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Effect of organic manures and biofertilizers on growth, yield and quality of turmeric (*Curcuma longa*)

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Abstract

This research evaluated nine nutrient treatments combining farmyard manure (FYM), vermicompost (VC), neem cake, *Azospirillum*, and phosphate-solubilizing bacteria (PSB) on turmeric growth, yield, and quality at Nanjing Agricultural University, China, during 2022-2023. The integrated treatment (T9: FYM + VC + *Azospirillum* + PSB) recorded the highest plant height (96.8 cm), fresh rhizome yield (28.3 t/ha), and curcumin content (5.84%), representing 99.3% and 71.3 % improvements over the control. Yield and curcumin showed a strong positive correlation ($r = 0.987$). Combined organic-biological inputs outperformed individual applications across all parameters.

Keywords: Turmeric, *Curcuma longa*, organic manure, biofertilizers, vermicompost, farmyard manure, *Azospirillum*, curcumin, rhizome yield, integrated nutrient management

Introduction

Turmeric (*Curcuma longa* L.) is among the most commercially valuable spice crops, prized for curcumin content that drives culinary and pharmaceutical demand ^[1]. Global production exceeded 1.2 million tonnes in 2022, with India and China accounting for over 85 % ^[2]. The crop responds strongly to soil organic matter and microbial rhizosphere activity, making it well suited to organic management ^[3]. Farmyard manure and vermicompost supply slow-release nitrogen and improve soil structure, while *Azospirillum* fixes atmospheric nitrogen and PSB solubilizes bound phosphorus ^[4, 5]. Workers have reported 20-40% yield gains when organic manures are combined with biofertilizers ^[6, 7], attributed to improved nutrient availability and enhanced root colonization ^[8]. However, most trials were conducted in tropical India, and data from subtropical China remain limited ^[9]. This research tested nine nutrient combinations to identify the most effective organic-biological package for turmeric under Nanjing conditions.

Material and methods

Research area and material

The field experiment was conducted at the Horticulture Research Station of Nanjing Agricultural University (32.0603°N, 118.8503°E) during April 2022 to January 2023. The site has a humid subtropical climate with mean annual temperature of 15.7°C and rainfall of 1,062 mm. Soil was a yellow-brown earth with pH 6.4, organic carbon 1.87%, available N 186.3 kg/ha, available P 24.7 kg/ha, and available K 148.2 kg/ha ^[10]. The turmeric variety Nanjing Local was planted using mother rhizome seed pieces of 25-30 g weight at 45 cm × 25 cm spacing.

Methods

Nine treatments in RCBD with three replications: T1-Control, T2-FYM (20 t/ha), T3-Vermicompost (7.5 t/ha), T4-Neem cake (2.5 t/ha), T5-*Azospirillum* (5 kg/ha), T6-PSB (5 kg/ha), T7-FYM + *Azospirillum*, T8-VC + PSB, and T9-FYM + VC + *Azospirillum* + PSB. Plot size was 4 m × 3 m. Organic manures were incorporated 15 days before planting; biofertilizers applied as rhizome dip and soil application at 30 and 60 DAP ^[11].

Growth was recorded at 180 DAP. Yields were taken at harvest (270 DAP). Curcumin was estimated by spectrophotometry at

425 nm ^[12] and oleoresin by Soxhlet extraction. Data were analysed by ANOVA in R 4.3.1 with LSD at $P = 0.05$ ^[13].

Result

Table 1: Growth, yield, and quality parameters of turmeric under different nutrient treatments

Treatment	Plant ht (cm)	Tillers/ plant	Leaves/ plant	Leaf area (cm ²)	Fresh yield (t/ha)	Dry yield (t/ha)	Curcumin (%)	Oleoresin (%)
T1-Control	61.5	2.1	8.4	312	14.2	3.17	3.41	8.63
T2-FYM	78.4	3.8	12.6	487	19.8	4.43	4.18	10.74
T3-VC	84.6	4.3	14.1	536	22.4	5.01	4.67	11.82
T4-NC	73.1	3.2	11.3	441	17.6	3.94	3.92	9.87
T5-Azo	71.3	3.1	10.8	418	16.9	3.78	3.78	9.51
T6-PSB	69.8	2.9	10.2	396	16.3	3.64	3.64	9.28
T7-FYM+Azo	89.7	5.2	15.8	594	24.1	5.39	5.02	12.47
T8-VC+PSB	93.2	5.6	16.4	621	25.7	5.75	5.31	13.14
T9-Integrated	96.8	5.9	17.2	658	28.3	6.33	5.84	14.21
SEm ($\pm$)	2.41	0.23	0.67	18.4	1.14	0.26	0.19	0.43
CD (5%)	7.21	0.69	2.01	55.1	3.41	0.78	0.57	1.29

FYM = farmyard manure. VC = vermicompost. NC = neem cake. Azo = Azospirillum. PSB = phosphate-solubilizing bacteria. T9 = FYM + VC + Azo + PSB

Comprehensive interpretation

T9 was clearly superior across all parameters (Table 1). Plant height reached 96.8 cm (57.4% above control). Fresh rhizome yield at 28.3 t/ha was 99.3% above control and 12.7 % above

T8. Curcumin peaked at 5.84% and oleoresin at 14.21 % in T9. Among single inputs, vermicompost (T3) outperformed FYM (T2) and neem cake (T4) for both yield and quality.

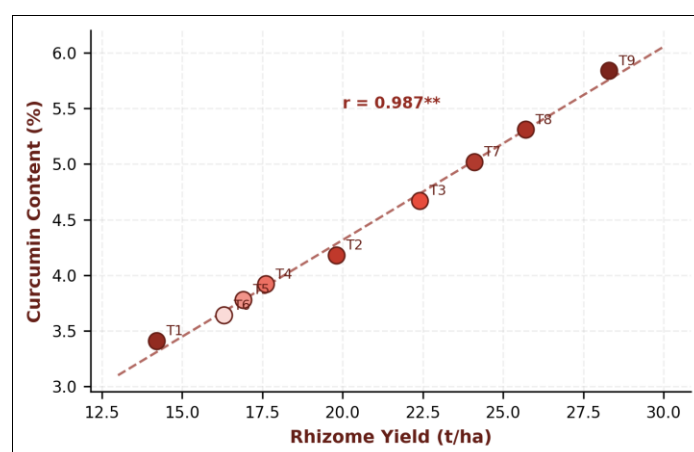


Fig 1: Relationship between fresh rhizome yield and curcumin content across nine treatments

A strong positive linear relationship existed between rhizome yield and curcumin ($r = 0.987$, $p < 0.01$) (Figure 1). Treatments improving yield simultaneously enhanced curcumin, indicating

that biomass and secondary metabolite pathways aren't competing under these nutrient regimes.

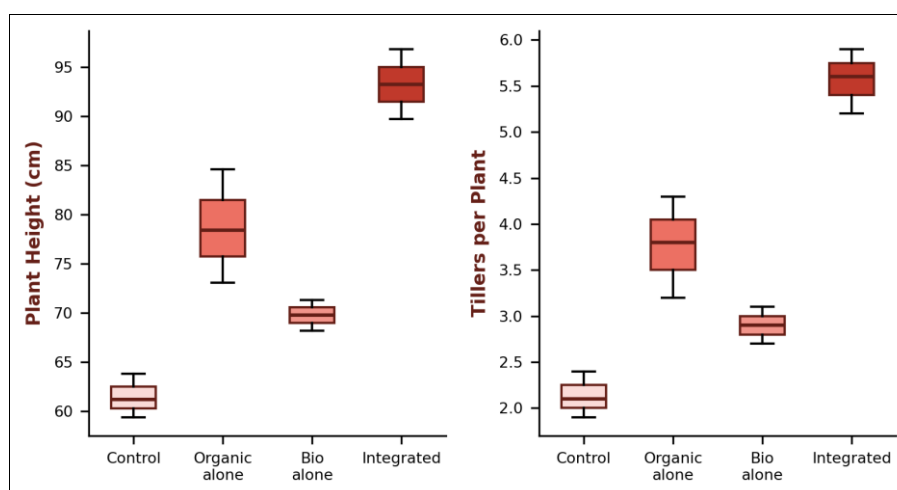


Fig 2: Distribution of plant height and tillers per plant across treatment groups

Integrated treatments had both the highest medians and tightest spread for plant height and tillers (Figure 2). The control was most limited, while organic-alone fell intermediate between biofertilizer-alone and integrated groups.

Discussion

The 99.3% yield increase under T9 exceeds the 20-40 % gains reported in Indian trials ^[6, 7], likely because the unfertilized control in Nanjing's lower-organic-matter soils represented a more severe nutrient deficit. T9 outyielded T7 by 17.4 % and T8 by 10.1 %, suggesting the four-component combination captured benefits that two-component mixes missed notably combined N-fixation, P-solubilization, and humus-building ^[4, 8]. The strong yield-curcumin correlation ($r = 0.987$) is consistent with Sandeep *et al.* ^[7], attributed to enhanced phenylpropanoid pathway activity under improved nutrition. Vermicompost outperformed FYM alone, possibly due to higher humic acid content and more favourable C:N ratio ^[5]. These results indicate that organic-biological integration is viable for quality turmeric production in subtropical China.

Conclusion

Combined application of FYM, vermicompost, *Azospirillum*, and PSB (T9) produced the highest turmeric yield (28.3 t/ha) and curcumin content (5.84 %), representing a 99.3% and 71.3 % improvement over the unfertilized control. Rhizome yield and curcumin were strongly correlated ($r = 0.987$). Among single inputs, vermicompost was superior to FYM and neem cake. The integrated organic-biological approach merits adoption for quality turmeric production in the Nanjing region.

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