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Effect of Plant Growth Regulators on Growth, Yield and Quality of Chilli (*Capsicum annuum* L.) in cv. Bidhan Chilli-4

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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

Present experiment entitled “Effect of Plant Growth Regulators on Growth, Yield and Quality of Chilli (*Capsicum annuum* L.) in cv. Bidhan Chilli-4" was conducted at experimental farm of Horticulture and Post-harvest Technology, Palli Siksha Bhavana, Palli Shikhsha Bhavana Visva Bharati West Bengal during *rabi* season of 2020. The experiment was laid out in randomized block design (RBD) with three replications and ten treatments. The concentrations of treatments were T_1 =NAA 25 ppm, T_2 = NAA 50 ppm, T_3 = NAA 75 ppm, T_4 = GA3 5 ppm, T_5 = GA3 15 ppm, T_6 = GA3 30 ppm, T_7 = CCC 200 ppm), T_8= CCC 400 ppm, T_9 = CCC 600 ppm and T_{10} Control. The result of the study revealed that maximum plant height (30.96, 44.40, 54.06 and 67.01cm at 30,60, 90 and 120 DAT respectively), number of branches per plant (8.96, 13.43, 18.00 and 23.53 at 30, 60, 90 and 120 DAT respectively), plant spread (19.50, 30.96, 40. 10 and 54.73 cm at 30, 60, 90 and 120 DAT respectively), flowers per plant (400.20), fruits per plant (144.33), fruit length (9.63 cm), breadth of fruit (1.93 cm), yield per plant (399.43 g), yield per plot (98.74 kg/ plot) , yield per hectare (134.53 q/ha), ascorbic Acid (190.76mg/100g), capsaicin (0.38 %) capsanthin content (296.109 ASTA Unit), Oleoresin content (11.57%) and minimum days required to 50% flowering (41.68 DAT), were recorded in treatment T_3- NAA (75 ppm). Therefore, it is recommended to employ the NAA 75 ppm to chilli growing farmers to enhance growth and maximize yield.

Keywords: Chilli; plant growth regulator; NAA; GA3; CCC.

1. INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important vegetable cum spice crop grown in almost all parts of tropical and subtropical regions of the world. It belongs to the family Solanaceae and originated from South America or Mexico. Where, it was domesticated around 7000 BC. The genus *Capsicum* includes 30 species, five of which are cultivated: *Capsicum annuum* L., *C. frutescence* L., *C*. *chinense* J., *C. pubescence* R. and *C. baccatum* L. [1]. Despite being planted across the nation in a variety of agro-climatic zones, dry chilli is primarily grown in southern states. It is produced in large quantities throughout the nation, both under rained and irrigated conditions, on an area of 377 thousand hectares (NHB, Final Estimate 2018-19). The majority of the world's export of chillies comes from India. India exports chilli in the form of dry pods, chilli powder, and oleoresins to the USA, UK, Russia, Canada, Italy, Netherlands, Singapore, Saudi Arabia, UAE, and Germany. Major chilli producing states are Andhra Pradesh, Karnataka, Maharashtra, Odisha, Rajasthan, Tamil Nadu, and Madhya Pradesh.

The pungency of the chilli fruits is due to the presence of capsaicin content. The size of fruit ranges between 1 to 20 cm and has a variety of shapes, including thin, long, conical, and blocky with thick flesh. The majority of the cultivars grown in the nation have strong to mildly strong flavours. Chilli is employed in the food and beverage industries in the form of oleoresin, which allows for improved flavour and colour distribution in food. The vitamins C, B and K are abundant in green chillies. It is frequently used in the preparation of sauces, soups, pickles, curry paste, and curry powder. No other spice has possibly gained as much popularity or has become as essential to the everyday diet of the majority of people in the globe as the chilli. Chaudhary et al., [2].

After fertilizers, insecticides, and herbicides, plant growth regulators are called next generation agro-chemicals since they help achieve this. Plant growth regulators may be able to boost vegetable productivity. Premature bloom and fruit drop in chilli is a major issue in hot regions like Vidarbha. One of the main production bottlenecks for chilies is poor fruit set caused by hormonal imbalance brought on by a fast increase in atmospheric temperature, which has a direct impact on yield**,** Vijayaraghavan, H., and Tamilselvi, C. [3].

Moreover, PGRs have been shown to mitigate the effects of biotic and abiotic stresses in chilli plants. For example, salicylic acid and abscisic acid are involved in enhancing resistance to drought and pathogen attacks by modulating the plant’s stress response mechanisms [4,5]. The strategic application of these regulators can lead to improved stress resilience and yield stability, particularly in regions prone to climatic variability.

The growth regulators NAA, GA_3, and CCC all have positive effects on various crops. There is a

dearth of knowledge regarding the effects of CCC, NAA, and GA_3 on chilli in Vidarbha. Hence, the suggested experiment was designed to examine the impact of NAA, GA_3, and CCC on chilli plant growth, yield, and quality enhancement [6].

2. MATERIALS AND METHODS

The trial was performed during *Rabi* season of 2022-23 at experimental farm department of Horticulture, Palli Shiksha Bhavana Visva Bharati West Bengal, The experiment's was laid out in randomised block design (RBD) with three replications and ten treatment combinations *viz.* T_1= NAA 25 ppm, T_2 = NAA 50 ppm, T_3= NAA 75 ppm, T_4= GA_3 5 ppm, T_5, = GA_3 15 ppm, T_6 = GA3 30 ppm, T_7 = (CCC 200 ppm), T_8= CCC 400 ppm, T_9 = (CCC 600 ppm), and T_{10}, = Control. The treatments were applied foliar at 30 DAT, 60 DAT, and 90 DAT. The crop was raised at the spacing of 60×30 cm in plot size of 2 ×1.75m. Standard culture practices recommended for chilli were followed uniformly in all experimental plots.

2.1 Growth and Yield Parameters

Plant height**,** Number of branches per plant, Plant spreads (cm), Plant spreads (cm), Flowers per plant, Fruits per plant, Length of fruit (cm), Breadth of red fruit Yield per plant (kg), Yield per plot (kg/ plot), Yield per hectare (q/ha).

2.2 Quality Parameters

Ascorbic Acid (mg/100g), capsaicin (%), capsanthin content (ASTA Unit) and oleoresin (%).

2.3 Statistical Analysis

Experimental data was subjected to biometrical analysis as per the standard as procedure given by Gomez and Gomez [7].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The plant height was measured at 30, 60, 90, and 120 days after transplanting. Application of plant growth regulators were found statistically significant at 30 DAT 60 DAT, 90 and 120 DAT. Treatment T_3 (NAA at 75 ppm) produced the highest plant height (30.96, 44.40, 54.06 and 67.01cm at 30,60, 90 and 120 DAT respectively.), followed by treatment T_6 (GA_3 at 15 ppm), (25.83, 37.73, 51.26 and 56.96cm at 30,60, 90 and 120 DAT respectively), and the lowest plant height (24.73, 28.53, 42.00, and 48.53cm at 30,60, 90 and 120 DAT respectively) was recorded in treatment T_9 (CCC at 600 ppm). These findings are similar to Anolisa et al., [8], Table 1 and Fig. 1.

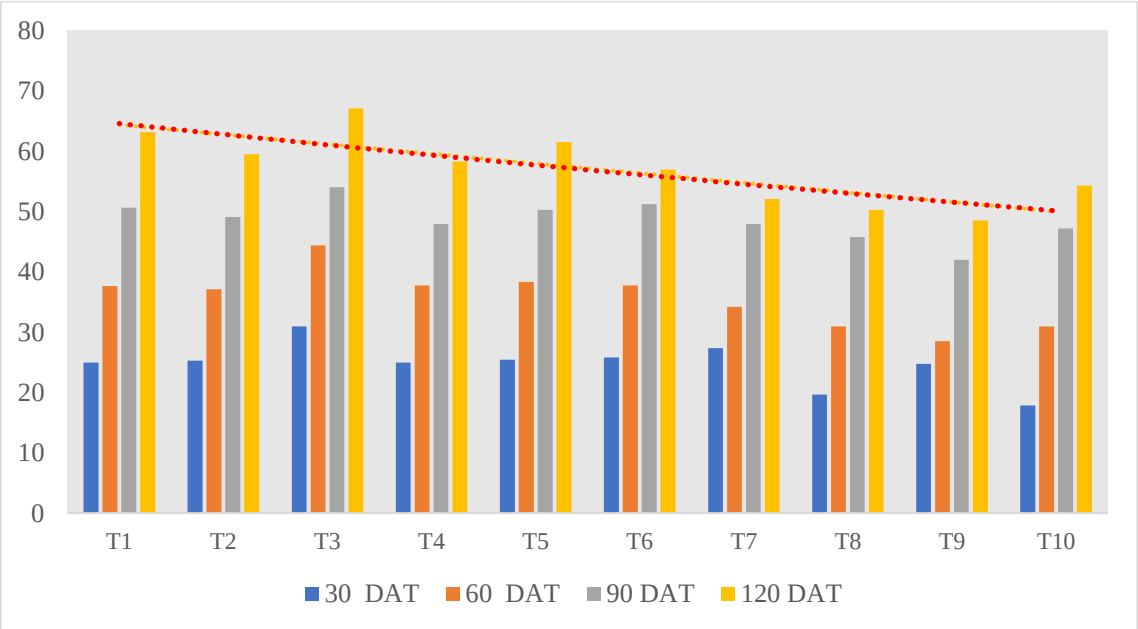

Fig. 1. Plant height (cm) at 30, 60, 90 and 120 DAT

Table 1. Effect of plant growth regulators on growth parameters

Treatments	Plant Height (cm)				Number of Branches Per Plant				Plant Spread (cm)				Days Required to 50%Flowering
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	
T_1 - NAA (25 ppm)	24.96	37.63	50.66	63.20	6.10	10.53	15.87	19.33	15.86	27.20	36.20	39.96	40.43
T_2 - NAA (50 ppm)	25.30	37.10	49.10	59.53	6.00	10.53	14.20	16.76	16.06	25.63	31.33	49.10	42.86
T_3- NAA (75 ppm)	30.96	44.40	54.06	67.10	8.96	13.43	18.00	23.53	19.50	30.96	40.10	54.73	39.06
T_4- GA_3 (5 ppm)	24.96	37.76	47.96	58.30	5.66	9.50	12.10	16.20	16.33	26.20	34.20	49.40	41.68
T_5- GA_3 (15 ppm)	25.43	38.33	50.26	61.53	6.66	9.43	14.53	19.10	13.10	26.63	35.20	52.20	43.50
T_6- GA_3 (30 ppm)	25.83	37.73	51.26	56.96	7.33	11.13	12.30	21.96	17.85	28.86	32.83	50.30	42.53
T_7- CCC (200ppm)	27.33	34.20	47.96	52.10	6.01	9.35	13.50	18.09	12.56	20.45	28.56	43.01	43.90
T_8 - CCC (400ppm)	19.66	30.96	45.76	50.30	6.10	9.65	14.00	22.43	13.00	21.30	30.86	45.53	42.36
T_9- CCC (600 ppm)	24.73	28.53	42.00	48.53	6.86	10.63	15.53	19.20	13.63	22.20	32.86	46.63	42.38
T_{10}- Control	17.83	30.96	47.20	54.33	5.86	8.40	12.53	15.06	9.76	19.00	28.30	37.73	40.63
CV%	**3.30**	**3.60**	**3.70**	**4.67**	**5.50**	**2.74**	**3.18**	**4.94**	**2.78**	**6.09**	**4.98**	**3.76**	**2.09**
CD%	**1.40**	**2.12**	**1.40**	**2.15**	**2.90**	**1.90**	**1.67**	**2.52**	**0.87**	**3.15**	**2.87**	**2.20**	**2.53**

Table 2. Effect of plant growth regulators on yield and quality parameters

	Yield							Quality			
Treatments	**Flowers Per Plant**	**Fruits Per Plant**	**Length of Fruit (cm)**	**Breadth of Fruit**	**Yield Per Plant (g)**	**Yield per Plot (kg/ Plot)**	**Yield Per Hectare (q/ha)**	**Ascorbic Acid (mg/100g)**	**Capsaicin (%)**	**Capsanthin Content (ASTA Unit)**	**Oleoresin (%)**
T_1 - NAA (25 ppm)	318.16	126.46	8.06	1.30	380.6	8.55	126.16	186.98	0.37	285.01	10.10
T_2 - NAA (50 ppm)	333.86	126.56	7.86	1.63	359.61	7.35	129.48	189.98	0.37	290.28	10.76
T_3- NAA (75 ppm)	400.20	144.53	9.63	1.93	399.43	9.74	134.53	190.76	0.38	296.10	11.57
T_4- GA_3 (5 ppm)	324.20	129.20	8.03	1.30	376.21	7.96	120.68	170.80	0.28	241.91	9.43
T_5- GA_3 (15 ppm)	390.96	127.81	8.33	1.36	369.68	6.26	125.65	172.60	0. 29	247.98	9.96
T_6- GA_3 (30 ppm)	351.73	128.96	8.40	1.56	390.61	8.71	117.48	175.65	0.31	250.50	10.21
T_7- CCC (200ppm)	281.40	121.76	7.43	1.23	350.58	6.50	107.23	165.74	0.27	218.67	8.75
T_8 - CCC (400ppm)	297.96	124.30	8.43	1.60	363.85	8.11	120.30	158.90	0.28	222.82	8.17
T_9- CCC (600 ppm)	329.83	129.03	8.20	1.36	375.51	7.43	116.36	160.74	0.30	213.94	9.85
T_{10}- Control	261.66	111.66	6.63	1.13	330.58	6.25	100.88	110.22	0.25	201.16	7.75
CV%	**5.91**	**4.20**	**3.05**	**1.09**	**2.43**	**2.09**	**3.61**	**4.09**	**3.54**	**3.14**	**2.94**
CD @5%	**3.09**	**2.56**	**1.48**	**0.87**	**1.65**	**2.45**	**2.43**	**2.65**	**1.28**	**1.39**	**1.10**

A significant difference was recorded in number of branches with the application of various plant growth regulators at 30, 60, 90 and 120 DAT. maximum number of branches (8.96, 13.43, 18.00 and 23.53 at 30, 60, 90 and 120 DAT respectively) in T_3 (NAA at 75ppm) followed by treatment T_6 (GA3 (30 ppm), (7.33, 11.13, 12.30 and 21.96 at 30, 60, 90 and 120 DAT respectively.) Lowest number of branches in T_{10} (control) 6.86, 10.86, 15.53, 19.20 at 30, 60, 90 and 120 DAT respectively).

The spread of plant was recorded at 30, 60, 90 and 120 DAT, and showed significant differences due to application of the plant growth regulators. Maximum plant spread (19.50, 30.96, 40. 10 and 54.73 cm at 30, 60, 90 and 120 DAT respectively) was found in treatment T_3 (NAA at 7 5 ppm), which was found at par T_6 (17.85, 28.86, 32.83 and 50.30 cm at 30, 60, 90 and 120 DAT respectively) cm. whereas, minimum (9.76, 19.0, 28.30 and 37.73cm) in plant spread was recorded in application of treatment T_{10} (Control). These results are in line with the findings of Kalshyam et al., [9] and Chandini et al., [10] in chilli.

Significantly the minimum days (39.06) were required to 50% flowering in chilli plant was recorded in the treatment T_3 (NAA 75 ppm), followed by 40.43 with treatment T_1 (NAA 25 ppm). Whereas, the maximum 43.90 days were required to 50% flowering was recorded due to application of treatment T_7 (NAA 75 ppm). Similar results were also reported by Singh and Mukherjee [11] in chilli, (Table 1.)

3.2 Yield and Yield Attributes

Significantly the maximum number of flowers 400.20 per plant in chilli was recorded in the treatment T_3 (NAA 7 5ppm), and followed by 390.96 treatment T_5 (GA_3 15ppm), However, the minimum 261.66 number of flowers per plant was recordedwith treatment T_{10} (Control).

Analysis of number of fruits per plant data have been sown in Table 2. Significantly the maximum 144.53 number of fruits per plant in chilli crop was recorded in the treatment T_3 (NAA75 ppm), and followed by 129.20 with treatment T_4 (GA_3 5 ppm), and the minimum 111.66 number of fruits per plant was observed in treatment T_{10} (Control). Application of Naphthalene Acetic Acid at 50 ppm concentration and also the GA_3 at 30 ppm recorded significantly maximum number of fruits per plant. Similar results were also reported by Singh and Mukherjee (2000**)** in chilli.

The data in respect of length of fruit indicated significant differences in respect length of chilli fruit. The data from Table 2 clearly depicted that, significantly the maximum fruit length 9.63 cm length of fruit was obtained in the treatment T_3 and minimum 663 cm length of chilli fruit was recorded in treatment T_{10} (Control).

The data from Table 2 clearly indicated that, significantly the maximum 1.93 cm breadth of fruit was recorded in the treatment T_3 (NAA 75 ppm), and minimum 1.13 cm breadth of chilli fruit was recorded in treatment T_{10} (Control).

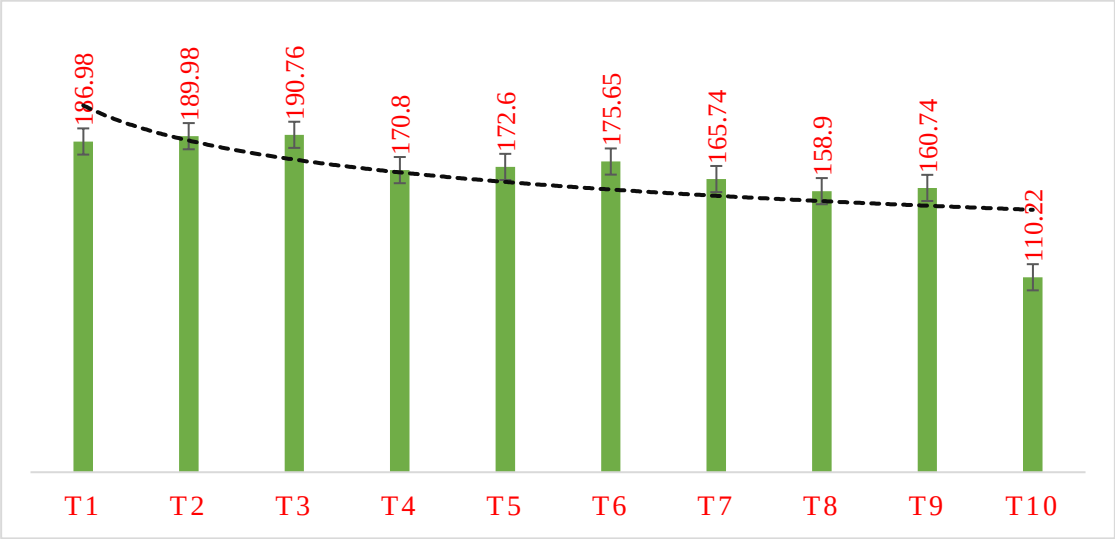

Fig. 2. Yield per hectare (q//ha)

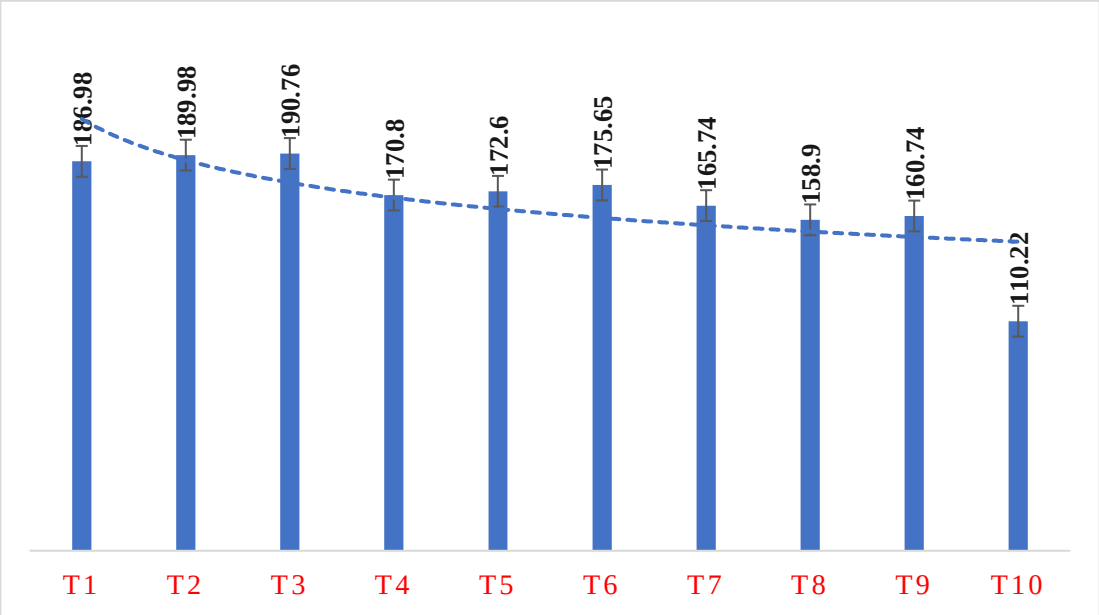

Fig. 3. Ascorbic acid (mg/100gm)

The information in Table 2 showed that the treatment T_3 (NAA at 75 ppm) produced the significantly highest yield per plant (399.43 g), yield per plot (9.74 kg), and yield per hectare (134.53 q) in the chilli crop. However, it was noted that treatment T_{10} (Control) produced the lowest yield of chilli fruit per plant (399.43 g), yield per plot (9.47 kg), and yield per hectare (134.53 q). This might be because NAA might be responsible for increasing photosynthetic activities within the plant, which may have led to more production of carbohydrates and related products, which are responsible for the increase in growth. These findings concur with those of Sultana et al., [12] studied in chilli.

3.3 Quality Parameters

Among the quality parameters, maximum ascorbic acid (190.76mg/100gm), capsaicin (0.38%), capsanthin (296.10 ASTA unit), and oleoresin (11.57%) were reported with the application of T_3- NAA (75 ppm) followed by T_6- GA3 (30 ppm), (ascorbic acid 175.65 mg/100gm, capsaicin 0.31 %, capsanthin content 250.50 ASTA unit, oleoresin 10.21%) and T_9- CCC (600 ppm) (ascorbic acid 160.74 mg/100gm, capsaicin 0.30 %, capsanthin content 213.94 ASTA unit, oleoresin 9.85 %). Whereas these all-qualitative parameters were minimum in T_{10} (ascorbic acid 110.22 mg/100gm, capsaicin 0.25 %, capsanthin content 201.16 ASTA unit and oleoresin 7.75 %), (Table 2) [13,14].

4. CONCLUSION

Based on this study, it can be concluded that application of plant growth regulators significantly influenced the growth, yield, and quality parameters of chilli plants. Treatment T_3 (NAA at 75 ppm) consistently produced the highest plant height, number of branches, plant spread, number of flowers, and number of fruits per plant across all measured intervals). Additionally, T_3 resulted in the shortest time to 50% flowering. This treatment also achieved the highest fruit length, breadth, and yield per plant, per plot, and per hectare. Based on the results of this study, we recommend that chili growers use T3 (NAA at 75 ppm) to improve growth, yield, and quality.

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 manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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