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Efficiency of Organic Manures on Growth and Yield of Hybrid Cabbage under Prayagraj Agro-climatic Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

The present investigation was conducted during 2025–2026 at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh. The experiment was laid out in a randomised block design with three replications using the hybrid cabbage variety 'Raizy'. It comprised thirteen treatments: T0 (control), T1 [FYM @ 10 t ha^{-1}], T2 [FYM @ 15 t ha^{-1}], T3 [FYM @ 20 t ha^{-1}], T4 [vermicompost @ 10 t ha^{-1}], T5 [vermicompost @ 15 t ha^{-1}], T6 [vermicompost @ 20 t ha^{-1}], T7 [poultry manure @ 10 t ha^{-1}], T8 [poultry manure @ 15 t ha^{-1}], T9 [poultry manure @ 20 t ha^{-1}], T10 [goat manure @ 10 t ha^{-1}], T11 [goat manure @ 15 t ha^{-1}] and T12 [goat manure @ 20 t ha^{-1}]. Significant differences were observed among treatments for growth, yield and economic traits. T8 recorded the maximum plant height (36.17 cm), number of leaves per plant (30.25), plant spread (48.30 cm), polar diameter (18.78 cm), equatorial diameter (28.82 cm), gross head

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weight (1529.50 g), net head weight (1200.71 g) and head yield per plot (4.06 kg), as well as the earliest horticultural maturity (72.79 days). It also recorded the highest gross return (Rs. 3,97,000 ha^{-1}), net return (Rs. 3,65,450 ha^{-1}) and benefit:cost ratio (5.36). The findings indicate that poultry manure @ 15 t ha^{-1} was the most effective organic nutrient source among the tested treatments for improving the growth, yield and profitability of hybrid cabbage under Prayagraj agro-climatic conditions.

Keywords: Hybrid cabbage; organic manures; poultry manure; farmyard manure; vermicompost; goat manure; growth; yield; benefit:cost ratio; Prayagraj agro-climatic conditions.

1. Introduction

Vegetables play an important role in human nutrition by supplying essential vitamins, minerals, carbohydrates, proteins and dietary fibre required for maintaining good health. Regular consumption of vegetables supports nutritional security and helps prevent various diseases. India is the second-largest producer of vegetables in the world after China and contributes significantly to global vegetable production. Among vegetable crops, cabbage (*Brassica oleracea* var. *capitata*) is one of the most important cole crops, belongs to the family Brassicaceae (Cruciferae) and has a chromosome number of 2n = 18. It is believed to have originated in Western Europe and the Mediterranean region from its wild ancestor *Brassica oleracea* var. *oleracea* through mutation, natural introgression and human selection (Rana et al., 2020). The crop is widely cultivated in temperate, subtropical and tropical regions because of its adaptability to diverse agro-climatic conditions.

Cabbage is grown throughout the country for its compact leafy head, which is consumed in both raw and cooked forms. It is widely used in salads, soups, pickles and processed products. Besides its culinary importance, cabbage has medicinal value and has traditionally been used in indigenous medicine for treating ailments such as cough, fever and skin disorders (Katyal & Chadha, 1985). Cabbage is highly nutritious and is considered an excellent source of vitamins and minerals. One hundred grams of edible portion contains vitamin A, vitamin C, calcium, phosphorus and potassium. It also contains sulphur-containing glucosides, such as sinigrin, which impart a characteristic flavour and possess anti-carcinogenic properties (Rai & Yadav, 2005; Kim et al., 2004).

Cabbage is a cool-season crop and grows best under cool and moist climatic conditions, with an optimum temperature range of 13–16°C. Fertile, well-drained soils rich in organic matter are considered ideal for its cultivation (Fageria et al., 2022). India is among the major cabbage-producing countries in the world, with a production of 9562 thousand metric tonnes from an area of 412 thousand hectares and an average productivity of 28.3 t ha^{-1} (NHB, 2025). Since cabbage is a heavy-feeding crop with high nutrient requirements, the maintenance of adequate soil fertility is essential for obtaining optimum growth, head development, yield and quality.

Continuous and indiscriminate use of chemical fertilisers has resulted in deterioration of soil fertility, nutrient imbalance, reduced microbial activity and environmental pollution. Therefore, the use of organic manures has gained considerable importance as an eco-friendly and sustainable approach for improving crop productivity and maintaining soil health (Zhang et al., 2024). Organic manures, such as farmyard manure, vermicompost, poultry manure and goat manure, not only supply essential nutrients but also improve soil physical, chemical and biological properties. Vermicompost-related soil processes are also linked with earthworm activity, which contributes to sustainable agricultural systems (Datta et al., 2016). Organic manures provide a slow and steady release of nutrients, improve nutrient-use efficiency and enhance soil moisture retention, thereby promoting better crop growth and productivity (Debrah et al., 2021). Recent cabbage studies have further shown that organic nutrient sources, including poultry manure and liquid organic manure, can improve growth- and yield-related traits; however, the response varies with manure type, crop environment and management practice (Bhattarai et al., 2023; Zhou et al., 2026). Recent studies have also demonstrated that the integrated use of organic nutrient sources significantly enhances the growth, yield and profitability of cabbage cultivation while reducing dependence on synthetic fertilisers (Daniel et al., 2023; Chanu et al., 2025). Organic-substrate nursery practices have also been evaluated in vegetable systems, including cabbage, indicating their relevance to sustainable vegetable production while requiring crop- and location-specific validation (Rahaman et al., 2026). Recent review evidence supports the role of organic management strategies in cabbage production while emphasising the need for suitable nutrient-source selection (Saba et al., 2025). Since the nutrient composition and release pattern of organic manures vary considerably, their evaluation is essential for identifying efficient and sustainable nutrient management practices. However, comparative information on the performance of farmyard manure, vermicompost, poultry manure and goat manure at different application rates for hybrid cabbage under Prayagraj agro-climatic conditions remains limited. Therefore, the present study was undertaken to evaluate the effects of different organic manures on the growth, yield, fertiliser-use efficiency and economics of hybrid cabbage.

2. Materials and Methods

The present investigation was conducted during 2025–2026 at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh. The experiment was laid out in a randomised block design with three replications and comprised thirteen treatments. The treatments were T0 (control), T1 [FYM @ 10 t ha^{-1}], T2 [FYM @ 15 t ha^{-1}], T3 [FYM @ 20 t ha^{-1}], T4 [vermicompost @ 10 t ha^{-1}], T5 [vermicompost @ 15 t ha^{-1}], T6 [vermicompost @ 20 t ha^{-1}], T7 [poultry manure @ 10 t ha^{-1}], T8 [poultry manure @ 15 t ha^{-1}], T9 [poultry manure @ 20 t ha^{-1}], T10 [goat manure @ 10 t ha^{-1}], T11 [goat manure @ 15 t ha^{-1}] and T12 [goat manure @ 20 t ha^{-1}]. The hybrid cabbage variety 'Raizy' was used as the planting material. Seeds were sown in protrays, and healthy seedlings aged 25–30 days were transplanted at a spacing of 60 cm × 30 cm. Observations were recorded at 20, 40 and 60 days after transplanting. The experimental plot size was 1.8 m × 0.9 m (1.62 m^2), with nine plants maintained at a spacing of 60 cm × 30 cm. Observations were recorded from selected plants in each plot, and the total experimental area comprised 241.58 m^2 (gross) and 197.36 m^2 (net).

The experimental site is situated in the subtropical region of the Indo-Gangetic plains at 25°24′42″ N latitude and 81°50′56″ E longitude, with an altitude of 98 m above mean sea level. The climate of Prayagraj is characterised by hot summers and cold winters. The maximum temperature during summer may rise above 47°C, while during winter it may fall as low as 3°C. The initial experimental soil was sandy loam in texture, with pH 6.36, EC 0.18 dS m^{-1} and organic carbon 0.60%. The available nitrogen, phosphorus and potassium contents were 214.32, 38.55 and 218.74 kg ha^{-1}, respectively. Observations on plant height, number of leaves, plant spread and days to horticultural maturity were recorded as growth parameters. Yield parameters included polar diameter, equatorial diameter, gross head weight, net head weight and head yield per plot. The data recorded during the investigation were subjected to analysis of variance (ANOVA) appropriate for a randomised block design. The significance of treatment effects was tested at the 5 per cent level of significance. Fertiliser-use efficiency (FUE) was calculated as the ratio of crop yield to the quantity of fertiliser applied. Gross income was computed by multiplying marketable yield by the prevailing market price. Net income was obtained by deducting the total cost of cultivation from gross income. The benefit:cost (B:C) ratio was calculated by dividing gross income by the total cost of cultivation.

3. Results and Discussion

Statistical data on plant height, number of leaves per plant, plant spread, days to horticultural maturity, polar diameter, equatorial diameter, gross head weight, net head weight, head yield per plot and the economics of hybrid cabbage are presented in Tables 1 and 2. Significant differences among treatments were observed for all the parameters studied.

Plant height increased progressively from 20 to 60 days after transplanting (DAP). At 20, 40 and 60 DAP, the maximum plant height was recorded in T8 (poultry manure @ 15 t ha^{-1}), with values of 20.48 cm, 31.24 cm and 36.17 cm, respectively, followed by T9 (poultry manure @ 20 t ha^{-1}), with values of 20.17 cm, 30.85 cm and 35.77 cm, respectively. The minimum plant height was observed in T0 (control), with values of 15.84 cm, 25.25 cm and 29.82 cm, respectively. The increase in plant height under poultry manure treatments may be attributed to the continuous supply of essential nutrients, improved soil physical properties and enhanced microbial activity. Similar findings were reported by Choudhary et al. (2024) and Chanu et al. (2025).

The number of leaves increased with crop growth and differed significantly among treatments. The maximum number of leaves at 20, 40 and 60 DAP was recorded in T8 (poultry manure @ 15 t ha^{-1}), with values of 11.48, 20.65 and 30.25, respectively, followed by T9, with values of 11.26, 20.24 and 29.88 leaves, respectively. The minimum number of leaves was recorded in T0 (control), with values of 8.61, 15.17 and 23.97 leaves, respectively. The higher number of leaves under poultry manure application may be due to increased nutrient availability, especially nitrogen, which promoted vigorous vegetative growth. Similar findings were reported by Debrah et al. (2021).

Table 1. Effect of different organic manures on growth parameters of hybrid cabbage

Treatments	Plant Height (cm)			No. of Leaves			Plant Spread (cm)			Days to Horticultural Maturity	Polar Diameter (cm)	Equatorial Diameter (cm)
	20 DAP	40 DAP	60 DAP	20 DAP	40 DAP	60 DAP	20 DAP	40 DAP	60 DAP			
T0 – Control	15.84	25.25	29.82	8.61	15.17	23.97	15.26	35.16	43.54	78.12	15.51	24.53
T1 –FYM @ 10 t/ha	17.70	27.76	32.21	9.51	16.36	25.50	16.31	36.31	44.41	75.40	16.18	25.47
T2 –FYM @ 15 t/ha	18.48	28.75	33.21	10.00	17.39	26.38	16.87	37.32	45.21	74.60	16.77	26.25
T3 –FYM @ 20 t/ha	18.18	28.24	32.75	9.84	17.89	27.03	17.41	37.88	45.74	74.87	16.64	25.95
T4 –Vermicompost @ 10 t/ha	18.87	29.26	33.71	10.26	18.69	27.81	17.80	38.51	46.24	74.19	17.40	26.97
T5 –Vermicompost @ 15 t/ha	19.57	30.14	34.62	10.77	19.58	28.68	18.30	39.19	47.07	73.58	17.76	27.65
T6 –Vermicompost @ 20 t/ha	19.29	29.74	34.13	10.49	19.18	28.27	18.13	38.80	46.67	73.89	17.49	27.24
T7 –Poultry Manure @ 10 t/ha	19.98	30.64	35.12	10.99	19.95	29.36	18.75	39.61	47.49	73.20	18.20	28.17
T8 –Poultry Manure @ 15 t/ha	20.48	31.24	36.17	11.48	20.65	30.25	19.34	40.23	48.30	72.79	18.78	28.82
T9 –Poultry Manure @ 20 t/ha	20.17	30.85	35.77	11.26	20.24	29.88	19.08	40.01	48.02	73.01	18.56	28.56
T10 –Goat Manure @ 10 t/ha	17.27	27.25	31.74	9.31	16.69	25.89	16.28	35.83	44.22	75.77	15.76	25.01
T11 –Goat Manure @ 15 t/ha	16.85	26.75	31.24	9.16	16.29	25.42	16.09	35.60	44.02	76.16	15.77	24.82
T12 –Goat Manure @ 20 t/ha	16.47	26.23	30.73	8.86	15.86	24.84	15.78	35.32	43.70	76.58	15.56	24.69
F-test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	S	S	S
S.Ed (±)	**0.03**	**0.04**	**0.03**	**0.106**	**0.043**	**0.034**	**0.100**	**0.054**	**0.047**	**0.080**	**0.125**	**0.066**
CD (P=0.05)	**0.05**	**0.07**	**0.06**	**0.219**	**0.089**	**0.070**	**0.207**	**0.111**	**0.097**	**0.167**	**0.259**	**0.137**

Table 2. Effect of different organic manures on yield parameters and economics of hybrid cabbage

Treatments	Gross Head Weight (g)	Net Head Weight (g)	Head Yield/Plot (kg)	Gross Return (Rs.)	Net Return (Rs.)	B:C Ratio
T0 – Control	1298.19	845.14	3.42	3,25,000	3,00,100	2.51
T1 –FYM @ 10 t/ha	1320.15	900.34	3.55	3,55,000	3,25,750	4.18
T2 –FYM @ 15 t/ha	1379.27	953.52	3.72	3,71,000	3,41,600	4.52
T3 –FYM @ 20 t/ha	1370.67	940.10	3.66	3,66,000	3,36,450	4.45
T4 –Vermicompost @ 10 t/ha	1429.03	1022.90	3.76	3,75,000	3,45,950	4.74
T5 –Vermicompost @ 15 t/ha	1456.28	1077.92	3.83	3,83,000	3,52,600	4.98
T6 –Vermicompost @ 20 t/ha	1443.36	1060.09	3.80	3,74,000	3,43,450	4.83
T7 –Poultry Manure @ 10 t/ha	1489.89	1145.30	3.93	3,89,000	3,58,300	5.02
T8 –Poultry Manure @ 15 t/ha	1529.50	1200.71	4.06	3,97,000	3,65,450	5.36
T9 –Poultry Manure @ 20 t/ha	1514.25	1180.53	3.97	3,93,000	3,61,300	5.18
T10 –Goat Manure @ 10 t/ha	1308.12	890.14	3.51	3,51,000	3,19,650	4.09
T11 –Goat Manure @ 15 t/ha	1303.78	880.32	3.46	3,47,000	3,14,300	3.97
T12 –Goat Manure @ 20 t/ha	1300.34	870.47	3.44	3,44,000	3,11,150	3.91
F-test	**S**	**S**	**S**	-		
S.Ed (±)	**0.244**	**0.502**	**0.075**	-		
CD (P=0.05)	**0.506**	**1.042**	**0.155**	-		

Significant variation in plant spread was observed among treatments. The maximum plant spread at 20, 40 and 60 DAP was recorded in T8 (poultry manure @ 15 t ha^{-1}), with values of 19.34 cm, 40.23 cm and 48.30 cm, respectively, followed by T9, with values of 19.08 cm, 40.01 cm and 48.02 cm, respectively. The minimum plant spread was observed in T0 (control), with values of 15.26 cm, 35.16 cm and 43.54 cm, respectively. The increased plant spread under poultry manure treatments may be due to improved nutrient uptake and better root growth, resulting in enhanced vegetative development. Similar results were reported by Daniel et al. (2023).

The number of days taken for horticultural maturity was significantly influenced by the treatments. The minimum days to maturity (72.79 days) were recorded in T8 (poultry manure @ 15 t ha^{-1}), followed by T9 (73.01 days), whereas the maximum days to maturity (78.12 days) were recorded in T0 (control). The early maturity observed under poultry manure treatments may be attributed to balanced nutrient supply and improved physiological activity, leading to faster crop growth and development.

The maximum polar diameter (18.78 cm) was recorded in T8 (poultry manure @ 15 t ha^{-1}), followed by T9 (18.56 cm) and T7 (18.20 cm), whereas the minimum polar diameter (15.51 cm) was observed in T0 (control). Increased head size under poultry manure application might be due to enhanced photosynthetic efficiency and greater accumulation of assimilates in the developing heads. Similar findings were reported by Chatterjee et al. (2012).

The data revealed significant differences in equatorial diameter among treatments. The maximum equatorial diameter (28.82 cm) was recorded in T8 (poultry manure @ 15 t ha^{-1}), followed by T9 (28.56 cm) and T7 (28.17 cm), whereas the minimum equatorial diameter (24.53 cm) was recorded in T0 (control). The increased equatorial diameter under poultry manure application may be attributed to adequate nutrient availability and improved soil fertility status.

The maximum gross head weight (1529.50 g) was recorded in T8 (poultry manure @ 15 t ha^{-1}), followed by T9 (1514.25 g) and T7 (1489.89 g), whereas the minimum gross head weight (1298.19 g) was observed in T0 (control). The increased gross head weight might be due to improved vegetative growth and efficient translocation of photosynthates to the developing heads. Similar results were reported by Zhang et al. (2024).

Significant differences were observed in net head weight among treatments. The maximum net head weight (1200.71 g) was recorded in T8 (poultry manure @ 15 t ha^{-1}), followed by T9 (1180.53 g) and T7 (1145.30 g), whereas the minimum net head weight (845.14 g) was observed in T0 (control). The increased net head weight may be attributed to better nutrient utilisation and enhanced head development under poultry manure application. The highest head yield per plot (4.06 kg) was recorded in T8 (poultry manure @ 15 t ha^{-1}), followed by T9 (3.97 kg) and T7 (3.93 kg), whereas the lowest head yield per plot (3.42 kg) was recorded in T0 (control). Increased yield under poultry manure treatments may be due to improved nutrient availability, enhanced microbial activity and better plant growth. Similar findings were reported by Chanu et al. (2025).

The total cost of cultivation for this experiment was Rs. 27,900. Economic analysis indicated that T8 (poultry manure @ 15 t ha^{-1}) recorded the highest gross return (Rs. 3,97,000 ha^{-1}), net return (Rs. 3,65,450 ha^{-1}) and benefit:cost ratio (5.36), while the minimum economic returns were observed in T0 (control). The higher profitability under poultry manure application was mainly due to the higher marketable yield of cabbage heads.

4. Conclusion

The study showed that organic manure treatments significantly influenced the growth, yield and economic performance of hybrid cabbage under Prayagraj agro-climatic conditions. Among the treatments evaluated, poultry manure @ 15 t ha^{-1} gave the best performance for most recorded parameters. This treatment produced the tallest plants, the highest number of leaves, the maximum plant spread and the earliest horticultural maturity. It also recorded superior head-development traits, including the maximum polar diameter, equatorial diameter, gross head weight, net head weight and head yield per plot. Economic analysis showed that poultry manure @ 15 t ha^{-1} produced the highest gross return, net return and benefit:cost ratio among the tested treatments. On the basis of these findings, poultry manure at this rate may be considered a suitable organic nutrient source for improving hybrid cabbage productivity and profitability in the study location. However, the recommendation should be interpreted within the limits of the experimental season, cultivar, soil condition and management practices used in the study.

5. Limitations

This study was conducted during one Rabi season at a single location using one hybrid cabbage variety. The nutrient composition of the manures and residual soil effects were not fully reported. Yield was mainly presented on a plot basis, while hectare-level yield was not clearly shown in the tables. Economic analysis did not include a detailed cost breakdown. Future studies should include multi-season validation, soil and manure analysis, full cost accounting and testing under different agro-climatic conditions.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation, and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement, reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgment of the author(s). All AI-assisted outputs, including content, references, and interpretations, were carefully reviewed, revised, verified, and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Bhattarai, S., Bhatta, S., Shriswastav, C. P., & Subedi, J. (2023). Effect of organic source of nutrients on soil physico-chemical properties, growth and yield of cabbage (*Brassica oleracea* var. *capitata*). *Asian Journal of Soil Science and Plant Nutrition, 9*(1), 45–55. https://doi.org/10.9734/ajsspn/2023/v9i1171

Chanu, N. C., Sanasam, J., Maisnam, G., & Thakur, D. (2025). Effect of various organic on growth and yield of cabbage (*Brassica oleracea* L.). *BIO Web of Conferences, 178*, Article 01009. EDP Sciences. https://doi.org/10.1051/bioconf/202517801009

Chatterjee, R., Jana, J. C., & Paul, P. K. (2012). Enhancement of head yield and quality of cabbage (*Brassica oleracea*) by combining different sources of nutrients. *The Indian Journal of Agricultural Sciences, 82*(4), 323–327. https://doi.org/10.56093/ijas.v82i4.16641

Choudhary, M., Garg, K., Reddy, M. B., Meena, B. L., Mondal, B., Tuti, M. D., Kumar, S., Awasthi, M. K., Giri, B. S., Kumar, S., & Rajawat, M. V. S. (2024). Unlocking growth potential: Synergistic potassium fertilization for enhanced yield, nutrient uptake, and energy fractions in Chinese cabbage. *Heliyon, 10*(7), e28765. https://doi.org/10.1016/j.heliyon.2024.e28765

Daniel, K. A., Muindi, E. M., & Muti, S. M. (2023). Cabbage (*Brassica oleracea*) production in Kenya: A review of its economic importance, ecological requirement and production constraints. *International Journal of Plant & Soil Science, 35*(18), 245–254. https://doi.org/10.9734/ijpss/2023/v35i183287

Datta, S., Singh, J., Singh, S., & Singh, J. (2016). Earthworms, pesticides and sustainable agriculture: A review. *Environmental Science and Pollution Research, 23*(9), 8227–8243. https://doi.org/10.1007/s11356-016-6375-0

Debrah, P. Y., Afriyie-Debrah, C., Nuhu, F., Ribeiro, P. F., & Obeng, E. A. (2021). Response of cabbage (*Brassica oleracea* var. *capitata* L.) to organic and inorganic fertilizer. *Journal of Experimental Agriculture International, 43*(2), 105–114. https://doi.org/10.9734/jeai/2021/v43i230651

Fageria, M. S., Choudhary, B. R., & Dhaka, R. S. (2022). *Vegetable crops production technology* (Vol. 2). Kalyani Publishers.

Katyal, S. L., & Chadha, K. L. (1985). *Vegetable growing in India* (2nd ed.). Oxford & IBH Publishing Co.

Kim, D. O., Padilla-Zakour, O. I., & Griffiths, P. D. (2004). Flavonoids and antioxidant capacity of various cabbage genotypes at juvenile stage. *Journal of Food Science, 69*(9), C685–C689. https://doi.org/10.1111/j.1365-2621.2004.tb09916.x

National Horticulture Board. (2025). *Area and production estimates for horticulture crops* [Interactive query-based module]. https://nhb.gov.in/OnlineClient/rptProduction.aspx

Rahaman, M. A., Rahman, M. M., Hasan, S. M. R., Nawmi, U. R., Hasan, M. M., Islam, M. O., Sanzid, F., Islam, A. M. R., Sorwar, S. S. R. M. M. A., & Ahmmed, A. N. F. (2026). Evaluation of sustainable agroecological practices based on the application of organic substrates (cocodust) in vegetable seedlings at the nursery level in the producing areas of Bangladesh. *Asian Journal of Agriculture and Allied Sciences, 9*(1), 1–13. https://doi.org/10.56557/ajaas/2026/v9i178

Rai, N., & Yadav, D. S. (2005). *Advances in vegetable production*. Researchco Book Centre.

Rana, S., Thakur, K. S., Bhardwaj, R. K., Kansal, S., & Sharma, R. (2020). Effect of biofertilizers and micronutrients on growth and quality attributes of cabbage (*Brassica oleracea* var. *capitata* L.). *International Journal of Chemical Studies, 8*(1), 1656–1660. https://doi.org/10.22271/chemi.2020.v8.i1x.8501

Saba, M., Abo-Elyousr, K. A. M., & Al-Solaimani, S. G. (2025). Organic production of cabbage (*Brassica oleracea* L.) for agricultural sustainability and healthy nutrition: An overview. *Journal of Applied and Natural Science, 17*(1), 253–264. https://doi.org/10.31018/jans.v17i1.6335

Zhang, Y., Zhang, J., Zhang, J., Li, H., Li, C., & Wang, X. (2024). Effects of the application of organic fertilizers on the yield, quality, and soil properties of open-field Chinese cabbage (*Brassica rapa* spp. *pekinensis*) in China: A meta-analysis. *Agronomy, 14*(11), 2555. https://doi.org/10.3390/agronomy14112555

Zhou, M., Musabayana, Z., Tembo, L., Mathema, N., & Zanamwe, P. (2026). Growth and yield response of cabbage (*Brassica oleracea var. capitata* 'Star 3011') to different liquid organic manure types and their combinations. Cogent Food & Agriculture, 12(1), Article 2666927. https://doi.org/10.1080/23311932.2026.2666927

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