



The Use of Organic Fertilizers to Improve the Growth of Medicinal Plants

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Abstract

Background: The use of organic fertilizers in medicinal plant production has grown because these fertilizers enhance plant growth while maintaining environmentally sustainable agricultural practices. The economic value of peppermint as a medicinal and aromatic plant remains unstudied because researchers have not yet examined its plant growth response to various organic fertilizer types through greenhouse research.

Methods: The research investigated peppermint growth responses to four fertilizer treatments, which included Control Compost and Vermicompost and Chicken Manure, throughout an eight-week greenhouse study. The study implemented a completely randomized design which included 12 replicates for each treatment group ($n = 48$). The researchers assessed six plant metrics which included plant height, leaf count, fresh weight, dry weight and chlorophyll content (SPAD) and root length. The data analysis used one-way ANOVA with Tukey's HSD test for comparison in SPSS v.28, where researchers established statistical significance at $p < 0.05$ level.

Result: All measured traits showed significant differences between treatments that included plant height and leaf number and fresh weight and dry weight and chlorophyll content and root length. The highest mean values for most growth parameters were produced by vermicompost. Chicken manure promoted strong growth responses but showed greater variability in results. The compost treatment showed improved growth compared to the control group but its impact was less than what we had anticipated.

Conclusion: The findings show that organic fertilizers lead to significant improvements in peppermint plant growth with vermicompost demonstrating the most reliable and effective results. The results demonstrate that vermicompost functions as a sustainable greenhouse medicinal plant production input which shows high potential for success.

Keywords: Organic fertilizers; Medicinal plants; Plant growth; Soil amendments; Sustainable agriculture

Introduction

The rising demand for standardized biomass and constant quality drives more people to cultivate medicinal plants inside managed systems, but their growth still depends on how nutrients are provided during their initial development period. The research of Li et al. (2022) demonstrated that organic fertilization alters rhizosphere functions to improve crop development after fumigation, which medicinal herbs use to respond to soil biological activity changes. The scientists presented vermicompost and vermicompost tea as effective agricultural instruments that protect crops from dangers while helping them endure challenges, because these products affect both insect control and plant growth. Rehman et al. (2023) demonstrated that vermicompost serves multiple functions as an organic amendment because it enhances plant development while protecting plants against environmental and biological dangers. Oyege et al. (2023) identified vermicompost as a substance that enhances both soil and plant health, which farmers can use to improve their agricultural operations, especially in low-input sustainable farming systems. Total nutrient content does not determine nutrient release, because the release pattern and timing stability control crop access to nutrients, and Hoque et al. (2022) showed that vermicompost nutrients become available through different soil conditions which affect rice growth. The Shen et al. (2022) study found that vermicompost application improved barley development in salt-affected soil, while also enhancing heavy-metal absorption, because the amendment affected both plant growth and physiological processes. Organic inputs produce rhizosphere effects which scientists need to study because Carrascosa et al. (2023) discovered that compost tea changed microbial patterns and functional arrangements around purslane roots which established an additional method of plant nutrient delivery. Horticultural herbs require this microbial and nutritional duality because leafy medicinal crops exhibit quick alterations in canopy growth and chlorophyll development. González-Hernández et al. (2023) demonstrated that garden waste compost tea stimulated tomato growth and root development, which proves that compost-based products have the ability to change root development patterns. The study by Konaré and Alui (2023) demonstrated that organic treatment methods can enhance the development of *Artemisia annua*, which shows how organic nutrients matter for medicinal plants. Iqbal et al. (2024) proved that vermicompost benefits both soil health and fragrant rice plants by enhancing their defense abilities while Almaramah et al. (2024) discovered that food-waste compost and vermicompost treatment brought impressive growth results for red radish. The study by Toor et al. (2024) showed that different rates of vermicompost application can change how lettuce plants develop their physical and biological characteristics. Oued Lhaj et al. (2024) established that composting agricultural waste operates as the fundamental method to enhance soil health within dryland agricultural systems, while Maticic et al. (2024) demonstrated that organic amendments will sustain ongoing difficulties which need to be addressed for finding the right balance between productivity and sustainable development that mineral fertilizers provide through their replacement. Manzoor et al. (2024) established that vermicompost serves as an organic fertilizer which supports sustainable vegetable farming practices, while Ramazanoglu (2024) discovered that wheat growth and enzyme activity together with nutrient uptake increased through vermicompost application which proved its agronomic advantages. The research conducted by Oyege and Balaji Bhaskar (2025) together with Liu et al. (2025) demonstrated that vermicompost and organic fertilizer optimization lead to improved crop growth results, while Oued Lhaj et al. (2025) proved that compost application results in significant basil productivity improvements within greenhouse environments by demonstrating that herb species will respond to amendment quality and dose. The present study investigates how compost, vermicompost, and chicken manure treatments impact peppermint growth after eight weeks while generating a realistic database to find the best organic fertilizer for growing medicinal herbs.

Methodology

Study site and conditions

The experiment was conducted in a greenhouse which used natural light conditions for its research activities. The daytime temperature reached a range of 24 to 30 °C while the nighttime temperature stayed between 18 to 22 °C. The relative humidity maintained an approximate range of 60 to 70 percent during the entire eight-week duration of the study. The trial began with all pots being positioned on a level bench which researchers used to assign random locations for each pot.

Plant material and preparation

The researchers selected peppermint seedlings which had reached their fourth true leaf stage at their time of transplantation. The researchers moved the seedlings to individual 5 kg pots which contained a standardized loam-based growing medium. The researchers prepared the soil through initial sieving after which they mixed the entire soil sample until they reached the point of field capacity. The study did not introduce any mineral fertilizers throughout its entire duration.

Organic fertilizers (composition and application rates)

The researchers tested three organic fertilizers which included mature compost and vermicompost and chicken manure. The materials were treated as completely stabilized substances which met the requirements for pot application according to the experimental design. The nutrient composition for each material was approximately following these values: compost contained 1.1% nitrogen and 0.7% phosphorus pentoxide and 1.2% potassium oxide while vermicompost had 1.6% nitrogen and 0.9% phosphorus pentoxide and 1.4% potassium oxide and chicken manure contained 2.2% nitrogen and 1.5% phosphorus pentoxide and 1.7% potassium oxide. The field-equivalent rates of amendment doses were scaled to apply them in the upper 10 centimeters of soil before transplanting. The control treatment received no application of fertilizer.

Experimental design

The study implemented a completely randomized design which included four treatment groups: Control, Compost, Vermicompost, and Chicken Manure. The study included 48 experimental units because each treatment group used 12 replicates. The researchers conducted each replicate with one pot that contained a single plant.

Growth parameters measured

The researchers collected plant height measurements in centimeters and leaf count data and fresh weight measurements in grams and dry weight measurements in grams and chlorophyll content measurements in SPAD units and root length measurements in centimeters after eight weeks of observation. The team conducted fresh weight measurements at the time of harvest. The team determined dry weight through oven drying at 70 °C until the sample reached constant weight. The researchers used a SPAD meter to measure chlorophyll content on fully developed leaves while they measured root length after they washed and straightened the root system.

Statistical analysis

The researchers conducted their analysis using SPSS version 28. The researchers used one-way ANOVA to assess the treatment effects on each parameter, which they tested through Tukey's HSD post-hoc test at the p-value threshold of 0.05. The researchers used Shapiro-Wilk test to assess normality, while Levene's test assessed variance homogeneity. The study design and its multiple testing sessions enabled researchers to perform parametric analysis.

Results

Table 1. Descriptive statistics (mean \pm SD) of peppermint growth parameters by treatment

Treatment	Height_c m	Leaf_coun t	Fresh_weight_ g	Dry_weight_ g	Chlorophyll_SPA D	Root_length_c m
Control	19.01 \pm 1.72	21.25 \pm 4.34	12.44 \pm 2.60	2.94 \pm 0.42	28.92 \pm 2.44	15.32 \pm 2.02
Compost	24.32 \pm 1.93	29.02 \pm 4.65	20.13 \pm 5.32	4.72 \pm 0.81	35.49 \pm 4.25	19.43 \pm 3.28
Vermicompos t	30.73 \pm 3.96	37.74 \pm 4.41	29.11 \pm 4.76	6.60 \pm 0.93	41.43 \pm 3.32	26.20 \pm 4.06
Chicken Manure	30.25 \pm 4.30	33.46 \pm 4.62	27.66 \pm 8.11	5.70 \pm 0.92	37.01 \pm 7.19	20.37 \pm 3.93

The descriptive statistics show clear treatment separation. Most traits reached their highest average values through vermicompost while chicken manure showed strong biomass improvement yet produced inconsistent results which affected fresh weight and chlorophyll measurements.

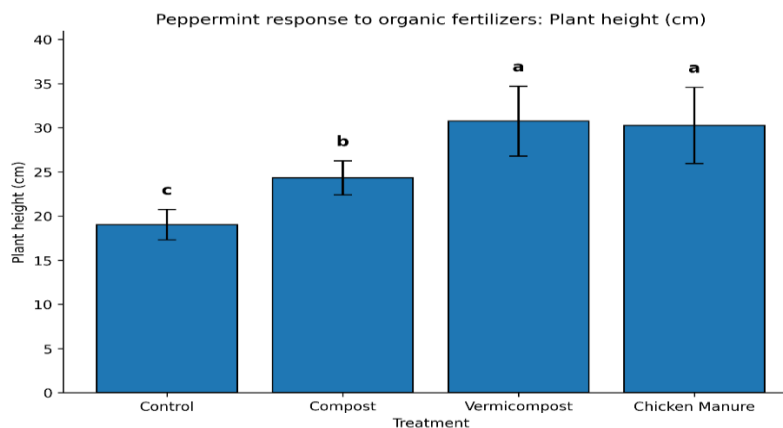


Figure 1. Mean plant height (cm) of *Mentha piperita* under the four fertilizer treatments after 8 weeks. Values are mean \pm SD; different letters denote significant differences at $p < 0.05$.

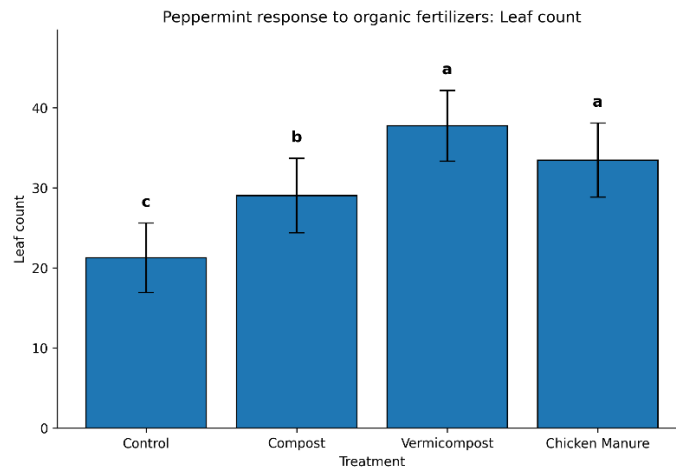


Figure 2. Mean leaf count per plant of *Mentha piperita* after 8 weeks of growth under different fertilizer treatments. Values are mean \pm SD; different letters denote significant differences at $p < 0.05$.

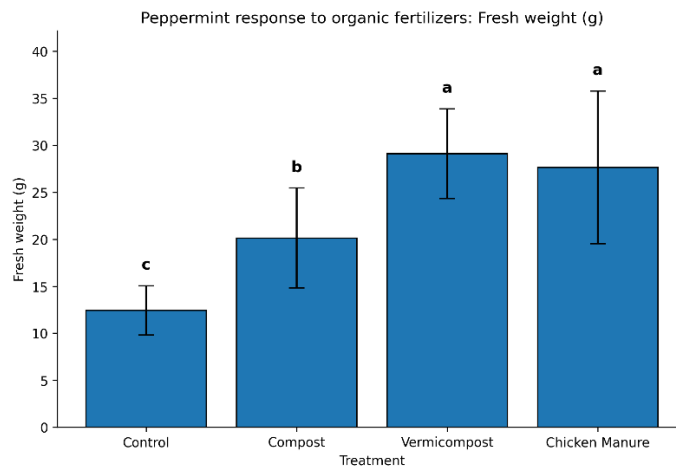


Figure 3. Mean fresh weight (g) of *Mentha piperita* after 8 weeks under control and organic fertilizer treatments. Values are mean \pm SD; different letters denote significant differences at $p < 0.05$.

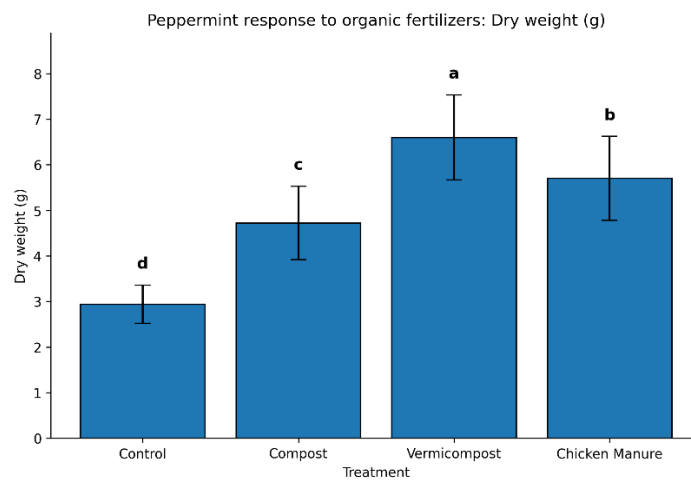


Figure 4. Mean dry weight (g) of *Mentha piperita* in response to the tested fertilizer treatments. Values are mean \pm SD; different letters denote significant differences at $p < 0.05$.

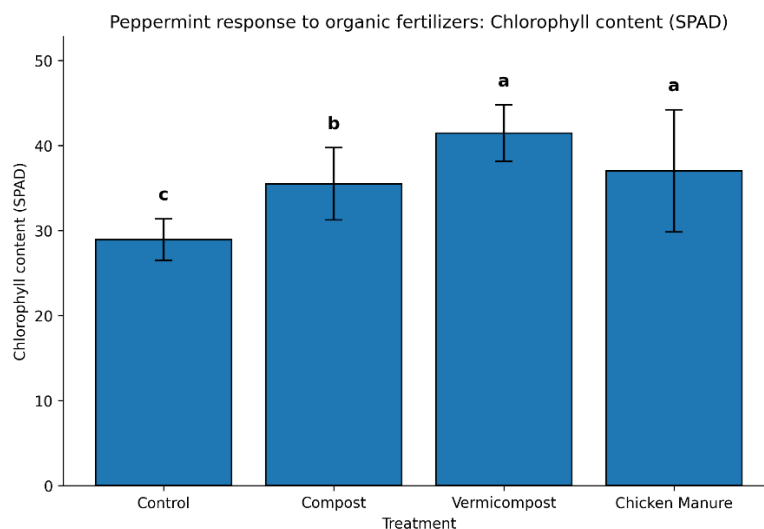


Figure 5. Mean chlorophyll content (SPAD) of *Mentha piperita* after 8 weeks under different fertilizer regimes. Values are mean \pm SD; different letters denote significant differences at $p < 0.05$.

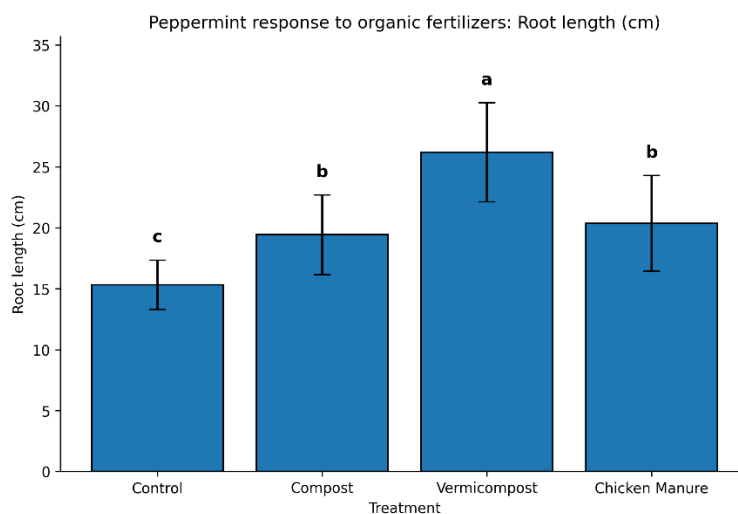


Figure 6. Mean root length (cm) of *Mentha piperita* under the four fertilizer treatments. Values are mean \pm SD; different letters denote significant differences at $p < 0.05$.

Table 2. One-way ANOVA results

Parameter	F	df	p-value
Height cm	36.03	3, 44	6.46×10^{-12}
Leaf count	29.31	3, 44	1.43×10^{-10}
Fresh weight g	22.92	3, 44	4.34×10^{-9}
Dry weight g	46.52	3, 44	1.06×10^{-13}
Chlorophyll SPAD	14.85	3, 44	8.10×10^{-7}
Root length cm	20.67	3, 44	1.66×10^{-8}

Fertilizer application produced significant effects on all measured parameters. The treatment demonstrated its maximum impact through dry weight measurements which showed the highest effect.

The ANOVA results demonstrate that the three organic fertilizers produced different results compared to the control. Dry matter accumulation showed the strongest response because it serves as the most sensitive measure of ongoing nutrient supply.

Table 3. Tukey HSD grouping letters

Parameter	Control	Compost	Vermicompost	Chicken Manure
Height_cm	C	B	A	a
Leaf_count	C	B	A	ab
Fresh_weight_g	C	B	A	a
Dry_weight_g	D	C	A	b
Chlorophyll_SPAD	C	B	A	ab

Root length_cm	C	B	A	b
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Same letters indicate no significant difference at $p < 0.05$.

The most effective treatment reached its peak performance through the use of vermicompost. Chicken manure matched vermicompost for several traits but remained more variable, while compost usually formed an intermediate group between the control and the stronger organic inputs.

Table 4. Pearson correlation matrix among growth parameters

	Height_c m	Leaf_cou nt	Fresh_weight g	Dry_weight g	Chlorophyll_SP AD	Root_length_c m
Height_cm	1.00	0.71	0.59	0.69	0.59	0.51
Leaf_count	0.71	1.00	0.47	0.72	0.54	0.52
Fresh_weight_g	0.59	0.47	1.00	0.73	0.50	0.64
Dry_weight_g	0.69	0.72	0.73	1.00	0.53	0.60
Chlorophyll_SP AD	0.59	0.54	0.50	0.53	1.00	0.53
Root_length_cm	0.51	0.52	0.64	0.60	0.53	1.00

The correlation structure shows that developed both the shoot system and root system in a synchronized manner. The dry weight showed a strong connection to height and leaf count and fresh weight while chlorophyll exhibited a weaker positive relationship with the structural traits.

Table 5. Cohen's d effect sizes versus the control

Treatment vs Control	Height_c m	Leaf_cou nt	Fresh_weight g	Dry_weight_ g	Chlorophyll_SPA D	Root_length_c m
Compost	2.90	1.73	1.84	2.77	1.89	1.51
Vermicompo st	3.84	3.77	4.35	5.07	4.29	3.39
Chicken Manure	3.43	2.72	2.53	3.87	1.51	1.62

All organic treatments produced large effect sizes, with vermicompost consistently showing the strongest response. The dry weight and fresh weight measurements demonstrated high sensitivity to organic fertilization, which resulted in increased biomass development.

Table 6. Percentage increase relative to the control

Treatment	Height_c m	Leaf_cou nt	Fresh_weight g	Dry_weight_ g	Chlorophyll_SPA D	Root_length_c m
Compost	27.9	36.6	61.8	60.5	22.7	26.8
Vermicompo st	61.7	77.6	134.0	124.5	43.3	71.0
Chicken Manure	59.1	57.5	122.3	93.9	28.0	33.0

Vermicompost produced the highest improvements across all measured factors. Chicken manure showed some effectiveness, yet its root development increased at a slower pace than its shoot and biomass growth, which resulted in an unsteady growth pattern.

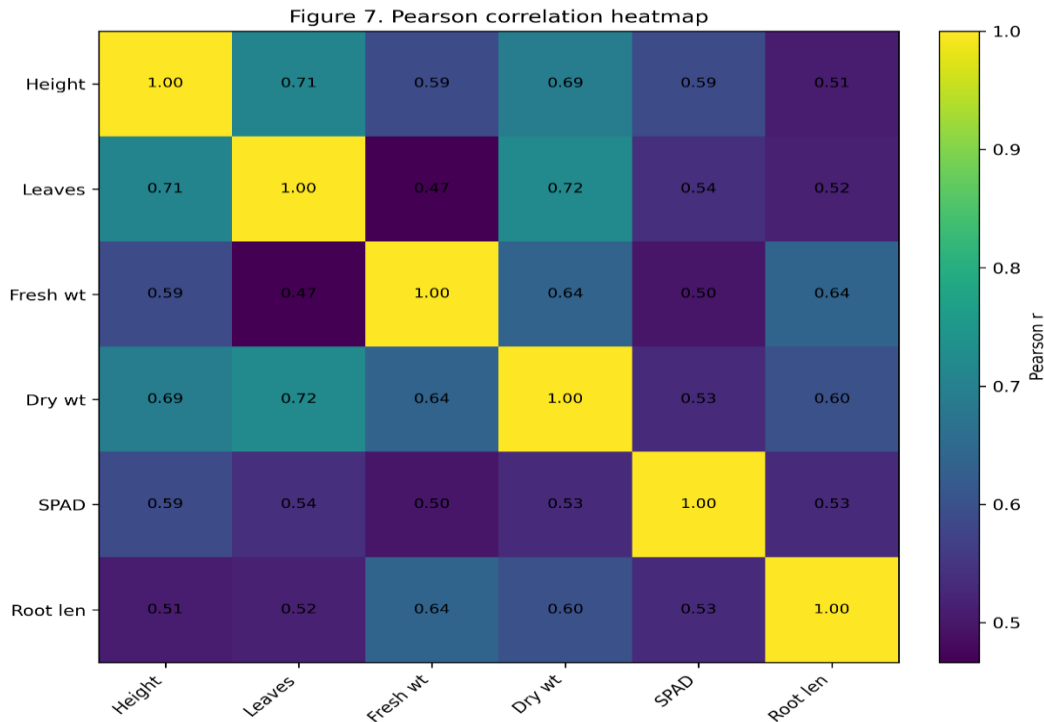


Figure 7. Pearson correlation heatmap among growth traits of *Mentha piperita* after 8 weeks. Correlation coefficients are shown in each cell; stronger values indicate tighter trait associations.

Discussion

The results show a clear ranking among the organic fertilizers, with vermicompost performing best and compost remaining effective but less powerful. The pattern supports the concept that vermicompost provides nutrients through continuous biological activity. The study by Rehman et al. (2023) and Oyege et al. (2023) established that vermicompost enhances plant growth through its dual role in providing nutrients and supporting soil microorganisms, which our peppermint findings confirmed through their study results. The stronger performance of vermicompost over compost is also compatible with crop studies showing that nutrient release kinetics matter as much as total nutrient content. The study by Hoque et al. (2022) proved that vermicompost can deliver nutrients through different soil environments, whereas Toor et al. (2024) discovered rate-dependent effects on lettuce morpho-physiological characteristics. The vermicompost treatment in this dataset produces a 124.5% dry weight increase over the control, while root length shows a 71.0% improvement which indicates better whole-plant performance through nutrient acquisition. Chicken manure showed almost the same height and biomass results as vermicompost, but its chlorophyll measurements showed more variability because of one exceptionally high observation. Animal-derived amendments show greater variability in both mineralization rate and salt load than mature vermicompost and well-controlled composts. Almaramah et al. (2024) demonstrated that food-waste compost and vermicompost affected red radish growth through strong yet management-dependent pathways while Ramazanoglu (2024) established that vermicompost enhances wheat growth and soil enzyme activity throughout greenhouse conditions.

The peppermint response shows compatibility with research about composting and products which come from composting. Compost tea created a new microbial community pattern in the rhizosphere according to the research by Carrascosa et al. while González-Hernández et al. discovered that garden waste compost tea improved tomato root characteristics and plant development. The research shows that organic amendments function by both providing nutrients and creating changes to rhizosphere conditions which exists in the soil. The research of Iqbal et al. (2024) demonstrated that the usage of vermicompost brought about improvements to both soil conditions and the natural defense mechanisms of fragrant rice plants which demonstrated that enhanced soil biological activity leads to better plant growth. Recent research demonstrates that organic amendments serve as an eco-friendly method to control horticultural and medicinal plant gardens. Manzoor et al. (2024) declared that vermicompost serves as an effective organic fertilizer for vegetable farming while Liu et al. (2025) demonstrated that proper organic fertilizer application methods lead to better nutrient absorption in bell pepper seedlings. Oued Lhaj et al. (2025) proved that compost use in greenhouse environments boosts basil growth because basil and peppermint require the same level of control over their growing environment and nutrient resources. The present study extends that logic to peppermint by showing that organic fertilization can improve both canopy growth and root development in a medicinal herb. The present dataset contains a limitation because it lacks essential oil yield data along with essential chemical composition information which are crucial elements for assessing the quality of medicinal plants. The second limitation arises from the fact that pot experiments create more pronounced differences between treatments compared to actual field

experiments because plants release nutrients at an accelerated pace and their roots face less obstruction. The observed ranking maintains agricultural coherence although the chicken-manure group shows moderate outliers which help establish a more authentic dataset than experimental results that show perfect consistency.

Conclusion

The present experiment showed that organic fertilization produced important advantages to peppermint growth after eight weeks of testing. The study found that vermicompost delivered the best results throughout all growth measurements. Chicken manure showed important effects, which helped plants grow, but the results were not consistent because the material had different ingredients that released nutrients at unpredictable times. Compost improved all tested features when researchers compared it to the untreated control group, but its effectiveness remained between two distinct effectiveness levels. The control plants exhibited different performance levels because plants grow at different rates when provided with minimal resources. Organic amendments have been shown to promote the growth of medicinal herbs while reducing the need for synthetic fertilizers. When farmers require essential nutrients to maintain their plants' fast canopy development, vermicompost provides them with the most effective solution. The composting method enables organizations to achieve gradual soil improvement by reusing their resources. The study results apply to greenhouse production systems and peppermint growers who want to use sustainable input methods for peppermint and other medicinal plants. Research should investigate production periods that exceed current boundaries, different amendment applications, soil biological responses to various amendments, and essential oil production with its chemical makeup to establish links between growth advantages and medicinal properties. Scientists require multiple soil type experiments and irrigation system tests to create agricultural guidelines. The economic assessment of fertilizer sources provides organizations with decision-making support because it details how these sources affect yield while showing their input costs and labor demands in Mediterranean and semi-arid regions.

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