

International Journal of Agriculture Extension and Social Development

Volume 9; Issue 6; June 2026; Page No. 662-665

Received: 02-03-2026
Accepted: 03-04-2026

Indexed Journal
Peer Reviewed Journal

Effect of inorganic fertilizer levels and application strategies on growth, yield, and quality of cabbage (*Brassica oleracea* var. *capitata* L.)

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DOI: <https://www.doi.org/10.33545/26180723.2026.v9.i6i.3751>

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Abstract

The study evaluated the impact of different levels and application methods of inorganic fertilizers on growth, yield, quality, and economics of cabbage (*Brassica oleracea* var. *capitata*) during the 2025–2026 rabi season at Rama University, Kanpur. Nine treatments (including control, 50–150% RDF, split nitrogen, foliar micronutrients, and foliar urea) were tested in a Randomized Block Design with three replications. Growth and yield parameters increased with fertilizer dose up to 125% RDF. The best performance was recorded with 100% RDF + foliar micronutrients (Zn & B at 0.5%), giving maximum plant height (66.8 cm), head diameter (19.2 cm), fresh head weight (1230.5 g), and marketable yield (307.6 q ha⁻¹). This treatment also produced superior quality traits (TSS 7.0 °Brix, ascorbic acid 64.1 mg/100 g, compactness index 0.95). Excessive fertilization (150% RDF) caused slight declines. Economically, this treatment gave the highest net returns (₹2, 25,320 ha⁻¹, B:C ratio 2.57), while 75% RDF + foliar urea recorded the best B:C ratio (2.61).

Keywords: Cabbage, inorganic fertilizers, foliar micronutrients, zinc, boron, split nitrogen, yield, quality, economics

Introduction

Cabbage (*Brassica oleracea* var. *capitata*) is a cool-season leafy vegetable of the Brassicaceae family, valued globally for its dense, nutrient-rich heads. It is rich in vitamins (especially C and K), minerals, dietary fibre and antioxidants, making it an important component of human nutrition and health. As a heavy feeder, cabbage requires balanced fertilization for optimal growth, head compactness, yield and quality. In 2023, global cabbage production reached approximately 74 million tonnes, with China and India as the leading producers. In India, output was around 10 million tonnes during 2023-24 from 412,000 hectares, with an average productivity of 23 t ha⁻¹. Fertilizer application is critical for cabbage productivity. Inorganic fertilizers supply readily available N, P and K, promoting rapid vegetative growth and higher yields. However, excessive use often causes nutrient imbalances, delayed maturity and reduced quality. The present study was conducted to evaluate the effect of different levels and application strategies of inorganic fertilizers (graded doses, split nitrogen and foliar supplementation) on growth, yield, quality and economics of cabbage under Kanpur conditions.

Research methodology

The field experiment was conducted at the research farm of the Faculty of Agricultural Sciences and Allied Industries, Rama University, Mandhana, Kanpur (26.5697° N, 80.2169° E) during the rabi season of 2025–2026. The soil was sandy loam with pH 7.9, EC 0.42 dS m⁻¹, organic

carbon 0.48%, available N 210 kg ha⁻¹, P₂O₅ 22 kg ha⁻¹, and K₂O 245 kg ha⁻¹. The experiment was laid out in a Randomized Block Design with nine treatments and three replications. Plot size was 3 m × 2.5 m (gross 7.5 m²). The recommended dose of fertilizer (RDF) for cabbage was 120:60:60 kg N:P:K ha⁻¹. Treatments were: T₀ – Control (no fertilizer) T₁ – 50% RDF T₂ – 75% RDF T₃ – 100% RDF T₄ – 125% RDF T₅ – 150% RDF T₆ – 100% RDF (split N: 50% at 15 & 30 DAT), T₇ – 100% RDF + 2 foliar sprays of micronutrients (Zn & B at 0.5% each at 30 & 45 DAT), T₈ – 75% RDF + 2 foliar sprays of 2% urea (at 30 & 45 DAT). Urea, single superphosphate, and muriate of potash were used as sources of N, P, and K, respectively. Full P and K were applied basally; N was applied as per treatment schedule. A high-yielding cabbage variety was sown in nursery beds in October 2025 and transplanted at the 4–5 true leaf stage with 60 cm × 45 cm spacing. Standard cultural practices (irrigation, weed control, and integrated pest management) were followed. Data were recorded on five randomly selected plants per plot for growth parameters (plant height at 30, 60, and 90 DAT; plant spread at 60 DAT; stalk length and head diameter at harvest), yield attributes (fresh and dry head weight, yield per plot, marketable yield per hectare), quality attributes (TSS, ascorbic acid, compactness index) and economic parameters (cost of cultivation, gross returns, net returns, B:C ratio). Data were statistically analyzed using ANOVA in RBD; critical difference (CD) was calculated at 5% level of significance.

Results and discussion

Growth parameters

Table1: Effect of inorganic fertilizer levels on growth parameters of cabbage

Treatment	Plant Height (cm)			Plant Spread at 60 DAT (cm ²)	Stalk Length at Harvest (cm)	Head Diameter at Harvest (cm)
	30 DAT	60 DAT	90 DAT			
T ₀ (Control)	12.8	25.4	39.2	292.7	14.2	10.8
T ₁ (50% RDF)	15.6	33.1	47.5	418.4	16.8	13.4
T ₂ (75% RDF)	18.2	39.6	55.8	505.9	18.5	15.2
T ₃ (100% RDF)	20.1	45.8	62.9	589.6	20.1	17.6
T ₄ (125% RDF)	20.8	47.9	65.7	622.8	21.4	18.9
T ₅ (150% RDF)	19.5	46.2	63.4	605.1	20.9	18.3
T ₆ (100% RDF – Split N)	20.6	46.7	65.1	597.3	19.7	18.1
T ₇ (100% RDF + Micronutrients)	21.3	48.4	66.8	635.2	19.3	19.2
T ₈ (75% RDF + 2% Urea foliar)	20.4	46.3	64.5	592.8	19.9	17.8
SEM	0.4	0.8	1.1	9.2	0.6	0.4
CD (5%)	1.3	2.6	3.4	29.4	1.8	1.1
CV (%)	6.2	7.1	6.8	8.7	7.9	6.5

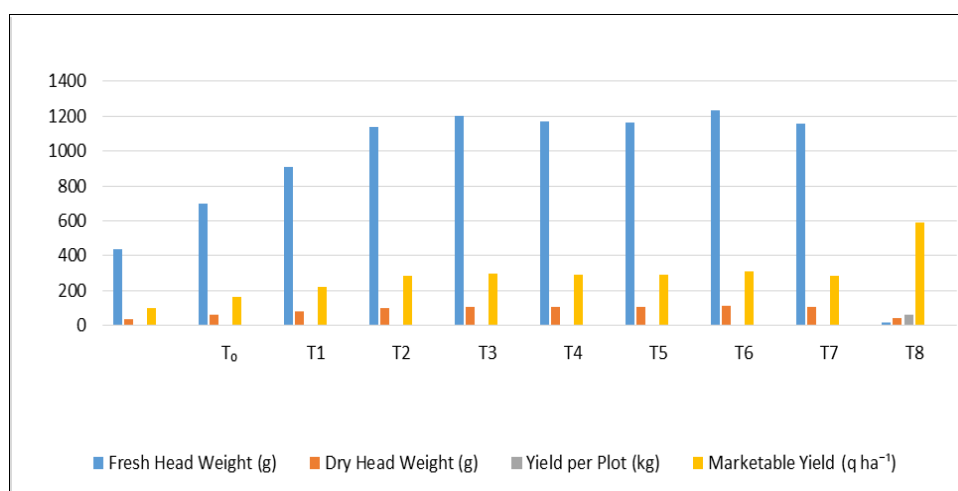


Fig 1: Effect of inorganic fertilizer levels on growth parameters of cabbage

Plant height, plant spread, stalk length and head diameter increased significantly with increasing fertilizer levels up to 125% RDF (Table 1). The tallest plants at harvest (66.8 cm) were recorded in T₇ (100% RDF + foliar Zn & B), followed by T₄ (125% RDF) at 65.7 cm. The control produced the shortest plants (39.2 cm). Treatments T₃, T₄, T₆, T₇ and T₈ were statistically at par at harvest. The progressive improvement in growth up to 125% RDF is mainly due to the role of nitrogen in cell division and elongation. Foliar application of zinc and boron in T₇ further boosted these parameters by enhancing chlorophyll synthesis, enzyme

activity and translocation of photosynthates. The slight reduction at 150% RDF (T₅) indicates nutrient imbalance and excessive vegetative growth that diverts resources away from head development. These results support the findings of Anushriet *et al.* (2022) ^[1] and Rabindra *et al.* (2021) ^[5], who observed maximum vegetative growth in cole crops with balanced NPK supply. Similar trends were also reported by Sharma and Suryavanshi (2020) ^[6] in cauliflower, where micronutrient supplementation significantly improved canopy development.

Yield and Yield attributes

Table 2: Effect of Inorganic Fertilizer Levels on Yield and Yield Attributes of Cabbage

Treatment	Fresh Head Weight (g)	Dry Head Weight (g)	Yield per Plot (kg)	Marketable Yield (q ha ⁻¹)
T ₀ (Control)	435.8	38.6	2.18	102.6
T ₁ (50% RDF)	698.4	62.4	3.52	166.2
T ₂ (75% RDF)	905.7	81.2	4.68	222.4
T ₃ (100% RDF)	1138.2	102.5	5.96	282.5
T ₄ (125% RDF)	1202.6	108.7	6.38	300.8
T ₅ (150% RDF)	1167.9	105.3	6.14	291.4
T ₆ (100% RDF – Split N)	1164.3	104.9	6.09	289.7
T ₇ (100% RDF + Micronutrients)	1230.5	111.4	6.52	307.6
T ₈ (75% RDF + 2% Urea foliar)	1153.8	103.8	6.02	286.2
SEM	15.8	1.5	0.09	—
CD (5%)	49.7	4.8	0.28	13.2
CV (%)	9.1	8.3	7.4	7.4

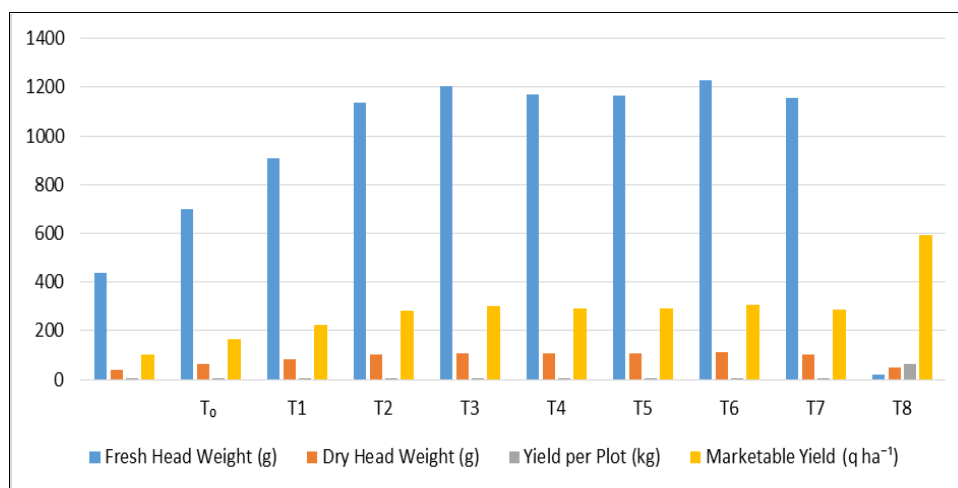


Fig 2: Effect of inorganic fertilizer levels on yield and yield attributes of cabbage

Fresh head weight, dry head weight, yield per plot and marketable yield per hectare followed the same trend as growth parameters (Table 2). The highest fresh head weight (1230.5 g), dry head weight (111.4 g), plot yield (6.52 kg) and marketable yield (307.6 q ha⁻¹) were obtained in T₇. Treatment T₄ (125% RDF) recorded 300.8 q ha⁻¹. The control gave the lowest yield (102.6 q ha⁻¹). Differences were significant up to 125% RDF, but T₃, T₄, T₆, T₇ and T₈ remained statistically similar. The superior performance of T₇ is attributed to the synergistic effect of adequate macronutrients and micronutrients, which improved

assimilate partitioning, head filling and biomass accumulation. Split nitrogen application (T₆) also performed well by matching nitrogen supply with crop demand and minimizing losses. Over-fertilization at 150% RDF caused a marginal decline in yield due to nutrient antagonism and poor partitioning to the edible head. These observations are in line with Chandel *et al.* (2021)^[2] and Sreekanth *et al.* (2022)^[9], who reported highest head yield in cabbage with balanced inorganic nutrition supplemented with micronutrients. Similar results were documented by Singh *et al.* (2020a)^[7] in cabbage and Kumar *et al.* (2021)^[4] in cauliflower.

Economic Analysis

Table 3: Effect of Inorganic Fertilizer Levels on Economics

Treatment	Cost of Cultivation (₹ ha ⁻¹)	Gross Returns (₹ ha ⁻¹)	Net Returns (₹ ha ⁻¹)	B:C Ratio
T ₀ (Control)	86,500	1,23,120	36,620	1.42
T ₁ (50% RDF)	1,06,800	1,99,440	92,640	1.87
T ₂ (75% RDF)	1,19,200	2,66,880	1,47,680	2.24
T ₃ (100% RDF)	1,33,500	3,39,000	2,05,500	2.54
T ₄ (125% RDF)	1,46,800	3,60,960	2,14,160	2.46
T ₅ (150% RDF)	1,60,200	3,49,680	1,89,480	2.18
T ₆ (100% RDF – Split N)	1,36,800	3,46,800	2,10,000	2.54
T ₇ (100% RDF + Micronutrients)	1,43,800	3,69,120	2,25,320	2.57
T ₈ (75% RDF + 2% Urea foliar)	1,31,500	3,43,680	2,12,180	2.61

Treatment T₇ recorded the highest net returns (₹2,25,320 ha⁻¹) with a B:C ratio of 2.57 (Table 3). Treatment T₈ (75% RDF + foliar urea) gave the highest B:C ratio (2.61), showing better input-use efficiency at lower fertilizer doses. The control was economically unviable. The high profitability of T₇ resulted from the optimal combination of higher yield and moderate cost of cultivation. Reduced fertilizer levels with foliar supplementation (T₈) proved most efficient for resource-poor farmers. These results highlight that balanced inorganic fertilizer management with targeted foliar sprays offers both high productivity and strong economic returns. This finding is consistent with Zargaret *al.* (2021)^[10], who reported superior economic returns in cabbage under integrated nutrient management, and with Sharma and Suryavanshi (2020)^[6], who noted high benefit-cost ratios in cauliflower when micronutrients were supplemented.

Conclusion

The study concludes that 100% RDF supplemented with foliar micronutrients (Zn and B) is the most effective treatment for achieving higher growth, yield, quality, and economic returns in cabbage under Kanpur conditions. Application of 125% RDF also performed well, while 75% RDF with foliar urea offers a cost-effective alternative with the highest B:C ratio. Excessive fertilization (150% RDF) is not recommended due to marginal declines in performance. These findings provide evidence-based recommendations for sustainable and profitable cabbage production, emphasizing balanced inorganic nutrition with targeted foliar supplementation.

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