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Evaluation of organic nutrient combinations on vegetative growth of red cabbage under semi controlled conditions

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Abstract

A study was conducted to evaluate the effect of different organic nutrient combinations on the growth parameters of red cabbage under naturally ventilated polyhouse conditions in rabi season of 2025- 2026. The experiment included treatments comprising farmyard manure (FYM), vermicompost, neem cake, lignite and microbial consortium applied in various combinations. Observations on growth parameters such as plant height, number of leaves, leaf length, leaf width and plant spread were recorded at 30, 45 and 60 days after transplanting (DAT). The results revealed significant differences among treatments, indicating the positive influence of integrated organic nutrient management on vegetative growth. Among all treatments, T₆ (FYM 5 t ha⁻¹ + Vermicompost 2 t ha⁻¹ + Neem cake 1 t ha⁻¹ + Lignite 2 t ha⁻¹ + Microbial consortium 2 L ha⁻¹) consistently recorded superior performance in all growth parameters.

Keywords: Red jewel, organic production, FYM, vermicompost, neem cake, semi controlled conditions

1. Introduction

Red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) is an important Cole crop belonging to the family Brassicaceae, cultivated for its compact and colourful heads. It is a cool-season vegetable that grows best under mild temperature conditions and is widely cultivated in temperate as well as subtropical regions during the winter season. The crop has gained commercial importance due to its attractive appearance, good shelf life, and increasing demand in fresh markets, salads, and processed products. From a nutritional point of view, red cabbage is considered highly beneficial due to its rich content of vitamins A, C and K, along with minerals such as potassium, calcium and iron. It is also a good source of dietary fiber and bioactive compounds, particularly anthocyanins, which are responsible for its characteristic colour and antioxidant properties. These compounds are known to support human health by reducing oxidative damage and enhancing immunity. Because of its nutritional and therapeutic value, red cabbage is increasingly included in health-conscious diets.

Organic production plays a vital role in sustainable agriculture by improving soil health, maintaining ecological balance and reducing dependence on synthetic fertilizers. The use of organic inputs such as farmyard manure (FYM), vermicompost, neem cake, lignite and microbial consortium enhance soil structure, increases organic carbon content and promotes beneficial microbial activity (Sengupta, S., 2024) [6]. FYM improves soil aeration and water-holding capacity, while vermicompost supplies readily available nutrients and growth-promoting substances. Neem cake acts as both a nutrient source and a natural pest deterrent, contributing to healthier crop growth. Lignite supports microbial viability and improves soil fertility, whereas microbial consortiums facilitate nutrient availability through biological processes like nitrogen fixation and phosphorus solubilization. Together, these inputs ensure balanced nutrient supply and long-term soil productivity.

These combinations of organic manures, when applied under naturally ventilated polyhouse conditions, have been found to support better growth parameters compared to open field conditions. The controlled microclimate inside the polyhouse, including regulated temperature,

humidity and airflow, enhances nutrient use efficiency and reduces environmental stress on plants. As a result, crops exhibit improved growth characteristics such as increased plant height, higher number of leaves, larger leaf size, wider plant spread and better root development. In contrast, open field conditions are more prone to fluctuations in weather, which can limit nutrient availability and plant growth. Therefore, the integration of organic manures under naturally ventilated conditions provides a

more favorable environment for achieving superior growth and overall crop performance.

2. Materials and Methods

Research experiment was carried out in the School of Agricultural Sciences, Malla Reddy University, Hyderabad in 2025- 2026. The methodology followed and the materials used in the present study are detailed below.

Table- 1: Treatment details

Treatment	Combinations	Concentration/ha
T ₁	FYM + Lignite + MC	20t+ 2t + 2L
T ₂	Vermicompost + Lignite + MC	2t + 2t + 2L
T ₃	Neem cake + Lignite + MC	1t + 2t + 2L
T ₄	FYM + Vermicompost + Lignite + MC	10t + 2t + 2t + 2L
T ₅	Vermicompost + Neem cake + Lignite + MC	2t + 1t + 2t + 2L
T ₆	FYM + Vermicompost + Neem cake + Lignite + MC	5t + 2t + 1t + 2t + 2L
T ₇	Absolute Control (no organics)	-

2.2 Experimental Design

The experiment was laid out using a Randomized Block Design (RBD), which is one of the most commonly used designs in agricultural research. This design was selected because it effectively controls the variability that naturally occurs in the field. In open-field and semi-controlled environments, factors such as soil fertility, moisture levels, temperature variation or microclimatic differences can influence plant growth. RBD minimizes the impact of such variability by dividing the field into homogeneous blocks, ensuring that each block experiences similar environmental conditions. Each of the 7 treatments (T₁-T₇) was included once in each block and the blocks were replicated three times, resulting in a total of 28 experimental units. Within every block, the seven treatments were assigned randomly to avoid bias and to ensure that differences in plant performance are due to treatments alone and not to positional effects.

The RBD structure therefore helped achieve:

- Better precision by reducing experimental error

- Fair comparison among treatments
- Statistically reliable conclusions



Fig 1: Overall experiment plot

3. Results and discussion

a. Plant height (cm)

Table 2: Effect of different organic manures on plant height(cm)

Treatment Details		Plant height (cm)		
		30 DAT	45 DAT	60 DAT
T ₁	FYM (20t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	28.71	33.00	34.70
T ₂	Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	29.05	34.75	37.13
T ₃	Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	31.01	36.04	37.61
T ₄	FYM (10t ha ⁻¹) + Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	31.39	36.18	38.01
T ₅	Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	31.76	36.81	38.94
T ₆	FYM (5t ha ⁻¹) + Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	33.23	37.03	39.10
T ₇	Absolute control (no organics)	26.56	31.26	32.86
S.Em (+)		0.96	0.88	0.83
CD (p=0.05)		3.00	2.76	2.61

Plant height is an important indicator of vegetative growth, reflecting efficient nutrient uptake and utilization by the plant. Observations recorded at 30, 45 and 60 days after transplanting (DAT) showed that different organic manure combinations significantly influenced plant height. The highest plant height was recorded in treatment T₆ (FYM 5 t ha⁻¹ + Vermicompost 2 t ha⁻¹ + Neem cake 1 t ha⁻¹ + Lignite 2 t ha⁻¹ + MC 2 L ha⁻¹) with values of 33.23, 37.03, and 39.10 cm at 30, 45 and 60 DAT respectively, which was on par with T₅ (31.76, 36.81, and 38.94 cm). The lowest plant height was observed in the control (T₇) with 26.56, 31.26, and 32.86 cm at the respective stages.

The superior performance of T₆ may be due to the combined presence of all organic inputs, which provided a more balanced and continuous supply of nutrients compared to other treatments. The inclusion of FYM along with vermicompost, neem cake, lignite and microbial consortium might have improved soil structure, enhanced microbial activity and increased nutrient availability in a more efficient manner (Kumazr *et al.*, 2015). This synergistic effect likely resulted in better root development and higher nutrient uptake, ultimately leading to greater plant height in T₆ compared to other treatments.

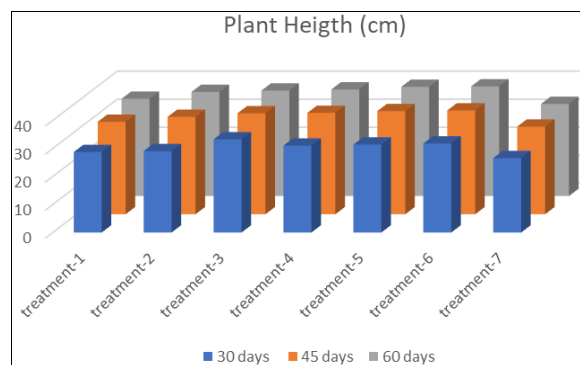


Fig 2: Graphical representation on plant height (cm)

b. Leaf length (cm)

Table 3: Effect of different organic manures on leaf length (cm)

Treatment Details		Leaf length (cm)		
		30 DAT	45 DAT	60DAT
T ₁	FYM (20t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	20.30	24.02	27.45
T ₂	Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	20.38	24.15	27.62
T ₃	Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	20.81	26.58	30.56
T ₄	FYM (10t ha ⁻¹) + Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	22.23	26.31	31.13
T ₅	Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	23.38	26.42	32.19
T ₆	FYM (5t ha ⁻¹) + Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	24.98	28.55	32.51
T ₇	Absolute control (no organics)	19.89	23.05	27.08
SEm (+)		1.08	1.05	0.92
CD (p=0.05)		3.38	3.29	2.86

Leaf length is an important parameter reflecting photosynthetic efficiency and vegetative growth of the plant. The data recorded at 30, 45 and 60 DAT showed significant variation among treatments. Among them T₆ recorded the highest leaf length (24.98, 28.55 and 32.51 cm), which was on par with T₅ (23.38, 26.42, and 32.19 cm), while the lowest values were observed in the control T₇ (19.89, 23.05 and 27.08 cm).

The higher leaf length in T₆ may be attributed to improved physiological activity resulting from the combined organic inputs. The presence of vermicompost and lignite might have enhanced the availability of humic substances, which are known to stimulate cell elongation and increase membrane permeability. This could have facilitated better nutrient transport within the plant system, supporting longitudinal leaf growth. Additionally, the steady nutrient release from FYM and neem cake may have maintained uninterrupted metabolic activity during critical growth stages, allowing continuous leaf elongation (Diksha Thakur *et al.*, 2024) [3]. The microbial consortium might have further improved enzymatic activity in the rhizosphere, enhancing nutrient transformation and uptake, ultimately contributing to increased leaf length.

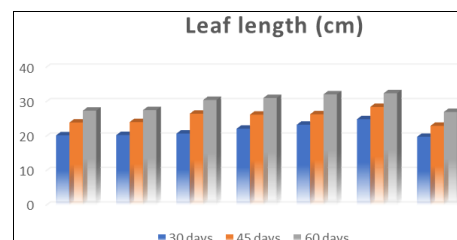


Fig 3: Graphical representation on leaf length (cm)

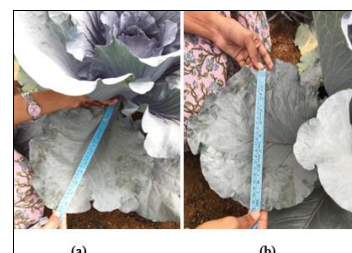


Fig 4: (a) measuring leaf length (cm), (b) measuring leaf width (cm)

c. Leaf width (cm)

Table 4: Effect of different organic manures on leaf width (cm)

Treatment Details		Leaf width (cm)		
		30 DAT	45 DAT	60DAT
T ₁	FYM (20t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	17.46	21.86	26.11
T ₂	Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	18.56	22.32	27.41
T ₃	Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	19.96	24.83	28.30
T ₄	FYM (10t ha ⁻¹) + Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	21.36	25.08	30.31
T ₅	Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	22.83	26.33	32.61
T ₆	FYM (5t ha ⁻¹) + Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	23.86	27.53	33.85
T ₇	Absolute control (no organics)	15.66	20.16	24.11
SEm (+)		0.08	0.37	0.85
CD (p=0.05)		0.27	1.17	2.67

Leaf width is another important growth parameter indicating the extent of leaf expansion and plant vigor. Significant differences were observed among treatments at all growth stages. T₆ recorded the maximum leaf width (23.86, 27.53 and 33.85 cm at 30, 45, and 60 DAT, respectively), which was on par with T₅ (22.83, 26.33 and 32.61 cm), whereas the minimum leaf width was observed in the control T₇ (15.66, 20.16 and 24.11 cm). The increased leaf width in T₆ may be due to enhanced cellular expansion and better turgor maintenance under improved soil conditions. The combined application of organic manures might

have increased the availability of potassium and calcium, which play a key role in regulating stomatal activity and cell wall flexibility. This could have promoted lateral expansion of leaf tissues, resulting in wider leaves. Moreover, improved soil moisture retention and reduced nutrient fluctuations under this treatment may have supported uniform cell enlargement across the leaf surface (Santosh Kumar Chaudhary *et al.*, 2024) ^[5]. The microbial consortium might have also contributed to improved nutrient solubilization, ensuring consistent nutrient supply for sustained leaf expansion.

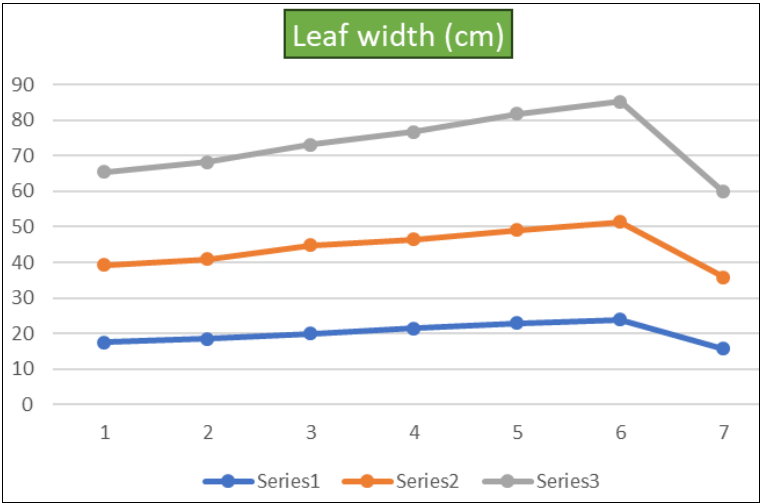


Fig 5: Graphical representation on leaf width (cm)

d. Number of leaves

Table 5: Effect of different organic manures on number of leaves

Treatment Details		No. of leaves		
		30 DAT	45 DAT	60DAT
T ₁	FYM (20t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	8.20	14.66	15.33
T ₂	Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	9.13	15.06	17.66
T ₃	Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	10.20	15.23	19.76
T ₄	FYM (10t ha ⁻¹) + Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	11.13	16.33	20.00
T ₅	Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	12.00	17.33	22.66
T ₆	FYM (5t ha ⁻¹) + Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	12.13	18.78	23.66
T ₇	Absolute control (no organics)	7.66	10.66	14.00
SEm (±)		0.27	0.93	0.85
CD (p=0.05)		0.84	2.91	2.65

The number of leaves per plant was recorded at 30, 45 and 60 days after transplanting (DAT) to assess the vegetative growth response of red cabbage under different organic nutrient treatments. A gradual increase in leaf number was observed across all treatments, indicating progressive vegetative growth before head formation. Significant differences were noticed among treatments at each stage. Among them, T₆ (FYM 5 t ha⁻¹ + Vermicompost 2 t ha⁻¹ + Neem cake 1 t ha⁻¹ + Lignite 2 t ha⁻¹ + Microbial consortium 2 L ha⁻¹) recorded the highest number of leaves with 12.13, 18.78 and 23.66 leaves at 30, 45 and 60 DAT, respectively. This treatment was on par with T₅, which recorded 12.00, 17.33 and 22.66 leaves. The lowest number of leaves was observed in the control (T₇) with 7.66, 10.66 and 14.00 leaves at the respective stages. The higher number of leaves observed in T₆ may be due to improved physiological efficiency and favorable root-soil interactions created by the combined organic inputs. The

integration of these manures might have enhanced soil biological activity and enzymatic processes, leading to better nutrient transformation and availability at critical growth stages. This could have supported continuous meristematic activity and faster leaf initiation (Ahmet Safak *et al.*, 2017) ^[1]. Additionally, improved soil moisture retention and reduced nutrient loss under this treatment may have provided a stable growth environment, enabling plants to produce more leaves consistently. Further, the balanced nutrient supply under T₆ might have improved photosynthetic efficiency and energy utilization, which are essential for sustained vegetative growth. The presence of multiple organic inputs could also have reduced stress conditions and supported better metabolic activity within the plant system. This overall improvement in plant health and internal processes likely contributed to higher leaf production compared to other treatments and the control.

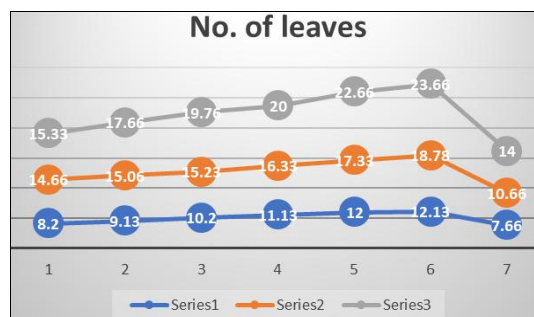


Fig 6: Graphical representation on No. of leaves

v. Plant spread (cm)

Table 6: Effect of different organic manures on plant spread(cm)

Treatment Details		Plant spread (cm)		
		30 DAT	45 DAT	60DAT
T ₁	FYM (20t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	37.94	53.59	58.76
T ₂	Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	40.16	55.15	59.54
T ₃	Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	43.74	56.44	61.15
T ₄	FYM (10t ha ⁻¹) + Vermicompost (2t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	50.66	56.50	62.44
T ₅	Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	52.33	58.00	66.00
T ₆	FYM (5t ha ⁻¹) Vermicompost (2t ha ⁻¹) + Neem cake (1t ha ⁻¹) + Lignite (2t ha ⁻¹) + MC (2L ha ⁻¹)	54.33	60.30	68.30
T ₇	Absolute control (no organics)	36.83	51.85	56.54
SEm (±)		1.08	0.32	0.36
CD (p=0.05)		3.38	1.01	1.12

Plant spread was measured at 30, 45 and 60 days after transplanting (DAT) to assess the lateral vegetative growth of red cabbage under different organic nutrient treatments. A continuous increase in plant spread was observed across all treatments, indicating progressive canopy development during the crop growth period. Significant differences were recorded among treatments at each stage. Among them, T₆ [FYM (5 t ha⁻¹) + Vermicompost (2 t ha⁻¹) + Neem cake (1 t ha⁻¹) + Lignite (2 t ha⁻¹) + Microbial consortium (2 L ha⁻¹)] recorded the maximum plant spread with values of 54.33, 60.30 and 68.30 cm at 30, 45, and 60 DAT, respectively, which was on par with T₅ (52.33, 58.00 and 66.00 cm). The minimum plant spread was observed in the control (T₇) with 36.83, 51.85 and 56.54 cm at the respective stages.

The increased plant spread in T₆ may be attributed to enhanced canopy development due to improved nutrient availability and favorable soil conditions created by the combined organic inputs. The integration of FYM, vermicompost, neem cake, lignite and microbial consortium likely promoted better root proliferation and efficient uptake of water and nutrients, supporting vigorous vegetative growth (Bhatt, R., 2023) [2]. In addition, the balanced supply of macro and micronutrients might have improved leaf orientation and expansion, allowing plants to occupy more horizontal space. The presence of organic inputs could also have improved soil porosity and reduced compaction enabling unrestricted root growth and better anchorage. Furthermore, enhanced microbial activity may have stimulated the production of growth-promoting substances, which supported branching and lateral development. These combined effects ultimately resulted in greater plant spread in T₆ compared to other treatments and the control.

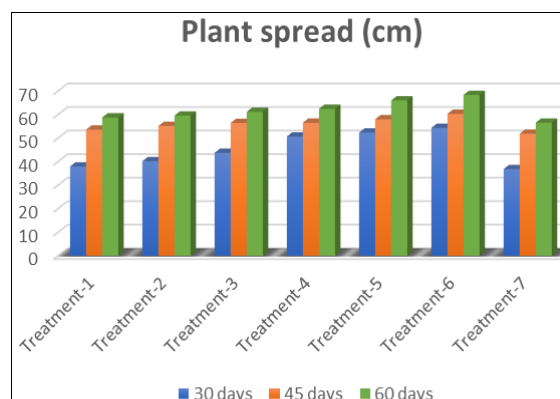


Fig 7: Graphical representation on plant spread (cm)

4. Conclusion

From the present investigation, it can be concluded that the application of combined organic nutrient sources significantly influenced the growth parameters of red cabbage. Among the treatments, T₆ proved to be the most effective in promoting plant height, number of leaves, leaf length, leaf width, and plant spread, followed closely by T₅. The superior performance of T₆ may be due to the synergistic effect of FYM, vermicompost, neem cake, lignite and microbial consortium, which ensured balanced nutrient supply, improved soil health, and enhanced nutrient uptake. In contrast, the control treatment recorded the lowest growth values, highlighting the importance of organic nutrient supplementation. Therefore, the integrated use of these organic inputs under naturally ventilated polyhouse conditions can be recommended for achieving better vegetative growth and overall crop performance in red cabbage.

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