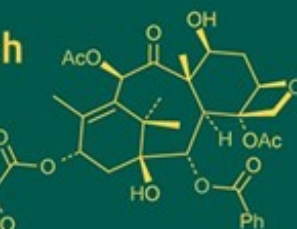
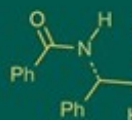
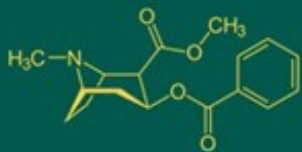


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Response of different organic nutrient sources on major growth parameters, yield attributes and carbon sequestration of mint (*Mentha spicata* L.)

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ABSTRACT

A field experiment was conducted to assess the response of different organic nutrient sources on growth, root development, herbage yield, carbon sequestration and economics of mint (*Mentha spicata* L.). Seven treatments comprising control, FYM @ 20 t ha⁻¹, vermicompost @ 5 t ha⁻¹, neem cake @ 4 t ha⁻¹, Jeevamrut @ 8000 L ha⁻¹, Panchagavya @ 6400 L ha⁻¹ and Go-Krupa Amrut @ 2500 L ha⁻¹ were evaluated. The results indicated considerable variation among organic nutrient sources for major growth and yield parameters. Vermicompost promoted vegetative growth, recording higher values for number of leaves (516). Go-Krupa Amrut (T₇) significantly improved plant height (41.33 cm), the number of branches (83.53) and root-to-shoot ratio (0.22), resulting in vigorous plant growth and higher biomass accumulation. The maximum herbage yield was obtained with Go-Krupa Amrut (496.03 g/plant, 14.88 kg/plot, 44,640 kg/ha), followed by Vermicompost (463.80 g/plant, 13.91 kg/plot, 41,740 kg/ha). Carbon sequestration had also shown superior results for both Go-Krupa Amrut and Vermicompost (119.79 t CO₂ ha⁻¹) compared to rest. The highest benefit-cost ratio of (3.00) was obtained with Go-Krupa Amrut, followed by vermicompost (2.82). The study indicated that vermicompost was particularly effective in improving vegetative growth and root development, while Go-Krupa Amrut enhanced biomass production, herbage yield and economic returns of mint.

Keywords: Carbon sequestration, Go-Krupa Amrut, *Mentha spicata*, Organic nutrients, Vermicompost

1. Introduction

Medicinal and aromatic plants play an important role in agriculture, healthcare and allied industries because of their therapeutic, nutritional and commercial value. India, with its diverse agroclimatic conditions, is well suited for the cultivation of a wide range of medicinal and aromatic crops. Among these, mint (*Mentha* spp.), belonging to the family Lamiaceae, is an economically important aromatic herb widely used in food, pharmaceuticals, cosmetics, perfumery and oral-care industries. Spearmint (*Mentha spicata* L.) is particularly valued for its aromatic foliage and essential oil, which is rich in carvone (57.71%), along with phellandrene, limonene, L-pinene and cineole (Wink, 2010) [1].

India is one of the leading producers and exporters of mint oil, with major cultivation concentrated in Uttar Pradesh, Punjab, Haryana, Bihar and Himachal Pradesh. Uttar Pradesh alone contributes about 80–90% of India's mint production (Karvy, 2011) [2]. Although mint is adaptable to a wide range of soils and climatic conditions, its cultivation remains relatively underexplored in regions such as the Konkan belt of Maharashtra. The growing demand for natural products and mint-derived essential oils further highlights the need for sustainable production practices.

Nutrient management is a major factor influencing the growth, yield and quality of mint. Excessive dependence on chemical fertilizers may adversely affect soil fertility, microbial activity and environmental quality. Therefore, organic nutrient sources such as farmyard manure, vermicompost, neem cake, Panchagavya, Jeevamrut and Go-Krupa Amrut have gained importance as sustainable alternatives. These inputs can improve nutrient availability, soil biological activity, soil structure and nutrient-use efficiency (Natrajan, 2002; Stamatiadis *et al.*, 1999; Kumar and Kumar, 2019) [3, 4, 5]. Neem seed cake additionally possesses pesticidal and nitrification-retarding properties (Parmar, 1986; Soon *et al.*, 1994) [6, 7].

Sustainable nutrient management can also contribute to carbon sequestration by increasing biomass production, soil organic carbon and biological activity. Crop carbon stock can be estimated using a carbon conversion factor of 0.45, while total carbon stock is obtained from crop and soil carbon pools. Carbon dioxide equivalent sequestration is estimated using the conversion factor 3.67 (Kumar *et al.*, 2023) [8]. Thus, organic nutrient management has the potential to improve mint productivity while enhancing soil health and carbon storage.

However, systematic information on the comparative performance of different organic nutrient sources in mint under Konkan conditions is limited. Therefore, the present study was undertaken to evaluate different organic nutrient management practices for their effects on growth, yield, soil fertility, profitability and carbon sequestration in mint.

2. Materials and methods

The field experiment was conducted at Nursery No. 4, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, under the College of Horticulture 2025-26. The experiment was conducted with different organic nutrient sources as treatments, which were replicated thrice. The design used was Randomized Block Design (RBD). Raised beds measured 3 m × 1 m were maintained, with a spacing of 45 cm × 30 cm. FYM, vermicompost and neem cake were applied uniformly at the rate of 20 t/ha, 5 t/ha and 4 t/ha, respectively to the respective plots and incorporated thoroughly into the soil. Whereas, drenching of jeevamrut, panchagavya and Go-Krupa Amrut was done frequently at 15 day intervals up to final harvest. Mint seedlings were transplanted by placing them approximately 5 cm deep into the soil, followed by proper soil covering and irrigation.

The crop was harvested thrice, 45 days after transplanting when the plant height reaches to about 24 cm or more. Harvesting was performed manually using a sharp scissor at a height of 2-3 cm above ground level. Second harvest was done at 60 days after transplanting and the final harvest was done at 30 days after second harvest. The economic performance of each treatment was assessed using gross return, net return and benefit-cost ratio.

3. Results and Discussion

3.1 Growth parameters

3.1.1 Plant height

Plant height of mint was significantly influenced by organic nutrient management at all stages of crop growth. Plant height increased progressively from 15 to 60 DAT under all treatments. At 15, 30 and 45 DAT, vermicompost @ 5 t ha⁻¹ (T₃) recorded the maximum plant height of 13.80, 19.57 and 27.20 cm, respectively, and remained statistically at par with Go-Krupa Amrut @ 2500 l ha⁻¹ (T₇). At 60 DAT, Go-Krupa Amrut recorded the highest plant height (41.33 cm), which was at par with vermicompost (40.20 cm), FYM (38.27 cm) and neem cake (37.93 cm), while the control recorded the lowest value (35.13 cm).

Similar treatment responses were observed after the second harvest. At 15 DAH, vermicompost recorded the maximum plant height (22.57 cm), whereas at 30 DAH, vermicompost and Go-Krupa Amrut recorded the highest value (36.87 cm). The superior performance of vermicompost and Go-Krupa Amrut may be attributed to improved nutrient availability, microbial activity, nutrient mineralization and root development, which favour cell division and elongation. Similar enhancement in plant height with vermicompost was reported by Shahjahan *et al.* (2013) [9] in kalmegh, Ayyobi *et al.* (2014) [10] in peppermint, Mahmoodabad *et al.* (2014) [11] in green mint and Keshavarz *et al.* (2018) [12] in mint. Mushar (2023) [13] also reported improved crop growth with Go-Krupa Amrut application.

3.1.2 Number of leaves

Organic nutrient management significantly affected the number of leaves plant⁻¹ at all stages of observation. Leaf production increased substantially from 15 to 60 DAT under all treatments. Vermicompost @ 5 t ha⁻¹ (T₃) produced the maximum number of leaves at 15 DAT (35.00), while Go-Krupa Amrut @ 2500 l ha⁻¹ (T₇) recorded the highest values at 30, 45 and 60 DAT (197.00, 469.67 and 516.00 leaves plant⁻¹, respectively). During crop regeneration, Go-Krupa Amrut recorded the maximum leaf number at 15 DAH (217.00), whereas vermicompost recorded the highest value at 30 DAH (404.67), which was at par with Go-Krupa Amrut (390.00).

The greater leaf production under vermicompost and Go-Krupa Amrut may be associated with improved nutrient availability, microbial activity, soil structure and root growth, resulting in enhanced vegetative development and photosynthetic capacity. The present findings are in agreement with Ayyobi *et al.* (2014) [10], who reported increased leaf production in peppermint with vermicompost application, and Uthirapandi *et al.* (2018) [14], who observed enhanced leaf production in holy basil with Panchagavya. Mushar (2023) [13] also reported improved vegetative growth with Go-Krupa Amrut.

3.1.3 Number of branches

The number of branches plant⁻¹ was significantly influenced by organic nutrient treatments at all stages. Branch production increased progressively during crop growth. Go-Krupa Amrut @ 2500 l ha⁻¹ (T₇) recorded the highest number of branches at 15, 30 and 45 DAT (4.60, 18.27 and 63.67 branches plant⁻¹, respectively) and also at 60 DAT (83.53 branches plant⁻¹). During regeneration, T₇ recorded the maximum branches at 15 DAH (23.33), while vermicompost @ 5 t ha⁻¹ (T₃) produced the highest number at 30 DAH (83.27), which was at par with Go-Krupa Amrut (81.13).

The improved branching under organic nutrient treatments may be attributed to enhanced nutrient availability, axillary bud development, root growth and photosynthetic assimilate production. Vermicompost-associated microorganisms and organic nutrient formulations may further improve nutrient mineralization and plant physiological activity. These results are supported by Shahjahan *et al.* (2013) [9] in kalmegh, Ayyobi *et al.* (2014) [10] in peppermint and Valiki *et al.* (2015) [15] in fennel, who reported improved branching with vermicompost application. Basavaraj *et al.* (2015) [16] also observed enhanced branching in French bean with Jeevamrut application.

Treatment	Growth Parameters (At 60 DAT)		
	Plant height (cm)	No. of leaves	No. of branches
T ₁ - Control	35.13	410.20	63.07
T ₂ - FYM (20 t/ha)	38.27	458.73	64.33
T ₃ - Vermicompost (5 t/ha)	40.20	410.67	61.60
T ₄ - Neem cake (4 t/ha)	37.93	439.53	62.00
T ₅ - Jeevamrut (8000 l/ha)	37.63	449.80	69.27
T ₆ - Panchagavya (6400 l/ha)	37.53	483.33	67.93
T ₇ - Go-Krupa Amrut (2500 l/ha)	41.33	516.00	83.53
Range	35.13 - 41.33	410.20 - 516.00	61.60 - 83.53
Mean	38.29	452.61	67.39
S.E. m (±)	1.150	9.236	3.987
CD at 5%	3.418	27.442	11.846
Result	SIG	SIG	SIG

3.2 Yield attributes

Herbage yield of mint was significantly influenced by organic nutrient management at all three harvests. At the first harvest (45 DAT), Go-Krupa Amrut @ 2500 l ha⁻¹ (T₇) recorded the highest yield (5650 kg ha⁻¹), which was at par with vermicompost @ 5 t ha⁻¹ (T₃; 5580 kg ha⁻¹). A similar trend was observed at the second and third harvests, with T₇ producing the maximum yields of (21410 and 17580 kg ha⁻¹), respectively and remaining statistically at par with T₃ (19380 and 16780 kg ha⁻¹).

Consequently, the highest total herbage yield was obtained with Go-Krupa Amrut (44640 kg ha⁻¹), followed by vermicompost (41740 kg ha⁻¹), whereas the control recorded (29570 kg ha⁻¹). The enhanced yield under Go-Krupa Amrut and vermicompost may be attributed to improved nutrient availability, microbial activity, root development and better expression of yield-contributing traits such as leaf and branch production, resulting in greater biomass accumulation. Similar positive responses of organic nutrient sources on crop growth and yield were reported by Prabu *et al.* (2013) [17], Ayyobi *et al.* (2014) [10], Bajeli *et al.* (2015) and Mushar (2023) [13].

3.3 Root to shoot ratio (dry weight basis)

Root-to-shoot ratio of mint was influenced by organic nutrient management. The mean ratio was 0.20, with the highest value (0.22) recorded under Go-Krupa Amrut (T₇) and neem cake (T₄), followed by vermicompost and control (0.21). Jeevamrut (T₅) recorded the lowest ratio (0.16). The higher ratio under Go-Krupa Amrut and neem cake may be associated with improved root development, nutrient uptake and balanced dry matter partitioning between roots and shoots. Organic nutrient sources may improve soil properties and nutrient availability, thereby supporting root growth and efficient biomass allocation.

Treatment	Herbage yield (kg ha ⁻¹)			
	1 st Harvest (At 45 DAT)	2 nd Harvest (At 60 DAT)	3 rd Harvest (At 30 DAH)	Total
T ₁ - Control	2580.00	14550.00	12440.00	29570.00
T ₂ - FYM (20 t/ha)	3070.00	18410.00	15230.00	36710.00
T ₃ - Vermicompost (5 t/ha)	5580.00	19380.00	16780.00	41740.00
T ₄ - Neem cake (4 t/ha)	630.00	16800.00	13090.00	30520.00
T ₅ - Jeevamrut (8000 l/ha)	2030.00	17420.00	13910.00	33360.00
T ₆ - Panchagavya (6400 l/ha)	2320.00	18200.00	14410.00	34930.00
T ₇ - Go-Krupa Amrut (2500 l/ha)	5650.00	21410.00	17580.00	44640.00
Range	630.00-5650.00	14550.00-21410.00	12440.00-17580.00	
Mean	3122.86	18024.29	14777.14	251470.00
S.E m (±)	553.263	939.236	602.791	
CD at 5%	1643.890	2790.717	1791.051	
Result	SIG	SIG	SIG	

3.4 Days to first harvest

Organic nutrient treatments significantly influenced the days required for first harvest. The mean duration was 46.14 days. Vermicompost (T₃) and Go-Krupa Amrut (T₇) resulted in the earliest harvest, both reaching harvestable stage at 45.00 days, whereas neem cake (T₄) required the longest period (47.33 days). The earlier harvest under vermicompost and Go-Krupa Amrut may be attributed to improved nutrient availability, microbial activity and root development, which promoted faster vegetative growth and biomass accumulation.

4. Carbon sequestration

Carbon sequestration is the process of capturing and storing carbon dioxide from the atmosphere to help reduce global warming and limit climate change. Carbon sequestration was significantly influenced by organic nutrient management and ranged from 85.03 to 119.79 t CO₂ ha⁻¹, with a mean of 105.22 t CO₂ ha⁻¹. The highest carbon sequestration (119.79 t CO₂ ha⁻¹) was recorded under Go-Krupa Amrut @ 2500 L ha⁻¹ (T₇) and vermicompost @ 5 t ha⁻¹ (T₃), whereas the control recorded the lowest value (85.03 t CO₂ ha⁻¹). The greater carbon sequestration under these treatments may be associated with enhanced nutrient availability, microbial activity, biomass production and plant growth which leads to high carbon content in biomass accumulation, ultimately increasing the amount of carbon retained in the crop-soil system.

5. Economics

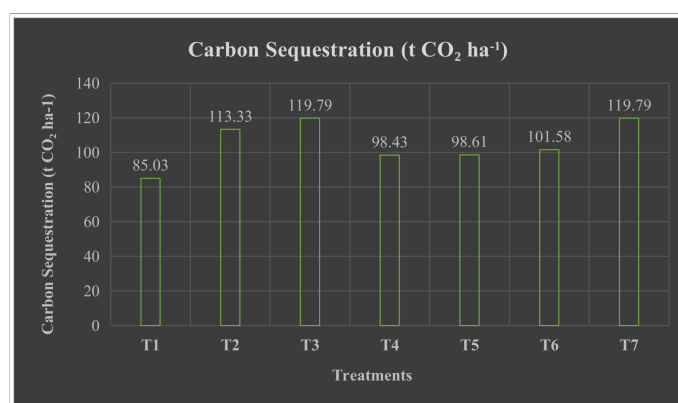
Economic analysis showed considerable differences among the treatments. The highest gross return was recorded with Go-Krupa Amrut (Rs. 17,85,600 ha⁻¹), followed by vermicompost (Rs. 16,69,600 ha⁻¹). Among the treatments, Go-Krupa Amrut @ 2500 l ha⁻¹ (T₇)

generated the highest net return of (₹ 11,89,664 ha⁻¹) and the highest B:C ratio of (3.00). Vermicompost @ 5 t ha⁻¹ (T₃) ranked second, with a net return of (₹ 10,78,497.70 ha⁻¹) and a B:C ratio of (2.82). Panchagavya @ 6400 l ha⁻¹ (T₆) recorded the lowest net return of (₹ 47,617 ha⁻¹) and the lowest B:C ratio of (1.04) due its high input cost.

Treatment	Root to shoot ratio (Dry weight basis)	Days to 1 st harvest
T ₁ - Control	0.21	46.67
T ₂ - FYM (20 t/ha)	0.20	46.00
T ₃ - Vermicompost (5 t/ha)	0.21	45.00
T ₄ - Neem cake (4 t/ha)	0.22	47.33
T ₅ - Jeevamrut (8000 l/ha)	0.16	46.67
T ₆ - Panchagavya (6400 l/ha)	0.20	46.33
T ₇ - Go-Krupa Amrut (2500 l/ha)	0.22	45.00
Range	0.16 - 0.22	45.00 - 47.33
Mean	0.20	46.14
S.E m (±)	0.005	0.313
CD at 5%	0.016	0.930
Result	SIG	SIG

Thus, Go-Krupa Amrut provided the highest economic return among the nutrient sources evaluated under the conditions of the experiment.

Treatment	Carbon sequestration (t CO ₂ ha ⁻¹)	Total cost of cultivation (Rs)	Yield (kg/ha)	Gross return (Rs)	Net return (Rs)	B:C ratio
T ₁ - Control	85.03	422969.3	29570	1182800	759830.7	2.80
T ₂ - FYM (20 t/ha)	113.33	702569.3	36710	1468400	765830.7	2.09
T ₃ -Vermi-compost (5 t/ha)	119.79	591102.7	41740	1669600	1078497.0	2.82
T ₄ - Neem cake (4 t/ha)	98.43	498902.7	30520	1220800	721897.3	2.45
T ₅ - Jeevamrut (8000 l/ha)	98.61	643116	33360	1334400	691284.0	2.07
T ₆ - Panchagavya (6400 l/ha)	101.58	1349583	34930	1397200	47617.0	1.04
T ₇ - Go-Krupa Amrut (2500 l/ha)	119.79	595936	44640	1785600	1189664.0	3.00
Range	85.03 -119.79					
Mean	105.22					
S.E m (±)	0.603					
CD at 5%	1.793					
Result	SIG					



6. Conclusion

The present study demonstrated that organic nutrient sources substantially influenced the growth, root development, biomass production and yield of mint. Vermicompost @ 5 t ha⁻¹ was particularly effective in improving vegetative growth in terms of number of leaves. In contrast, Go-Krupa Amrut @ 2500 L ha⁻¹ recorded superior performance for major growth-related parameters, including plant height, number of branches and also total herbage yield. It produced the highest total herbage yield of 44,640 kg ha⁻¹ and the highest B:C ratio of 3.00. Overall, Go-Krupa Amrut was associated with higher biomass production, herbage yield, carbon sequestration and economic returns in mint under the conditions of the present investigation.

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