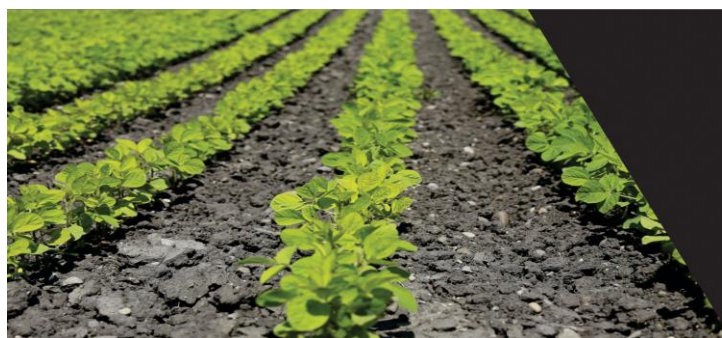




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Evaluation of organic nutrient management practices on growth, yield, quality and nutrient uptake of foxtail millet (*Setaria italica* (L.) P. Beauv.) and soil properties

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Abstract

A field experiment was conducted during *Rabi* season of 2025-26 at Zonal Agricultural and Horticultural Research Station, Hiriya, Karnataka to evaluate the impact of organic nutrient management practices on performance of foxtail millet (*Setaria italica* (L.) P. Beauv.) and soil properties. The field experiment was conducted in RCBD (Randomized Complete Block Design) consisted of 8 treatments viz. 75 per cent, 100 per cent, 125 per cent N equivalent organic nutrition through vermicompost and poultry manure along with recommended dose of FYM and control. Among these treatments, Application of the recommended dose of FYM together with 125 per cent N equivalent poultry manure (T₃) produced the tallest plants (120.95 cm), the highest number of tillers (2.53 plant⁻¹) and the largest leaf area (415.2 cm² plant⁻¹) at harvest, and recorded the highest grain yield (1334 kg ha⁻¹), straw yield (3136 kg ha⁻¹) and panicle length (12.2 cm), statistically on par with FYM + 125 per cent N equivalent vermicompost (T₆; 1283 kg ha⁻¹, 3015 kg ha⁻¹ and 11.7 cm, respectively). Test weight and grain crude protein content were not significantly influenced by treatment, whereas grain crude fibre content was significantly higher under T₆ (7.51%). Nitrogen, phosphorus and potassium concentrations in grain were not significantly affected by treatment, but nutrient uptake by both grain and straw was significantly higher under T₆ and T₃ than under all other treatments: T₆ recorded the highest grain N, P and K uptake (26.69, 5.77 and 4.65 kg ha⁻¹, respectively), statistically on par with T₃, while T₃ recorded the highest straw N, P and K uptake (26.35, 5.33 and 52.07 kg ha⁻¹, respectively), statistically on par with T₆. All growth, yield, quality and nutrient-uptake attributes were markedly depressed under the absolute control and under FYM applied alone relative to the combined organic treatments. The results indicate that supplementing FYM with a 125 per cent nitrogen equivalent dose of either poultry manure or vermicompost is agronomically superior to FYM applied alone for maximizing the growth, yield, grain quality and nutrient uptake of foxtail millet under semi-arid *rabi* conditions.

Keywords: Farmyard manure, foxtail millet, vermicompost, poultry manure, organic nutrient management

Introduction

Millets are small-seeded, climate-resilient cereals that have been cultivated for more than 10,000 years, primarily across the arid and semi-arid regions of the world, and constitute an important source of food, fodder and nutritional security as global agriculture is increasingly called upon to adapt to climate change and water scarcity (Sendhil *et al.*, 2023) [16]. India accounts for roughly 43 per cent of world millet production, with an annual output of 13.5 million tonnes from 9.5 million hectares (Muskan *et al.*, 2025) [13], and the Government of India has designated millets "Nutri-Cereals" following the United Nations' declaration of 2023 as the International Year of Millets (Muskan *et al.*, 2025) [13]. Foxtail millet (*Setaria italica* (L.) P. Beauv.) is one of the oldest cultivated cereals, believed to have originated along the Yellow River basin of China (Hariprasanna, 2023) [11]. It is nutritionally superior to many conventional cereals, being comparatively rich in protein (11%-12%) and dietary fibre (6.7%), low in fat (4%), and possesses a moderate glycaemic index of 59 that makes it a suitable dietary option for diabetic patients, in addition to being a valuable source of iron, zinc, magnesium and B-vitamins (Hariprasanna, 2023) [11]. As a short-duration C4 crop completing its life cycle in 60-90 days with limited soil moisture, foxtail millet is well suited to the Central Dry Zone (Agro-Climatic Zone IV) of Karnataka, where it is typically grown under rainfed conditions with

minimal external inputs by small and marginal farmers, making the development of efficient, low-cost organic nutrient packages agronomically and socio-economically relevant.

Continuous and injudicious use of synthetic nitrogen and phosphorus fertilizers has progressively degraded soil health across major agricultural zones of India, increasing the loss of reactive nitrogen to the environment roughly five-fold and reducing the nitrogen use efficiency of the food system (Adhya, 2010) ^[1]. Replacing chemical fertilizers with organic manures is increasingly recognized as an effective means of reversing these trends, improving soil fertility and physico-chemical characteristics while sustaining crop productivity and grain quality (Wang *et al.*, 2024) ^[22]. Because organic materials must be mineralized by soil microorganisms before their nutrients become plant-available, they supply nutrients gradually across the growth cycle in a manner that more closely matches crop demand than the rapid but transient availability associated with chemical fertilizers, and have also been shown to reshape soil biology in ways that favour sustained crop performance (Chen *et al.*, 2024) ^[8]. Among locally available organic resources, farmyard manure (FYM) has historically formed the base input of most organic nutrient management systems in India, improving soil physical properties and building soil organic carbon, but its relatively low and slow-release nitrogen content makes it an inadequate sole nitrogen source for short-duration, high-nitrogen-demand cereals such as foxtail millet. Poultry manure is comparatively rich in nitrogen and decomposes rapidly, favouring the quick crop response needed within the crop's roughly 60-day nitrogen-demand window, whereas vermicompost, produced through the bioconversion of organic residues by earthworms, is richer in humic and fulvic acids, plant growth regulators and a diverse beneficial microflora, and releases nutrients more gradually while contributing more distinctly to long-term soil fertility. Both materials have been reported to promote taller plants, greater tillering and higher leaf area when combined with FYM in millets (Bindu *et al.*, 2024; Naik *et al.*, 2017; Upendranaik *et al.*, 2018) ^[4, 14, 21], yet direct, dose-graded comparisons of the two under the semi-arid conditions of the Central Dry Zone of Karnataka remain limited.

Information on the relative efficiency of FYM supplemented with graded nitrogen equivalent doses of poultry manure or vermicompost on the growth, yield and grain quality of foxtail millet under these agro-climatic conditions is therefore scarce, despite its direct relevance to smallholder organic production systems. The present investigation was undertaken to study the "Influence of organic nutrient management practices on the growth, yield and quality of foxtail millet (*Setaria italica* (L.) P. Beauv.)" with the specific objective of comparing farmyard manure applied alone against farmyard manure supplemented with 75 per cent, 100 per cent and 125 per cent nitrogen equivalent doses of poultry manure or vermicompost, to identify the most agronomically effective organic nutrient combination for growth, yield and grain quality under rabi conditions in this agro-climatic zone.

Materials and Methods

Experimental site and weather conditions

The field experiment was conducted during *Rabi* 2025-26 at Babbur Farm, Zonal Agricultural and Horticultural Research Station (ZAHRS), Hiriyrur, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences (KSNUAHS), Shivamogga, Karnataka, India. The site falls under the Central Dry Zone (Agro-Climatic Zone IV) and is situated at 13°96' N latitude and 76°64' E longitude at an altitude of 613 m above mean

sea level. During the cropping season (November 2025 to February 2026), total rainfall was 33.4 mm, with the highest monthly total (19 mm) recorded in November and no rainfall in January or February; maximum temperature increased from 29.4°C to 34.0°C while minimum temperature was lowest in January (13.0°C); and relative humidity declined from 74.2 per cent to 51.05 per cent across the season.

Experimental design and treatments

The experiment comprised eight treatments replicated thrice in a randomized complete block design (RCBD), with a gross plot size of 4.5 m × 3.0 m (13.5 m²) and net plot size of 4.0 m × 2.5 m (10 m²). The recommended dose of FYM (6.25 t ha⁻¹) was common to all treatments except the absolute control, applied 10 days before sowing. The recommended dose of fertilizer (RDF) equivalent for the crop was 40:40:0 kg N:P₂O₅:K₂O ha⁻¹, and 100 per cent N equivalent poultry manure and vermicompost corresponded to 1315 and 2740 kg ha⁻¹, respectively. Foxtail millet variety SiA-326 (Prasad), a short-duration (70-75 days), drought-tolerant cultivar suited to rainfed and irrigated semi-arid conditions with a yield potential of 10-15 q ha⁻¹, was sown at 10 kg seed ha⁻¹ at a spacing of 30 cm × 10 cm.

T ₁	Absolute control
T ₂	Recommended dosage of FYM
T ₃	Recommended dosage of FYM + 125% N equivalent poultry manure
T ₄	Recommended dosage of FYM + 100% N equivalent poultry manure
T ₅	Recommended dosage of FYM + 75% N equivalent poultry manure
T ₆	Recommended dosage of FYM + 125% N equivalent vermicompost
T ₇	Recommended dosage of FYM + 100% N equivalent vermicompost
T ₈	Recommended dosage of FYM + 75% N equivalent vermicompost

Note: Recommended FYM (6.25 t ha⁻¹) was common to all treatments except T₁.

100% N equivalent poultry manure = 1315 kg ha⁻¹

100% N equivalent vermicompost = 2740 kg ha⁻¹.

Initial soil characterization

Composite soil sample from the experimental site was collected, thoroughly mixed and kept for air drying under shade. The air-dried soil sample was analysed for different physical and chemical properties and the result of the analysis is given in Table 1. Initial characterization of soil used for the field experiment indicates that the soil had a neutral pH of 8.39 with an electrical conductivity of 0.834 dS m⁻¹ and organic carbon content of 0.947 per cent. (Table 1)

Table 1: Initial physico-chemical properties of the experimental soil

Property	Value
pH (1:2.5)	8.39
Electrical conductivity (dS m ⁻¹)	0.834
Organic carbon (g kg ⁻¹)	0.947
Bulk Density (g cm ⁻³)	1.342
Textural class	Clay Loam
Available N (kg ha ⁻¹)	328.97
Available P ₂ O ₅ (kg ha ⁻¹)	49.55
Available K ₂ O (kg ha ⁻¹)	250.04

Crop husbandry

The land was ploughed once with a disc plough followed by two

harrowing to achieve fine tilth, after which stubble and weeds were removed. Nitrogen equivalent quantities of poultry manure and vermicompost were calculated from their respective nitrogen content and applied along with FYM 10 days before sowing, after which the manures were incorporated by ploughing. Seeds were sown by mixing with sand in furrows opened with a hand hoe. Thinning was carried out at 20 days after sowing (DAS) to maintain the required plant spacing. The crop received a life-saving irrigation immediately after sowing, with subsequent irrigations at early growth and reproductive stages, and was maintained weed-free by hand weeding. The crop was harvested when more than 75 per cent of panicles and leaves had turned brownish, after which the produce was sun-dried, threshed and winnowed.

Growth, yield and quality observations

Growth parameters plant height, number of tillers plant⁻¹ and leaf area were recorded from five randomly tagged plants per net plot at 30 DAS, 60 DAS and at harvest; leaf area was estimated by the Montgomery equation (Blaise and Girardin, 1992)^[6]. At harvest, test weight (g per 1000 seeds), grain yield and straw yield (kg ha⁻¹) were recorded from each net plot, and panicle length (cm) was measured on the tagged plants. Grain crude protein content was estimated from total nitrogen determined by the Kjeldahl method and multiplying by the factor 6.25 (Jackson, 1973; Doubetz and Wells, 1968)^[12, 9], and grain crude fibre content was determined by acid-alkali digestion following AOAC (1995)^[2].

Plant nutrient analysis

Grain and straw samples collected at harvest, and straw samples additionally collected at 30 and 60 DAS, were oven-dried at 65 ± 5°C to constant weight, ground and analysed for nitrogen, phosphorus and potassium concentration. Nitrogen was estimated

by the micro-Kjeldahl method following diacid digestion, phosphorus was estimated colorimetrically by the vanado-molybdo-phosphoric acid yellow-colour method, and potassium was estimated by flame photometry after diacid digestion (Piper, 1950; Jackson, 1973)^[15, 12]. Nutrient uptake by grain and straw was computed by multiplying the respective nutrient concentration (%) by the corresponding dry matter yield (kg ha⁻¹) and expressed as kg ha⁻¹.

Results

Growth parameters

Plant height, number of tillers plant⁻¹ and leaf area were significantly influenced by organic nutrient management practices at all recorded growth stages, except for tiller number at 30 DAS (Table 2). At 30 DAS, the tallest plants (41.44 cm) were recorded under T₃ (FYM + 125% N equivalent poultry manure), on par with T₆ (37.46 cm), T₇ (36.26 cm) and T₄ (35.04 cm), against 28.59 cm under T₂ (FYM alone). At 60 DAS, T₃ again recorded the tallest plants (74.43 cm), followed by T₆ (66.72 cm), compared with 50.92 cm under T₂. At harvest, T₃ produced the tallest plants (120.95 cm, a gain of approximately 55.6 per cent over the absolute control), followed by T₆ (106.73 cm), while T₂ and T₁ recorded the shortest plants (85.60 and 77.72 cm, respectively).

Tiller number did not differ significantly among treatments at 30 DAS, ranging numerically from 1.00 to 1.20 plant⁻¹. However, at 60 DAS and at harvest, T₃ recorded significantly higher tiller numbers (2.40 and 2.53 plant⁻¹, respectively) than all other treatments. Leaf area was significantly higher under T₃ at every stage observed (280.2, 622.8 and 415.2 cm² plant⁻¹ at 30 DAS, 60 DAS and harvest, respectively), compared with the lowest values recorded under T₁ (197.7, 439.5 and 293.1 cm² plant⁻¹).

Table 2: Effect of organic nutrient management practices on growth parameters of foxtail millet

Treatment	Plant height (cm)			Tillers (plant ⁻¹)			Leaf area (cm ² plant ⁻¹)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T ₁ - Absolute control	26.01	46.32	77.72	1.00	1.13	1.13	197.7	439.5	293.1
T ₂ - FYM	28.59	50.92	85.60	1.00	1.20	1.20	215.4	478.9	319.2
T ₃ - FYM + 125% PM	41.44	74.43	120.95	1.20	2.40	2.53	280.2	622.8	415.2
T ₄ - FYM + 100% PM	35.04	62.41	101.72	1.07	1.60	1.60	258.1	573.9	382.3
T ₅ - FYM + 75% PM	32.98	58.74	96.80	1.00	1.33	1.33	234.6	521.5	347.7
T ₆ - FYM + 125% VC	37.46	66.72	106.73	1.13	1.80	1.80	269.5	599.1	399.4
T ₇ - FYM + 100% VC	36.26	63.74	101.77	1.07	1.80	1.80	246.9	548.7	365.9
T ₈ - FYM + 75% VC	32.06	57.09	93.84	1.00	1.27	1.27	224.2	498.4	332.3
S.Em.±	2.59	3.00	5.02	0.05	0.12	0.13	3.43	7.33	4.87
CD (p=0.05)	7.86	9.21	15.08	NS	0.38	0.39	10.41	22.23	14.80

Note: PM = poultry manure; VC = vermicompost; FYM = farmyard manure; DAS = days after sowing; NS = non-significant.

Yield parameters

Grain yield, straw yield and panicle length were significantly improved by organic nutrient management (Table 3). T₃ recorded the highest grain yield (1334 kg ha⁻¹), statistically on par with T₆ (1283 kg ha⁻¹) and T₄ (1226 kg ha⁻¹), compared with T₁ (935 kg ha⁻¹), T₂ (1003 kg ha⁻¹) and T₈ (1060 kg ha⁻¹). Straw yield followed the same trend, with T₃ (3136 kg ha⁻¹), T₆ (3015 kg ha⁻¹) and T₄ (2881 kg ha⁻¹) exceeding T₁, T₂ and T₈ (2198, 2358 and 2492 kg ha⁻¹, respectively). Panicle length was greatest under T₃ (12.2 cm), on par with T₆ and T₄ (11.7 and 11.4 cm, respectively), compared with 9.7 cm under T₂. Test weight was not significantly

affected by treatment, ranging numerically from 3.07 g (T₁) to 3.32 g per 1000 seeds (T₃).

Grain quality parameters

Grain crude protein content was not significantly influenced by organic nutrient management, ranging numerically from 9.13 per cent under T₁ to 13.00 per cent under T₆ (Table 3). In contrast, grain crude fibre content differed significantly among treatments, with the highest value recorded under T₆ (7.51%), followed by T₃ (7.22%) and T₇ (6.90%), compared with 5.65 per cent under T₂ and 5.27 per cent under T₁.

Table 3: Effect of organic nutrient management practices on yield and grain quality parameters of foxtail millet

Treatment	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Test weight (g/1000 seeds)	Panicle length (cm)	Crude protein (%)	Crude fibre (%)
T ₁ - Absolute control	935	2198	3.07	9.1	9.13	5.27
T ₂ - FYM	1003	2358	3.19	9.7	9.81	5.65
T ₃ - FYM + 125% PM	1334	3136	3.32	12.2	11.44	7.22
T ₄ - FYM + 100% PM	1226	2881	3.20	11.4	12.50	6.58
T ₅ - FYM + 75% PM	1112	2613	3.15	10.4	10.88	6.26
T ₆ - FYM + 125% VC	1283	3015	3.29	11.7	13.00	7.51
T ₇ - FYM + 100% VC	1169	2747	3.12	10.9	11.94	6.90
T ₈ - FYM + 75% VC	1060	2492	3.14	10.0	10.37	5.97
S.Em.±	51	104	0.09	0.31	3.75	0.29
CD (p=0.05)	151	307	NS	0.94	NS	0.88

Note: PM = poultry manure; VC = vermicompost; FYM = farmyard manure; NS = non-significant.

Nutrient concentration and uptake by grain

Nitrogen, phosphorus and potassium concentrations in grain were not significantly affected by treatment, ranging numerically from 1.46 per cent to 2.08 per cent (N), 0.31 per cent to 0.45 per cent (P) and 0.26 per cent to 0.36 per cent (K), with the highest values recorded under T₆ (Table 4). In contrast, nutrient uptake by grain was significantly influenced by treatment: the highest N (26.69 kg ha⁻¹), P (5.77 kg ha⁻¹) and K (4.65 kg ha⁻¹) uptake occurred

under T₆, statistically on par with T₃ (26.68, 5.74 and 4.24 kg ha⁻¹, respectively), against markedly lower values under T₂ (15.75, 3.31 and 2.73 kg ha⁻¹) and T₁ (13.65, 2.90 and 2.38 kg ha⁻¹). This pattern indicates that the higher nutrient uptake by grain under the combined organic treatments was driven predominantly by the greater grain dry-matter yield rather than by differences in grain nutrient concentration.

Table 4: Effect of organic nutrient management practices on N, P and K concentration and uptake in grain of foxtail millet

Treatment	N (%)	N uptake (kg ha ⁻¹)	P (%)	P uptake (kg ha ⁻¹)	K (%)	K uptake (kg ha ⁻¹)
T ₁ - Absolute control	1.46	13.65	0.31	2.90	0.26	2.38
T ₂ - FYM	1.57	15.75	0.33	3.31	0.27	2.73
T ₃ - FYM + 125% PM	2.00	26.68	0.43	5.74	0.32	4.24
T ₄ - FYM + 100% PM	1.83	22.44	0.39	4.78	0.35	4.29
T ₅ - FYM + 75% PM	1.74	19.35	0.37	4.11	0.30	3.36
T ₆ - FYM + 125% VC	2.08	26.69	0.45	5.77	0.36	4.65
T ₇ - FYM + 100% VC	1.91	22.33	0.41	4.79	0.33	3.89
T ₈ - FYM + 75% VC	1.66	17.60	0.35	3.71	0.29	3.05
S.Em.±	0.60	1.05	0.07	0.14	0.03	0.13
CD (p=0.05)	NS	3.17	NS	0.43	NS	0.39

Note: PM = poultry manure; VC = vermicompost; FYM = farmyard manure; NS = non-significant.

Nutrient concentration and uptake by straw

Nitrogen concentration in straw increased progressively through the season and was significantly influenced by treatment at all stages; at harvest, the highest concentration (0.88%) was recorded under T₅, while T₁ and T₈ recorded the lowest (0.68%). Phosphorus concentration in straw was not significantly affected at 30 or 60 DAS but differed significantly at harvest, being highest under T₆ (0.19%) and lowest under T₁, T₂ and T₈ (0.13%). Potassium concentration in straw was significant only at harvest, with T₆ (1.71%) and T₄ (1.70%) recording the highest values

against 1.61 per cent under T₁. Nutrient uptake by straw at harvest, summarized in Table 5, was consistently highest under T₃, statistically on par with T₆, for all three nutrients: N uptake reached 26.35 kg ha⁻¹ under T₃ versus 14.94 kg ha⁻¹ under T₁; P uptake reached 5.33 kg ha⁻¹ under T₃ versus 2.86 kg ha⁻¹ under T₁; and K uptake reached 52.07 kg ha⁻¹ under T₃, on par with T₆ (51.55 kg ha⁻¹), versus 35.38 kg ha⁻¹ under T₁. Potassium uptake by straw substantially exceeded grain K uptake across all treatments, reflecting the typical partitioning of K toward vegetative tissue in millets.

Table 5: Effect of organic nutrient management practices on N, P and K concentration and uptake by straw of foxtail millet at harvest

Treatment	N (%)	N uptake (kg ha ⁻¹)	P (%)	P uptake (kg ha ⁻¹)	K (%)	K uptake (kg ha ⁻¹)
T ₁ - Absolute control	0.68	14.94	0.13	2.86	1.61	35.38
T ₂ - FYM	0.77	18.16	0.15	3.54	1.66	39.15
T ₃ - FYM + 125% PM	0.84	26.35	0.17	5.33	1.66	52.07
T ₄ - FYM + 100% PM	0.74	20.33	0.18	4.94	1.70	46.70
T ₅ - FYM + 75% PM	0.88	23.00	0.16	4.18	1.66	43.38
T ₆ - FYM + 125% VC	0.81	24.42	0.19	5.13	1.71	51.55
T ₇ - FYM + 100% VC	0.71	20.46	0.18	5.19	1.68	48.40
T ₈ - FYM + 75% VC	0.68	16.95	0.15	3.74	1.66	41.37
S.Em.±	0.04	0.773	0.016	0.163	0.006	1.685
CD (p=0.05)	0.13	2.345	NS	0.493	0.02	5.110

Note: PM = poultry manure; VC = vermicompost; FYM = farmyard manure; NS = non-significant.

Discussion

The consistently superior growth of foxtail millet under T₃ (FYM + 125% N equivalent poultry manure) is attributable to the comparatively rapid nutrient release of poultry manure, which would have provided nitrogen in excess of the crop's basal requirement early in the season, stimulating meristematic activity, cell elongation and greater leaf expansion through its central role in chlorophyll and protein synthesis. Bindu *et al.* (2024) [4] similarly reported taller plants, higher leaf area index and dry matter production with the recommended dose of nitrogen supplied through poultry manure, comparable with vermicompost but superior to FYM alone, in agreement with the present findings, while the common FYM baseline across treatments (except T₁) likely contributed to sustained soil physical structure and moisture retention favouring cell turgor and elongation (Upendranaik *et al.*, 2018) [21]. The higher tiller number under T₃ reflects the promotive effect of readily available nitrogen on axillary bud growth, consistent with Naik *et al.* (2017) [14], who observed higher tiller numbers in finger millet with an FYM plus bio-digester liquid manure combination attributed to sustained nitrogen availability, and with Swaroop and Debbarma (2023) [18], who reported significantly higher tiller numbers with poultry manure application. Ullasa *et al.* (2020) [19] recorded comparable tillering gains from FYM combined with 100 per cent N equivalent vermicompost in a long-term finger millet experiment, underscoring the general benefit of combined organic nutrition over sole FYM.

The higher grain and straw yields recorded under T₃, statistically on par with T₆, represent the integrated outcome of improved vegetative growth, greater tiller production and larger photosynthetic area translating into more efficient grain filling. These results parallel Bindu *et al.* (2024) [4], who reported comparable grain yield gains from poultry manure and vermicompost relative to FYM alone in foxtail millet, and Chandana *et al.* (2024) [7], who recorded a grain yield of 1.40 t ha⁻¹ with a vermicompost-based treatment, consistent with the present vermicompost-treatment yields. The longer panicles observed under T₃ are consistent with an abundant, timely nitrogen supply promoting cell division and elongation in the developing rachis during the reproductive phase, as also reported by Bindu *et al.* (2024) [4] and Upendranaik *et al.* (2018) [21]. Among quality parameters, the higher crude fibre content recorded under T₆ may reflect the more sustained, gradual nutrient release characteristic of vermicompost, which could shift the balance between structural carbohydrate and storage starch accumulation during grain filling toward greater fibre deposition, a pattern also reported by Bandita *et al.* (2022) [3] for FYM plus vermicompost combinations in finger millet.

The lack of a significant treatment effect on grain nutrient concentration, despite significant effects on total grain nutrient uptake, indicates that the observed uptake differences were driven primarily by dry-matter yield rather than by tissue nutrient concentration a pattern consistent with Bindu *et al.* (2022) [5] and Upendra (2017) [20], who reported that richer organic combinations of poultry manure or vermicompost maximized nitrogen, phosphorus and potassium uptake in foxtail millet mainly through higher biomass production rather than through elevated nutrient concentration per unit dry matter. The slightly higher nutrient concentrations recorded under vermicompost-based treatments (T₆, T₇) relative to poultry-manure-based treatments at equivalent nitrogen equivalent doses may reflect the more diverse and balanced nutrient profile of vermicompost, which supplies phosphorus and potassium alongside nitrogen in forms rendered more readily available through the humification

process, consistent with the findings of Sree *et al.* (2022) [17] in finger millet, who reported that vermicompost-supplemented treatments produced grain and straw nutrient concentrations comparable to or exceeding equivalent doses of poultry manure. The markedly higher straw nutrient uptake under T₃, statistically on par with T₆, mirrors the pattern observed for straw yield and reflects the greater vegetative biomass accumulated under both treatments across the season; the disproportionately higher potassium uptake by straw relative to grain across all treatments is consistent with the known physiological role of potassium in osmoregulation and enzyme activation within vegetative tissue, and with previous reports in millets that potassium is preferentially retained in straw rather than translocated to the grain (Bindu *et al.*, 2022) [5]. Taken together, the concordance between the growth, yield and nutrient-uptake responses across treatments confirms that combined organic nutrient management, whether through poultry manure or vermicompost supplementation of FYM, enhances plant nitrogen, phosphorus and potassium economy primarily by promoting greater biomass production rather than by altering the inherent nutrient-concentrating capacity of the plant tissue.

Conclusion

The results of the present field experiment demonstrate that organic nutrient management comprising farmyard manure supplemented with graded nitrogen equivalent doses of poultry manure or vermicompost significantly enhanced the growth, yield, grain quality and nutrient uptake of foxtail millet relative to farmyard manure applied alone, under rabi conditions of the Central Dry Zone of Karnataka. Farmyard manure combined with 125 per cent N equivalent poultry manure (T₃) recorded the highest plant height, tiller number and leaf area at all growth stages, together with the highest grain yield (1334 kg ha⁻¹), straw yield (3136 kg ha⁻¹), panicle length (12.2 cm) and straw nitrogen, phosphorus and potassium uptake, and was statistically on par with farmyard manure combined with 125 per cent N equivalent vermicompost (T₆) for grain and straw yield. Farmyard manure combined with 125 per cent N equivalent vermicompost (T₆) recorded the highest grain crude fibre content (7.51%) and the highest grain nitrogen, phosphorus and potassium uptake, statistically on par with T₃. Test weight, grain crude protein content and grain nutrient concentration were not significantly influenced by organic nutrient management, indicating that the observed gains in nutrient uptake were driven principally by increased biomass production rather than by changes in tissue nutrient concentration. Farmyard manure applied alone, although superior to the absolute control, was markedly inferior to the combined organic treatments for every growth, yield, quality and nutrient-uptake attribute studied. Farmyard manure supplemented with a 125 per cent nitrogen equivalent dose of poultry manure or vermicompost is therefore recommended as an agronomically superior organic nutrient management strategy for maximizing the growth, yield, grain quality and nutrient uptake of foxtail millet under semi-arid rabi conditions.

Future line of work

Based on the findings of the present investigation, the following areas are suggested for future research, evaluation of the same treatments on foxtail millet growth, yield and quality under kharif season conditions with higher rainfall variability, to determine whether the relative ranking of poultry manure and vermicompost treatments is consistent across contrasting moisture regimes; and multi-season evaluation of the same treatments across consecutive kharif and rabi seasons to determine whether the

yield and quality advantages observed in a single season are sustained or amplified with repeated organic inputs.

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