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Response of organic nutrient and biofertilizer management on growth yield and quality parameter of Cabbage (*Brassica oleracea* L. var. *capitata*)

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Abstract

Cabbage (*Brassica oleracea* var. *capitata* L.) is an indispensable cole crop within Indian olericulture, distinguished by its high nutrient density and significant economic footprint in both domestic and commercial markets. To mitigate the ecological constraints associated with exclusive chemical fertilization and to enhance soil health, a strategic shift toward integrated nutrient management (INM) is essential for sustainable production. Accordingly, a field experiment was conducted during the *Rabi* season of 2025-2026 at the Primary Experimental Station, Rama University, Kanpur, Uttar Pradesh, India, to evaluate the efficacy of diverse organic and microbial inputs on cabbage performance. The study was laid out in a Randomized Block Design (RBD) featuring eight treatments replicated thrice, comprising various combinations of organic manures (Vermicompost, FYM, Mustard cake, Poultry manure and Neem cake) and bio-fertilizer (*Azotobacter*, PSB, and KSB).

According to the results of the current study, treatment T₈ (Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + *Azotobacter* + PSB + KSB) recorded the most significant effects on growth attributes, including the maximum plant height (34.89 cm) and the highest number of leaves per plant (20.00) at the harvest stage. Regarding yield and quality parameters, T₈ (Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + *Azotobacter* + PSB + KSB) achieved the maximum head diameter (14.89 cm), greatest head weight (1040.43 g), and the highest total yield per hectare (24.57 t/ha). In terms of quality, T₈ (Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + *Azotobacter* + PSB + KSB) also produced the highest TSS (5.80 °Brix) and ascorbic acid content (31.97 mg/100g).

Keywords: *Azotobacter*, Bio-fertilizers, Cabbage, Integrated Nutrient Management (INM), KSB, Mustard Cake, PSB, Quality, Vermicompost, and Yield

Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.; 2n = 18) represents one of the most economically and nutritionally significant leafy vegetables cultivated globally within the Brassicaceae family (Sher and Mishra, 2023) [17]. Originating from the Mediterranean coastline, the species has demonstrated remarkable phenotypic plasticity, enabling its successful diversification from temperate European climates into the varied agro-climatic zones of the tropics (Maggioni *et al.*, 2010) [10]. Beyond its geographical distribution, cabbage is highly valued for its complex biochemical profile and therapeutic potential, particularly due to its high concentration of sulfurcontaining glucosinolates like sulforaphane, which contribute to its documented anti-carcinogenic properties (Melim *et al.*, 2022) [11]. From a nutritional standpoint, 100 g of the edible portion delivers a robust mineral and vitamin complex, including 114 mg of potassium, 44 mg of phosphorus, 40 mg of calcium, and an ascorbic acid content ranging from 30 to 65 mg, providing a low-caloric yet nutrient-dense energy source (Rai *et al.*, 2005) [16]. National production data for India indicates a cultivated area of 454,000 hectares with a total output of 10.51 million tonnes, while in Uttar Pradesh, the crop occupies approximately 12,990 hectares, contributing significantly to the regional horticultural economy (Anonymous, 2025) [2].

The optimization of yield and quality in cruciferous vegetables is heavily dependent on a balanced supply of primary macronutrients and essential secondary elements; however, the prevailing agronomic trend involves the disproportionate and indiscriminate application of

synthetic nitrogenous fertilizers (Ojetayo *et al.*, 2011) ^[13]. To mitigate the deleterious environmental impacts and soil health deterioration associated with chemical over-dependence, the implementation of Integrated Nutrient Management (INM), defined by the synchronized application of organic amendments alongside inorganic fertilizers represents a superior agronomic paradigm (Yadav and Yadav, 2005) ^[16]. Organic inputs such as farmyard manure (FYM), vermicompost, and poultry manure optimize the soil-plant continuum by acting as structural conditioners and supplying essential macro- and micronutrients (Prasad & Sinha, 2000; Kumar *et al.*, 2017). Furthermore, specialized oil cakes like neem cake (5.2% N, 1.0% P, 1.4% K) and mustard cake (4.8% N, 2.0% P, 1.3% K) serve a dual purpose by enhancing nutrient-use efficiency through nitrification inhibition and providing secondary bio-fumigant properties against soil-borne pathogens (Swati *et al.*, Elnasikh *et al.*, 2011) ^[15].

Complementing these organic substrates, bio fertilizers constitute a vital biological intervention to mobilize immobile element pools in the soil matrix without environmental degradation (Yadav *et al.*, 2005) ^[15]. The incorporation of free-living aerobic nitrogen-fixing *Azotobacter* species can substitute 10% to 20% of required inorganic nitrogen while synthesizing critical growth-promoting phytohormones like indole acetic acid (IAA) and gibberellins (Aasfar *et al.*, 2021) ^[1]. Similarly, Phosphorus Solubilizing Bacteria (PSB) and Potassium Solubilizing Bacteria (KSB) effectively transform insoluble mineral complexes into plant-available forms through the secretion of organic acids, minimizing reliance on chemical potash and phosphate inputs (Wang *et al.*, Dakshayini *et al.*, 2024) ^[4]. In the intensive agro-climatic conditions of Uttar Pradesh, evaluating the precise integration of these diverse organic matrices, microbial bioinoculants, and chemical fertilizers is essential to establish stable nutrient mineralization. This investigation aims to identify a superior integrated nutrient treatment combination that maximizes the vegetative growth, head compactness, and biochemical quality of cabbage while ensuring longterm soil fertility and environmental resilience.

Materials and Methods

The field experiment was conducted during the *rabi* season of 2025-26 at the primary experimental station of Rama University, located in Kanpur (U.P.). The farm reflects the typical physiographic and agroclimatic conditions of the Central Plain Zone in Uttar Pradesh. The location is identified by coordinates ranging between 25°34' to 26°11' N latitude and 81°19' to 82°27' E longitude, with an elevation of roughly 137 meters above mean sea level. The experimental field exhibited a sandy loam texture in its soil composition, with a measured pH level of 7.2, indicating a neutral acidity level. The sample exhibited low organic carbon levels of 0.51 per cent and available nitrogen measured at 171.48 kg N/ha. The analysis indicated low levels of available phosphorus, measured at 17.60 kg P/ha, and medium levels of available potassium, recorded at 216.40 kg K/ha. The crop received a total of 7.51 mm of rainfall throughout the duration of the experiment.

The experiment consisted eight treatments viz. T₁: Control 100% RDF (175: 75 :70), T₂: Vermicompost @ 10 t ha⁻¹ + *Azotobacter*, T₃: FYM @ 10 t ha⁻¹ + Vermicompost @ 5 t ha⁻¹ + PSB, T₄: FYM @ 20 t ha⁻¹ + *Azotobacter* + PSB, T₅: FYM @ 10 t ha⁻¹ + Poultry manure @ 1 t ha⁻¹ + *Azotobacter*, T₆: FYM @ 10 t ha⁻¹ + Neem cake @ 1 t ha⁻¹ + PSB, T₇: Mustard cake @ 5 t ha⁻¹ + *Azotobacter* + KSB, T₈: Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + *Azotobacter* + PSB + KSB which was

analyzed in randomized block design with three replications. The experimental field underwent primary tillage with a moldboard plough followed by harrowing to attain an optimal, finely pulverized tilth. Prior to transplanting, raised nursery beds were cleared of weeds, and uniform, healthy seedlings of cabbage variety 'Pride of India' were transplanted at a standardized spacing of 60 cm between rows and 45 cm between plants. Before sowing in the nursery, the seeds were treated with the systemic fungicide Carbendazim (Bavistin), and for specified biological treatments, *Azotobacter*, PSB, or KSB biofertilizers were soil-applied at a rate of 5 kg/ha by pre-mixing with organic manure. A consistent plant population was maintained through gap-filling operations conducted one week after transplanting. In the cultivation of cabbage, a total recommended inorganic dose of 175 kg of nitrogen (N), 75 kg of phosphorus (P₂O₅) and 70 kg of potassium (K₂O) was applied using Urea, Single Super Phosphate, and Muriate of Potash, with half of the nitrogen and the full quantum of phosphorus and potassium applied basally at transplanting, while the remaining nitrogen was top-dressed 30 days post-transplanting. Additionally, farmyard manure (FYM), vermicompost, poultry manure, neem cake and mustard cake were incorporated as a basal dose in accordance with the specified treatment combinations. Crucial observations concerning the vegetative growth, head yield and biochemical quality attributes of cabbage were documented at the appropriate developmental intervals. Statistical analysis was conducted on the data collected during the experiment, in accordance with the guidelines established by Panse and Sukhatme (1985) ^[14]. The "F" test, along with a significance level of 5%, was employed to evaluate the differences in treatment outcomes.

Result and Discussion

Effect of organic nutrient and bio fertilizer management on growth attributes of cabbage

The data on growth traits of cabbage presented in the table 1 indicates the significant effects of integrated organic nutrients and biofertilizer management regimes. Plant vegetative parameters, including plant height and the number of leaves, varied significantly across different treatments. The highest plant height was consistently recorded in treatment Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + *Azotobacter* + PSB + KSB (T₈), observing a maximum height of 34.89 cm, which significantly surpassed all other treatments except FYM @ 10 t ha⁻¹ + Vermicompost @ 5 t ha⁻¹ + PSB (T₃), which was found to be statistically at par with a height of 33.84 cm. Conversely, the minimum plant height was recorded under treatment Mustard cake @ 5 t ha⁻¹ + *Azotobacter* + KSB (T₇) at 16.96 cm.

Regarding the leaf characteristics, the number of leaves per plant followed an identical trend to plant height, showing highly significant variations among the nutrient regimes. The maximum number of leaves (20.00) was achieved under treatment Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + *Azotobacter* + PSB + KSB (T₈) showing a significant increase over Mustard cake @ 5 t ha⁻¹ + *Azotobacter* + KSB (T₇) (11.09 leaves) which recorded the lowest number of leaves per plant.

The physiological transition periods, measured by the days taken to head initiation and days taken to head maturity, were strongly influenced by the different treatment combinations. Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + *Azotobacter* + PSB + KSB (T₈) demonstrated the highest crop efficiency and rapid development, taking the minimum number of days to initiate head formation (40.02 days) and the shortest

duration to reach head maturity (71.60 days), significantly advancing crop maturity compared to the other groups. In contrast, the application of Mustard cake @ 5 t ha⁻¹ + Azotobacter + KSB (T₇) significantly delayed the crop growth cycle, requiring the maximum duration for both head initiation (52.68 days) and maturity (87.58 days), indicating that unbalanced organic inputs lacking a dense, multi-strain microbial and structural compost matrix slow down metabolic efficiency and vegetative development.

The significant acceleration and enhancement of vegetative growth attributes and phenological transitions in cabbage under treatment Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + Azotobacter + PSB + KSB (T₈) is a direct result of the favorable nutritional and physiological environment established by combining structured organic substrates with a multistrain microbial consortium. The maximum plant height and number of leaves per plant recorded in T₈ stem from the steady mineralization of the humified vermicompost base paired with the concentrated nitrogen reserves of mustard cake, which collectively fueled rapid chlorophyll synthesis and leaf primordia initiation. This vegetative expansion was further catalyzed by *Azotobacter*, which not only fixed atmospheric nitrogen but also biosynthesized endogenous phytohormones like gibberellins and indoles that promote cellular division and apical meristem elongation, while the synchronized activities of PSB and KSB maintained high rhizosphere bioavailability of phosphorus and potassium to preserve the metabolic energy and cellular turgor pressure necessary for rapid expansion. Consequently, this optimal nutrient assimilation enabled the plants to quickly satisfy their vital vegetative biomass thresholds, thereby triggering the earliest head initiation and hastening physiological head maturity via the efficient translocation of solutes from the foliar source to the compact economic sink. These interpretations closely mirror the empirical results documented by Gujar *et al.* (2025), Kumar and Parmar (2024) [6, 8], Singh *et al.* (2023) [18] and Mohanta *et al.* (2018) [12].

Effect of organic nutrient and biofertilizer management on yield attributes of cabbage

The data on the yield attributes and yield of cabbage presented in the table 2 reveals a highly significant impact from the integrated use of organic amendments and functional bio-fertilizers. The physical dimensions of the cabbage head, measured via head diameter, exhibited notable variations across the different nutrient treatments. The maximum head diameter was recorded under treatment Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + Azotobacter + PSB + KSB (T₈) at 14.89 cm. On the other hand, the smallest head diameter was observed in treatment Mustard cake @ 5 t ha⁻¹ + Azotobacter + KSB (T₇), recording 12.82 cm diameter.

The average weight of the cabbage head followed a corresponding trend, showing a highly significant response to the synchronized nutrient treatments. The highest average head weight was successfully achieved under treatment Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + Azotobacter + PSB + KSB (T₈) observing 1040.43 g weight. Conversely, the treatment combination Mustard cake @ 5 t ha⁻¹ + Azotobacter + KSB (T₇) recorded the lowest average head weight at 553.77 g, highlighting a substantial decrease in physical growth.

Total marketable yield per hectare was strongly influenced by the various nutrient management matrices. Reflecting the patterns observed in head diameter and weight, treatment

Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + Azotobacter + PSB + KSB (T₈) produced the maximum yield at 24.57 t/ha, performing statistically at par with treatment FYM @ 10 t ha⁻¹ + Vermicompost @ 5 t ha⁻¹ + PSB (T₃), which yielded 23.41 t/ha. The lowest total yield was documented under Mustard cake @ 5 t ha⁻¹ + Azotobacter + KSB (T₇), showing that exclusive reliance on high-dose single oil cakes without structural manure frameworks or comprehensive phosphorus/potassium mobilization restricts overall crop productivity.

The highly significant enhancement in the yield attributes and total marketable output of cabbage under Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + Azotobacter + PSB + KSB (T₈) is a direct consequence of the synergistic interaction between humified organic amendments and a multi-strain microbial consortium. The maximum head diameter and peak average head weight achieved under T₈ indicate a highly efficient source-to-sink translocation of photosynthates during the critical head-filling stage. The structural matrix of vermicompost combined with the high nitrogen reserves of mustard cake provided a steady, slow-release nutrient flux, while the biological activities of *Azotobacter*, PSB, and KSB dramatically optimized the rhizosphere's bioavailability of nitrogen, phosphorus, and potassium. This continuous supply of essential macro- and micronutrients facilitated the high metabolic energy required for cell division, inner leaf expansion, and compact dry matter accumulation within the storage head. Consequently, these superior growth traits directly culminated in the maximum total yield. These findings are strongly validated by the independent work of Chanu *et al.* (2025) [3], Kumar and Parmar (2024) [8] and Singh *et al.* (2023) [18].

Effect of organic nutrient and biofertilizer management on quality attributes of cabbage

The data on the quality parameters of cabbage presented in the table 3 demonstrates that integrated nutrient and biofertilizer management regimes exert a highly significant influence on the physical structure and biochemical composition of the crop. Head compactness, a crucial physical parameter determining marketability and shelf life showed notable variations among the evaluated treatment matrices. The maximum index of head compactness was recorded under treatment Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + Azotobacter + PSB + KSB (T₈) at 31.86 g/cm³. The lowest head compactness was registered under Mustard cake @ 5 t ha⁻¹ + Azotobacter + KSB (T₇) at 25.82 g/cm³.

The biochemical sweetness and consumer preference index, evaluated through TSS (°Brix), followed a closely corresponding trend with highly significant responses across the treatment combinations. The highest TSS concentration was successfully achieved under Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + Azotobacter + PSB + KSB (T₈), reaching a peak value of 5.80 °Brix indicating that a robust, multi-strain biological inoculation combined with balanced organic sources effectively satisfies the physiological demands for secondary metabolite and carbohydrate synthesis. In contrast, the lowest accumulation of soluble solids was documented under treatment Mustard cake @ 5 t ha⁻¹ + Azotobacter + KSB (T₇), which yielded only 4.61 °Brix.

The antioxidant and nutritional profile of the cabbage heads, quantified by the ascorbic acid (Vitamin C) content, was strongly enhanced by the integrated bio-organic frameworks. Consistent with the other quality metrics, treatment Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ +

Azotobacter + PSB + KSB (T_8) produced the maximum ascorbic acid content at 31.97 mg/100g. Conversely, the application of Mustard cake @ 5 t ha⁻¹ + Azotobacter + KSB (T_7) resulted in a significant reduction in nutritional quality, recording the minimum ascorbic acid concentration of 24.16 mg/100g. This demonstrates that unbalanced organic fertilization strategies lacking integrated macro- and micronutrient mobilization constraints can negatively impact the plant's overall biochemical biosynthesis and nutritional value.

The significant enhancement of physical and biochemical quality attributes in cabbage under Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + Azotobacter + PSB + KSB (T_8) can be attributed to the steady, balanced supply of macro and micronutrients combined with the continuous mobilization of fixed mineral pools by functional bio-inoculants. The maximum head compactness achieved under T_8 indicates optimal cellular elongation and tight foliage folding, which is facilitated by the structured carbon matrix of vermicompost that enhances soil

moisture and tissue turgidity. For the biochemical parameters, the peak Total Soluble Solids and highest ascorbic acid concentration observed in T_8 are directly linked to the metabolic synergy between organic amendments and microbial inoculants. The active secretion of organic acids by Potassium Solubilizing Bacteria (KSB) and Phosphorus Solubilizing Bacteria (PSB) efficiently liberates recalcitrant potassium and phosphorus within the rhizosphere; these available elements act as key enzymatic co-factors that accelerate the biosynthesis, accumulation, and translocation of photoassimilates and hexose sugars from the leaf source to the developing head sink. This optimized carbohydrate flux serves as the primary precursor for both soluble solids accumulation and ascorbic acid synthesis, thereby bolstering the antioxidant profile and market value of the crop. These findings closely align with the investigations of Jaswal *et al.* (2025) ^[7], Singh *et al.* (2023) ^[18], Rana *et al.* and Mohanta *et al.* (2018).

Table 561: Effect of organic nutrient and bio fertilizer management on growth attributes of cabbage

S. No.	Treatment	Treatment combination	Plant height (cm)	Number of leaves per plant	Days taken to head initiation	Days taken to head maturity
1	T_1	Control 100% RDF (175: 75 :70)	30.51	17.07	44.39	76.46
2	T_2	Vermicompost @ 10 t ha ⁻¹ + Azotobacter	23.24	12.54	50.02	81.27
3	T_3	FYM @ 10 t ha ⁻¹ + Vermicompost @ 5 t ha ⁻¹ + PSB	33.84	19.17	42.28	74.01
4	T_4	FYM @ 20 t ha ⁻¹ + Azotobacter + PSB	21.71	11.56	51.29	83.91
5	T_5	FYM @ 10 t ha ⁻¹ + Poultry manure @ 1 t ha ⁻¹ + Azotobacter	27.88	15.41	46.52	77.71
6	T_6	FYM @ 10 t ha ⁻¹ + Neem cake @ 1 t ha ⁻¹ + PSB	26.36	14.40	47.87	78.83
7	T_7	Mustard cake @ 5 t ha ⁻¹ + Azotobacter + KSB	16.96	11.09	52.68	87.58
8	T_8	Vermicompost @ 10 t ha ⁻¹ + Mustard cake @ 1 t ha ⁻¹ + Azotobacter + PSB + KSB	34.89	20.00	40.02	71.60
S.E. (m) (±)			1.10	0.61	1.75	3.14
C.D. @ 5%			3.34	1.86	5.30	9.52

Table 2: Effect of organic nutrient and bio fertilizer management on yield attributes and yield of cabbage

S. No.	Treatment	Treatment combination	Head diameter (cm)	Average weight of head (g)	Yield per hectare (t)
1	T_1	Control 100% RDF (175: 75 :70)	14.47	877.98	20.73
2	T_2	Vermicompost @ 10 t ha ⁻¹ + Azotobacter	13.29	633.48	14.96
3	T_3	FYM @ 10 t ha ⁻¹ + Vermicompost @ 5 t ha ⁻¹ + PSB	14.61	991.19	23.41
4	T_4	FYM @ 20 t ha ⁻¹ + Azotobacter + PSB	13.11	580.97	13.72
5	T_5	FYM @ 10 t ha ⁻¹ + Poultry manure @ 1 t ha ⁻¹ + Azotobacter	13.97	788.06	18.61
6	T_6	FYM @ 10 t ha ⁻¹ + Neem cake @ 1 t ha ⁻¹ + PSB	13.78	731.82	17.28
7	T_7	Mustard cake @ 5 t ha ⁻¹ + Azotobacter + KSB	12.82	553.77	13.08
8	T_8	Vermicompost @ 10 t ha ⁻¹ + Mustard cake @ 1 t ha ⁻¹ + Azotobacter + PSB + KSB	14.89	1040.43	24.57
S.E. (m) (±)			0.40	32.34	0.76
C.D. @ 5%			1.21	98.09	2.32

Table 3: Effect of organic nutrient and bio fertilizer management on quality attributes of cabbage

S. No.	Treatment	Treatment combination	Head compactness (g/cm ³)	TSS (°Brix)	Ascorbic acid (mg/100g)
1	T_1	Control 100% RDF (175: 75 :70)	29.07	5.60	30.43
2	T_2	Vermicompost @ 10 t ha ⁻¹ + Azotobacter	27.03	4.79	25.47
3	T_3	FYM @ 10 t ha ⁻¹ + Vermicompost @ 5 t ha ⁻¹ + PSB	31.58	5.67	31.03
4	T_4	FYM @ 20 t ha ⁻¹ + Azotobacter + PSB	25.82	4.70	24.81
5	T_5	FYM @ 10 t ha ⁻¹ + Poultry manure @ 1 t ha ⁻¹ + Azotobacter	28.97	5.30	28.60
6	T_6	FYM @ 10 t ha ⁻¹ + Neem cake @ 1 t ha ⁻¹ + PSB	28.05	5.17	27.69
7	T_7	Mustard cake @ 5 t ha ⁻¹ + Azotobacter + KSB	26.33	4.61	24.16
8	T_8	Vermicompost @ 10 t ha ⁻¹ + Mustard cake @ 1 t ha ⁻¹ + Azotobacter + PSB + KSB	31.86	5.80	31.97
S.E. (m) (±)			1.27	0.11	0.69
C.D. @ 5%			3.86	0.35	2.10

Conclusion

From the above results of the current experiment, Vermicompost @ 10 t ha⁻¹ + Mustard cake @ 1 t ha⁻¹ + Azotobacter + PSB + KSB (T₈) had the best effect in terms of growth attributes, yield parameters, and quality traits of cabbage. In terms of integrated nutrient management practices, treatment T₈ was found to be significantly effective over all other treatments on growth and yield attributes like plant height, number of leaves per plant, head diameter, average weight of head and total marketable yield, while also optimizing biochemical quality indices including head compactness, TSS and ascorbic acid content. Given that this is based on a single season trial, additional evaluation trials are required to validate the findings.

References

1. Aasfar A, Bargaz A, Yaakoubi K, Hilali A, Bennis I, Zeroual Y, *et al.* Nitrogen fixing Azotobacter species as potential soil biological enhancers for crop nutrition and yield stability. *Front Microbiol.* 2021;12:628379.
2. Anonymous. Area and production of horticulture crops, 2025-26 (First Advance Estimates). Department of Agriculture & Farmers' Empowerment; 2025.
3. Chanu NC, Sanasam J, Maisnam G, Thakur D. Effect of various organic manures on growth and yield of cabbage (*Brassica oleracea* L.). *BIO Web Conf.* 2025;178:01009. doi:10.1051/bioconf/202517801009.
4. Dakshayini G, Kammar SC, Rama A. Biodiversity and functional role of potassium solubilizing bacteria (KSB) in sustainable crop production: A review. *Current Innovation in Agriculture Science.* 2024;1(3):268-287.
5. Elnasikh M, Osman AG, Sherif AM. Impact of neem seed cake on soil microflora and some soil properties. *J Sci Technol.* 2011;12(1):144-150.
6. Gujar ML, Regar OP, Meghwal ML, Mishra D. Effect of organic manures and biofertilizers on growth and yield of cabbage (*Brassica oleracea* var. *capitata* L.) in humid climatic zone of Rajasthan, India. *Annu Res Rev Biol.* 2025;40(7):40-47.
7. Jaswal S, Kumar A, Sepehya S, Kochithara EJ, Jaswal K. Synergistic effect of nitrogen substitution through vermicompost on productivity and quality of cauliflower in low hills of Himachal Pradesh, India. *Int J Plant Soil Sci.* 2025;37(9):435-445.
8. Kumar S, Parmar K. Effect of biofertilizers and manures on growth, yield, and quality of cabbage (*Brassica oleracea*). *BIO Web Conf.* 2024;110:04003.
9. Kumar P, Kumar C, Meena RK, Kumar R, Rawat R. Efficacy of biofertilizers on growth and yield of sprouting broccoli (*Brassica oleracea* var. *italica* L. Plenck). *Plant Arch.* 2017;17:1647-1650.
10. Maggioni L, Bothmer R, Poulsen G, Branca F. Origin and domestication of cole crops (*Brassica oleracea* L.): Linguistic and literary considerations. *Econ Bot.* 2010;64(2):109-123.
11. Melim C, Lauro MR, Pires IM, Oliveira PJ, Cabral C. The role of glucosinolates from cruciferous vegetables (Brassicaceae) in gastrointestinal cancers: From prevention to therapeutics. *Pharmaceutics.* 2022;14(1):190.
12. Mohanta R, Nandi AK, Mishra SP, Pattnaik A, Hossain MM, Padhiary AK. Effects of integrated nutrient management on growth, yield, quality and economics of sprouting broccoli (*Brassica oleracea* var. *italica*) cv. Shayali. *J Pharmacogn Phytochem.* 2018;7(1):2229-2232.
13. Ojetayo AE, Olaniyi JO, Akanbi WB, Olabiyi TI. Effect of fertilizer types on nutritional quality of two cabbage varieties before and after storage. *J Appl Biosci.* 2011;48(5):3322-3330.
14. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. New Delhi: Indian Council of Agricultural Research; 1985. p. 87-89.
15. Prasad B, Sinha SK. Long-term effects of fertilizers and organic manures on crop yields, nutrient balance and soil properties in rice-wheat cropping system in Bihar. In: Long-term soil fertility experiments in rice-wheat cropping systems. Rice-Wheat Consortium Paper Series. 2000;6:105-119.
16. Rai N, Yadav GD. Advances on vegetable production. New Delhi: Kalyani Publications; 2005. p. 52.
17. Sher A, Mishra S. Effect of FYM, biochar and biofertilizers on growth and yield of kharif cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India. *The Pharma Innovation Journal.* 2023.
18. Singh BK, Delgado-Baquerizo M, Egidi E, Guirado E, Leach JE, Liu H, Trivedi P. Climate change impacts on plant pathogens, food security and paths forward. *Nature Reviews Microbiology.* 2023 Oct;21(10):640-56.