

Exploring the impact of vermicomposting on growth of wheat under organic farming system

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Abstract. Barla A, Patel S, Swain SS, Parida S. 2025. Exploring the impact of vermicomposting on growth of wheat under organic farming system. *Asian J Agric* 9: 298-304. Climate Resilient Agriculture (CRA) includes the sustainable use of natural resources through crop production to attain long-term higher productivity and income from farms under variable climatic conditions. Though organic farming is criticized as a lower-yielding system than the conventional system and is unable to meet the food demand of the world's population, still simultaneously it has a positive impact on the environment and on maintaining the soil ecosystem including a positive impact on human health. Therefore, consumer demand for organic products is increasing which encourages organic farming systems. This paper focuses on integrating organic farming particularly the use of organic compost in promoting soil health and wheat crop growth. In this study, vermicompost and cow dung compost were applied to observe its impact on the growth of wheat (*Triticum aestivum* L.) crops under pot experiments. A pot containing normal soil was taken as control, soil: cow dung (2:1) and vermicompost was applied in different proportions of soil and vermicompost (S: V) in 1:1, 2:1, and 4:1 ratios to evaluate the vegetative crop growth. For wheat crop, the application of vermicompost (S: V with 2:1) in soil showed better results on crop growth than the cow dung compost (S: C with 2:1). Mineral contents of leaf were also analyzed by X-ray fluorescence (XRF) study and detected more in the leaves of wheat plant raised in S: V with (2:1) than the S: C (2:1) pots. Organic farming systems can be used for superior nutritional qualities in comparison to conventional systems.

Keywords: Crop growth, mineral contents, organic farming, *Triticum aestivum*, vermicompost

INTRODUCTION

Agriculture plays an important role in the economic development of any country, and low productivity is resulted because of declining soil fertility (Mubarak et al. 2021; Salem et al. 2022). Wheat (*Triticum aestivum* L.) makes a significant contribution to one-third of overall food grain cultivation in India. India ranks second among wheat-growing countries worldwide. As a result of the "Green Revolution," India's agricultural production increased dramatically from the 1960s to the 1980s (Gupta 1996). Agrochemicals harm soil quality and pollute the environment. Healthy soil is a dynamic ecosystem enriching with microscopic to macroscopic organisms that perform several vital functions such as conversion of minerals to plant nutrients (nutrient cycling), conversion of dead and decaying matter, and improved water and nutrient holding capacity for improving crop growth and productivity. Wheat grain yield depends upon soil type, wheat genotype, persistent meteorological conditions, and their interaction. Soil quality is directly linked to crop growth, quality, and quantity of the produce. Soil supplies water, oxygen, and essential nutrients to the plants. Organic farming is a rapidly growing sector in many nations and is assessed in terms of sustainability. Everyone wants sustainable agriculture, but how to progress is not clear. Soil conditions showed the highest effect on variation in grain yield of wheat, and salinity resulted in a reduction in grain yield (Matkovic et al. 2022).

Climate Resilient Agriculture (CRA) is an agricultural approach that use the existing natural resources to induce crop growth, higher crop productivity, and farm incomes. Organic farming can enhance food quality without any adverse effect on both soil and crop produce and can ensure sustainability (Simsek-Ersahin 2010). The use of vermicompost is increasing day by day, both in developed and developing countries (Simsek-Ersahin 2011), to enhance crop yield. Organic farming has been shown to enhance different environmental components of the agroecosystem (Bulluck et al. 2002; Kramer et al. 2006). The soil's organic carbon and nitrogen content are increased by the application of compost and other organic manures. Traditional thermophilic compost is recognized as an effective method to enhance soil aggregation, fertility, and porosity, thereby improving water-holding capacity (Przemieniecki et al., 2021), increasing microbial diversity, and increasing cation exchange capacity of the soil, which results in the production of disease-free crops (Nardi et al. 2004).

Global increasing population demands the acquisition of an extensive and intensive cropping system expecting higher production (Sadowski and Baer-Nawrocka 2018). This drives for vigorous use of agrochemicals, which leads to unsustainable practices leading to soil toxicities and nutrient imbalance, which is an important drawback for sustainable production (Rojas et al. 2016). Food products containing the residues of these agrochemicals affect both livestock and human beings (Rasmussen et al. 2016; Pimentel et al. 2018). The addition of organic amendments is

important to improve soil health and sustainable productivity (Hijbeek 2017; Gamage et al. 2023). Amongst the organic fertilizers, vermicompost is one of the potential sources to enhance crop growth. Earthworms are involved in producing vermicompost with other associated microbes (Abou el-Goud et al. 2021, by non-thermophilic biodegradation of organic wastes Manzoor et al. 2024). It is proven as a crucial biofertilizer that enhances crop yields by adapting to environmental stresses.

Vermicompost contains approximately 1.5-2.2% nitrogen, 1.8-2.2% phosphorus, and 1.0-1.5% potassium. Vermicompost is a substantial source of micronutrients (Adhikary 2012). Vermicompost improves plant growth by regulating soil properties (Xu et al. 2023). Vermicompost is also a well-known source of essential nutrients and promotes the yield and growth of plants when applied in small amounts (Atiyeh et al. 2002; Arancon et al. 2005). Soil organic matter is protected from biodegradation physically because of soil aggregates and soil aggregates also improve the structure of the soil and pore size distribution (Tisdall and Oades 1982; Xuan et al. 2023), all of which can affect the soil hydraulic properties. The use of vermicompost in crop fields can improve soil organic matter and reduce pesticide contamination in soils (Yen et al. 2021). In this study, vermicompost and cow dung compost were applied to observe their impact on the growth of wheat (*T. aestivum*) crops under pot experiments.

MATERIALS AND METHODS

Experiment site for wheat crop growth

A pot experiment was carried out in February 2022 to study the vegetative growth of the wheat crop in pot cultivation methods at Centurion University of Technology and Management, Bhubaneswar campus, Odisha.

Collection of cow dung manure and vermicompost

Cow dung manure and vermicompost were collected from the composting unit of Centurion University, Bhubaneswar campus.

Pot preparation

A pot containing normal soil (sandy loam soil with a pH value ranging from 6.73 to 6.85) (T0) was taken as control. Soil (S) was mixed with cow dung (C) manure (S: C) in a 2:1 (kg/kg) ratio (T1). Vermicompost (V) was applied to the soil in different proportions i.e., (S: V) in 1:1 (T2), 2:1(T3), and 4:1 (w/w) ratio (T4) and mixed properly and 15 pots were filled separately in triplicate for each treatment to evaluate the vegetative crop growth in interval of 15, 25 and 35 Days After Sowing (DAS).

Raising of seedlings

Seeds of wheat variety HD 3226 were procured from an online shopping agency. Before sowing the wheat seeds were soaked in water on overnight and sown in the soil filled pots in row manner. After 3-5 days' small wheat plants started appearing. Ten plants were randomly selected from each replication at 15 days and 25 days to measure

the growth parameter. The growth of the plant in S: V treated pot in 2:1 ratio and control pot was measured at 35 days of showing (Figure 8) as other treated pots did not show any positive response in comparison to the plants raised in control pots.

Sampling and data collection

Growth parameters were recorded after 15 DAS intervals and after 25 DAS. A total of 10 plants were selected randomly from each treatment and the average plant height and leaf length were recorded in cm.

Elemental composition of leaf samples by X-ray fluorescence analyses

The leaves were collected from the T4-treated pots showing maximum vegetative growth and also from the S: C (2:1) pots with minimum vegetative growth to measure the nutritional content by X-Ray-Fluorescence Spectroscopy (XRF). Two grams of leaf samples were separately weighed for the analyses.

Statistical analysis

All determinations were carried out in triplicate. The reported values are averages of 10 plants selected from each pot. Experimental data was expressed as mean \pm S. E. and one-way Analysis of Variance (ANOVA) was carried out using a One-Way ANOVA Calculator, including Tukey HSD, to determine significant differences from the control ($p \leq 0.05$).

RESULTS AND DISCUSSION

Vegetative crop growth

The vegetative crop growth was measured in an interval of 15, 25 and 35 DAS (Figures 1-7). Data depicted in Table 1 showed that the average length of the shoot at 15 DAS was measured to be more in the pot containing soil: vermicompost (2:1) with 9.86 cm followed by control soil with 9.60 cm, equal proportion of S: V (1:1) with 7.20 cm, S: V (4:1) with 7.08 cm and least growth in soil: cow dung (2:1) with 6.08 cm (Figures 1.A-1.H). The average root length of the wheat after 15 DAS in S: V (2:1) was maximum with 4.08 cm followed soil grown plants with 3.08 cm, S: V (4:1) with 2.98 cm, S:C (2:1) 2.36 cm and least in S: V (1:1) with 2.70 cm. Similarly, maximum leaf length was recorded in S: V (2:1) with 17.82 cm followed by control (soil) with 3.08 cm and least in S: C (2:1) with 6.08 cm.

Table 1. Result details of one-way analysis of variance including Tukey HSD test

Source	SS	df	MS
Between-treatments	141.2256	1	141.2256
Within-treatments	30.8523	8	3.8565
Total	172.078	9	

F = 36.61978

Average length of the shoot at 25 DAS was also measured to be more in the pot containing S: V (2:1) with 14.50 cm followed by control soil with 12.20 cm, equal proportion of S: V with 11.70 cm, S: V (4:1) with 11.80 cm and least growth in S: C (2:1) with 9.60 cm. The average leaf length of the wheat at 25 DAS was measured a maximum of 17.40 cm in the control condition followed by S: V (2:1) with 13.70 cm and least in S: C (2:1) with 9.80 cm. Standard Deviation (SD), and standard error were calculated and the error graph is shown in Figure 2.

The findings of another work revealed that vermicompost-applied soil positively influenced the growth and productivity performance of wheat cultivars (Ahmed et al. 2022). Previous studies revealed the positive influence of the combined application of vermicompost with other organic fertilizers influences the morpho-physiological and yield characteristics under drought stress conditions (Aboelsoud and Ahmed 2020; Hafez et al. 2020).

A one-way ANOVA calculator is used, including the Tukey Honestly Significant Difference (HSD) test, which gives a statistically significant result; this indicates that at least one group differs from the other groups. The f-ratio value is 36.61978 and the *p*-value is .000305 (Table 1). The result is statistically significant under the value of significance level at *p* < .05.

It was observed that the growth of the wheat plants was maximum in T2 followed by T0 pots. Therefore, the height of the plant and leaf length was measured after 35 DAS. Table 2 revealed that the average plant height grown in the T2 pot after 35 DAS was 26.30 cm in comparison to T0, with an average height of 22.60 cm. Average leaf height was also higher in the case of the T2 pot than T0, with 20.9 and 18.70 cm, respectively. Other treated pots were not taken into consideration as the plant growth did not show any positive response on the growth parameter in comparison to the control condition (Figure 3).

Figure 3 revealed that the average height of the plant grown in T2 pot after 35 DAS was 26.3 cm in comparison to T0 pot with an average height of 22.6 cm. Average leaf height was also higher in the case of the T2 pot than T0, with 20.9 and 18.7 cm, respectively. From the error bar graph it is shown that plant growth in T0 and T2 shows more growth than T1, T3 and T4 treatments. Therefore, T1, T3 and T4 treated pots were not taken into consideration as the plant growth did not show any positive response on the growth parameter in comparison to the control condition.

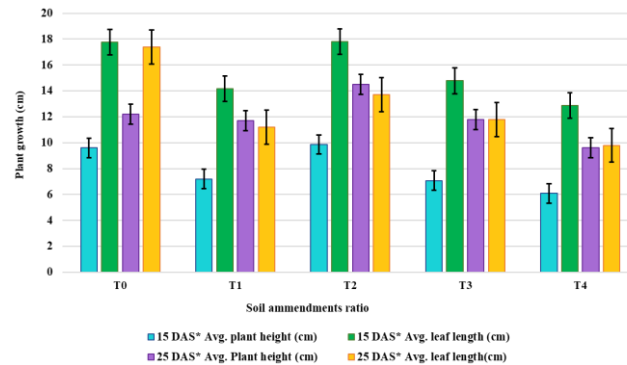


Figure 2. *Triticum aestivum* crop growth after 15 DAS on different soil composition

Table 2. Average plant height and leaf length of wheat in T0 and T2 pots at 35 DAS

Soil treatment	35 DAS*	
	Avg. plant height (cm)	Avg. leaf length (cm)
T0	22.60	18.70
T2	26.30	20.90

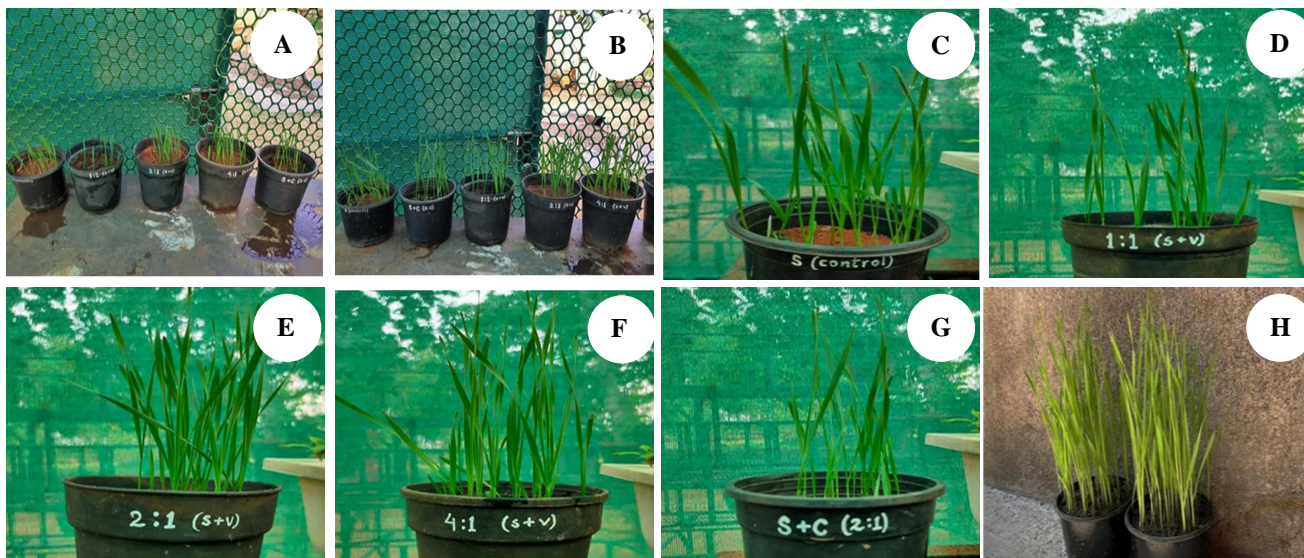


Figure 1. Wheat seedlings growth: A. After 7 DAS; B. After 15 DAS; C. After 25 DAS; D. Wheat grass growth in S: V (1:1) after 25 DAS; E. Wheat grass growth in S: V (2:1) after 25 DAS; F. Wheat grass growth in S: V (4:1) after 25 DAS; G. Wheat grass growth in S:C (2:1) after 25 DAS; H. Wheat grass growth in control and S: V (2:1) after 35 DAS

Table 3. Mineral contents in leaves of T0 (Control), T2 (S:V::2:1) and T4 (S:C::2:1) grown plants (%)

Compounds	Soil (control)	S:V (2:1)	S:C (2:1)
SiO ₂	19.23	15.52	11.01
P ₂ O ₅	6.23	7.37	7.6
SO ₃	2.7	4.12	5.01
Cl	6.32	5.25	14.26
K ₂ O	63.9	65.28	60.48
TiO ₂	0.5	0.40	0.22
MnO	0.36	0.14	-
Fe ₂ O ₃	1.21	1.8	1.22

Table 4. Mineral contents in leaves of T0 (Control), T2 (S:V::2:1) and T4 (S:C::2:1) grown plants (ppm)

Compounds	Soil (control)	S:V (2:1)	S:C (2:1)
V ₂ O ₅	67.3	86.5	71.1
CuO	102.3	141.3	105.1
ZnO	-	534.2	-
Br	36.5	47.5	-
Rb ₂ O	127.9	141.3	130.3
Zr ₂ O	68.5	77.7	-
Eu ₂ O ₃	203.7	261.5	383.8

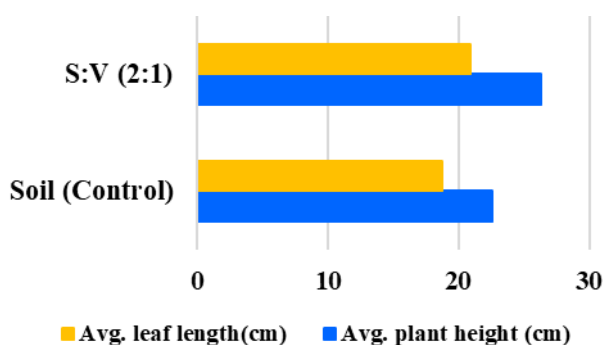


Figure 3. Comparative wheat crop growth after 35 DAS on T0 and T2

Element analyses of wheat leaves in T2 and T4 pots by XRF method

The elemental composition of leaves from both pots was measured by XRF analyses. Data in Table 3 revealed that 15 different elemental compounds were detected in the leaves of wheat plants after 15 DAS raised in T2. K₂O was

detected in the maximum amount of 65.28% followed by SiO₂, P₂O₅, Cl, SO₃, and Fe₂O₃ with 15.52, 7.37, 5.25, 4.12, and 1.8%, but the leaves collected from T4 pots were detected with 11 different elements with a maximum of K₂O 60.48 followed by Cl, SiO₂, P₂O₅, SO₃, Fe₂O₃, and TiO₂ with 14.26, 11.01, 7.6, 5.01, 1.22 and 0.22 % respectively. MnO is not detected in leaves of T4 (S: C::2:1) grown plants.

ZnO was detected in leaves of T2 (S:V::2:1) with 534.2 followed by Eu₂O₃ (261.5 ppm), CuO and Rb₂O with 141.3ppm, V₂O₅ with 86.5 ppm, Zr₂O with 77.7 ppm, Eu₂O₃ with 383.8 ppm. In the leaves of T4 (S:C::2:1) grown plants, different trace elements were detected, including Rb₂O at 130.3 ppm, followed by CuO with 105.1 ppm and V₂O₅ with 71.1 ppm. In T4 treatment ZnO, Br, and Zr₂O are not detected (Table 4). XRF graph represented the elemental composition in leaf samples in soil (control), S:V (2:1) and S:C (2:1) grown pots (Figures 4-6).

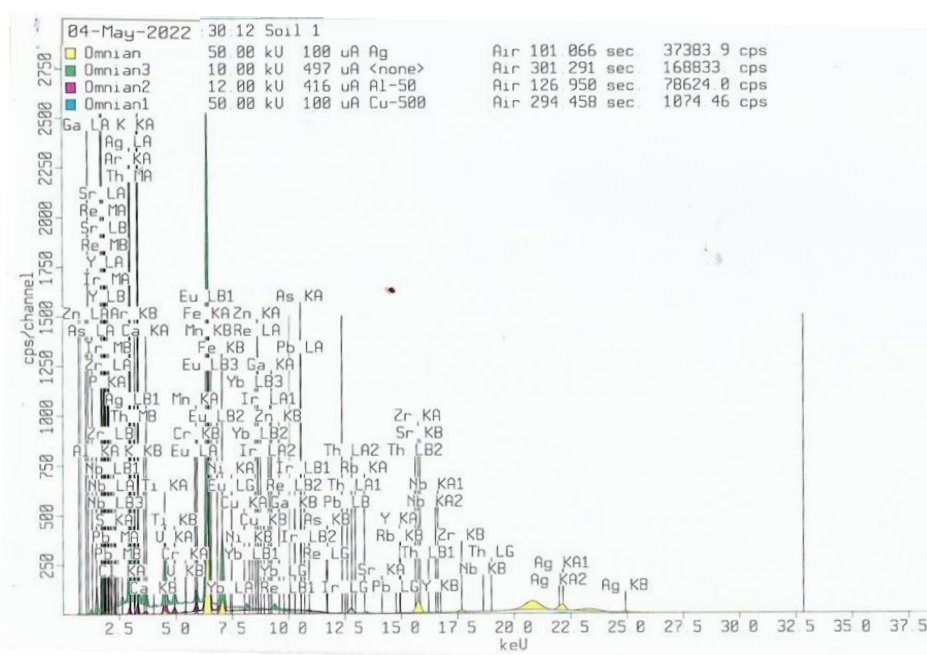


Figure 4. XRF graph showing mineral contents of leaf samples grown in normal soil (control) containing pots

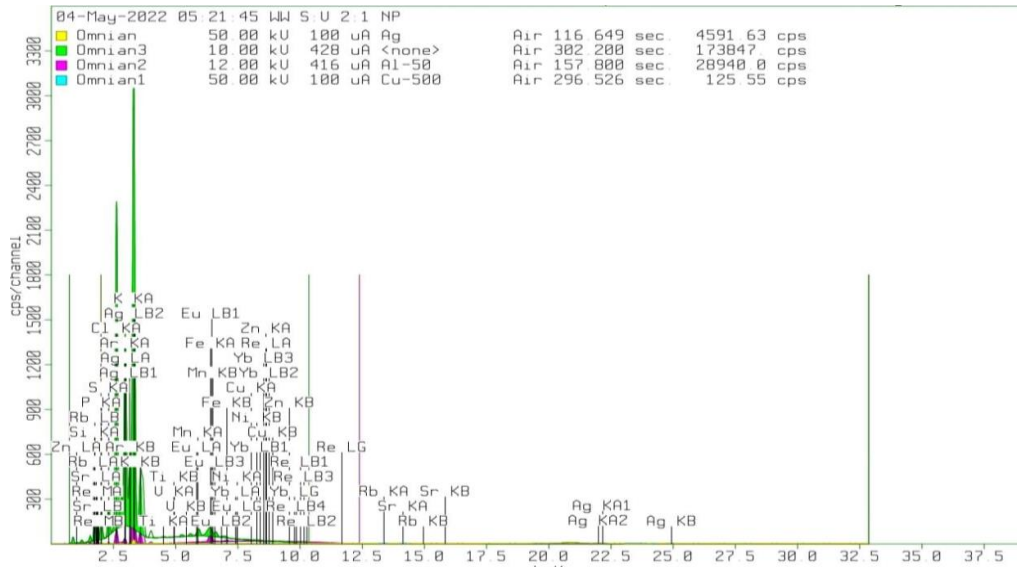


Figure 5. XRF graph showing mineral contents of leaf samples in S: V (2:1) grown pots

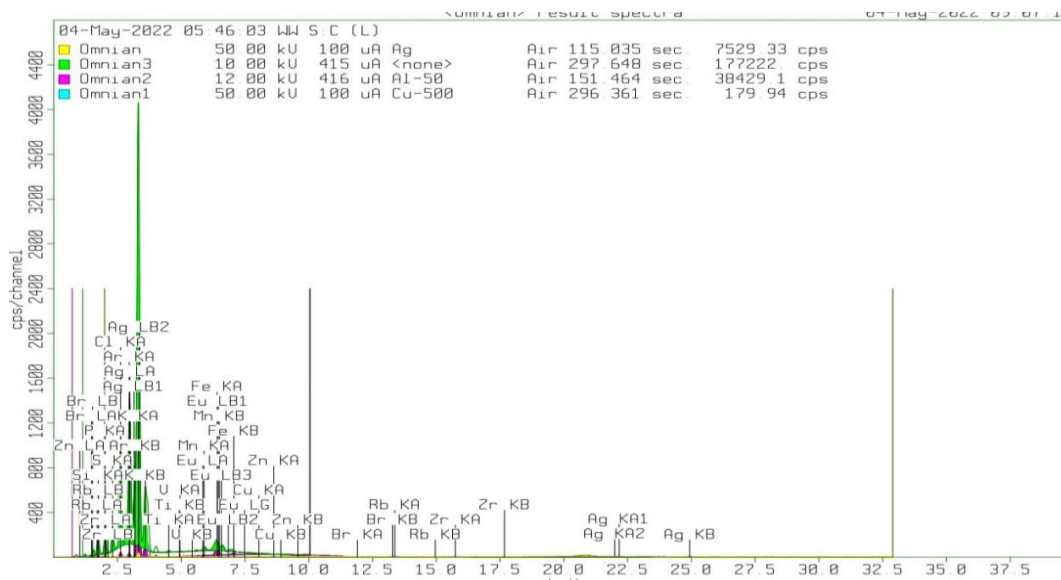


Figure 6. XRF graph showing mineral contents in wheat leaves in S:C (2:1) grown pots

The organic farming systems maintain plant vigor, yield (Burkhard et al. 2009) and quality with positive, acceptable environmental impacts (Tilman et al. 2002; Bhaskaran and Krishna 2009). This experiment shows a significant impact of vermicompost on wheat crop growth in T2, but the leaf length was more in the T0 than T4 pot, which was found to be similar to the findings of Trewavas (2004). Organic agriculture has been criticized as low-yielding and less efficient than conventional agriculture in its use of land and resources (Trewavas 2004). Several yield trial comparisons between organic and conventional farming systems have shown significantly lower yields for organic systems (Stanhill 1990; Ryan et al. 2004). In another study, grain yield, the weight of the kernel, test weight, and protein content were reported to be unaffected by the tillage system

(Carr et al. 2003). It was reported that application of vermicompost alone, without any addition of inorganic fertilizer, cannot enhance productivity significantly (Ryan et al. 2004). Another study in 30 villages in Patiala and Faridkot Districts of Punjab also reported that the total variable cost per acre for wheat cultivation under the organic farming system was less as compared to the inorganic method, but the lower yield of the organic wheat crop was compensated by its higher market price (Singh and Grover 2011). The total variable cost for organic wheat cultivation has been also found less in comparison to the inorganic method of cultivation (Singh and Grover 2011).

Organic wheat cultivation, therefore, has been found more profitable but simultaneously the reduction in crop productivity poses a very serious challenge in terms of food

security for the growing population of the nation. Significant increases in micronutrient content were reported in the soil after vermicompost application (Hussain et al. 2018). The amount of nitrogen in the soil increased significantly (Sreenivas et al. 2000), and the potassium and phosphorus amounts were also increased (Venkatesh 1998). It is also revealed that the growth parameters in clay soil at 50% field capacity mixed with sandy soil at 100% field capacity showed (109.34 t/ha) highest in the combined use of organic matter at the rate of 15g/2 kg with vermicompost at the rate of 5 g/2 kg (Ahmed et al. 2022). Selected Integrated Soil Fertility Management practices (ISFM) were studied at different watersheds and central highlands of Ethiopia, in the 2021-2022 cropping seasons to improve the soil quality and increase crop production. A combination of vermicompost, urea, and NPS fertilizers can help farmers in reducing their inorganic fertilizer requirements by 50 percent (Habtamu et al. 2024).

Vermicompost significantly affects plant growth (Blouin et al. 2019) because it might contain Plant Growth Promoting Rhizobacteria (PGPR) (Gopinath and Prakash 2014), which supports wheat growth, increases the grain yield, and is found as a good alternative to using chemical fertilizer in terms of economic benefits for winter wheat growth, and yield (Öksel et al. 2022). Integrated Soil Fertilization Management (ISFM) practices have been shown to improve soil quality and crop productivity. New evidence shows vermicompost and effective microorganisms can improve wheat drought tolerance by regulating photosynthetic efficiency, nutrient acquisition, root H⁺-pump activity, and membrane stability, thereby overcoming drought-related challenges (Talaat and Abdel-Salam 2024). Vermicompost treatments show improved vegetative growth and yield attributes of the wheat cultivar in a specific amount. Vermicompost, rich in macro-nutrients and micro-nutrients, can be used with chemical fertilizers to reduce doses and is a beneficial biofortification source. It indirectly acts as a biocontrol agent through phytohormone synthesis and increases nitrogen and phosphorous uptake. In this study soil vermicompost in a 2:1 ratio resulted in better vegetative growth and showed more elements in comparison to S:C (2:1) treated pots, which might be due to the availability of optimum level of mineral contents required for the wheat crop in comparison to other treatments.

Vermicompost significantly affects plant growth (Blouin et al. 2019) by PGPR which supports wheat growth, increases the grain yield, and is found as a good alternative to using chemical fertilizer in terms of economic benefits for winter wheat growth and yield (Öksel et al. 2022). In another study, PGPR has been isolated from vermicompost (Prakash and Hemalatha 2013), therefore in this study, PGPR may be present in the vermicompost, which may be responsible for the growth of the plants along with the rich nutritional composition of vermicompost. In this study, PGPR treatment had not been given, but the vermicompost may contain the plant growth promoting rhizobacteria according to Prakash and Hemalatha (2013), which may contribute in enhancing the wheat crop growth or the nutrient rich vermicompost may enhance the plant growth.

In conclusion, the present experiment was conducted to study the application of organic manure to the growth of the wheat plant (*T. aestivum*). In this experiment, it was observed that the highest root leaf and shoot length were observed in the S:V (2:1) ratio, other ratios were not found beneficial for wheat crops and the least growth was noticed in S:C (2:1) treated pots. It was also noticed that cow dung compost is not beneficial for wheat crop growth, rather a soil vermicompost in 2:1 ratio showed more impact on crop growth. From this study, it can be concluded that the growth and yield are dependent on the adaptations of the cultivars, and poorly adapted cultivars might be partly responsible for lesser growth and lower yields in the organic farming system. These results demonstrated that vermicompost has a positive response over the animal-based manure i.e., cow dung compost. Vermicompost and effective microorganisms are effective in alleviating environmental stresses. The productivity depends upon the variety, which should adapt to the particular conditions in organic systems then, organic farming will be better to show its full potential as the high-yielding system alternative to conventional systems of agriculture.

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