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

**ABSTRACT**

The present investigation entitled “effect of plant growth regulators on growth, yield and quality of chilli (*capsicum annuum l*.) Cv. Hybrid chilli bnhp-104 (f1)” 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 (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 cm²). 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 and Quality Parameters.

**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, 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 j. P. *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. Pgrs are organic compounds that regulate plant physiological processes even in small amounts (**Tejpal B.S *et al.*, 2018**). 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 b.l. *et al.,* 2022).**

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.

**MATERIAL 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 × 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.

**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 4.1.

**4.1. 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 (Triacontanol 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 A.A. *et al.* (2019)** and **Benjawan *et al.* (2007),** who reported reduced plant height with paclobutrazol due to gibberellin inhibition.

**4.2. 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 A.A. *et al.* (2019).**

**4.3. Leaf Area (cm²)**

Leaf area varied significantly among treatments. The largest leaf area (31.66 cm²) was recorded with T6 (NAA @ 10 ppm), while the smallest (16.42 cm²) 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)**.

**4.4. 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.

**4.5. 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).**

**4.6. 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).**

**4.7. 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).**

**4.8. 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)**

**4.9. 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)**

**4.10. 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).**

**4.11. 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.

**Quality Parameters**

**4.12. 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.

**4.13. 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).**

**4.14. 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 **Anbarasi** and **Venkatraman (2022)**, who demonstrated that NAA improves chlorophyll content and overall plant productivity.

**Summary and Conclusion**

The present investigation entitled "Effect of Plant Growth Regulators on Growth, Yield, and Quality of Chilli (*Capsicum annuum L*.)" was carried out from February to June 2023 at the Instructional Farm, Department of Vegetable and Spice Crops, UBKV, Pundibari, West Bengal. The experiment was laid out in a Randomized Complete Block Design (RCBD) with eight treatments and three replications. The treatments included different concentrations of Paclobutrazol, Triacontanol, and Alpha Naphthalene Acetic Acid (NAA) with foliar applications at 30, 50, and 70 days after transplanting (DAT).

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).

**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.

**REFRENCES**

**Aloni R (2015)** Ecophysiological implications of vascular differentiation and plant evolution. *Trees* **29**:1-16.

**Anbarasi D and Venkatraman M (2022)** Effect of plant growth regulators on growth, yield and quality characters of chilli (*Capsicum annuum* L.). *Annals of Plant and Soil Research* **24**(4):543-546.

**Aijaz Ali Baloch, Nadir Ali, Zafar Ullah, Kaleemullah, Siraj Ahmad, Honak Baloch, Adul Jabbar, Adul Razzaq Reki, Sulaman Jaffar and Zia-ul-haq (2019).** Effect of paclobutrazol on growth and fruit characteristics of ornamental pepper (*Capsicum annum L*.). *Pure and Applied Biology.* Vol. 8, Issue 4, pp2302-23120. <http://dx.doi.org/10.19045/bspab.2019.80177>

**Chutichudet Benjawan, P. Chutichudet and T. Chanaboon, 2007.** Effect of Chemical Paclobutrazol on Growth, Yield and Quality of Okra (*Abelmoschus esculentus*L.) Har Lium Cultivar in Northeast Thailand. *Pakistan Journal of Biological Sciences,* 10: 433-438.

**Bosland, P.W., & Votava, E.J. (2000)**. Peppers: Vegetable and Spice Capsicums. *CABI Publishing*, New York.

**Joshi, N. C. and D. K. Singh. 2001.** Effect of plant growth regulators on chilli. *J. of Vegetable Sci* **28**(1): 70-75.

**Khandaker, M.M., M. Syafiq, M.D. Abdulrahman, K.S. Mohd, N. Yusoff, M.H. Sajili and N.A. Badaluddin, 2020.** Influence of paclobutrazol on growth, yield and quality of eggplant (*Solanum melongena*). *Asian J. Plant Sci.,* 19: 361-371.

**Kumar J P, Paramaguru, P, Arumugam T, Boopathi N M, and Venkatesan K (2021)** Correlation and path-coefficient analysis in Ramnad Mundu chilli (*Capsicum annuum* L.) for yield and quality traits. *International Journal of Plant Sciences* ***16***(1), 1-6.

**Naga B L, Deepanshu D S, and Bahadur V (2022)** Effect of plant growth regulators on growth, yield and quality of chilli (*Capsicum annuum* L.). *The Pharma Innovation Journal* **11**(10): 227-233

**Nerson H, Cohen R, Edelstein M and Burger Y (1989)** Paclobutrazol - A plant growth retardants for increasing yield and fruit quality in muskmelon. *J. Am. Soc. hortic. Sci* **114**(5): 762-766.

**Rahman S U, Nabi G, Khan M N, Shah F A, Rukh S, Ali W, ... and Hilal M (2021)** Influence of Tryptophan on the growth, yield and quality of chilli with and without fertilizer. Pure and Applied Biology (PAB), (4): 1287-1302.

**Rai N, Nath A, Yadav D S and Yadav R K (2003)** Effect of different concentration of paclobutrazol on growth, flowering and quality of bottle guard. *Agric. Sci. Digest* **23**(1): 44-46.

**Rademacher, W. (2000)**. Growth retardants: Effects on gibberellin biosynthesis and other metabolic pathways. *Annual Review of Plant Physiology and Plant Molecular Biology,* 51, 501-531.

**Salvador M H (2002)** Genetic resources of chilli (*Capsicum annuum* L.) in Mexico. Proceedings of the 16th Int. Pepper Conf., Tampico, Tamaulipas, Mexico, November Pp.10–12.

**Saisupriya P, Saidaiah P, Pandravada S R and Sudini H K (2020)** Correlation and path analysis in chilli (*Capsicum annuum* L.) genotypes. *Journal of Pharmacognosy and Phytochemistry* **9**(6): 532-540.

**Sarker P, Hossain T, Mia M A, Islam R and Miah M N A (2009)** Effect of NAA on growth, yield and quality of Chilli (*Capsicum frutescence*). *Bangladesh Research Publications Journal* **6**(2):612-617.

**Tejpal Singh Bisht, Laxmi Rawat, Binayak Chakraborty and Vikas Yadav. 2018**. A Recent Advances in Use of Plant Growth Regulators (PGRs) in Fruit Crops - A Review. *Int.J.Curr.Microbiol.App.Sci.* 7(05): 1307-1336. doi: <https://doi.org/10.20546/ijcmas.2018.705.159>

**Usman M, Noureen S, Fatima B and Zaman Q (2014)** Long days foster callogenesis in spinach and lettuce cultivars. *J. Anim. Plant Sci* **24**(2): 585-591.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.No.** | **Treatments**(Formulations per ha) | **Plant height (cm)** | **N.of 10 branches** | **Leaf area (cm²)** | **D.to 50 % Flowering** |  **Fruit length (cm)** | **Fruit Diameter (mm)** | **No.of fruits per plant**  | **Yield per plant (g)** |  **1 fruit weight (g)** | **Yield per plot (kg)** | **Yield per ha (tonnes)** | **TSS (°Brix)** | **Ascorbic acid (mg/100g)** | **Chlorophyll 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% SC70 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% SC250 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 | AlphaNaphthaleneAceticacid 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 %SC140ml 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 |

 Table 4.1 Mean Performance table showing the Effect of Plant Growth Regulators on Growth, Yield, and Quality of Chilli (*Capsicum annuum L*.)