Original Research Article

Effect of plant growth regulators on growth, yield and quality of Chilli (*Capsicum annum* L.)

ABSTRACT

The present investigation entitled on effect of plant growth regulators on growth, yield and quality of Chilli(*Capsicum annum* L.) was carried out at the Horticulture Research Field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during *Kharif*season 2022on variety TMPH-409. The experiment was laid out in Randomized block design with 19 treatmentand 3 replications including control with differentplant growth regulators. Different plant growth regulators (NAA, GA_3, 2-4 D)were used with different treatment combination and doses. Among the various treatmentssignificant results showed by T_7(NAA@40ppm+GA_3@100 ppm) in terms of plant height (88.06 cm at 90 DAT), number of primary branches (9.97 branches), leaf area (192.78 cm^2), early days to 50% flowering (64.94 DAT) and yield viz., fruit weight (3.71 g), length of fruit (7.96 cm), fruit girth (3.00 cm), number of fruits per plant (251.62 fruits), and yield per plant (878.93 g/plant).

Keywords: *NAA, GA_3, 2-4 D,TMPH,PGRs,*Chilli(*Capsicum annum* L.).

1. INTRODUCTION

Chilli (vernacular name: *Mirchi*), botanically known as *Capsicum annuum* (L.) is one of the well-known plants belonging to Solanaceae. It is a diploid cross-pollinated dicot plant species with chromosome number 2n=2x=24 **(Haque, 2016).** Chilli is one of the first self-pollinating crops cultivated in Mexico, Central America, and parts of South America.In India Chilli is grown in Andhra Pradesh, Telangana, Madhya Pradesh, Karnataka, West Bengal, and Himachal Pradesh on large scale. The substances that give chili peppers their pungency (spicy heat) when ingested or applied topically are capsaicin (8-methyl-N-vanillyl-6-nonenamide) and several related chemicals, collectively called capsaicinoids. The quantity of capsaicin varies by variety, and on growing conditions. Water-stressed peppers usually produce stronger pods. When a habanero plant is stressed, by absorbing low water The varieties of chilies that are cultivated in India are Naga, Jwala, Guntur, Kanthari, Bhut Jolokia

and many more. Lycopene, which is soluble in water, is responsible for the red colour of red chili peppers.

PGRs have been found to alleviate the adverse effects of various abiotic stresses on chilli plants, including drought, salinity, and extreme temperatures. They can enhance stress tolerance and improve the plant's ability to withstand challenging environmental conditions **(Kumar and Sharma, 2020)**. Auxins like NAA, are commonly used as rooting hormones during propagation, leading to improved root establishment and overall plant vigour **(Aggrawal *et al.*, 2018)**. Gibberellic acid (GA) and cytokinin can stimulate flowering and increase fruit set in chilli plants. They can help in synchronizing flowering, resulting in uniform fruit production and higher yields **(Arora and Bist, 2016)**. Plant growth regulators (PGRs) are crucial for the growth and development of chilli plants. They promote cell division, elongation, and differentiation, leading to better plant growth, flowering, fruiting, and seed formation. PGRs can also enhance nutrient uptake efficiency, increase resistance to biotic and abiotic stresses, and improve crop quality and yield. In chilli cultivation, PGRs like gibberellic acid (GA_3) and salicylic acid can improve plant vigour and health, synchronize maturity, promote fruit set, and increase marketable yield, thereby increasing profitability. The use of PGRs is a valuable tool for growers to maximize crop potential and meet consumer demand. Therefore,the present investigation was undertaken with aim to study the effect of plant growth regulators on growth, yield and quality of Chilli.

2.MATERIALS AND METHODS

The present investigation was done to study the impact of combine application and sole application of plant growth regulators on plant growth, fruit yield and quality of fruit of chilli variety TMPH-409 with spacing 60x45 cm (RXP) which was carried out at Horticultural Research FieldDepartment of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the *Kharif* season of 2022. The experiment was laid out in Randomized block design with 19 treatments and 3 replications with different combination in plant growth regulators*viz.* $\mathbf{T_0}$ (Water Spray (Control)); $\mathbf{T_1}$ (NAA at40 ppm); $\mathbf{T_2}$ (NAA at 60 ppm); $\mathbf{T_3}$ (GA_3 at 100 ppm); $\mathbf{T_4}$ (GA_3at150 ppm); $\mathbf{T_5}$ (2,4-D at 5 ppm); $\mathbf{T_6}$ (2,4 D at 7.5 ppm); $\mathbf{T_7}$ (NAA at 40 ppm + GA_3at 100 ppm); $\mathbf{T_8}$ (NAA at40 ppm + GA_3 at150 ppm); $\mathbf{T_9}$ (NAA at60 ppm + GA_3at 100 ppm); $\mathbf{T_{10}}$ (NAA at 60 ppm + GA_3at 150 ppm); $\mathbf{T_{11}}$ (NAA at 40 ppm + 2,4 D at 5 ppm); $\mathbf{T_{12}}$ (NAA at40 ppm + 2,4 D at 7. 5 ppm); $\mathbf{T_{13}}$ (NAA at 60 ppm + 2,4 D at 5 ppm); $\mathbf{T_{14}}$ (NAA at 60 ppm + 2,4 D at 7.5 ppm); $\mathbf{T_{15}}$ (GA_3at 100 ppm + 2,4 D at 5 ppm); $\mathbf{T_{16}}$ (GA_3at 100 ppm + 2,4 D at 7.5 ppm); $\mathbf{T_{17}}$ (GA_3at150 ppm + 2,4 D at 5 ppm); $\mathbf{T_{18}}$ (GA_3at 150 ppm + 2,4 D at 7.5 ppm).Observations

were recorded at different stages of growth periods and studied for growth parameters like plant height, number of branches per plant, leaf area, earliness parameters like days to 50% flowering, days to first fruit picking, yield parameters like fruit length, fruit girth, fruit weight and quality parameters TSS and vitamin C content. The data were analysed by the method suggested by **Fisher and Yates, 1963.** The observation of randomly five selected plants from each plot was measured in cm by a 100 cm scale from ground level to tip of the shoot at 90 DAT stage. The parameter, numbers of branches per plant, are observed from main shoot were counted and were averaged to represent numbers of primary branches per plant. Number of branches per plant basis was counted at harvest stage

3.RESULTS AND DISCUSSION:

3.1 Growth parameters

3.1.1 Influence of plant growth regulators (PGRs) on plant height (cm)

The maximum plant height at 90 DAT (88.06 cm) was observed with treatment T_7 (NAA @40 ppm + GA_3 @100 ppm). Minimum plant height at 90 DAT (72.76 cm) was observed in T_0 (Control) while the remaining treatments were moderate in their growth habit. PGRs application regulates plant height in chilli by influencing cell division and elongation, promoting internode elongation, and altering hormonal balance. Specific PGRs, such as gibberellic acid (GA_3), can stimulate stem elongation and increase plant height. Similar findings were reported by **Kanan *et al.*, (2020); Mahato *et al.*, (2020); Kumar *et al.*, (2022) and Kumar and Topno (2022).**

3.1.2 Influence of Plant growth regulators (PGRs) on number of branches per plant

The maximum number of primary branches per plant at 90 DAT (9.97 branches) was observed with treatment T_7 (NAA at40 ppm + GA_3at100 ppm). Minimum number of primary branches per plant at 90 DAT (6.33 branches) was observed in T_0 (Control). PGRs application regulates the number of branches in chilli by influencing axillary bud development and branching patterns. Certain PGRs, promotes lateral bud growth and increase the number of branches. By manipulating hormonal signals and bud activation, PGRs play a crucial role in controlling the branching architecture of chilli plants and determining the number of branches they produce.Similar findings were reported by **Kumar *et al.*, (2018); Tayde *et al.*, (2018); and Kumar and Topno (2022).**

3.1.2. Leaf area (cm^2)

The maximum Leaf area at flowering (192.78 cm^2) was observed with treatment T_7 (NAA at40 ppm + GA_3at100 ppm). Minimum Leaf area at flowering (117.65 cm^2) was observed in

T_0 (Control) while the remaining treatments were moderate in their growth habit. PGRs application regulates leaf area in chilli by stimulating leaf expansion and increasing leaf size. Certain PGRs, such as auxins and gibberellins, promote cell division and elongation, resulting in larger leaf size and overall increased leaf area in chilli plants.Similar findings were reported by **Ahmadi and Majidi(2016)**in tomato; **Tayde *et al.*, (2018); Mishra*et al.*, (2019); Kanan *et al.*, (2020)**.

3.2. Earliness parameter

3.2.1 Influence of plant growth regulators (PGRs) on days to first flowering and days to first fruit harvest

The minimum days to first flowering at flowering (36.83 days) was observed with treatment T_7 (NAA at40 ppm + GA_3 @100 ppm). Maximum days to first flowering at flowering (45.62 days) was observed in T_0 (Control). The minimum days to first harvest at flowering (64.94 days) was observed with treatment T_7 (NAA at40 ppm + GA_3at100 ppm). Maximum days to first harvest at flowering (78.88 days) was observed in T_0 (Control). PGRs application regulates early flowering and maturity in chilli by influencing flowering hormone levels and accelerating reproductive development. PGRs, such as gibberellins can promote flower bud initiation, shorten the time to flowering, and facilitate early fruit set and maturation, leading to an expedited flowering and maturity process in chilli plants. Similar conclusions were inferred by **Farooq *et al.*, (2018)** in tomato; **Mishra*et al.*, (2019); Kanan *et al.*, (2020);Mahato *et al.*, (2020)**.

3.3 Yield parameters

3.3.1 Influence of plant growth regulators (PGRs) on number of fruits per plant

The maximum number of fruits per plant at flowering (251.62 fruits) was observed with treatment T_7 (NAA at40 ppm + GA_3at100 ppm). Minimum number of fruits per plant at flowering (90.36 fruits) was observed in T_0 (Control). PGRs application enhances the number of fruits per plant in chilli by stimulating flower initiation, improving pollination and fertilization, and increasing fruit set. PGRs, such as auxins promote flower bud differentiation, enhance flower viability, and ultimately contribute to an increased yield of fruits per plant in chilli crops. Similar conclusions were inferred by **Mahato *et al.*, (2020);**and**Kumar and Topno (2022)**.

3.3.2 Influence of plant growth regulators (PGRs) on fruit length (cm) and fruit girth (cm)

Themaximum average fruit length at flowering (7.96 cm) was observed with treatment T_7 (NAA at40 ppm + GA_3 @100 ppm). Minimum average fruit length at flowering (4.55 cm) was observed in T_0 (Control). The maximum average fruit girth at flowering (3.00 cm) was observed with treatment T_7 (NAA at40 ppm + GA_3at100 ppm). Minimum average fruit girth at flowering (1.33 cm) was observed in T_0 (Control). PGRs application regulates the enhancement of fruit length and fruit girth in chilli by influencing cell division and expansion processes. PGRs, such as gibberellins and auxins, promote cell elongation, increase fruit size, and stimulate fruit development, resulting in larger and more substantial fruits in terms of length, girth, and diameter in chilli plants. These results are in close conformity with the findings of**Kumar *et al.*, (2018);Mishra*et al.*, (2019)**.

3.3.3 Influence of plant growth regulators (PGRs) on fruit weight (g) and fruit yield per plant (g/plant)

The maximum average fruit weight at flowering (3.71 g) was observed with treatment T_7 (NAA at40 ppm + GA_3at100 ppm). Minimum average fruit weight at flowering (2.11 g) was observed in T_0 (Control). The maximum fruit yield per plant at flowering (878.93 g/plant) was observed with treatment T_7 (NAA at40 ppm + GA_3at100 ppm). Minimum fruit yield per plant at flowering (190.66 g/plant) was observed in T_0 (Control). PGRs application regulates the enhancement of fruit weight and yield in chilli through multiple mechanisms. PGRs, such as gibberellins and auxins promote cell division, elongation, and expansion, leading to increased fruit size and weight. They also enhance nutrient uptake, photosynthesis, and carbohydrate partitioning, providing the necessary resources for fruit development. Additionally,PGRs can improve flower initiation, pollination, and fruit set, ensuring a higher number of fruits per plant, ultimately resulting in enhanced fruit weight and overall yield in chilli crops. Similar inferences were also concluded by**Kumar and Topno (2022)**.

3.4. Quality parameters

3.4.1. Influence of plant growth regulators (PGRs) on TSS(° Brix)

The maximum TSS at flowering (4.28 °Brix) was observed with treatment T_7 (NAA at40 ppm + GA_3at100 ppm). Minimum TSS at flowering (3.22 °Brix) was observed in T_0 (Control). Similar inferences were also concluded by**Ahmadi and Majidi(2016)**in tomato; **Arivazhan *et al.*, (2018)** in brinjal; **Kumar *et al.*, (2018);Kumar *et al.*, (2022)**.

3.4.2. Influence of plant growth regulators (PGRs) on Ascorbic Acid (mg/100g)

The maximum ascorbic acid content at flowering (2.15 mg/100g) was observed with treatment T_7 (NAA at40 ppm + GA_3at100 ppm). Minimum ascorbic acid content at flowering (1.40 mg/100g) was observed in T_0 (Control). Similar inferences were also concluded by**Kumar *et al.*, (2018);Mahato *et al.*, (2020);Kumar *et al.*, (2022)**.

4.CONCLUSION

According to the current research, the use of plant growth regulators (PGRs) on the growth, yield and quality of chilli. Among the various treatments that were evaluated, T_7 yielded the most favourable results in terms of growth viz., plant height (88.06 cm at 90 DAT), number of primary branches (9.97 branches at harvest), leaf area (192.78 cm^2), early days to 50% flowering (64.94 DAT) and yield viz., fruit weight (3.71 g), length of fruit (7.96 cm), fruit girth (3.00 cm), number of fruits per plant (251.62 fruits), and yield per plant (878.93 g/plant). T_7 consisted of NAA at40 ppm + GA_3at 100 ppm.

REFERENCE

Agarwal, R., Kaur, N., & Pathania, V. (2018). PGRs: A boon for horticulture crops. *HortFlora Research Spectrum,* 7(1), 1-6.

Ahmadi, R., & Majidi, M. M. (2016). Effect of plant growth regulators on the growth and yield of tomato. *International Journal of Horticultural Science and Technology.* 3(2), 187-195.

Arivazhagan, E., Kavitha, A. and Kandasamy, R. (2018). Influence of plant growth regulators on growth characters of brinjal (*Solanum melongena* L.) c.v. Annamalai. *The Asian Journal of Horticulture.* 13(2): 59-63.

Arora, N., & Bist, V. (2016). The role of plant growth regulators in horticultural crops. *Journal of Applied and Natural Science*, 8(1), 429-440.

Farooq, S., Azam, F., & Akhtar, J. (2018). Effect of plant growth regulators on growth and yield of tomato under drought stress. *Pakistan Journal of Agricultural Sciences.* 55(4), 827-834.

Fisher, R.A. and Yates, F. (1967)."The Design of Experiments: Statistical Principles for Practical Applications." New York: *Hafner Publishing Company*.

Haque, A. N. (2016). Chilli (*Capsicum annuum* L.). In: Handbook of Cucurbits: Growth, Cultural Practices, and Physiology (pp. 131-137). *CRC Press.*

Haque, M. S. K., Paul, S. and Ghosh, B. (2016). Karyological studies of two hot chilli pepper cultivars from two different geographical regions of India: Bhut jolokia,

Capsicum Chinese Jacq. and Bullet Lanka, *Capsicum annuum* L. *The Nucleus.* 59: 227–233.

Kannan, N., Ganeshkumar, T., & Thangamalar, R. (2020). Influence of plant growth regulators on growth and yield of chilli (*Capsicum annuum* L.) cv. K1 hybrid. International Journal of Chemical Studies, 8(2), 3428-3432.

Kumar, P., Yadav, S., Singh, R. K., Kumar, A., & Kumar, V. (2020). Effect of plant growth regulators and chemical fertilizers on growth, yield and quality of chilli (*Capsicum annuum* L.) under sub-tropical conditions. *Journal of Plant Nutrition*, 43(15), 2268-2281.

Kumar, R., Singh, R., & Dwivedi, P. (2018). Influence of plant growth regulators on growth, yield and quality of chilli. *International Journal of Current Microbiology and Applied Sciences.* 7(7), 1486-1495.

Kumar, P., Shweta, P., Amarnath, K. S., Veerendra, P. B. T., Dileep, B., Kamal K., Mani, S. and Anaytullah, S. (2018). Effect of growth regulator on morpho-physiological attributes of chilli: a case study. *Plant Archives*. 18(2): 1771-1776.

Kumar, P., & Sharma, S. (2020). Role of growth regulators in crop production and its management strategies. *International Journal of Current Microbiology and Applied Sciences*, 9(5), 3433-3444.

Kumar, R., Deepandhu and Singh, D. (2022). Evaluation trial on hybrid chilli genotype under Prayagraj agro-climatic conditions (*Capsicum annuum* L.). *The Pharma Innovation Journal.* 11(9): 2756-2760.

Kumar, S. R. and Topno S. E. (2022). Effect of different plant growth regulators on growth and yield of chilli (*Capsicum annum*). *The Pharma Innovation Journal*. 11(5): 328-330.

Mahato, S., Sengupta, C., & Karmakar, P. (2020). Impact of Plant Growth Regulators on Growth and Yield of *Capsicum annuum* (L.) cv. Kashi Anmol. *International Journal of Current Microbiology and Applied Sciences*, 9(8), 168-175.

Mishra, S. S., Sharma, S., & Singh, A. K. (2019). Effect of plant growth regulators on growth, yield and quality of tomato under greenhouse conditions. *International Journal of Chemical Studies.* 7(3), 1300-1303.

Malik, A. A., Narayan, S., Magray, M. M., Shameem, S. A., Hussain, K., & Bangroo, S. (2020). Effect of foliar application of micronutrients on growth, yield, quality and seed yield of chilli (*Capsicum annuum* L.) under temperate conditions of Kashmir Valley. *International Journal of Chemical Studies*, 8(4), 2781-2784.

NJB (2021). National Horticultural Board, Ministry of Agriculture & Farmers Welfare (DAC & FW), Government of India, 2020-21.

Pickersgill, B. (1971). "Relationships Between Weedy and Cultivated Forms in Some Species of Chili Peppers (Genus *Capsicum*)". *Evolution; International Journal of Organic Evolution.* 25(4): 683–691.

Ranganna, S. (1986). Handbook of Analysis and Quality Control of Fruit and Vegetable Products. *2nd Edition, Tata McGrow-Hill Education,* New York.

Tayade, P. B., Kharche, V. K., & Padole, R. C. (2018). Effect of plant growth regulators and their mode of application on growth and quality of green chilli (*Capsicum annuum* L.) cv. Kaka. *International Journal of Chemical Studies*, 6(3), 2835-2841.

Table (1):Effect of PGRs in different treatments on various parameters of Chilli.

Treatment Notation	Plant height (cm) [at 90 DAT]	No of branches/ plant [at first Harvest]	Leaf area (cm^2)	Days to first flowering	Days to first fruit harvest	No of fruits / plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield / plant (g/plant)	TSS [°Brix]	Ascorbic acid content (mg/ 100g)
T_0	72.76	6.33	117.65	45.62	78.88	90.36	4.55	1.33	2.11	190.66	3.22	1.40
T_1	79.73	7.62	136.16	42.76	71.30	114.02	6.02	1.86	2.57	321.61	3.69	1.79
T_2	79.69	7.45	135.79	43.32	71.41	107.46	5.98	1.74	2.56	318.55	3.62	1.69
T_3	79.82	7.77	137.79	42.74	71.08	120.42	6.60	2.10	2.63	324.85	3.77	1.79
T_4	78.93	6.77	119.79	44.24	72.30	94.29	5.91	1.54	2.52	313.26	3.50	1.67
T_5	79.15	7.45	179.78	43.63	71.43	97.19	5.96	1.60	2.52	314.81	3.57	1.67
T_6	74.00	6.42	119.16	44.28	72.95	91.98	4.91	1.54	2.12	194.49	3.45	1.41
T_7	88.06	9.97	192.78	36.83	64.94	251.62	7.96	3.00	3.71	878.93	4.28	2.15
T_8	85.80	8.97	181.58	38.65	66.97	220.62	7.45	2.82	3.32	622.65	4.04	1.89
T_9	82.62	8.65	167.52	41.24	69.35	182.62	7.34	2.78	2.86	469.58	3.89	1.85
T_{10}	81.75	8.57	161.72	41.43	69.54	155.89	7.29	2.76	2.81	461.60	3.88	1.84
T_{11}	86.88	9.78	183.89	37.27	66.76	228.37	7.51	2.84	3.33	647.57	4.10	2.02
T_{12}	80.80	7.85	156.59	42.41	70.66	136.22	6.94	2.13	2.72	372.62	3.82	1.79
T_{13}	81.00	8.57	160.40	41.46	69.57	148.70	7.09	2.76	2.74	418.16	3.85	1.80
T_{14}	80.79	7.85	141.29	42.55	70.87	125.62	6.68	2.12	2.68	343.43	3.80	1.79
T_{15}	86.96	9.96	190.60	37.24	65.38	245.54	7.55	2.85	3.58	794.51	4.11	2.13
T_{16}	84.04	8.85	169.48	39.95	68.28	186.64	7.38	2.79	3.01	495.28	3.91	1.87
T_{17}	85.73	8.97	179.78	38.86	67.15	200.13	7.40	2.81	3.20	602.93	3.99	1.89
T_{18}	85.30	8.85	177.20	39.04	68.06	192.91	7.40	1.74	3.15	551.18	3.94	1.87
F test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.E (d) (±)	**1.41**	**0.24**	**0.37**	**0.99**	**1.02**	**5.59**	**0.49**	**0.34**	**0.40**	**6.75**	**0.13**	**0.21**
CD $_{0.05}$	**2.86**	**0.50**	**0.76**	**2.00**	**2.08**	**11.37**	**1.00**	**0.69**	**0.80**	**1.37**	**0.25**	**0.43**
C.V.	**2.10**	**3.59**	**0.29**	**2.95**	**1.80**	**4.25**	**8.81**	**17.45**	**16.76**	**17.68**	**3.99**	**14.30**