male and female flower

The minimum days required for first male flower appearance was recorded with the treatment T_3 (GA_3 75 ppm), i.e., 40.8 days, as compared to the control, i.e., 51.1 days, and first female flower appearance was recorded with the treatment T_5 (Ethrel 200 ppm), i.e., 45.2 days, as compared to the control, i.e., 55.4 days.

Number of male flowers and female flowers per plant

The maximum number of male flowers (67.1) was recorded under the treatment T_3 (GA_3 75 ppm), and the minimum number of male flowers (40.4) was observed under T_5 (Ethrel 200 ppm). However, the treatments T_1 (GA_3 25 ppm) and T_2 (GA_3 50 ppm) were statistically at par with T_3 (GA_3 300 ppm), and the maximum number of female flowers (15.5) was recorded under the treatment T_5 (Ethrel 200 ppm), and the minimum number of female flowers (8.4) was observed in T_0 (control). However, the treatments T_6 (Ethrel 300 ppm) were statistically at par with T_5 (Ethrel 200 ppm).

Sex Ratio

The significantly lowest male: female sex ratio (2.6: 1) was recorded in Ethrel 200 ppm. the maximum male: female sex ratio was recorded in the control (7.1: 1). The lowest sex ratio in Ethrel 200ppm might be due to a higher number of female flowers and a lower number of male flowers. Similar results were also obtained by Sharma *et al*. (1988) [11] and Patel (1992) [9] in bottle gourd.

Yield parameter

Average fruit length (cm)

The maximum length of marketable fruit was recorded in treatment Ethrel 200 ppm (43.2 cm), followed by Ethrel 100 ppm (41.2 cm), Ethrel 300 ppm (42.4 cm), and GA3 75 ppm (42.4 cm). However, the minimum length of marketable fruit was recorded in the control (27.8 cm). The length of the fruit with the application of ethrel might be due to cell enlargement as well as activation of the metabolic activity of the fruit. Similar results were also obtained by Arora *et al*. (1987) [11] in ridge gourd.

Average fruit diameter (cm)

Maximum fruit diameter (8.6 cm) was recorded under treatment T_5 (Ethrel 200 ppm), and minimum (6.1 cm) was found under control treatment T_0 (control). The length of the fruit with the application of ethrel might be due to cell enlargement as well as activation of the metabolic activity of the fruit. Similar results were also obtained by Kumar *et al*. (1988) [6] in bottle gourd, Sabu *et al*. (2022) [10] in bottle gourd.

Average fruit weight (g)

The data revealed that the maximum weight of fruit was recorded in treatment Ethrel 200 ppm (856.3 g), followed by Ethrel 100 ppm (778.2 g) and Ethrel 300 ppm (801.3 g). However, the minimum weight of fruit was recorded in the control (612 g). The increase in fruit weight by the application of ethrel is due to the plant remaining physiologically more active to build up sufficient food stock for developing flowers and fruits, ultimately leading to higher fruit weight. Similar findings were also reported by Kumar and Rao (1988) [6] in ridge gourd, Kabir *et al*. (1989) in bitter gourd, and Patel (1992) [9] in bottle gourd.

Number of fruit per plant

Significantly, the highest number of fruits per plant was recorded in treatment Ethrel 200 ppm (13.11), followed by Ethrel 300 ppm (12.33). All these treatments were found statistically at par with each other. However, the minimum number of marketable fruits per plant was observed in the control (8.10). The increase in the yield of fruit per plant in ethrel was due to better fruit set because of a larger number of female flowers. Similar results were reported by Mandal *et al*., (1990) [7] in bottle gourd, Parmar *et al*., (2003) [8] and Gedam *et al*., (1998) [5] in bitter gourd.

Yield per plant (kg)

Fruit yield per plant was recorded as maximum (11.22 kg) with treatment T_5 (Ethrel 200 ppm), which was found statistically at par with T_6 (Ethrel 300 ppm), i.e., 9.89 kg. Minimum fruit yield per plant (4.96 kg) was observed in the T_0 (control) treatment. The increase in the yield of fruit per plant in ethrel was due to better fruit set because of a larger number of female flowers.

Yield per plot (kg)

The foliar spray of plant growth regulators significantly increased the number of fruits per plot. Fruit yield per plot was recorded as maximum (67.33 kg) with treatment T_5 (Ethrel 200 ppm), which was found statistically at par with T_6 (Ethrel 300 ppm), i.e., 59.32 kg. Minimum fruit yield per plant 26.51 kg was observed in the T_0 (control) treatment. The increase in the yield of fruit per plot in ethrel was due to better fruit set because of a larger number of female flowers.

Yield (ton/hectare)

Total yield per hectare (q/ha) was recorded as maximum (47.25 ton/ha) with treatment T_5 (Ethrel 200 ppm), which was found statistically at par with T_6 (Ethrel 300 ppm), i.e., 41.63 ton/ha. Minimum fruit yield (20.88 ton/ha) was observed in the T_0 (control) treatment. An increase in fruit yield with PGRs in treated plants may further be attributed to the reason that plants remained physiologically more active to build up sufficient food stock for the developing flowers and fruits, ultimately leading to higher yield. An increase in fruit yield was also due to the increase in pistillate flower production and, ultimately, a larger number of fruits per vine. These findings are also in consonance with those of Gedam *et al*. (1998) [5] in bitter gourd, Sharma *et al*. (1988) [11] and Patel (1992) [9] in bottle gourd.

Table 1: Impact of plant growth regulators on growth parameter on bottle gourd (*Lagenaria siceraria* (Mol.) standl.)

Treatment Notation	Vine Length (cm)	Node at first male flower	Node at first female flower	Days to first appear of male flower	Days to first appear of female flower	No. of male flower/plant	No. of female flower/plant	Sex Ratio
T_0	4.77	11.3	15.1	51.1	55.4	59.3	8.4	7.04
T_1	7.18	9.1	13.1	46.5	53.2	63.2	10.2	5.31
T_2	7.43	8.7	13.3	41.2	52.5	61.3	10.4	4.94
T_3	7.75	8.3	13.7	40.8	51.2	67.1	11.5	4.60
T_4	6.32	9.7	10.3	44.7	47.3	49.4	12.3	4.02
T_5	6.48	9.8	11.7	42.5	45.2	40.4	15.5	2.60
T_6	6.82	10.3	11.8	42.3	46.6	45.7	14.7	3.11
T_7	5.45	10.4	12.2	47.9	54.3	54.1	8.9	6.32
T_8	5.76	10.7	12.4	45.9	53.5	51.4	9.7	6.07
T_9	5.78	10.9	12.9	44.5	52.3	51.2	10.2	5.84
SEM	0.26	0.45	0.57	2.03	2.11	2.11	0.55	0.18
CD at 5%	0.78	1.33	1.67	6.02	6.27	6.27	1.64	0.54
CV	7.15	7.81	8.41	7.85	7.34	7.02	8.57	10.19

Table 2: Impact of plant growth regulator on the fruit Yield of bottle gourd

Treatment Notation	Average fruit length (cm)	Average fruit Diameter (cm)	Average fruit weight (g)	Number of fruit per plant	Yield per plant (kg)	Yield per plot (kg)	Yield per ha (ton)
T_0	27.8	6.1	612.0	8.10	4.96	26.51	20.88
T_1	34.7	6.9	685.1	9.78	6.71	40.26	28.25
T_2	36.2	7	701.7	10.08	7.08	42.46	29.80
T_3	37.8	7.2	730.4	10.75	7.86	47.15	33.09
T_4	41.2	7.4	778.2	11.45	8.92	53.51	37.55
T_5	43.2	8.6	856.3	13.11	11.22	67.33	47.25
T_6	42.4	8.3	801.3	12.33	9.89	59.32	41.63
T_7	31.27	6.5	621.3	8.35	5.19	29.96	21.84
T_8	32.6	6.6	633.1	8.67	5.50	33.03	23.18
T_9	34.1	6.8	651.5	9.12	5.94	35.64	25.01
SEM	1.79	0.32	31.01	0.50	0.44	2.66	1.86
CD at 5%	5.33	0.96	92.12	1.47	1.32	7.89	5.54
CV	6.03	7.87	7.59	8.50	10.47	10.47	10.47

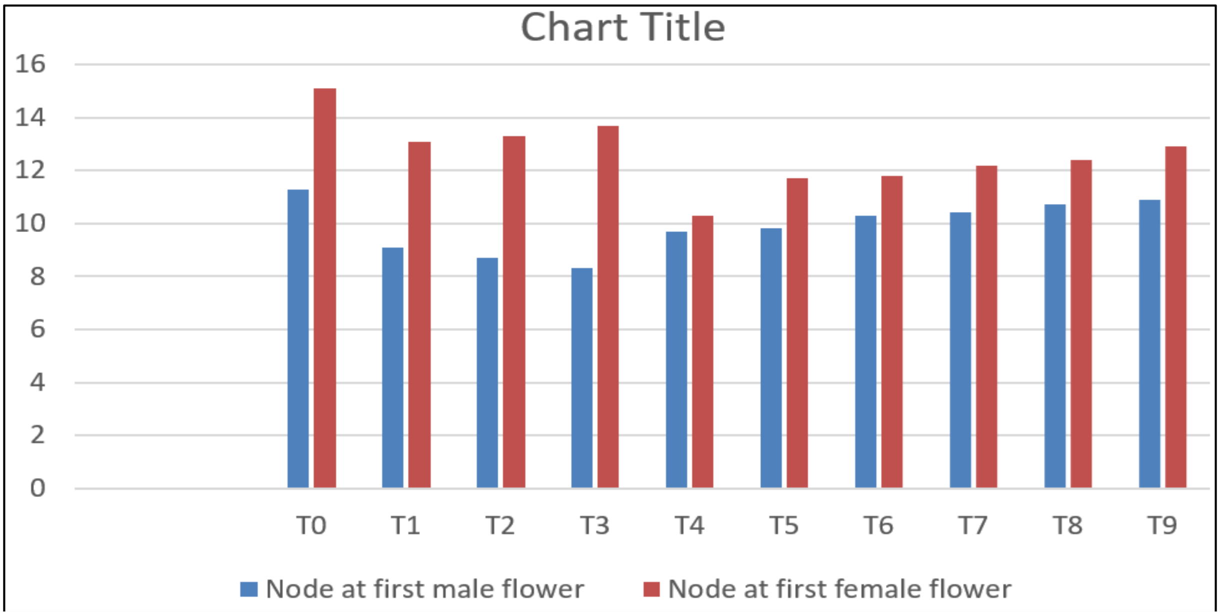

Fig 1: Impact of plant growth regulators on Node at first male and female flower on bottle gourd

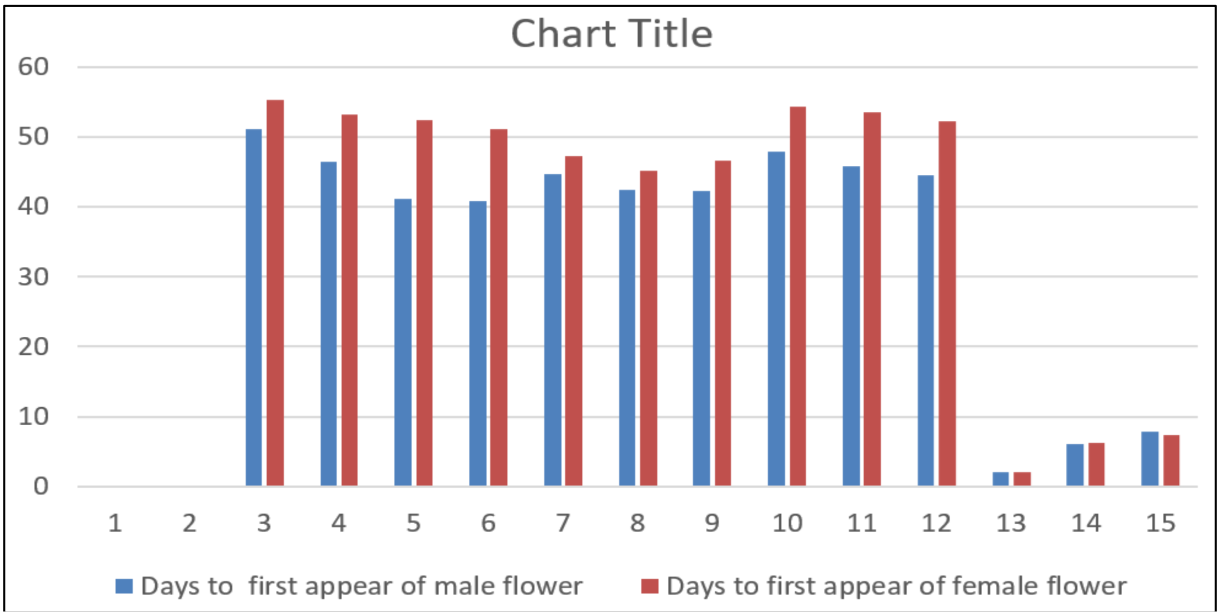

Fig 2: Impact of plant growth regulators on Days to first appear of male and female flower on bottle gourd.

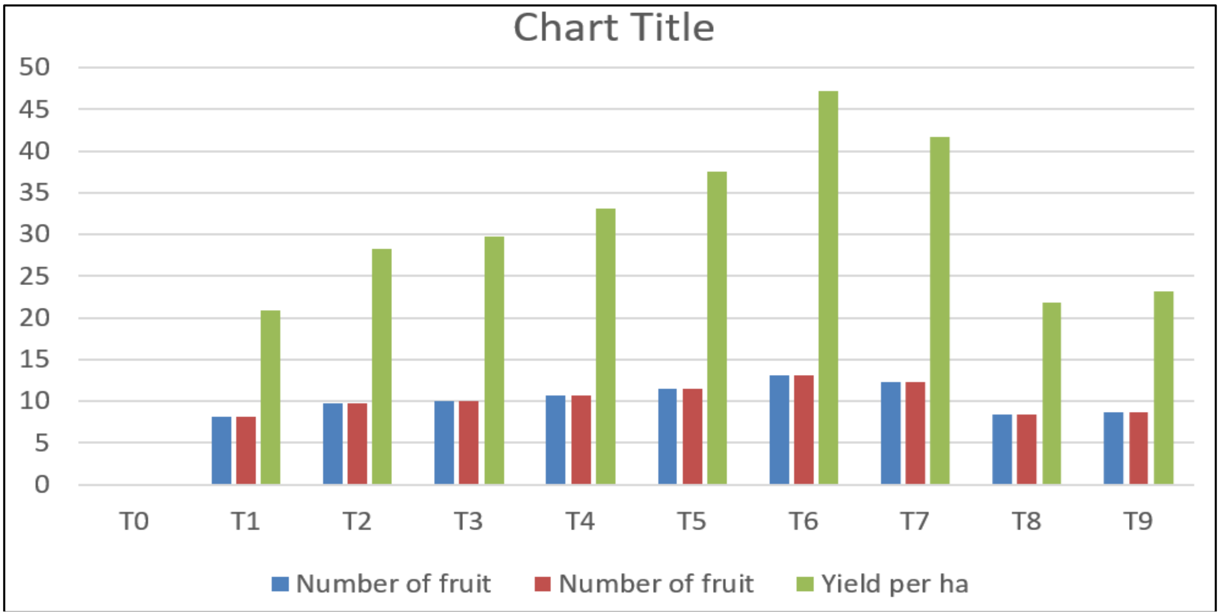

Fig 3: Impact of plant growth regulators on Number of male and female flowers per plant and sex ratio on bottle gourd.

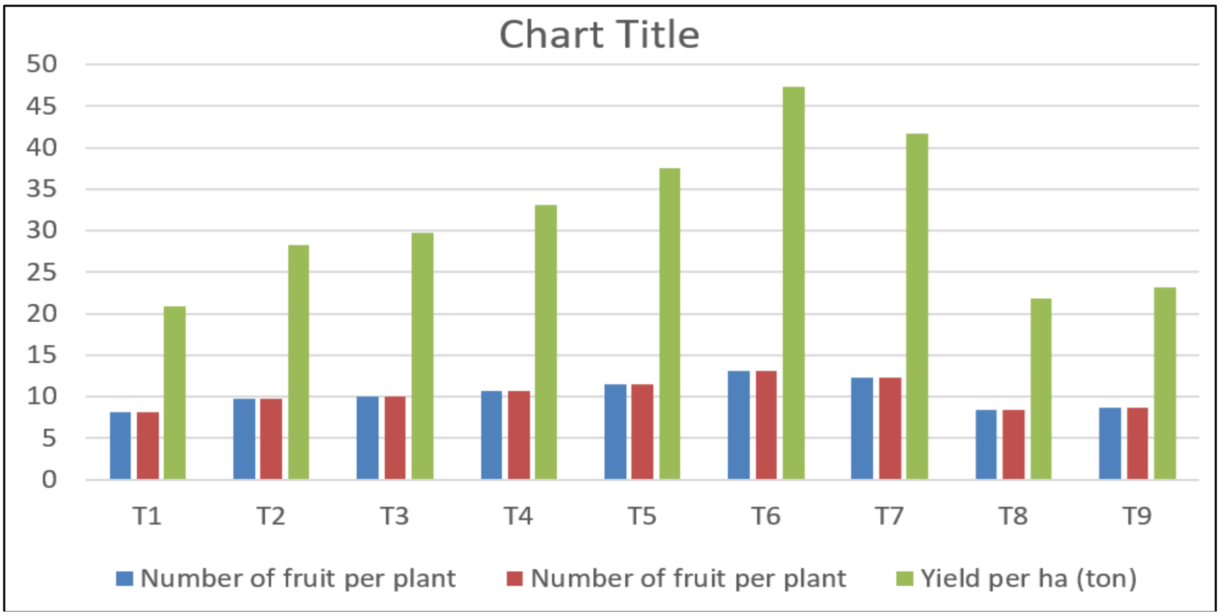

Fig 4: Impact of plant growth regulators on fruit yield of bottle gourd

Conclusion

The present investigation clearly demonstrated that the application of plant growth regulators significantly influenced the growth, flowering, and yield attributes of bottle gourd cv. Arka Bahar. Among the treatments, Ethrel at 200 ppm was found to be the most effective in enhancing femaleness, maximum number of female flowers per plant, a favorable sex ratio, early initiation of female flowers, increased average fruit length, fruit diameter, and fruit weight, and ultimately higher fruit yield per plant and per hectare. In contrast, GA_3 promoted vine elongation, male flower production, and early initiation of female flowers. Overall, the study concludes that foliar application of Ethrel at 200 ppm proved to be the most beneficial treatment for achieving higher productivity and better yield traits in bottle gourd.

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