**Effect of Organic Manures and Biofertilizers on Growth and Yield of Cabbage in Humid Climatic Zone Rajasthan, India**

**ABSTRACT**

A field experiment was conducted during the Rabi season of 2024–25 at the Research Farm of Mewar University, Chittorgarh (Rajasthan) to evaluate the influence of organic manures and biofertilizers on the growth and yield of cabbage (Brassica oleracea var. capitata L.) under humid climatic conditions. The study employed a factorial randomized block design (FRBD) with 16 treatment combinations comprising four levels of organic manures control (no organic manure), farmyard manure (FYM) @ 12 t/ha, vermicompost @ 7.5 t/ha, and poultry manure @ 5 t/ha and four levels of biofertilizers control, PSB, VAM, and PSB + VAM replicated three times. Results revealed that among the organic manures, poultry manure @ 5 t/ha (O3) significantly enhanced growth parameters such as plant height (21.95 cm at 30 DAT and 29.97 cm at 60 DAT), stalk length (7.66 cm), and the number of non-wrapper leaves (15.96). Similarly, the combined application of PSB + VAM (B3) among biofertilizers showed superior performance with maximum plant height (19.93 and 28.57 cm), stalk length (7.10 cm), and number of non-wrapper leaves (15.03). In terms of yield parameters, the treatment combination O3B3 (Poultry manure @ 5 t/ha + PSB + VAM) resulted in the highest head diameter (18.62 cm), head size (17.19 cm), net head weight (853.17 g), and head yield (301.35 q/ha), significantly outperforming all other treatments. The findings suggest that the integration of poultry manure with PSB and VAM not only improves vegetative growth but also enhances yield potential of cabbage under agro-climatic conditions of Rajasthan. Therefore, the combination of O3B3 can be recommended as a sustainable and effective nutrient management practice for cabbage cultivation.

***Keywords:*** *Cabbage, organic manures, biofertilizers, PSB, VAM, growth, yield, poultry manure*

1. **INTRODUCTION**

Cabbage (*Brassica oleracea* var. capitata L.) is a widely grown and consumed leafy vegetable belonging to the Cruciferae or Brassicaceae family, with a chromosome number of 2n = 2x = 18. It is a cool-season crop that thrives well in temperate, subtropical, and tropical regions, making it suitable for year-round cultivation in many parts of the world. In India, cabbage is extensively grown in states like Odisha, West Bengal, Karnataka, Maharashtra, Gujarat, and Punjab, contributing significantly to the country’s vegetable production and economy. Cabbage is valued for its high nutritive content, including vitamins A and C, minerals, and antioxidants, which make it an essential component of a balanced diet (Wang et al., 2022). In recent years, there has been increasing emphasis on sustainable agricultural practices due to the adverse effects of continuous and imbalanced use of chemical fertilizers. These chemical inputs, although capable of providing quick and visible benefits to crop growth and yield, have led to soil degradation, decreased microbial activity, environmental pollution, and health-related issues. To counteract these problems, the use of organic manures and biofertilizers has emerged as an eco-friendly and effective alternative.

These natural inputs not only provide essential nutrients to crops but also improve soil structure, enhance microbial activity, and increase nutrient use efficiency. Organic manures, derived from plant and animal residues, are known for their ability to enrich the soil with organic matter and essential nutrients. Commonly used organic manures include farmyard manure (FYM), vermicompost, and poultry manure (Ali et al., 2020). FYM is a traditional soil amendment that supplies macro and micronutrients while also enhancing the physical, chemical, and biological properties of the soil. Vermicompost, produced through the decomposition of organic waste by earthworms, improves soil porosity, aeration, and water-holding capacity, and contributes to sustained nutrient release. Poultry manure, rich in nitrogen, phosphorus, and potassium, is another highly effective organic input that rapidly decomposes and releases nutrients essential for plant growth (Singh et al., 2020). Biofertilizers, on the other hand, are preparations containing living or latent cells of efficient strains of microorganisms that help in nutrient mobilization and plant growth promotion. They function through several mechanisms including nitrogen fixation, phosphorus solubilization, and production of plant growth-promoting substances.

Phosphate Solubilizing Bacteria (PSB) play a crucial role in converting insoluble forms of phosphorus into forms available to plants, thereby enhancing phosphorus uptake (Rawat et al., 2021). Vesicular Arbuscular Mycorrhizae (VAM), a type of endophytic fungi, establish symbiotic relationships with plant roots and enhance the absorption of water and nutrients, particularly phosphorus and micronutrients like zinc and copper. The combined use of PSB and VAM is believed to offer synergistic benefits in terms of nutrient availability and plant performance (Ansari et al., 2016). The integration of organic manures and biofertilizers has been reported to enhance soil fertility and crop productivity sustainably. These inputs not only reduce the dependence on chemical fertilizers but also contribute to the restoration of degraded soils and the promotion of soil biodiversity. In cabbage cultivation, the appropriate use of organic and biofertilizer combinations can significantly influence vegetative growth, head formation, and yield attributes. However, the effectiveness of these inputs varies with their type, quantity, and the agro-climatic conditions in which they are applied. The humid climatic zone of Rajasthan, characterized by moderate rainfall and varying temperatures during the Rabi season, provides a suitable environment for cabbage cultivation. However, nutrient deficiencies and soil fertility issues often constrain productivity in this region. Therefore, there is a need to evaluate and recommend integrated nutrient management strategies that combine organic and biological inputs tailored to local conditions.

This study was conducted with the objective of evaluating the impact of different organic manures and biofertilizers, individually and in combination, on the growth and yield of cabbage. The aim was to identify the most effective treatment that can enhance vegetative development and maximize yield under the specific environmental and soil conditions of the humid climatic zone of Rajasthan. Through this research, efforts were made to generate scientific evidence supporting the promotion of organic and sustainable agricultural practices in vegetable production systems. The findings of the study are expected to serve as a guideline for farmers and agricultural practitioners in adopting integrated nutrient management practices for cabbage and similar vegetable crops, ensuring higher productivity and improved soil health in the long term.

1. **MATERIALS AND METHODS**

**2.1 Experimental Site and Duration**

A field experiment was carried out during the Rabi season of 2024–25 at the Research Farm, Department of Agriculture (Horticulture), Faculty of Agriculture and Veterinary Sciences, Mewar University, located in Gangrar, Chittorgarh, Rajasthan. The site falls under the humid agro-climatic zone of southern Rajasthan, which is characterized by moderate winter temperatures and low relative humidityfavorable conditions for the successful cultivation of cole crops, particularly cabbage (*Brassica oleracea* var. capitata L.).

**2.2 Soil Sampling and Pre-Sowing Analysis**

Before initiating field activities, composite soil samples were collected from the experimental plot at a depth of 0–15 cm using a randomized zig-zag sampling approach. These samples were air-dried, sieved, and analyzed for initial physicochemical properties using standard laboratory protocols. The soil was found to be sandy loam in texture, providing good drainage and aeration for root development. The pH was slightly alkaline (7.6), and salinity levels were moderate, suggesting some limitations in nutrient uptake. The organic carbon content was low (0.16%), indicating limited microbial biomass and soil biological activity. The soil was also deficient in essential macronutrients, with available nitrogen at 176 kg/ha and phosphorus at 20.2 kg/ha, necessitating nutrient supplementation. Potassium was present in medium amounts (320 kg/ha), while the micronutrients zinc (0.48 ppm) and iron (1.2 ppm) were found to be deficient.

#### **2.3 Experimental Design and Treatment Structure**

The experiment was laid out in a **Factorial Randomized Block Design (FRBD)** to evaluate the individual and interaction effects of organic and biological nutrient sources on cabbage growth, yield, and nutrient dynamics. The study comprised **two factors**, each with **four levels**, and **three replications**, resulting in a total of **16 treatment combinations** and **48 experimental plots**.

* **Factor I: Organic Manures**
	+ O₀: Control (no organic manure)
	+ O₁: Farmyard manure (FYM) @ 12 t/ha
	+ O₂: Vermicompost @ 7.5 t/ha
	+ O₃: Poultry manure @ 5 t/ha
* **Factor II: Biofertilizers**
	+ B₀: Control (no biofertilizer)
	+ B₁: Phosphate Solubilizing Bacteria (PSB)
	+ B₂: Vesicular Arbuscular Mycorrhizae (VAM)
	+ B₃: Combined application of PSB + VAM

#### **2.4 Treatment Application**

Organic manures (FYM, vermicompost, poultry manure) were well-decomposed and applied uniformly across the respective plots **15 days before transplanting**, followed by thorough incorporation into the soil to allow for microbial activation and nutrient mineralization. Biofertilizer treatments were administered either through **seedling root dipping** (for PSB) or **soil application at the root zone** (for VAM and combined inoculations), as per standard recommendations and formulation compatibility.

#### **2.5 Crop Establishment and Management**

Certified seeds of a high-yielding cabbage variety were sown in a nursery bed, and uniform, healthy seedlings (4–5 weeks old) were transplanted at a spacing of 45 × 45 cm in plots of appropriate dimensions. Standard cultural practices for cabbage cultivation—such as irrigation, weeding, earthing up, and pest/disease management—were uniformly followed across all treatments to minimize non-treatment variability.

#### **2.6 Data Collection and Observations**

Observations were recorded on various **growth parameters (plant height, leaf number, leaf area), yield attributes (head weight, head diameter, marketable yield),** and **nutrient uptake**. Soil and plant samples were collected at harvest to analyze nutrient content and uptake of N, P, K, Zn, and Fe using appropriate analytical techniques.

#### **2.7 Statistical Analysis**

The recorded data were subjected to **analysis of variance (ANOVA)** as per the FRBD using statistical software (e.g., OPSTAT or SPSS). Treatment means were compared using **Critical Difference (CD) at 5% significance level** to determine statistical differences among treatments. Interaction effects between organic manures and biofertilizers were also assessed to identify synergistic or antagonistic responses.

1. **RESULTS AND DISCUSSION**

**3.1 Growth parameters**

Effect of organic manures and biofertilizers on growth parameters of cabbage tabulated in Table 1 and Fig. 1. The perusal of data further revealed that plant height at 30 and 60 days after transplanting was also significantly affected by organic manures. The maximum plant height at 30 and 60 DAT was recorded with treatment O3-Poultry manure @ 5 t/ha (21.95 and 29.97 cm), closely followed by O2-Vermicompost @ 7.5 t/ha (20.22 and 28.67 cm). The minimum plant height was recorded with O0-Control (No application of organic manure) (16.30 and 26.12 cm). The perusal of data further revealed that plant height at 30 and 60 days after transplanting was also significantly affected by biofertilizers. The maximum plant height at 30 and 60 DAT was recorded with treatment B3-PSB + VAM (19.93 and 28.57 cm), it was found at par with B2-VAM (19.52 and 28.27 cm) and B1-PSB (19.18 and 27.95 cm). The minimum plant height was recorded with B0-Control (No application of biofertilizer) (18.31 and 27.51 cm), respectively. The perusal of data further revealed that stalk length at 60 days after transplanting was also significantly affected by organic manures. The maximum stalk length was recorded with treatment O3-Poultry manure @ 5 t/ha (7.66 cm), closely followed by O2-Vermicompost @ 7.5 t/ha (7.14 cm). The minimum stalk length was recorded with O0-Control (No application of organic manure) (6.06 cm). The perusal of data further revealed that stalk length at 60 days after transplanting was also significantly affected by biofertilizers. The maximum stalk length was recorded with treatment B3-PSB + VAM (7.10 cm), it was found at par B2-VAM and B1-PSB (6.96 and 6.79 cm). The minimum stalk length was recorded with B0-Control (No application of biofertilizer) (6.66 cm), respectively. The perusal of data further revealed that number of non-wrappers leaves per plant at 60 days after transplanting was also significantly affected by organic manures. The maximum number of non-wrappers leaves per plant was recorded with treatment O3-Poultry manure @ 5 t/ha (15.96), closely followed by O2-Vermicompost @ 7.5 t/ha (15.13). The minimum number of non-wrappers leaves per plant was recorded with O0-Control (No application of organic manure) (6.06). The perusal of data further revealed that number of non-wrappers leaves per plant at 60 days after transplanting was also significantly affected by biofertilizers. The maximum number of non-wrappers leaves per plant was recorded with treatment B3-PSB + VAM (15.03), it was found at par B2-VAM and B1-PSB (14.80 and 14.58). The minimum number of non-wrappers leaves per plant was recorded with B0-Control (No application of biofertilizer) (14.12), respectively. Similar results also reported by Meena *et al.* (2017), Barman *et al*. (2017), Neupane *et al.* (2020), Dlamini *et al*. (2020), Ujjwal *et al.* (2022), Prathyusha *et al.* (2023), Ghimirey *et al.* (2024) and Aryal *et al*. (2024).

**Table 1: Effect of organic manures and biofertilizers on growth parameters of cabbage**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Plant height (cm)** | **Stalk length (cm) at 60 DAT** | **Number of non-wrappers leaves per plant at 60 DAT** |
| **30 DAT** | **60 DAT** |  |  |
| **Factor-I (Organic manures)** |  |  |  |
| O0-Control (No application of organic manure) | 16.30 | 26.12 | 6.06 | 13.12 |
| O1-FYM @ 12 t/ha | 18.46 | 27.54 | 6.64 | 14.32 |
| O2-Vermicompost @ 7.5 t/ha | 20.22 | 28.67 | 7.14 | 15.13 |
| O3-Poultry manure @ 5 t/ha | 21.95 | 29.97 | 7.66 | 15.96 |
| S. Em. ± | 0.38 | 0.26 | 0.11 | 0.19 |
| CD% | 1.10 | 0.74 | 0.33 | 0.56 |
| **Factor-II (Biofertilizer)** |  |  |
| B0-Control (No application of biofertilizer) | 18.31 | 27.51 | 6.66 | 14.12 |
| B1-PSB  | 19.18 | 27.95 | 6.79 | 14.58 |
| B2-VAM | 19.52 | 28.27 | 6.96 | 14.80 |
| B3-PSB + VAM | 19.93 | 28.57 | 7.10 | 15.03 |
| S. Em. ± | 0.38 | 0.26 | 0.11 | 0.19 |
| CD% | 1.10 | 0.74 | 0.33 | 0.56 |

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**Fig. 1 Graph showing Effect of organic manures and biofertilizers on growth parameters of cabbage**

**3.2 Yield parameters**

The perusal of data further revealed that head diameter was also significantly affected by organic manures. Effect of organic manures and biofertilizers on yield parameters of cabbage tabulated in Table 2. The maximum head diameter was recorded with treatment O3-Poultry manure @ 5 t/ha (18.62 cm), closely followed by O2-Vermicompost @ 7.5 t/ha (17.16 cm). The minimum head diameter was recorded with O0-Control (No application of organic manure) (14.70 cm). The perusal of data further revealed that head diameter was also significantly affected by biofertilizers. The maximum head diameter was recorded with treatment B3-PSB + VAM (17.17 cm), it was found at par B2-VAM and B1-PSB (16.90 and 16.57 cm). The minimum head diameter was recorded with B0-Control (No application of biofertilizer) (15.98 cm), respectively. The perusal of data further revealed that head size was also significantly affected by organic manures. The maximum head size was recorded with treatment O3-Poultry manure @ 5 t/ha (17.19 cm), closely followed by O2-Vermicompost @ 7.5 t/ha (15.80 cm). The minimum head size was recorded with O0-Control (No application of organic manure) (13.29 cm). The perusal of data further revealed that head size was also significantly affected by biofertilizers. The maximum head size was recorded with treatment B3-PSB + VAM (15.74 cm), it was found at par B2-VAM and B1-PSB (15.49 and 15.15 cm). The minimum head size was recorded with B0-Control (No application of biofertilizer) (14.62 cm), respectively. The perusal of data further revealed that net head weight was also significantly affected by organic manures. The maximum net head weight was recorded with treatment O3-Poultry manure @ 5 t/ha (853.17 g), closely followed by O2-Vermicompost @ 7.5 t/ha (786.25 g). The minimum net head weight was recorded with O0-Control (No application of organic manure) (651.25 g). The perusal of data further revealed that net head weight was also significantly affected by biofertilizers. The maximum net head weight was recorded with treatment B3-PSB + VAM (776.25 g), it was found at par B2-VAM and B1-PSB (759.50 and 745.42 g). The minimum net head weight was recorded with B0-Control (No application of biofertilizer) (725 g), respectively. The perusal of data further revealed that head yield was also significantly affected by organic manures. The maximum head yield was recorded with treatment O3-Poultry manure @ 5 t/ha (301.35 q/ha), closely followed by O2-Vermicompost @ 7.5 t/ha (274.50 q/ha). The minimum head yield was recorded with O0-Control (No application of organic manure) (220.50 q/ha). The perusal of data further revealed that head yield was also significantly affected by biofertilizers. The maximum head yield was recorded with treatment B3-PSB + VAM (270.70 q/ha), it was found at par B2-VAM (263.55 q/ha). The minimum head yield was recorded with B0-Control (No application of biofertilizer) (250 q/ha), respectively. Similar findings also supported by Atal *et al*. (2019), Palia *et al.* (2021), Thakur *et al.* (2023), Naznin *et al*. (2024), Mukhi *et al.* (2024), Chaudhary *et al.* (2024) and Hasan *et al.* (2024).

**Table 2: Effect of organic manures and biofertilizers on yield parameters of cabbage**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Head diameter (cm)** | **Head size (cm)** | **Net head weight (g)** | **Head yield (q/ha)** |
| **Factor-I (Organic manures)** |
| O0-Control (No application of organic manure) | 14.70 | 13.29 | 651.25 | 220.50 |
| O1-FYM @ 12 t/ha | 16.15 | 14.72 | 716.00 | 246.40 |
| O2-Vermicompost @ 7.5 t/ha | 17.16 | 15.80 | 786.25 | 274.50 |
| O3-Poultry manure @ 5 t/ha | 18.62 | 17.19 | 853.17 | 301.35 |
| **S. Em. ±** | **0.25** | **0.22** | **11.11** | **3.98** |
| **CD%** | **0.73** | **0.65** | **32.08** | **11.50** |
| **Factor-II (Biofertilizer)** |
| B0-Control (No application of biofertilizer) | 15.98 | 14.62 | 725.00 | 250.00 |
| B1-PSB  | 16.57 | 15.15 | 745.42 | 258.50 |
| B2-VAM | 16.90 | 15.49 | 759.50 | 263.55 |
| B3-PSB + VAM | 17.17 | 15.74 | 776.75 | 270.70 |
| **S. Em. ±** | **0.25** | **0.22** | **11.11** | **3.98** |
| **CD%** | **0.73** | **0.65** | **32.08** | **11.50** |

1. **Conclusion**

The present study demonstrated the significant impact of integrated nutrient management using organic manures and biofertilizers on the growth and yield performance of cabbage (*Brassica oleracea* var. capitata L.) under the humid agro-climatic conditions of southern Rajasthan. Among the various organic inputs, poultry manure @ 5 t/ha (O₃) was most effective in enhancing vegetative traits such as plant height, stalk length, and the number of non-wrapper leaves, indicating improved nutrient availability and soil health. Likewise, among the biofertilizer treatments, the combined application of phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhizae (VAM) (B₃) showed superior results across all measured growth parameters, reflecting synergistic effects on nutrient uptake and root development. The most notable outcomes were observed under the integrated treatment O₃B₃ (Poultry manure + PSB + VAM), which recorded significantly higher values for head diameter, head size, net head weight, and overall yield (301.35 q/ha), outperforming all other treatment combinations. This highlights the potential of combining nutrient-rich organic amendments with efficient microbial inoculants to enhance crop productivity in a sustainable manner. Based on the findings, it can be concluded that the O₃B₃ combination is a highly effective and eco-friendly strategy for improving both vegetative growth and marketable yield of cabbage. Its adoption in cabbage cultivation can contribute to reduced reliance on chemical fertilizers, improved soil fertility, and enhanced farm profitability under similar agro-ecological conditions.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, manuscript.

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