



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

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## Authors' contributions

This work was carried out in collaboration among all authors. Author SB supervised the research, guided the experimental design, analysed the data, and reviewed the manuscript. Author DS was responsible for experiment planning, execution, data collection, statistical analysis, and manuscript preparation. Authors SB, JCJ, NBA and VS assisted with field operations, data recording, and provided technical support. All authors read and approved the final manuscript.

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## ABSTRACT

The present investigation was carried out during 2023 at the instructional farm, faculty of horticulture, uttar banga krishi viswavidyalaya, pundibari, west bengal. The experiment was laid out in a randomized block design (rbd) with eight treatments and three replications. The study aimed to assess the influence of different plant growth regulators on growth, yield, and quality parameters of chilli. The results revealed that treatment t4 (paclobutrazol 40% sc @ 87.5 ml/ha) recorded the highest number of primary branches (4.25), maximum fruits per plant (130.62), yield per plant

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(449.32 g), yield per plot (6.73 kg), and yield per hectare (10.78 t). Treatment t3 (paclobutrazol 40% sc @ 70 ml/ha) achieved the highest fruit length (8.94 cm), fruit diameter (3.64 mm), and leaf area (3.66 cm<sup>2</sup>). In terms of quality, the maximum total soluble solids (6.35 °brix), ascorbic acid content (106.63 mg/100g), and total chlorophyll content (2.57 mg/100g) were observed in treatment t6 (alpha naphthalene acetic acid 4.5% sl @ 10 ppm/ha). Conversely, maximum plant height (46.07 cm) and maximum days to 50% flowering (57.38 days) were recorded in the control (t0). The study concludes that the application of paclobutrazol and naa significantly enhances the growth, yield, and quality of hybrid chilli bnhp-104 compared to untreated plants.

**Keywords:** Chilli; naphthalene acetic acid; triacontanol; yield; quality parameters.

## 1. INTRODUCTION

Chilli (*capsicum annuum l.*), a member of the solanaceae family with a diploid chromosome number of  $2n = 24$  (saisupriya et al., 2020), is an important vegetable and spice crop grown widely in tropical and subtropical regions. In india (Bosland & Votava, 2000), chilli holds significant economic and nutritional value due to its diverse uses as a vegetable, spice, condiment, medicine, and ornamental plant. It is rich in essential nutrients like vitamins c, a, and e, and contains capsaicin — the compound responsible for its pungency — which also offers medicinal and therapeutic benefits (kumar et al., 2021; Usman et al., 2014).

India is the world's largest producer, consumer, and exporter of chilli, with andhra pradesh contributing the highest share, followed by other states including west bengal. In west bengal, chilli is predominantly cultivated in districts like cooch behar, jalpaiguri, uttar dinajpur, malda, murshidabad, and nadia. The region's humid subtropical climate, annual rainfall ranging from 1500 to 3000 mm, and temperatures between 15°C and 35°C provide favorable conditions for chilli cultivation. However, productivity is often constrained by erratic weather patterns, pests, diseases, and physiological problems like flower and fruit drop.

Traditional farming practices combined with imbalanced fertilizer use and poor growth management frequently result in low yields and inferior fruit quality. In this context, plant growth regulators (pgrs) have emerged as effective tools for improving chilli growth, yield, and quality (Salvador, 2002). Pgrs are organic compounds that regulate plant physiological processes even in small amounts (Tejpal et al., 2018; Joshi & Singh, 2001). Among them, paclobutrazol reduces excessive vegetative growth, promotes branching, and improves fruit retention; naphthalene acetic acid (naa) enhances fruit set

by reducing flower and fruit drop; and triacontanol (tria) stimulates photosynthesis and nutrient use efficiency, leading to better growth and productivity (Naga et al., 2022) Baghel et al., (2024).

Despite proven benefits, limited research has been conducted on the response of hybrid chilli varieties to pgrs under west bengal's agro-climatic conditions. Therefore, the present study was undertaken to evaluate the effect of different pgrs on the growth, yield, and quality of chilli (*capsicum annuum l.*) Cv. Bnhp-104 (f1), aiming to develop effective crop management strategies for enhanced productivity and profitability for farmers.

## 2. MATERIALS AND METHODS

The field experiment was conducted at the Instructional Farm, Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, during February to June 2023. The site is located at 26°19'86"N latitude and 89°23'53"E longitude, with an elevation of 43 meters, falling under the Terai agro-climatic zone. The soil is sandy loam, slightly acidic (pH 5.5–6.5), with moderate fertility and poor water-holding capacity. The climate is characterized by high rainfall (>3000 mm annually), high humidity, and moderate temperatures.

The experiment was laid out in a Randomized Block Design (RBD) with eight treatments, replicated three times. Treatments included different concentrations of T1-Paclobutrazol 40% SC 50 ml, T2-Paclobutrazol 40% SC 60, T3-Paclobutrazol 40% SC 70 ml, T4-Paclobutrazol 40% SC 87.5 ml, T5-Triacontanol 0.05% SC at 250 ml/ha, T6- Alpha Naphthalene Acetic acid 4.5% SL 10ppm spray, T7-Paclobutrazol 40% SC 140 ml and a T0 control. The crop used was chilli hybrid BNHP-104 (F1), transplanted at 50 cm x 50 cm spacing. Standard agronomic practices were followed uniformly.

Observations were recorded on growth, flowering, yield, and quality parameters including plant height, branches, leaf area, days to 50% flowering, fruit length, fruit diameter, number of fruits per plant, fruit weight, yield, TSS, ascorbic acid, and chlorophyll content. Data were analyzed statistically using ANOVA at 5% significance, and Critical Difference (CD) was calculated where applicable.

## 2.1 Biochemical Analysis Methodology

- 1. Total Soluble Solids (TSS):** TSS was measured using an ERMA hand refractometer (0–32°Brix). One drop of juice (seeds removed) was placed on the prism and the reading was taken at 20°C. Results were expressed as °Brix.
- 2. Total Chlorophyll (mg/100g leaves):** Chlorophyll was estimated using the acetone extraction method (Sadasivam & Manickam, 1996). 1g of leaf was crushed in 80% acetone, kept in the dark for 48 hrs, centrifuged, and absorbance was measured at 663 nm and 645 nm. Total chlorophyll was calculated using standard formulas.
- 3. Ascorbic Acid (mg/100g):** Juice was diluted with 3% metaphosphoric acid and titrated against 2,6-dichlorophenol indophenol dye. Pink endpoint indicated completion. Content calculated using standard formula

## 3. RESULT AND DISCUSSION

The experiment revealed significant influence of plant growth regulators on growth, yield, and quality parameters of chilli (BNHP-104). Among the treatments, Paclobutrazol 40% SC @ 87.5 ml/ha recorded maximum reduction in plant height with increased number of primary branches, leaf area, and early flowering. It also significantly improved yield attributes like number of fruits per plant, fruit weight, and overall yield per hectare compared to control. Quality parameters such as TSS, ascorbic acid, and total chlorophyll content were also notably higher under Paclobutrazol treatments followed by NAA. The details of the mean performance of different treatments for various parameters are presented in Table 1.

### 3.1 Plant Height (cm) at 30, 60, and 90 DAT

Plant height showed significant variation across treatments. At 30 DAT, the maximum height (29.55 cm) was recorded with T4 (Paclobutrazol 87.5 ml/ha), while the minimum (25.52 cm) was with T5 (Triaccontanol 250 ml/ha). At 60 DAT, the control (T0) recorded the tallest plants (38.32 cm) due to the absence of growth retardants, whereas the shortest (29.68 cm) was in T7 (Paclobutrazol 140 ml/ha), indicating strong growth suppression at higher doses. A similar pattern was observed at 90 DAT, with T0 producing the tallest plants (46.07 cm) and T7 the shortest (33.63 cm). These results align with Baloch. *et al.* (2019) and Benjawan *et al.* (2007), who reported reduced plant height with paclobutrazol due to gibberellin inhibition.

### 3.2 Number of Primary Branches Per Plant

Significant differences were recorded in branching. The maximum number of primary branches (4.25) was observed in T4, while the minimum (1.96) was in T0. Paclobutrazol effectively suppressed apical dominance, promoting lateral branching. Similar trends were reported by Khandaker *et al.* (2020) and Baloch *et al.* (2019).

### 3.3 Leaf Area (cm<sup>2</sup>)

Leaf area varied significantly among treatments. The largest leaf area (31.66 cm<sup>2</sup>) was recorded with T6 (NAA @ 10 ppm), while the smallest (16.42 cm<sup>2</sup>) was found in T0. This indicates that NAA promotes leaf expansion through auxin-mediated cell enlargement and improved nutrient translocation, as also noted by Khandaker *et al.* (2020) and Aloni *et al.* (2015).

### 3.4 Days to 50% Flowering

Days to 50% flowering were significantly influenced. The maximum (57.38 days) occurred in T0 (control), reflecting delayed flowering without PGRs. The minimum (40.41 days) was recorded with T4, showing paclobutrazol's role in hastening flowering by shortening the vegetative phase. These results agree with Baloch *et al.* (2019), who found similar trends with paclobutrazol.

**Table 1. Mean Performance table showing the Effect of Plant Growth Regulators on Growth, Yield, and Quality of Chilli (*Capsicum annum L.*)**

S.No.	Treatments (Formulations per ha)	Plant height (cm)			N.of 1 <sup>o</sup> bran ches	Leaf area (cm <sup>2</sup> )	D.to 50 % Flow ering	Fruit lengt h (cm)	Fruit Diam eter (mm)	No.of fruits per plant	Yield per plant (g)	1 fruit weig ht (g)	Yield per plot (kg)	Yield per ha (tonne s)	TSS (°Brix )	Ascorbi c acid (mg/100 g)	Chloroph yll content (mg/100g)
		30 DAT	60 DAT	90 DAT													
T0	control	28.61	38.32	46.07	1.96	16.42	57.38	6.85	1.94	92.60	180.34	1.94	1.98	3.16	4.84	99.00	1.93
T1	Paclobutrazol 40% SC 50ml spray	28.39	36.88	43.43	3.16	22.17	45.03	7.45	2.85	100.53	286.54	2.85	4.01	6.41	5.55	102.70	2.17
T2	Paclobutrazol 40% SC 60 ml spray	29.10	35.70	41.73	3.56	24.46	43.05	7.98	3.05	106.43	325.26	3.05	4.22	6.75	5.39	101.55	2.31
T3	Paclobutrazol 40% SC 70 ml spray	26.94	34.36	40.70	3.85	25.63	41.61	8.94	3.64	117.40	427.67	4.19	5.13	8.20	5.75	103.37	2.38
T4	Paclobutrazol 40 % SC 87.5 ml spray	29.55	32.73	39.77	4.25	27.60	40.41	8.19	3.37	130.62	449.32	3.44	6.73	10.78	5.45	104.26	2.45
T5	Triacontanol 0.05% SC 250 ml spray	25.52	35.97	50.23	2.78	28.32	53.56	7.97	2.02	122.79	364.75	2.97	5.10	8.16	6.13	105.17	2.51
T6	AlphaNaphthaleneAc eticacid 4.5% SL 10ppm spray	29.45	37.63	53.14	2.12	31.66	45.67	7.66	2.19	113.17	328.16	2.89	4.26	6.82	6.35	106.63	2.57
T7	Paclobutrazol 40 %SC 140ml spray	27.973	29.68	33.63	2.62	19.42	49.83	7.12	2.24	96.58	216.38	2.24	2.37	3.70	5.00	99.33	2.13
F-test		S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
SE.d.(±)		0.691	0.898	0.642	0.185	0.938	0.998	0.09	0.094	1.322	14.58	0.267	0.192	0.309	0.103	0.671	0.044
CD 0.005		1.482	1.926	1.376	0.398	2.012	2.14	0.192	0.201	2.836	31.27	0.573	0.412	0.663	0.221	1.44	0.093

### 3.5. Fruit Length (cm)

Fruit length showed notable improvement with PGRs. The longest fruits (8.94 cm) were recorded in T3 (Paclobutrazol 70 ml/ha), while the shortest (6.85 cm) were in T0. Paclobutrazol's positive effect may be attributed to better resource allocation toward fruit development. Similar results were documented by Benjawan *et al.* (2007) and Rai *et al.* (2003).

### 3.6 Fruit Diameter (mm)

Significant variation was noted in fruit diameter. The highest (3.64 mm) was achieved with T3, and the lowest (1.94 mm) with T0. This indicates paclobutrazol's role in improving fruit girth, possibly through better nutrient utilization and hormone regulation, as also highlighted by Rademacher (2000) and Vanshika, *et al.* (2025).

### 3.7 Number of Fruits Per Plant

The number of fruits per plant significantly increased with PGR application. The highest number (130.62) was recorded with T4, while the lowest (92.60) was in T0. The increase is attributed to enhanced flower retention and reduced drop due to paclobutrazol's hormonal modulation. This aligns with findings by Khandaker *et al.* (2020) and Baloch *et al.* (2019).

### 3.8 Weight of Individual Fruit (g)

Fruit weight varied significantly among treatments. The maximum (4.19 g) was in T3, whereas the minimum (1.94 g) was in T0. The improvement is likely due to better assimilate partitioning and enhanced sink strength from growth regulator applications. These findings are supported by Baloch A.A. *et al.* (2019)

### 3.9 Yield Per Plant (g)

Yield per plant showed significant improvement with paclobutrazol. The maximum yield (449.32 g) was obtained in T4, while the minimum (180.34 g) was in T0. The higher yield results from a combination of more fruits and improved fruit size, corroborating studies by Nerson *et al.* (1989)

### 3.10 Yield Per Plot (kg)

Similar trends were observed for yield per plot. T4 recorded the highest yield (6.73 kg), while the

lowest (1.98 kg) was seen in T0. This demonstrates the efficacy of paclobutrazol in enhancing productivity by balancing vegetative growth with reproductive output, in line with Khandaker *et al.* (2020).

### 3.11 Projected Yield Per Hectare (Tonnes)

Extrapolating the yield data to a hectare basis showed that treatment T4 (Paclobutrazol 40% SC @ 87.5 ml/ha) achieved the highest projected yield per hectare, demonstrating the potential of paclobutrazol to significantly improve commercial chilli production under field conditions.

### 3.12 Quality Parameters

#### 3.12.1 Total soluble solids (TSS Brix)

Application of Alpha Naphthalene Acetic Acid (NAA) 4.5% SL at 10 ppm/ha significantly enhanced the TSS content of green chilli fruits. The highest TSS (6.35 °Brix) was recorded in the NAA-treated plots compared to the control (4.84 °Brix). This improvement could be attributed to the auxin-induced stimulation of carbohydrate metabolism and efficient translocation of soluble sugars to the fruits. Rahman *et al.* (2021) also reported that auxin application enhances metabolite accumulation, leading to improved fruit quality Vanshika, *et al.* (2025).

#### 3.13 Ascorbic Acid Content (mg/100g)

The ascorbic acid content was also positively influenced by NAA. The highest ascorbic acid content (106.63 mg/100g) was observed in the treatment with NAA @ 10 ppm/ha, while the control recorded the lowest (99.00 mg/100g). This suggests that NAA enhances physiological processes and promotes vitamin C biosynthesis in chilli, corroborating the findings of Sarkar *et al.* (2009). Nirankar *et al.* (2024) and Vanshika *et al.* (2025)

#### 3.14 Total Chlorophyll Content (mg/100g)

Total chlorophyll content in chilli leaves significantly increased with NAA application. The highest chlorophyll content (2.57 mg/100g) was found in the treatment with NAA @ 10 ppm/ha compared to the control (1.93 mg/100g). This increase indicates enhanced photosynthetic efficiency and plant vigor, likely due to NAA's role in stimulating chlorophyll synthesis and reducing degradation. These results align with (Saini, 2023; Anbarasi & Venkatraman 2022), who

demonstrated that NAA improves chlorophyll content and overall plant productivity

#### 4. SUMMARY AND CONCLUSION

The present investigation entitled "Effect of Plant Growth Regulators on Growth, Yield, and Quality of Chilli (*Capsicum annuum* L.)" The results revealed that plant growth regulators significantly influenced growth, yield, and quality parameters of chilli among the treatments T4 (Paclobutrazol 40% SC @ 87.5 ml/ha) recorded the best performance in terms of number of primary branches (4.25), number of fruits per plant (130.62), individual fruit weight (4.19 g), fruit yield per plant (449.32 g), yield per plot (6.73 kg), and projected yield per hectare (10.78 t/ha).

For quality parameters, T6 (NAA 4.5% SL @ 10 ppm/ha) showed the highest values for Total Soluble Solids (6.35°Brix), Ascorbic Acid content (106.63 mg/100g), and Total Chlorophyll content (2.57 mg/100g).

#### 4.1 Conclusion

It can be concluded that the application of Paclobutrazol 40% SC @ 87.5 ml/ha (T4) is most effective for improving growth and yield parameters in chilli, while NAA 4.5% SL @ 10 ppm/ha (T6) is effective for enhancing quality attributes. Therefore, these treatments are recommended for chilli growers to achieve higher productivity and better fruit quality under similar agro-climatic conditions.

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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 this manuscript.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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