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Impact of GA₃, NAA, and IBA foliar sprays on growth, yield, and quality of cauliflower (*Brassica oleracea* var. *botrytis* L.) cv. Pusa snowball

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Abstract

Cauliflower is a high-value cool-season cole crop prized for its compact, nutritious curd. A field trial was conducted during the 2025-26 *rabi* season at the Agricultural Research Field of Rama University, Kanpur, Uttar Pradesh, to examine the influence of foliar applications of plant growth regulators (PGRs) on growth, curd development, yield, quality, and profitability of cauliflower cv. Pusa Snowball. The experiment followed a randomized block design with eight treatments replicated three times. Treatments included foliar sprays of GA₃, NAA, and IBA at varying concentrations, applied singly or in combination at 20, 35, and 50 days after transplanting (DAT). The combined spray of GA₃ at 50 ppm + NAA at 50 ppm (T₇) outperformed all other treatments. It produced the tallest plants (58.9 cm), the highest number of leaves per plant (19.6), and the thickest stems (2.58 cm) at 60 DAT. This treatment also advanced curd initiation to 55 DAT and marketable curd maturity to 78 DAT. It yielded the largest curd diameter (19.8 cm), heaviest curd weight (742 g per plant), and highest marketable yield (5.46 kg per plot and 278.9 q ha⁻¹). Economically, T₇ delivered the maximum gross return (₹4,18,350 ha⁻¹), net return (₹2,21,850 ha⁻¹), and benefit-cost ratio (2.13). Quality attributes such as curd compactness and appearance were also superior under this treatment.

The study concludes that the integrated foliar application of GA₃ 50 ppm + NAA 50 ppm represents the most effective, productive, and economically viable PGR strategy for enhancing cauliflower performance under subtropical conditions of the Middle Gangetic Plain of Uttar Pradesh.

Keywords: Cauliflower, plant growth regulators, GA₃, NAA, curd yield, economics, Pusa Snowball

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) belongs to the Brassicaceae family and is cultivated worldwide for its edible, compact curd formed by arrested floral branches. It is a cool-season crop highly sensitive to temperature extremes, which can trigger disorders such as buttoning or ricey curds, thereby reducing marketable yield and quality. India ranks second globally in cauliflower production after China, contributing significantly to national vegetable output. Uttar Pradesh is a major producer, with stable area and production in recent years.

The edible curd is nutritionally rich, low in calories, and provides dietary fibre, vitamins, minerals, and antioxidants. Despite its importance, cauliflower productivity often remains suboptimal due to environmental stresses and physiological limitations in curd formation. Plant Growth Regulators (PGRs) such as Gibberellic Acid (GA₃), Naphthalene Acetic Acid (NAA), and Indole-3-Butyric Acid (IBA) can modulate hormonal balance, promote vegetative vigour, accelerate curd initiation, and improve assimilate partitioning toward reproductive structures.

Foliar application of PGRs is a practical, low-cost method that enhances nutrient uptake and physiological efficiency in vegetable crops. Previous studies have shown promising results with GA₃ and NAA in cole crops, but information on their optimal concentrations and combinations for the late-maturing cv. Pusa Snowball under Uttar Pradesh conditions is limited. The present investigation was therefore undertaken to standardize effective PGR treatments for improving growth, curd formation, yield, quality, and economic returns of cauliflower cv. Pusa Snowball.

Materials and Methods

The field experiment was conducted during the *rabi* season (September 2025-February 2026) at the Agricultural Research Field, Rama University, Mandhana, Kanpur (Uttar Pradesh). The experimental site has a subtropical climate with sandy loam soil (pH 7.45, EC 0.38 dS m⁻¹, organic carbon 0.48%, available N 195 kg ha⁻¹, P 21 kg ha⁻¹, K 235 kg ha⁻¹).

Cauliflower cv. Pusa Snowball, a late-maturing variety known for compact, snow-white curds, was used. Seeds

were sown in the nursery in early September, and 25-day-old seedlings were transplanted in mid-October at 60 cm × 45 cm spacing. The experiment was laid out in a randomized block design with eight treatments and three replications. Plot size was 2.16 m² (1.8 m × 1.2 m), accommodating eight plants per plot.

Treatments

T₀: Control (Water spray)

T₁: GA₃ @ 75 ppm

T₂: GA₃ @ 125 ppm

T₃: NAA @ 50 ppm

T₄: NAA @ 100 ppm

T₅: IBA @ 10 ppm

T₆: IBA @ 20 ppm

T₇: GA₃ @ 50 ppm + NAA @ 50 ppm

Foliar sprays were applied three times at 20, 35, and 50 DAT using a knapsack sprayer. Standard cultural practices were followed uniformly, including well-rotten FYM @ 25 t ha⁻¹ and recommended NPK (120:60:80 kg ha⁻¹). Irrigation, weeding, and plant protection measures were applied as needed. Observations were recorded on growth parameters (plant height, number of leaves, stem diameter at 60 DAT), phenological traits (days to curd formation and marketable curd stage), yield attributes (curd diameter, curd weight per plant, curd yield per plot and per hectare), and economic

parameters. Data were statistically analyzed using analysis of variance (ANOVA) for RBD, and treatment means were compared using Critical Difference (CD) at $P = 0.05$.

Results and Discussion

Growth parameters

PGR treatments significantly influenced vegetative growth parameters at 60 DAT (Table 1). The combination treatment T₇ (GA₃ 50 ppm + NAA 50 ppm) recorded the maximum plant height (58.9 cm), number of leaves per plant (19.6), and stem diameter (2.58 cm). These values were statistically superior to the control (T₀: 48.2 cm height, 14.8 leaves, 1.85 cm stem diameter) and most other single-PGR treatments. The synergistic interaction between GA₃ (which promotes cell elongation and internodal lengthening) and NAA (which enhances cell division and apical dominance) likely stimulated vigorous shoot growth and expanded photosynthetic surface area, leading to improved dry matter accumulation.

These observations are consistent with earlier findings. Reza *et al.* (2015) reported that 50 ppm GA₃ maximized plant height and leaf number in broccoli, while Jakharet *al.* (2018) documented enhanced stem thickness with NAA application. The superior performance of the GA₃ + NAA combination in the present study aligns with Verma *et al.* (2018), who noted synergistic effects on vegetative vigour when GA₃ was combined with auxins.

Table 1: Effect of PGR treatments on growth parameters at 60 DAT

Treatment	Plant height (cm)	No. of leaves plant ⁻¹	Stem diameter (cm)
T ₀	48.2	14.8	1.85
T ₁	55.6	18.2	2.42
T ₂	53.8	17.5	2.28
T ₃	52.4	17.1	2.15
T ₄	54.1	18.0	2.35
T ₅	50.9	15.9	2.05
T ₆	51.7	16.4	2.12
T ₇	58.9	19.6	2.58
SEm±	1.12	0.68	0.08
CD (P=0.05)	3.35	2.03	0.24
CV (%)	6.8	7.2	6.5

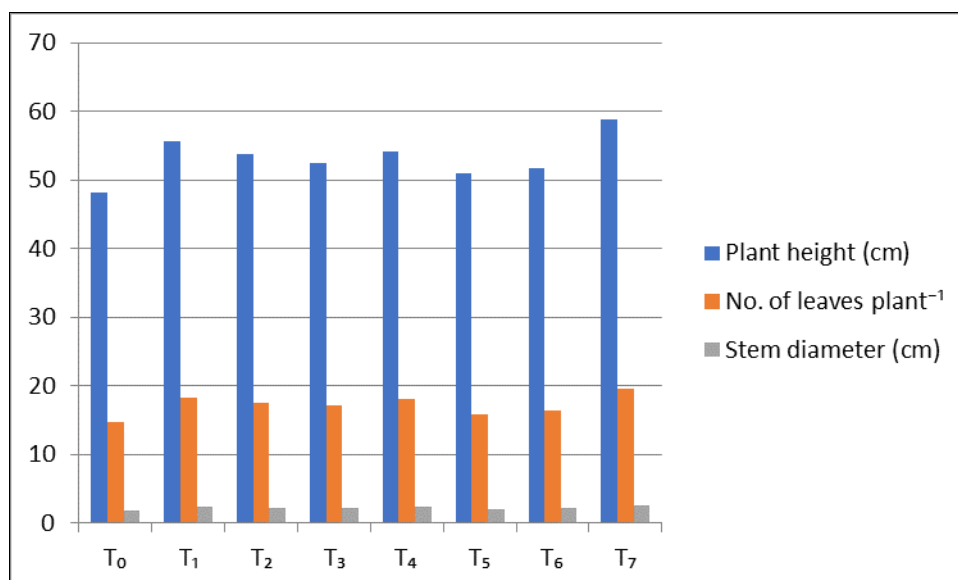


Fig 1: Effect of PGR treatments on growth parameters at 60 DAT

Phenological parameters

T₇ significantly reduced the time to curd formation (55 days) and marketable curd stage (78 days) compared to the control (68 and 92 days, respectively). The hormonal balance induced by the GA₃ + NAA combination accelerated the transition from vegetative to reproductive phase and optimized assimilate partitioning toward curd development.

Yield and Yield attributes

T₇ significantly shortened the time to curd formation (55 DAT) and marketable curd stage (78 DAT) compared to the control (higher by 13-14 days). It also produced the largest curd diameter (19.8 cm) and heaviest curd weight per plant

(742 g). Consequently, curd yield reached a maximum of 5.46 kg per plot and 278.9 q ha⁻¹ markedly higher than all other treatments. The accelerated phenology and enhanced curd development under T₇ can be attributed to improved hormonal balance that favoured assimilate translocation toward the curd (sink) and reduced competition from excessive vegetative growth at higher PGR concentrations. These results corroborate Kaur and Mal (2018) ^[1], who observed maximum curd diameter and weight with 50 ppm GA₃, and Chanwala *et al.* (2019) ^[3], who reported synergistic yield gains from NAA + GA₃ combinations in broccoli. The present findings further confirm that moderate combined doses optimize curd compactness and size without inducing disorders such as riceyness or buttoning.

Table 2: Effect of PGR treatments on curd yield attributes

Treatment	Days to curd formation	Days to marketable curd	Curd diameter (cm)	Curd weight (g plant ⁻¹)	Curd yield (kg plot ⁻¹)	Curd yield (q ha ⁻¹)
T ₀	68	92	14.5	485	3.88	198.4
T ₁	59	81	18.2	682	5.02	256.7
T ₂	61	83	17.8	658	4.85	248.2
T ₃	62	85	17.4	642	4.72	242.5
T ₄	58	80	18.6	695	5.11	261.3
T ₅	65	88	15.9	528	4.12	215.6
T ₆	64	87	16.3	562	4.38	222.8
T ₇	55	78	19.8	742	5.46	278.9
SEm±	1.32	1.45	0.52	18.5	0.18	6.85
CD (P=0.05)	3.95	4.33	1.55	55.3	0.54	20.48
CV (%)	5.8	5.9	6.4	7.8	8.2	8.9

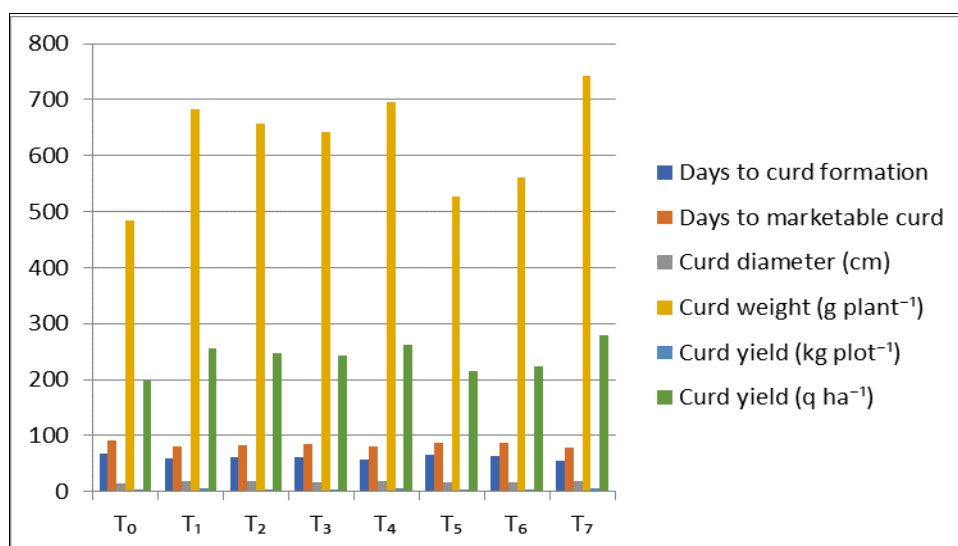


Fig 2: Effect of PGR treatments on curd yield attributes

Economics of production

Economic analysis revealed that T₇ delivered the highest gross return (₹4,18,350 ha⁻¹), net return (₹2,21,850 ha⁻¹), and benefit-cost ratio (2.13). The modest additional cost of

PGR application was more than compensated by the substantial yield increase. These economic advantages highlight the practical viability of the treatment for resource-constrained farmers.

Table 3: Effect of PGR treatments on economics of cauliflower production (₹ ha⁻¹)

Treatment	Cost of cultivation	Gross return	Net return	B:C ratio
T ₀	1,85,000	2,97,600	1,12,600	1.61
T ₁	1,92,500	3,85,050	1,92,550	2.00
T ₂	1,94,000	3,72,300	1,78,300	1.92
T ₃	1,91,800	3,63,750	1,71,950	1.90
T ₄	1,93,200	3,91,950	1,98,750	2.03
T ₅	1,90,800	3,23,400	1,32,600	1.69
T ₆	1,91,200	3,34,200	1,43,000	1.75
T ₇	1,96,500	4,18,350	2,21,850	2.13

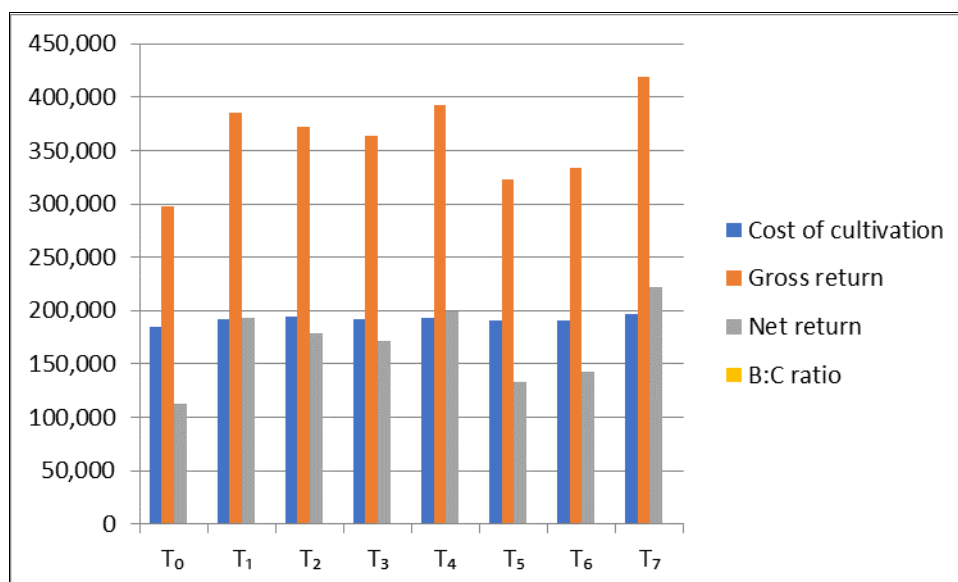


Fig 3: Effect of PGR treatments on economics of cauliflower production (₹ ha⁻¹)

Conclusion

The combined foliar application of GA₃ 50 ppm + NAA 50 ppm applied at 20, 35, and 50 DAT proved to be the most effective treatment for cauliflower cv. Pusa Snowball. It significantly enhanced vegetative growth, advanced curd maturity, increased curd size and weight, boosted marketable yield to 278.9 q ha⁻¹, and delivered the highest economic returns (B:C ratio 2.13). This treatment can be recommended to farmers in the Middle Gangetic Plain for realizing the full yield potential of the crop while improving profitability. Further studies on integration with micronutrients or biofertilizers may provide additional benefits.

References

1. Kaur P, Mal D. Effect of foliar spray of NAA and GA₃ on growth, curd formation and yield of cauliflower. *Journal of Pharmacognosy and Phytochemistry*. 2018;7(3):2805-2807.
2. Reza M, *et al.* Effect of GA₃ concentrations on broccoli growth and yield parameters. *International Journal of Horticultural Science and Technology*. 2015;2(1):45-53.
3. Chanwala K, *et al.* Combined effect of NAA and GA₃ on sprouting broccoli. *Vegetable Science*. 2019;46(2):112-119.
4. Akhter S, *et al.* Impact of plant growth regulators on the growth and yield of cole crops: A comprehensive review. *Journal of Horticultural Research*. 2019;27(1):89-98.
5. Jadon AS, *et al.* Evaluation of different PGRs on growth, yield and quality components of cauliflower (*Brassica oleracea* var. *botrytis*). *Indian Journal of Agricultural Sciences*. 2015;85(4):512-518.
6. Verma SK, *et al.* Influence of gibberellic acid and naphthalene acetic acid on growth and yield of cabbage (*Brassica oleracea* var. *capitata*). *Annals of Plant and Soil Research*. 2018;20(3):264-270.
7. Meena ML, *et al.* Effect of plant growth regulators on growth, yield and quality of broccoli (*Brassica oleracea* var. *italica*) cv. *KTS-1*. *Indian Journal of Horticulture*. 2018;75(2):245-252.