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Productivity enhancement of sorghum (*Sorghum bicolor* L.) through integrated nutrient management

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Abstract

A field experiment was conducted during the *kharif* season of 2025 at the College Farm, School of Agricultural Sciences, Malla Reddy University, Telangana, India, to evaluate the effect of integrated nutrient management (INM) practices on the growth, yield, and productivity of sorghum (*Sorghum bicolor* L.). The experiment was laid out in a randomized block design (RBD) with three replications. The treatments comprising different combinations of recommended doses of fertilizers (RDF), farmyard manure (FYM), urban compost, and NPK consortium. The recommended dose of fertilizer was 90:45:45 kg N: P₂O₅: K₂O ha⁻¹. Growth parameters, yield attributes, and yield were recorded at appropriate stages of crop growth.

The results revealed that the integrated use of organic and inorganic nutrient sources significantly affected sorghum growth and yield. Among the treatments, T₆ (100% recommended doses of fertilizer along with Urban compost @ 5 t ha⁻¹ and NPK consortium @ 2.5 kg ha⁻¹) recorded significantly higher plant height, dry matter production, leaf area index, grain yield, and stover yield, and was found to be superior over all other treatments. According to the study, applying an urban compost (5 t ha⁻¹) and NPK consortium (2.5 kg ha⁻¹) increased growth and yield characteristics of sorghum grains.

Keywords: Sorghum, Integrated nutrient management, Urban compost, FYM, NPK consortium, Productivity

Introduction

Sorghum (*Sorghum bicolor* L. Moench) is an important, climate-resilient cereal crop widely cultivated in semi-arid and arid regions worldwide, particularly in Asia and Africa. It plays a vital role in ensuring food, fodder, and livelihood security for smallholder farmers under low-input agricultural systems. Despite its adaptability to drought and marginal soils, sorghum productivity remains relatively low due to declining soil fertility, imbalanced nutrient application, and limited access to quality inputs (Verma *et al.*, 2025, and Singh *et al.*, 2025) ^[16, 12]. In India, sorghum is cultivated across a significant area, yet its average productivity remains below its global potential, underscoring the need for improved nutrient management strategies. The excessive and continuous use of chemical fertilizers has led to several adverse effects, including soil degradation, nutrient imbalance, reduced fertilizer-use efficiency, and environmental pollution. These challenges necessitate the adoption of sustainable nutrient management approaches that enhance crop productivity while maintaining soil health (Yadav *et al.*, 2025) ^[17]. Integrated Nutrient Management (INM) has emerged as an effective strategy that combines organic manures, biofertilizers, and inorganic fertilizers to achieve balanced nutrient supply and sustainable crop production.

Organic manures such as farmyard manure (FYM) play a crucial role in improving soil physical, chemical, and biological properties. FYM enhances soil structure, increases water-holding capacity, and promotes microbial activity, leading to improved nutrient availability and crop growth. Studies have demonstrated that the combined application of FYM with recommended doses of fertilizers significantly improves sorghum yield, nutrient uptake, and soil fertility status (Verma *et al.*, 2025) ^[16]. Similarly, urban compost derived from biodegradable municipal waste has gained importance as an eco-friendly nutrient source. It contributes to the recycling of organic waste, enhances soil organic carbon, and improves soil fertility when integrated with inorganic fertilizers (Patil *et al.*, 2024) ^[5].

Biofertilizers, particularly microbial consortia such as *Azotobacter*, phosphate-solubilizing bacteria (PSB), and potassium-mobilizing microorganisms, play a significant role in enhancing nutrient availability and plant growth. These microorganisms fix atmospheric nitrogen, solubilize insoluble phosphates, and produce growth-promoting substances in the rhizosphere. Integration of biofertilizers with organic and inorganic nutrient sources has been reported to improve crop productivity and soil biological health, often producing yields comparable to or higher than sole chemical fertilizer application (Singh *et al.*, 2025 and Tejbhan *et al.*, 2026) ^[12, 14].

INM not only improves crop yield but also enhances soil quality parameters such as soil organic carbon, microbial biomass, and nutrient cycling efficiency. In sorghum-based cropping systems, integrated use of FYM, compost, and biofertilizers along with chemical fertilizers has shown significant improvements in yield, nutrient uptake, and economic returns (Rajarithnam *et al.*, 2025 and Rani *et al.*, 2025) ^[8, 9]. Therefore, INM represents a sustainable and environmentally sound approach for improving sorghum productivity and maintaining long-term soil fertility under resource-constrained conditions.

Materials and Methods

The experiment was carried out during the kharif season of 2025 at the College Farm, School of Agricultural Sciences, Malla Reddy University, Telangana, India. The experimental site is situated at approximately 17° N latitude and 78° E longitude at an altitude of about 583 m above mean sea level. The climate of the region is semi-arid tropical in nature, characterized by moderate to high temperatures during the crop growth period with monsoonal rainfall.

The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction (pH), low to medium in organic carbon (0.29%), available nitrogen (196 kg ha⁻¹), available phosphorus (51.46 kg ha⁻¹) and available potassium (369 kg ha⁻¹) with electrical conductivity (0.34 dS m⁻¹), which was within the safe limit.

A field experiment was conducted in the experiment farm, SOAS, MRU. The experiment was set up in a randomized block design with 11 treatments, with a plot area of 4.5m x 3.9m. The treatments were as follows.

Treatment details

T₁ – Absolute control

T₂ – 100% RDF

T₃ – 100% RDF + FYM @ 12.5 t ha⁻¹

T₄ – 100% RDF+ FYM @ 12.5 t ha⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha⁻¹

T₅ – 100% RDF + Urban Compost @ 5 t ha⁻¹

T₆ – 100% RDF + Urban Compost @ 5 t ha⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha⁻¹

T₇ – 75% RDF

T₈ – 75% RDF + FYM @ 12.5 t ha⁻¹

T₉ – 75% RDF+ FYM @ 12.5 t ha⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha⁻¹

T₁₀ – 75% RDF + Urban Compost @ 5 t ha⁻¹ T₁₁ – 75% RDF + Urban Compost @ 5 t ha⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha⁻¹

RDF = 90:45:45 kg N, P₂O₅ and K₂O ha⁻¹

Half of the recommended dose of nitrogen was applied as basal at the time of sowing, while the remaining half was top-dressed in split doses at critical crop growth stages. Phosphorus and potassium were applied as basal at the time of sowing.

Crop management

The land was ploughed, cultivated, and rotavated to fine tilth and divided into 33 plots with irrigation channels. The recommended fertilizer dose (RDF) OF 90-45-45 kg N-P-K ha⁻¹ was applied through inorganic fertilizers. As per the treatments, FYM, urban compost, and NPK consortium were applied to the soil at the time of sowing. Half of the nitrogen, along with a full dose of phosphorus and potassium, was applied as basal, while the remaining nitrogen was top-dressed at critical growth stages of the crop. Seeds of sorghum were sown at a depth of 4 cm with a seed rate of 10 kg ha⁻¹. Gap filling was done at 10 days after sowing (DAS). Weed control involved pendimethalin @ 1 kg ha⁻¹ (pre-emergence) at 3 DAS, followed by hand weeding at 30 DAS. The crop was protected from pests and diseases by adopting recommended plant protection measures. The incidence of shoot fly was controlled by spraying imidacloprid @ 0.3ml L⁻¹, and grain mould disease was managed by spraying carbendazim @ 1g L⁻¹ at the flowering stage. At harvest, border rows were excluded, and the net plot produce was threshed and weighed for grain yield (adjusted to 14% moisture). Straw was sun-dried for 2-3 days before weighing.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) for a randomized block design with treatments as fixed effects and replications as blocks. Treatment means were compared using the critical difference (CD) at $p = 0.05$. The assumptions of normality and homogeneity of variance were verified from residual diagnostics.

Results and Discussion

Growth parameters

Table 1 shows that the plant height, leaf area index, and dry matter production were significantly influenced by integrated nutrient management treatments. Among all the treatments, T₆ (100% RDF + Urban compost @ 5 t ha⁻¹ + NPK consortium @ 2.5 kg ha⁻¹) recorded significantly higher growth attributes such as plant height (248 cm), leaf area index (4.0), and dry matter production (517 g plant⁻¹). It was statistically superior to all the treatments. The comparable performance among these treatments may be attributed to adequate nutrient supply through the recommended fertilizer dose with or without organic amendments. The improvement in growth under T₆ might be attributed to the enhanced availability of essential nutrients and improved physiological activity of the plant, which promoted cell division and elongation of growing tissue.

The improvement in leaf area index under integrated nutrient management may be due to the enhanced nutrient supply, particularly nitrogen, which plays a crucial role in leaf expansion and chlorophyll synthesis. The application of organic manure and biofertilizers improved soil fertility and microbial activity, leading to better nutrient availability and uptake. This resulted in increased leaf number, size, and duration, thereby enhancing the photosynthetic surface of the crop.

The higher dry matter production due to the improved photosynthetic efficiency and better nutrient utilization resulting from balanced nutrient supply. Improved leaf area and chlorophyll content increased photosynthesis and assimilate production, while improved plant growth facilitated nutrient uptake. These factors collectively lead to greater accumulation of biomass in plant tissues. Similar findings were reported by Verma *et al.* (2025) ^[16] and Suchithra *et al.* (2024) ^[13], who found that integrated nutrient management combining organic manures, biofertilizers, and inorganic fertilizers significantly

enhances plant height, leaf area index, and dry matter accumulation.

Grain yield

Table 2 shows that the treatments were significantly influenced by integrated nutrient management treatments. Among all the treatments, T₆ (100% RDF + Urban compost @ 5 t ha⁻¹ + NPK consortium @ 2.5 kg ha⁻¹) recorded the highest grain yield and was significantly superior to all other treatments. The superior performance of T₆ can be attributed to the combined effect of inorganic fertilizers ensuring immediate nutrient availability, urban compost improving soil physical properties, nutrient retention, and NPK consortium enhancing nutrient solubilization and microbial activity. The significant increase in grain yield under integrated nutrient management treatments corroborates earlier findings of Rao *et al.* (2024) [7] and Patel *et al.* (2025) [4], who reported enhanced grain productivity with the combined application of organic manures and chemical fertilizers. Shegokar *et al.* (2024) [10] showed significant improvements when biofertilizer and organic amendments were combined with recommended fertilization.

Stover yield followed a trend similar to grain yield. Treatment T₆ recorded significantly higher stover yield compared to all other treatments. This may be attributed to vigorous vegetative

growth, higher dry matter accumulation, and improved nutrient uptake resulting from integration of inorganic and organic nutrient sources. Higher stover yield observed under integrated nutrient management treatments is in agreement with Singh *et al.* (2024) [11] and Rao & Swamy (2024) [6], who attributed increased biomass production to continuous nutrient availability from organic and inorganic sources.

Harvest index was not significantly influenced by the integrated nutrient management treatments, indicating that nutrient sources have a limited effect on the partitioning of assimilates between grain and vegetative biomass. Although numerical differences were observed among treatments, they were not statistically significant. Similar observations were reported by Zhang *et al.* (2022) [18] and Kumar & Mehta (2024) [2].

Shelling percentage exhibited significant variation among the treatments. The highest shelling percentage recorded under T₆ - 100% RDF + Urban Compost @ 5 t ha⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha⁻¹, which is statistically superior over other treatments. Whereas T₁ - Absolute control recorded the lowest shelling percentage. The increase in shelling percentage could be attributed to better partitioning of assimilates towards grains rather than husk, resulting in a higher proportion of grain to total ear head weight. Similar results were reported by Tudu *et al.* (2023) [15].

Table 1: Effect of integrated nutrient management practices on growth attributes at 60 DAS, harvest of sorghum (*Sorghum bicolor* L.)

Treatments	Plant height (cm)		LAI		Dry matter production(g)	
	60 DAS	Harvest	60 DAS	Harvest	60 DAS	Harvest
T ₁ – Absolute control	88.5	160.2	2.35	2.82	23.7	48.3
T ₂ – 100% RDF	128.1	215.3	3.13	3.67	44.9	92.7
T ₃ – 100% RDF + FYM @ 12.5 t ha ⁻¹	130.1	218.3	3.15	3.72	45.5	94.6
T ₄ – 100% RDF+ FYM @ 12.5 t ha ⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha ⁻¹	149.3	241.0	3.52	4.18	53.3	115.0
T ₅ – 100% RDF + Urban Compost @ 5 t ha ⁻¹	133.0	221.0	3.16	3.78	45.9	99.2
T ₆ – 100% RDF + Urban Compost @ 5 t ha ⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha ⁻¹	160.0	251.8	3.53	4.20	55.8	121.1
T ₇ – 75% RDF	103.2	181.3	2.46	2.98	29.7	68.5
T ₈ – 75% RDF + FYM @ 12.5 t ha ⁻¹	118.0	201.4	2.81	3.38	35.9	84.2
T ₉ – 75% RDF+ FYM @ 12.5 t ha ⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha ⁻¹	120.0	209.3	2.72	3.54	37.4	86.7
T ₁₀ – 75% RDF + Urban Compost @ 5 t ha ⁻¹	116.5	206.6	2.78	3.42	38.3	86.4
T ₁₁ – 75% RDF + Urban Compost @ 5 t ha ⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha ⁻¹	124.2	212.7	3.08	3.58	38.9	90.5
SEm ±	4.3	6.4	0.10	0.13	2.0	4.0
CD (p = 0.05)	13.2	19.6	0.30	0.40	6.0	12.0

Table 2: Effect of integrated nutrient management practices on yield parameters of sorghum (*Sorghum bicolor* L.)

Treatments	Grain yield	Stover yield	Shelling percentage	Harvest index
T ₁ – Absolute control	2010	3565	60.43	35.6
T ₂ – 100% RDF	3880	6374	74.85	37.8
T ₃ – 100% RDF + FYM @ 12.5 t ha ⁻¹	3972	6512	73.38	37.7
T ₄ – 100% RDF+ FYM @ 12.5 t ha ⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha ⁻¹	4450	7578	76.91	38.0
T ₅ – 100% RDF + Urban Compost @ 5 t ha ⁻¹	4032	6603	73.65	37.9
T ₆ – 100% RDF + Urban Compost @ 5 t ha ⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha ⁻¹	4650	8261	77.78	38.0
T ₇ – 75% RDF	3116	5584	68.36	35.8
T ₈ – 75% RDF + FYM @ 12.5 t ha ⁻¹	3593	5917	72.95	37.7
T ₉ – 75% RDF+ FYM @ 12.5 t ha ⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha ⁻¹	3816	6273	74.12	37.8
T ₁₀ – 75% RDF + Urban Compost @ 5 t ha ⁻¹	3766	6195	72.34	37.8
T ₁₁ – 75% RDF + Urban Compost @ 5 t ha ⁻¹ + Soil application of NPK Consortia @ 2.5 kg ha ⁻¹	3968	6406	74.34	37.8
SEm ±	143	193	2.33	0.58
CD (p = 0.05)	379	585	7.07	NS

Conflict of Interest

The authors declare that they have no conflicts of interest relevant to this study.

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