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Effect of bioregulators and boron on growth, yield and quality of cauliflower (*Brassica oleracea* var. *botrytis* L.) cv. Kashi Kunwari

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Abstract

The present study evaluated the combined effect of bioregulators (GA₃ and NAA) and boron on growth, yield and quality of cauliflower cv. Kashi Kunwari during the kharif-rabi season of 2025 at Rama University, Kanpur. Twelve treatments comprising soil and foliar boron along with GA₃ (50 ppm) and NAA (100 ppm) were tested in a randomized block design with three replications. The combined foliar application of boron (0.2%) + GA₃ (50ppm) + NAA (100ppm) (T₁₁) recorded the maximum plant height (64.8 cm), number of leaves (27.4 plant⁻¹), plant spread (64.2 cm), earliest curd initiation (39.2days) and curd harvest (62.8days). It also produced the highest polar diameter (18.9cm), equatorial diameter (19.4cm), fresh curd weight (478g) and curd yield (305.7 q ha⁻¹). Quality parameters were superior under T₁₁ with TSS (7.5 °Brix), ascorbic acid (57.2 mg 100 g⁻¹), total sugars (3.01%) and shelf life (7.1 days). This treatment also gave the highest net return (₹ 2, 07,740 ha⁻¹) and benefit-cost ratio (2.31). The synergistic interaction between boron and bioregulators enhanced cell division, elongation, nutrient mobilization and curd development. The study recommends Integrated foliar application of boron (0.2%) + GA₃ (50ppm) + NAA (100 ppm) for higher productivity, superior quality and better economic returns in early cauliflower under central Uttar Pradesh conditions.

Keywords: Cauliflower, boron, GA₃, NAA, curd yield, quality

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is an important cool-season cole crop belonging to the family Brassicaceae. It is highly valued for its nutritious curd (inflorescence), which is rich in vitamins (C, K, and B-complex), minerals, dietary fibre, antioxidants, and glucosinolates with anti-cancer properties. The crop is widely consumed as a fresh vegetable, in curries, pickles, and processed forms, making it a significant component of the human diet, especially during the winter season in India. Globally, cauliflower and broccoli together constitute an important vegetable group. According to recent data, world production of cauliflower and broccoli reached approximately 27 million tonnes in 2024, with China and India being the leading producers. India ranks second in the world after China, contributing significantly to global output. In 2023-24, India produced about 9.55 million tonnes of cauliflower from an area of around 0.49 million hectares, with an average productivity of approximately 19.4 tonnes per hectare. In India, cauliflower is one of the most important winter vegetables. Uttar Pradesh is among

the major cauliflower-producing states, though it ranks around 9th in terms of production. During 2024-25, the area under cauliflower in Uttar Pradesh was reported at approximately 19.77 thousand hectares. The crop plays a vital role in the nutritional security and economy of small and marginal farmers in the state due to its short duration and relatively high market demand. Cauliflower is a highly nutrient-exhaustive crop and is particularly sensitive to micronutrient deficiencies. Among these, boron (B) deficiency is very common in Indian soils, especially in sandy loam and alluvial soils of central Uttar Pradesh. Boron plays a critical role in cell wall formation, sugar translocation, auxin metabolism, pollen germination, and curd compactness. Its deficiency often leads to serious disorders such as hollow stem, internal browning, buttoning (premature curd formation), and poor curd quality, resulting in significant yield losses. Plant bioregulators such as gibberellic acid (GA₃) and naphthalene acetic acid (NAA) are known to promote cell elongation, enhance assimilate partitioning, improve curd initiation, and increase overall sink strength. The strategic integration of boron nutrition

with these bioregulators is expected to exhibit synergistic effects on vegetative growth, curd formation, compactness, and quality parameters. However, limited systematic information is available on the combined application of boron and bioregulators, particularly in early cauliflower cultivars like ‘Kashi Kunwari’ under the agro-climatic conditions of central Uttar Pradesh.

Materials and Methods

The field experiment was conducted during the kharif-rabi season of 2025 at the Agricultural Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Mandhana, Kanpur (26°30'Nlatitude, 80°20'Elongitude, 126mabovemsl).The soil was sandy loam with pH 7.62, organic carbon 0.54%, available N224 kg ha^{-1} , P 26.8 kg ha^{-1} , K204 kg ha^{-1} and available boron 0.39 mg

kg $^{-1}$ (low). Cauliflower cv. Kashi Kunwari was used as the test variety. The experiment was laid out in a randomized block design with twelve treatments and three replications. Each plot measured 3.0 m $\times$ 2.4 m.The treatments were: T₀-Control (no boron, no bioregulators)T₁-GA₃50ppm(foliar)T₂-NAA100ppm(foliar)T₃-GA₃50ppm+NAA100 ppm(foliar)T₄-Soilboron2.0kg ha^{-1} T₅-Soilboron+GA₃50ppmT₆-Soilboron+NAA100 ppm T₇-Soil boron + GA₃ 50 ppm + NAA 100 ppm T₈-Foliar boron 0.2% T₉-Foliar boron + GA₃ 50 ppm T₁₀-Foliar boron + NAA 100 ppm T₁₁-Foliar boron 0.2% + GA₃ 50 ppm + NAA 100 ppm Boron was applied as basal soil dose (borax) or foliar spray (boric acid 0.2%) at 30 and 45 DAT. GA₃ and NAA were sprayed foliarly at 30 and 45 DAT with 0.1% Tween-20 as surfactant. Recommended dose of fertilizers (150:100:80 kg NPK ha^{-1}) and 25 t FYM ha^{-1} were applied.

Results and discussion
Growth parameters

Table 1: Effect of Bioregulators and Boron on Growth Parameters of Cauliflower at 60 DAT

Treatment	Plant height (cm)	No. of leaves/plant	Plant spread (cm)	Daystocurd initiation	Days to curd harvest
T ₀ (Control)	48.6	18.4	48.2	48.2	72.4
T ₁ (GA ₃ 50ppm)	55.4	21.6	54.8	44.6	68.9
T ₂ (NAA100 ppm)	54.9	21.2	54.3	45.1	69.3
T ₃ (GA ₃ +NAA)	58.7	23.1	57.9	42.8	66.7
T ₄ (Soil B 2.0 kg ha^{-1})	53.8	20.8	53.6	46.3	70.5
T ₅ (Soil B+GA ₃)	60.2	24.5	59.4	41.5	65.4
T ₆ (Soil B+NAA)	59.8	24.2	59.1	41.9	65.8
T ₇ (Soil B +GA ₃ +NAA)	63.9	26.8	63.5	39.7	63.2
T ₈ (FoliarB 0.2%)	54.5	21.0	54.1	45.8	70.1
T ₉ (FoliarB+GA ₃)	61.5	25.3	60.8	40.9	64.6
T ₁₀ (FoliarB+NAA)	61.1	25.0	60.4	41.2	64.9

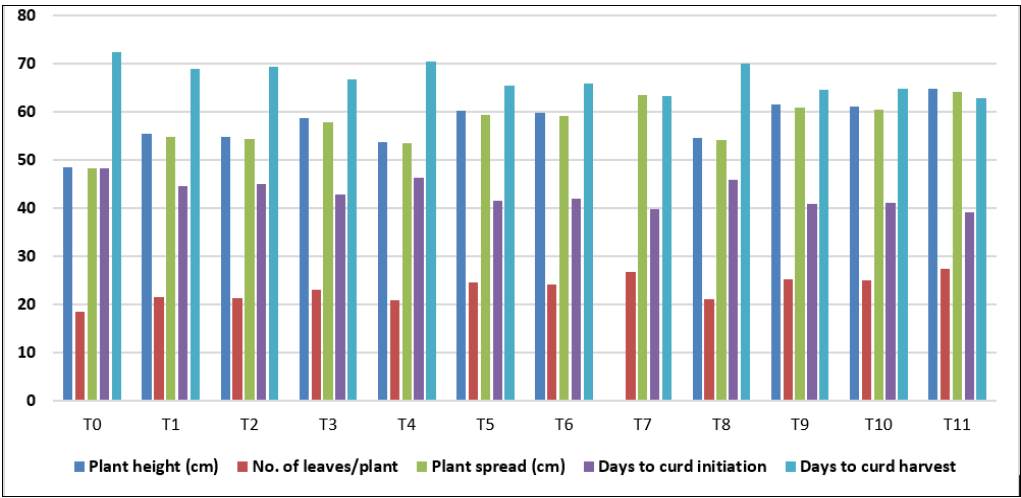


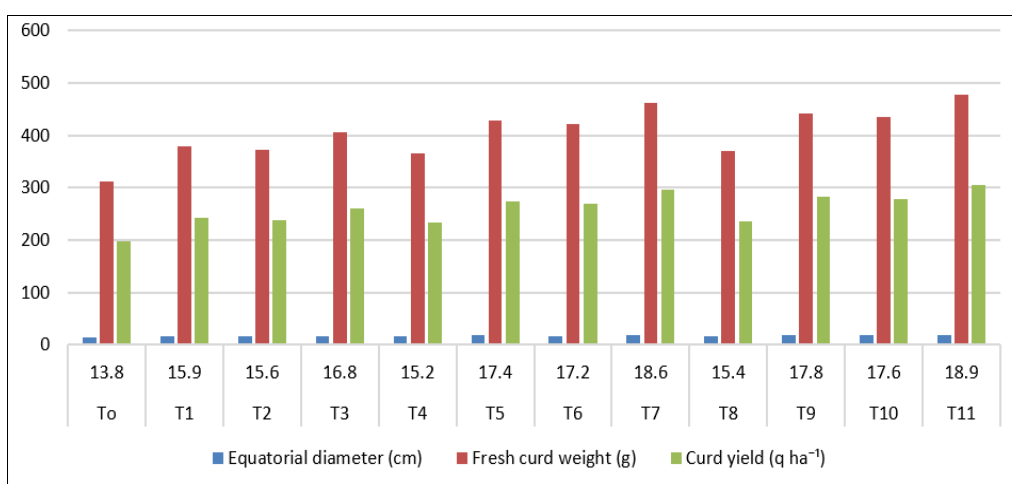
Fig 1: Effect of bioregulators and boron on growth parameters of cauliflower at 60 DAT

Treatment T₁₁ recorded significantly superior values for all growth parameters. The synergistic effect of GA₃ and NAA promoted cell elongation and division, while boron improved cell wall strength and auxin metabolism, resulting

in vigorous vegetative growth and early reproductive transition. These findings corroborate earlier reports (Meena *et al.*, 2018; Kaur and Mal, 2018; Pradhan *et al.*, 2024) [2, 4, 6].

Yield parameters**Table 2:** Effect of bioregulators and boron on yield attributes and curd yield of cauliflower.

Treatment	Polar diameter (cm)	Equatorial diameter (cm)	Fresh curd weight (g)	Curd yield (q ha ⁻¹)
T ₀ (Control)	13.8	14.2	312	198.4
T ₁ (GA ₃ 50 ppm)	15.9	16.4	378	241.6
T ₂ (NAA 100 ppm)	15.6	16.1	372	237.8
T ₃ (GA ₃ + NAA)	16.8	17.3	405	259.3
T ₄ (Soil B 2.0 kg ha ⁻¹)	15.2	15.7	365	232.7
T ₅ (Soil B + GA ₃)	17.4	17.9	428	273.5
T ₆ (Soil B + NAA)	17.2	17.6	421	269.8
T ₇ (Soil B + GA ₃ + NAA)	18.6	19.1	462	295.4
T ₈ (Foliar B 0.2%)	15.4	15.9	369	235.6
T ₉ (Foliar B + GA ₃)	17.8	18.3	441	282.1
T ₁₀ (Foliar B + NAA)	17.6	18.1	435	278.3
T ₁₁ (Foliar B + GA ₃ + NAA)	18.9	19.4	478	305.7
SEM±	0.42	0.39	8.6	6.8
CD (5%)	1.21	1.13	24.8	19.6
CV (%)	4.65	4.12	3.98	4.51

**Fig 2:** Effect of bioregulators and boron on yield attributes and curd yield of cauliflower

T₁₁ produced significantly higher curd dimensions, fresh weight and marketable yield. GA₃ and NAA enhanced cell expansion and assimilate partitioning, while boron facilitated efficient photosynthate translocation and reduced

physiological disorders. The results are consistent with Sitapara *et al.* (2011), Yasmin (2022) and Pradhan *et al.* (2024) [6, 7, 8].

Quality parameters**Table 3:** Effect of Bioregulators and Boron on Quality Parameters of Cauliflower Curd

Treatment	TSS (°Brix)	Ascorbic acid (mg 100 g ⁻¹)	Total sugars (%)	Shelf life (days)
T ₀ (Control)	5.8	42.6	2.14	4.2
T ₁ (GA ₃ 50 ppm)	6.4	48.9	2.48	5.1
T ₂ (NAA 100 ppm)	6.3	48.2	2.45	5.0
T ₃ (GA ₃ + NAA)	6.7	51.3	2.62	5.6
T ₄ (Soil B 2.0 kg ha ⁻¹)	6.2	47.5	2.39	4.9
T ₅ (Soil B + GA ₃)	6.9	53.8	2.78	6.2
T ₆ (Soil B + NAA)	6.8	53.1	2.75	6.1
T ₇ (Soil B + GA ₃ + NAA)	7.3	56.4	2.95	6.8
T ₈ (Foliar B 0.2%)	6.3	48.1	2.42	5.0
T ₉ (Foliar B + GA ₃)	7.1	54.9	2.85	6.4
T ₁₀ (Foliar B + NAA)	7.0	54.3	2.82	6.3
T ₁₁ (Foliar B + GA ₃ + NAA)	7.5	57.2	3.01	7.1
SEM±	0.12	0.85	0.06	0.18
CD (5%)	0.35	2.45	0.17	0.52
CV (%)	3.42	2.98	4.12	5.36

T₁₁ significantly improved all quality attributes. Enhanced metabolic activity, membrane stability, and carbohydrate

metabolism due to the combined application of boron and bioregulators resulted in higher TSS, ascorbic acid content,

total sugars, and extended shelf life. These observations are in agreement with the findings of Meena *et al.* (2018), Kaur

et al. (2018), and Pradhan *et al.* (2024)^[2, 4, 6].

Economic parameters

Table 4: Effect of Bioregulators and Boron on Economics of Cauliflower Production (₹ ha⁻¹)

Treatment	Cost of Cultivation	Gross Return	Net Return	B:C Ratio
T ₀ (Control)	1,48,650	2,38,080	89,430	1.60
T ₁ (GA ₃ 50 ppm)	1,52,300	2,89,920	1,37,620	1.90
T ₂ (NAA 100 ppm)	1,52,100	2,85,360	1,33,260	1.88
T ₃ (GA ₃ + NAA)	1,55,750	3,11,160	1,55,410	2.00
T ₄ (Soil B 2.0 kg ha ⁻¹)	1,51,800	2,79,240	1,27,440	1.84
T ₅ (Soil B + GA ₃)	1,55,450	3,28,200	1,72,750	2.11
T ₆ (Soil B + NAA)	1,55,250	3,23,760	1,68,510	2.08
T ₇ (Soil B + GA ₃ + NAA)	1,58,900	3,54,480	1,95,580	2.23
T ₈ (Foliar B 0.2%)	1,52,900	2,82,720	1,29,820	1.85
T ₉ (Foliar B + GA ₃)	1,56,550	3,38,520	1,81,970	2.16
T ₁₀ (Foliar B + NAA)	1,56,350	3,33,960	1,77,610	2.13
T ₁₁ (Foliar B + GA ₃ + NAA)	1,59,100	3,66,840	2,07,740	2.31

T₁₁ recorded the highest net return and benefit-cost ratio. The marginal increase in cost was more than offset by the substantial gain in curd yield, confirming the economic viability of the treatment. These findings are in agreement with those reported by Yasmin (2022) and Pradhan *et al.* (2022)^[8].

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