Determining the effect of Plant Growth Regulators on Growth, Yield and Quality of Chilli (*Capsicum annuum* L.)

ABSTRACT

Chili peppers are fruit-bearing plants from the Capsicum genus, and they are known for their spicy and pungent flavors. Chili peppers thrive in warm climates and can be grown in various types of soil. They are typically cultivated as annual plants, although some varieties can be perennial in suitable conditionsTherefore, the present investigation was carried out at the Central Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during *Kharif* 2021-22with a view to identify the effects of different doses plant growth regulators and its role in growth, yield and quality of Chillivariety TMPH-443. The experiment was laid in Randomized block design with 13 treatments and 3 replications with different combination in plant growth regulators. Under this experiment, overall, 13 treatment was taken including control. Different plant growth regulators (PGRs) used comprised of NAA, GA_3, 2-4 D and Triacontanolall four at different doses.According to the current research, the use of Plant growth regulators (PGRs) had a significantly positive impact on the growth and development of Chillies. Among the various treatments that were evaluated, T_5 (NAA @ 40 ppm spray) yielded the most favourable results in terms of growth viz., plant height, leaf area, early flowering and maturation and yield viz., fruit weight, length of fruit, fruit girth, number of fruits per plant, and yield per plant.

Keywords: *NAA, GA3, 2-4 D, PGRs,Chilli.*

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)**. Since roughly 7,500 BC, humans have been consuming capsicum plants, which are native to modern-day Bolivia (Pickersgill, 1971). They are among the Americas' first domesticated crops. The history of chilli pepper cultivation dates back approximately 6,000 years to east-central Mexico. However, according to research published in 2014 by the New York Botanical Garden Press, chilli plants were originally grown separately in a variety of American regions, including highland Bolivia, central Mexico, and the Amazon (Katherine et al., 2014). They were one of the first self-pollinating crops cultivated in Mexico, Central America, and parts of South America.India's major growing regions for chillies are Andhra

Pradesh, Telangana, Madhya Pradesh, Karnataka, West Bengal, and Himachal Pradesh. When consumed or applied topically, capsaicin (8-methyl-N-vanillyl-6-nonenamide) and a number of related compounds commonly referred to as capsaicinoids are what give chilli peppers their pungency (spicy heat). The amount of capsaicin varies depending on the cultivar and the growing environment. Peppers under water stress typically yield stronger pods. Some regions of the fruit have higher concentrations of capsaicin when a habanero plant is stressed, such as when it absorbs less water (Ruiz-Lao et al., 2011). The varieties of Chillies 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 Chilli peppers.

PGRs have been shown to mitigate the negative impacts of abiotic stimuli on chilli plants, such as salinity, drought, and high temperatures. They can strengthen the plant's resistance to stress and increase its capacity to endure harsh environmental circumstances (Kumar and Sharma, 2020). During propagation, auxins like NAA are frequently employed as rooting hormones, which improves root establishment and overall plant vigor (Aggrawal et al., 2018). In chilli plants, cytokinin and gibberellic acid (GA) can promote flowering and boost fruit set.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. Better plant growth, flowering, fruiting, and seed development are achieved by their promotion of cell division, elongation, and differentiation. PGRs can also boost resilience to biotic and abiotic stressors, increase nutrient uptake efficiency, and raise crop yield and quality. PGRs such as gibberellic acid (GA3) and salicylic acid have the potential to enhance plant vigor and health, synchronize maturation, encourage fruit set, and augment marketable production in the context of chilli cultivation—all of which can lead to increased profitability. PGRs are a useful tool that growers can employ to meet consumer demand and enhance crop potential. With the aforementioned in mind, the current study was conducted to examine how plant growth regulators affect the quantity, quality, and growth of chillies.

2.MATERIALS AND METHODS

The present investigation was done to understand 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-443. The details of the materials used, and the methods adopted in the investigation, which was carried out at Horticultural Research Field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the *Kharif* season of 2021-22. The experiment was laid in Randomized block design with 13 treatments and 3 replications with different combination in plant

growth regulators.Observations were recorded at different stages of growth periods and studied for growth parameters like plant height, leaf area, earliness parameters like days to 50% flowering, days to first harvest, yield parameters like fruit length, fruit girth, fruit weight and quality parameters TSS. The data were analysed by the method suggested by **Fisher and Yates, 1963.** The height of five randomly selected plants from each plot was measured in cm with of a 100 cm meter scale from ground level to tip of the shoot at 90 DAT stage. The numbers of days taken from the date of sowing to the date at which 50% plants flowered or date at which plants start 50% flowering in whole plot were recorded as days to 50% flowering, similarly, was taken days to first harvest. The percentage of total soluble solids of the fruit was determined with the help of Portable Hand Refractometer. The sample of juice for this purpose was taken from the strained juice. The observed value of T.S.S. was recorded from the scale of the instrument (0-32 range).

The details of treatment combination used are **T_0** (Water Spray (Control)); **T_1** (2,4-D2ppmspray); **T_2** (2,4-D3ppmspray); **T_3** (2,4-D4 ppmspray); **T_4** (NAA30ppm spray); **T_5** (NAA40ppm spray); **T_6** (NAA50ppm spray); **T_7** (Triacontanol4ppmspray); **T_8** (Triacontanol5 ppmspray); **T_9** (Triacontanol6 ppmspray); **T_{10}** ($GA_3$9ppmspray); **T_{11}** ($GA_3$10 ppmspray); **T_{12}** ($GA_3$11 ppmspray).

3.RESULTS AND DISCUSSION:

3.1 Growth parameters

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

The plant height significantly varied among different treatment combinations at 90 DAS.The maximumplant height at 90 DAS (47.13 cm) was observed with treatment T_5 (NAA @40 ppm spray) followed by T_6 (NAA @ 50 ppm spray) with46.26 cm. Minimumplant height at 90 DAS (35.18 cm) was observed in T_0 (Control).PGRs application regulates plant height in chilli by influencing cell division and elongation, promoting internode elongation, and altering hormonal balance. The taller plant height in chillies treated with NAA (40 ppm) spray, compared to treatments involving GA3, Triacontanol, and 2,4-D, is attributed to NAA's stimulation of cell elongation and growth-promoting hormones, resulting in increased stem elongation and overall plant height compared to the other treatments. Similar findings were reported by **Gare*et al.*, (2017); Mahindre*et al.*, (2018)** in Chilli.

3.1.2 Influence of Plant growth regulators (PGRs) on leaf area (cm^2)

The leaf area per plant significantly varied among different treatment combinations. The maximum leaf area per plant (440.16cm^2) was observed with treatment T_5 (NAA @ 40 ppm +spray) followed by T_6 (NAA @ 50 ppm spray) with 3017.85 cm^2. Minimum leaf area per plant

(1931.78cm^2) was observed in T_0 (Control) while the remaining treatments were moderate in their growth habit.

The notable increase in leaf area in chillies treated with NAA (40 ppm) spray, in comparison to treatments involving GA_3, Triacontanol, and 2,4-D, can be attributed to NAA's impact on cell division and expansion. NAA is recognized for its role in promoting cell division and enlargement, leading to enhanced leaf development. Conversely, GA_3, Triacontanol, and 2,4-D might primarily affect other physiological processes or focus on specific growth aspects. The targeted action of NAA at the given concentration likely prioritized leaf expansion, resulting in the observed augmented leaf area. Further investigations are necessary to comprehensively understand the intricate mechanisms underlying these distinct leaf area responses.Similar findings were reported by **Mahto*et al.*, (2020); Naga*et al.*, (2022); and Kumar and Topno (2022)** in Chilli.

3.2. Earliness parameter

3.2.1 Influence of Plant growth regulators (PGRs) on Days to 50% flowering and days to first harvest

The days to 50% flowering significantly varied among different treatment combinations at flowering. The minimum days to 50% flowering (40.23days) was observed with treatment T_5 (NAA @40 ppm spray) followed by T_6 (NAA @ 50 ppm spray) with 40.87days. Maximum days to 50% flowering (48.02days) was observed in T_0 (Control). The days to first harvest significantly varied among different treatment combinations at flowering. The minimum days to first harvest (80.50days) was observed with treatment T_5 (NAA @40 ppm spray) followed by T_6 (NAA @ 50 ppm spray) with 81.70days. Maximum days to first harvest (98.33days) was observed in T_0 (Control).

The accelerated flowering onset in chillies treated with NAA (40 ppm) spray, in contrast to treatments involving GA_3, Triacontanol, and 2,4-D, can be attributed to NAA's role in promoting floral induction and development. NAA is known to trigger the expression of genes associated with flowering, leading to early initiation of flowering processes and thus fruit formation ultimately to earliness in harvesting. Conversely, GA_3, Triacontanol, and 2,4-D may have varying effects on flowering-related genes or prioritize other physiological pathways. The targeted effect of NAA at the specified concentration likely expedited the molecular triggers for flower formation, resulting in the observed early flowering. Further molecular and hormonal investigations are warranted to uncover the precise mechanisms underpinning these distinct flowering time responses and thus intern maturity.Similar conclusions were inferred by **Gare*et al.*, (2017);Mahindre*et al.*, (2018); Naga*et al.*, (2022)** in Chilli.

3.3 Yield Parameters

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

The number of fruits per plant significantly varied among different treatment combinations at flowering. The maximum number of fruits per plant (115.26fruits) was observed with treatment T_5 (NAA @40 ppm spray) followed by T_6 (NAA @ 50 ppm spray) with 111.45fruits. Minimum number of fruits per plant (78.48fruits) was observed in T_0 (Control).

The increased fruit set in chillies treated with NAA (40 ppm) spray, in contrast to treatments involving GA_3, Triacontanol, and 2,4-D, can be attributed to NAA's role in promoting flowering and enhancing pollination efficiency. NAA is known to stimulate flowering by influencing hormonal pathways and enhancing flower bud differentiation. It may also improve pollination through increased nectar secretion and attracting pollinators. Conversely, GA_3, Triacontanol, and 2,4-D may prioritize other physiological processes or have different effects on floral development. The targeted effect of NAA at the provided concentration likely synergistically influenced flowering and pollination, resulting in the observed higher fruit set. Further studies on hormonal crosstalk and pollination mechanisms are necessary to fully elucidate these distinct fruit-setting responses.Similar conclusions were inferred by **Mahato *et al.*, (2020); Kumar and Topno (2022)** in Chilli.

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

The average fruit length significantly varied among different treatment combinations at flowering. The maximum average fruit length (10.61cm) was observed with treatment T_5 (NAA @40 ppm spray) followed by T_6 (NAA @ 50 ppm spray) with 10.38cm. Minimum average fruit length (6.55cm) was observed in T_0 (Control).The average fruit girth significantly varied among different treatment combinations at flowering. The maximum average fruit girth (3.58cm) was observed with treatment T_5 (NAA @40 ppm spray) followed by T_6 (NAA @ 50 ppm spray) with 3.44cm. Minimum average fruit girth (2.16cm) was observed in T_0 (Control).

The augmented fruit length and girth in chillies treated with NAA (40 ppm) spray, as opposed to treatments involving GA_3, Triacontanol, and 2,4-D, can be attributed to NAA's specific impact on cell elongation and fruit development. NAA is known to enhance cell division and elongation, leading to increased fruit size. It may also affect hormonal regulation related to fruit growth. Conversely, GA_3, Triacontanol, and 2,4-D might prioritize other aspects of plant physiology or have varying effects on fruit development. The focused action of NAA at the given concentration likely promoted elongation of fruit cells, resulting in the observed enhanced fruit length and girth. Further investigation into hormonal interactions and cellular mechanisms is essential to fully

understand these distinct fruit length and girth responses. These results are in close conformity with the findings of**Chaudhary*et al.*, (2006); Naga*et al.*, (2022)** in Chilli.

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

The average fruit weight significantly varied among different treatment combinations at flowering. The maximum average fruit weight (2.84g) was observed with treatment T_5 (NAA @40 ppm spray) followed by T_6 (NAA @ 50 ppm spray) with 2.75g. Minimum average fruit weight (1.96g) was observed in T_0 (Control).The average fruit yield per plant significantly varied among different treatment combinations at flowering. The maximum average fruit yield per plant (305.30g/plant) was observed with treatment T_5 (NAA @40 ppm spray) followed by T_6 (NAA @ 50 ppm spray) with 287.40g/plant. Minimum average fruit yield per plant (189.43g/plant) was observed in T_0 (Control).

The increased fruit weight in chillies treated with NAA (40 ppm) spray, in contrast to treatments involving GA_3, Triacontanol, and 2,4-D, can be attributed to NAA's influence on fruit development and biomass accumulation. NAA promotes cell division and enlargement in fruit tissues, leading to greater fruit size and weight and thus yield per plant. It may also enhance nutrient uptake and assimilation, contributing to increased biomass. Conversely, GA_3, Triacontanol, and 2,4-D might prioritize different physiological processes or have varying effects on fruit growth. The targeted action of NAA at the specified concentration likely facilitated enhanced cell division and nutrient utilization, resulting in the observed higher fruit weight and yield. Further exploration of cellular mechanisms and nutrient dynamics is crucial to fully grasp these distinct fruit weight responses.Similar inferences were also concluded by**Tayde *et al.*, (2018); Mishra*et al.*, (2019) and Kumar and Topno (2022)** in Chilli.

3.4. Quality Parameters

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

The TSS significantly varied among different treatment combinations at flowering. The maximum TSS (7.80°Brix) was observed with treatment T_{11} (GA_3 @ 10 ppm spray) followed by T_{10} (GA_3 @ 9 ppm spray) with 7.50°Brix. Minimum TSS (6.10°Brix) was observed in T_0 (Control).

The elevated fruit yield in chillies treated with GA_3 (10 ppm) spray, in contrast to treatments involving NAA, Triacontanol, and 2,4-D, can be attributed to GA3's direct influence on reproductive processes and fruit development. GA_3 promotes flower initiation, increases the number of flowers per plant, and enhances fruit set by stimulating hormonal pathways related to flowering and fruiting. It also contributes to the formation of larger and heavier fruits through cell

elongation and enlargement. Conversely, NAA, Triacontanol, and 2,4-D may have different impacts on flower and fruit development or prioritize other physiological responses. The targeted action of GA_3 at the specified concentration likely optimized flowering, fruiting, and ultimately resulted in the observed enhanced fruit yield. Further research on hormonal interactions and reproductive physiology is crucial to comprehensively understand these distinct yield outcomes.Similar inferences were also concluded by**Gare*et al.*, (2017);Kumar *et al.*, (2022)** in Chilli.

4.CONCLUSION

According to the current research, the use of Plant growth regulators (PGRs) had a significantly positive impact on the growth and development of Chillies. Among the various treatments that were evaluated, T_5 (NAA @ 40 ppm spray) yielded the most favourable results in terms of growth viz., plant height, leaf area, early flowering and maturation and yield viz., fruit weight, length of fruit, fruit girth, number of fruits per plant, and yield per plant and TSS.

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Table 1 Effect of PGRs on different treatments for various parameters of Chilli.

Treatment Notation	Plant height (cm) [at 90 DAT]	Leaf area (cm^2)	Days to % flowering	Days to first harvest	No of fruits per plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield per plant (g/plant)	TSS [°Brix]
T_0	35.18	1931.78	48.02	98.33	78.48	6.55	2.16	1.96	189.43	6.31
T_1	38.18	2228.99	46.34	90.00	85.26	7.57	2.57	2.17	197.63	6.59
T_2	38.62	2102.09	46.82	92.00	84.43	7.29	2.45	2.13	191.27	6.38
T_3	36.65	2012.59	47.14	85.67	81.16	6.88	2.32	2.13	195.40	6.51
T_4	45.19	2812.14	40.97	91.00	100.84	10.41	3.34	2.76	296.46	9.88
T_5	47.13	3440.16	40.23	80.50	115.26	10.61	3.58	2.84	305.30	10.18
T_6	46.26	3017.85	40.87	81.70	111.45	10.38	3.44	2.75	287.40	9.58
T_7	44.34	2517.15	44.41	87.17	91.75	8.75	3.07	2.24	207.80	6.93
T_8	45.47	2614.46	44.86	88.50	95.82	8.39	3.02	2.34	225.80	7.53
T_9	46.11	2741.24	44.25	89.00	99.53	8.44	3.13	2.42	241.93	8.06
T_{10}	46.24	2832.22	42.58	85.67	103.14	9.52	3.31	2.47	256.57	8.55
T_{11}	46.16	2854.14	42.45	90.83	106.29	9.64	3.23	2.54	268.03	8.93
T_{12}	45.93	2813.82	42.55	83.17	108.15	9.56	3.21	2.64	270.70	9.02
F test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.E (d) (±)	**0.09**	**3.77**	**0.03**	**1.63**	**0.14**	**0.02**	**0.01**	**0.02**	**0.54**	**0.02**
$CD_{0.05}$	**0.18**	**7.83**	**0.07**	**3.38**	**0.29**	**0.03**	**0.03**	**0.04**	**1.11**	**0.04**
C.V.	**0.25**	**0.18**	**0.09**	**5.26**	**0.18**	**0.23**	**0.49**	**0.97**	**0.27**	**0.29**