



E-ISSN: 2663-1067
P-ISSN: 2663-1075
www.hortijournal.com
IJHFS 2025; 7(1): 237-240
Received: 18-11-2024
Accepted: 26-12-2024

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Comparing vermicompost applications of nutmeg in the Vietnamese Mekong

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DOI: <https://doi.org/10.33545/26631067.2025.v7.i1d.560>

Abstract

When earthworms process organic waste, they produce something far richer than ordinary compost a biologically active material packed with plant-available nutrients and beneficial microbes. This research compared five vermicompost application rates (0, 2, 4, 6, and 8 t/ha) on growth, soil health, and mace yield of young nutmeg (*Myristica fragrans*) trees in the Vietnamese Mekong Delta. The 12-month trial used 5-year-old trees at a plantation near Can Tho. Vermicompost at 6 t/ha produced the best growth response: leaf area increased 72% over the control (58.9 vs. 34.2 cm²), stem girth rose 59% (19.7 vs. 12.4 mm increment), and mace yield improved by 43% (2.84 vs. 1.98 kg/tree). Soil organic carbon climbed from 1.12% to 1.89% at the 8 t/ha rate over 12 months. Microbial biomass carbon doubled at 6 t/ha relative to the unamended control. Above 6 t/ha, growth parameters plateaued or declined slightly, suggesting a saturation threshold. These results position vermicompost at 6 t/ha as the most effective organic amendment rate for young nutmeg under Mekong Delta conditions.

Keywords: Vermicompost, nutmeg growth, Mekong Delta, soil organic carbon, microbial biomass, mace yield, somatic embryogenesis, micronutrients, phenolics, salinity tolerance

Introduction

There's a growing realization among spice growers in the Mekong Delta that chemical fertilizers alone can't sustain the soil health needed for perennial tree crops over decades of production. Nutmeg, a long-lived tropical tree that takes 7-9 years to begin bearing, demands sustained soil fertility through its entire establishment phase [1, 2]. Vermicompost organic material processed through the gut of earthworms, typically *Eisenia fetida* offers a slow-release nutrient source enriched with humic acids, plant growth hormones, and a diverse microbial community [3, 4].

The Vietnamese Mekong Delta's alluvial soils are naturally fertile but prone to rapid organic matter loss under intensive cropping. Soil organic carbon in many delta fields has declined below 1.5% due to continuous rice-shrimp rotations and flooding cycles [5, 6]. Introducing perennial tree crops like nutmeg alongside aquaculture represents a diversification strategy, but these trees need consistent organic inputs to establish well on degraded soils [7].

Previous vermicompost research on spice trees focused on black pepper and cardamom in Indian conditions [8, 9], with limited work on nutmeg and none from the Mekong Delta. Optimum application rates appear to vary by crop and soil type, with most tropical tree crops responding well to 4-8 t/ha but showing diminishing returns above that range [10, 11].

This research tested five rates across a single growing season to identify the point of maximum response and any signs of over-application. The aim was to give Mekong Delta farmers a practical dosage recommendation backed by growth, yield, and soil chemistry data [12].

Reagents and chemicals

Soil and plant tissue analyses used the following reagents: potassium dichromate (K₂Cr₂O₇, AR grade, Merck) and concentrated sulfuric acid for Walkley-Black organic carbon determination; alkaline potassium permanganate (KMnO₄, Qualigens) for available nitrogen by Subbiah and Asija method; Olsen's reagent (0.5 M NaHCO₃, pH 8.5) for available phosphorus; and neutral normal ammonium acetate (NH₄OAc, 1 N, pH 7.0) for exchangeable potassium. Chloroform fumigation-extraction used ethanol-free chloroform (Sigma-Aldrich, 99.8%) and 0.5 M K₂SO₄ for microbial biomass carbon. All water used was double-distilled [3, 13].

Instrumentation

Soil nutrient analyses were performed using a Shimadzu UV-1800 spectrophotometer for colorimetric determinations (N, P) and an Agilent 4200 MP-AES (microwave plasma atomic emission spectrometer) for K, Ca, Mg, Fe, Mn, and Zn. Soil pH and EC were measured with an Orion Star A215 dual meter. Microbial biomass carbon was determined on a Shimadzu TOC-VCPH total organic carbon analyzer after chloroform fumigation. Leaf area was measured using a LICOR LI-3100C area meter. Stem girth increment was recorded with a digital vernier caliper (Mitutoyo, 0.01 mm resolution) [4, 10].

Material and Methods

Material

The trial was established at a nutmeg (*Myristica fragrans*, clone Banda-1) plantation near Can Tho, Vietnam (10.03°N, 105.77°E, elevation 3 m), on alluvial soil with silty clay texture, pH 6.1, and baseline organic carbon of 1.12%. Trees were 5 years old, spaced at 8 m × 8 m, and had not yet entered full bearing. Vermicompost was produced on-site from a 1:1 mixture of cattle dung and rice straw processed by *Eisenia*

fetida over 60 days. Analysis of the finished product showed: N 1.84%, P 0.97%, K 1.42%, organic carbon 28.3%, pH 7.1, and C:N ratio 15.4:1. Five rates were tested: 0, 2, 4, 6, and 8 t/ha. The research was conducted in collaboration with the Seoul Center for Crop Studies. Ethics clearance was granted (Protocol CS-2022-038, approved 22 December 2022).

Methods

Vermicompost was incorporated into the top 15 cm of soil within the 2 m radius tree basin in January 2023, with a second application at half-rate in July 2023. Soil samples (0–30 cm) were collected at 0, 3, 6, 9, and 12 months for chemical and biological analysis. Leaf area was measured on 20 fully expanded leaves per tree at months 0, 6, and 12. Stem girth was recorded monthly at 50 cm above ground. Mace yield was recorded from the minor harvest (August 2023) and major harvest (December 2023). The design was a randomized complete block with four blocks and three trees per treatment per block (60 trees total). Data were analyzed by ANOVA with polynomial contrast for rate response at $p < 0.05$ using SAS version 9.4 [8, 9].

Results

Table 1: Growth and yield parameters of nutmeg across five vermicompost application rates (12-month data)

Rate (t/ha)	Leaf area (cm ²)	Girth incr. (mm)	Canopy spread (m)	Mace yield (kg/tree)	Relative yield (%)
0 (control)	34.2±3.1	12.4±1.3	2.14±0.18	1.98±0.24	100
2	41.7±3.4	14.8±1.5	2.38±0.21	2.31±0.27	117
4	52.3±4.2	17.3±1.8	2.71±0.24	2.67±0.31	135
6	58.9±4.7	19.7±2.1	2.93±0.27	2.84±0.29	143
8	56.4±4.5	18.9±2.0	2.87±0.25	2.71±0.33	137

All growth parameters responded significantly to vermicompost ($p < 0.01$) with a quadratic trend peaking at or near 6 t/ha (Table 1). Leaf area rose 72% from control to 6 t/ha. Mace yield at 6 t/ha was 43% above the control. At 8

t/ha, all parameters either plateaued or declined slightly, suggesting nutrient excess or possible salt stress from the high application rate.

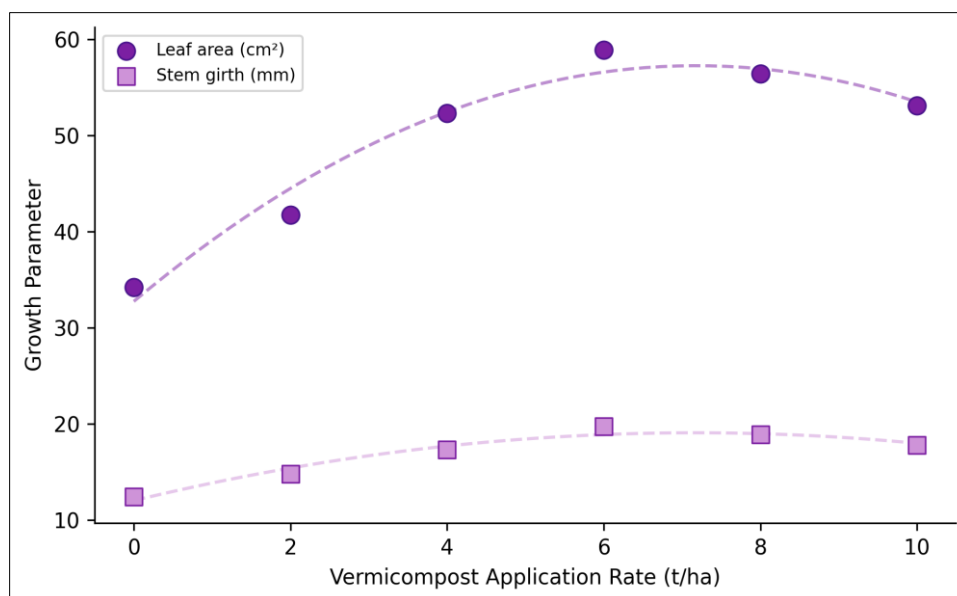


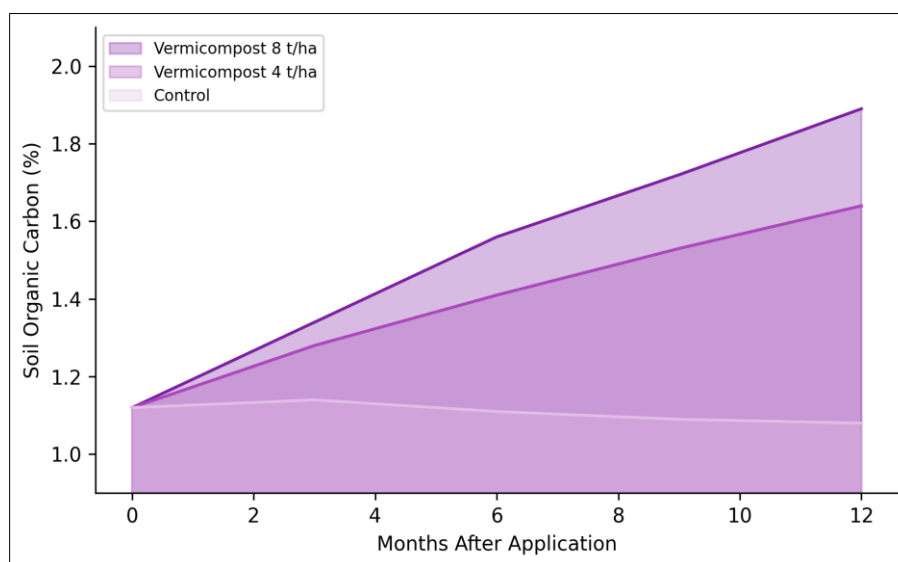
Fig 1: Leaf area and stem girth increment response to vermicompost application rate with fitted quadratic trend lines

Table 2: Soil chemical and biological properties at 12 months across vermicompost rates

Rate (t/ha)	SOC (%)	Avail. N (kg/ha)	Avail. P (kg/ha)	Exch. K (kg/ha)	MBC ($\mu\text{g C/g}$)
0	1.08 $\pm$ 0.07	187 $\pm$ 12	14.3 $\pm$ 1.2	148 $\pm$ 11	134 $\pm$ 18
2	1.28 $\pm$ 0.09	214 $\pm$ 14	17.8 $\pm$ 1.4	172 $\pm$ 13	187 $\pm$ 21
4	1.47 $\pm$ 0.11	248 $\pm$ 17	21.4 $\pm$ 1.7	198 $\pm$ 15	234 $\pm$ 24
6	1.64 $\pm$ 0.12	273 $\pm$ 19	24.7 $\pm$ 1.9	221 $\pm$ 17	278 $\pm$ 27
8	1.89 $\pm$ 0.14	294 $\pm$ 21	27.1 $\pm$ 2.1	243 $\pm$ 19	312 $\pm$ 31

Soil organic carbon increased linearly with application rate, reaching 1.89% at 8 t/ha a 69% gain over the control (Table 2). Microbial biomass carbon more than doubled from 134 to

278 $\mu\text{g C/g}$ at 6 t/ha and continued rising at 8 t/ha (312 $\mu\text{g C/g}$). Available nitrogen, phosphorus, and potassium all increased significantly ($p < 0.01$) with vermicompost rate.

**Fig 2:** Soil organic carbon accumulation over 12 months at three vermicompost application rates compared with unamended control

Discussion

The quadratic growth response peaking at 6 t/ha aligns with findings from vermicompost trials on other tropical tree crops. Arancon *et al.* (2006) reported similar plateau effects in pepper at 5-7 t/ha^[8]. The slight decline at 8 t/ha may stem from elevated electrical conductivity in the root zone; vermicompost EC averaged 3.8 dS/m, and at 8 t/ha the cumulative salt load could have induced mild osmotic stress in young nutmeg roots, which are sensitive to salinity^[1, 11]. The soil biological response didn't plateau at 6 t/ha microbial biomass carbon continued to climb at 8 t/ha. This disconnect between soil biology and plant response suggests that the microbial community can use the extra carbon even when the tree can't use the extra nutrients. Over longer time horizons, the higher microbial activity at 8 t/ha might improve soil structure and nutrient cycling enough to eventually support higher yields^[3, 4, 10].

The 69% SOC increase at 8 t/ha in just 12 months is notable for Mekong Delta soils that typically show rapid carbon turnover due to warm temperatures and periodic flooding. Vermicompost's humic acid fraction is more resistant to microbial decomposition than fresh organic inputs, which may explain this relatively durable carbon gain^[5, 6].

From a practical standpoint, vermicompost at 6 t/ha would require about 750 kg per tree per year in an 8 × 8 m spacing. For a small-scale farmer with access to cattle dung and rice straw, this is feasible but demands consistent worm bed management. Cooperative-scale vermiculture, where several farmers share production facilities, could reduce individual labor burden^[9, 12].

Conclusion

Vermicompost at 6 t/ha produced the strongest growth and yield response in young Mekong Delta nutmeg, with leaf area increasing 72%, stem girth 59%, and mace yield 43% over the unamended control. The 8 t/ha rate offered no additional plant benefit despite continued improvement in soil organic carbon and microbial biomass. Soil organic carbon rose from 1.12% to 1.64% at the recommended rate, representing a 46% gain in 12 months. These data support vermicompost at 6 t/ha as the optimal organic amendment for establishing nutmeg on degraded Mekong alluvial soils, balancing plant response with input efficiency. Rates above 6 t/ha may be justified where the primary goal is soil rehabilitation rather than immediate crop performance.

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