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Yield and growth dynamics of Foxtail Millet (*Setaria italica* L.) under natural farming systems

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Abstract

A field experiment was carried out during *kharif*, 2025 on sandy loam soils of College Farm, Agricultural College, Mahanandi campus of Acharya N. G. Ranga Agricultural University, Andhra Pradesh in foxtail millet to study the effect of different doses of natural organic manures on crop growth and yield. The experiment was laid out in Randomized Block Design (RBD) with nine treatments replicated thrice. The experimental results revealed that application of Ghanajeevamrutham @ 1000 kg ha⁻¹ + Dravajeevamrutham @ 1000 kg ha⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS or Saptha Dhanyakura Kashayam @ 25 l ha⁻¹ significantly resulted in higher growth and yield attributes viz., plant height, drymatter production, leaf area index, SPAD chlorophyll content, no. of tillers plant⁻¹, no. of panicles m⁻², panicle length. Panicle weight and single panicle grain weight, thereby resulting in highest grain and straw yield. In contrast, lower growth, yield attributes and yield was obtained in Ghanajeevamrutham @ 500 kg ha⁻¹ and enriched farmyard manure @ 5 t ha⁻¹ along with foliar spray of Panchagavya 5% at 30 DAS and 45 DAS.

Keywords: Dravajeevamrutham, Ghanajeevamrutham, Saptha Dhanyakura Kashayam

1. Introduction

Current agricultural practices worldwide are under scrutiny due to the widespread use of pesticides and their adverse effects on health and the environment, leading to a global consensus that they must be gradually replaced by more sustainable methods like organic and natural farming. Consumers increasingly seek out organic-labelled foods, driving the need to reorient agriculture toward practices that minimize external inputs, promote intercultivation, and create balanced ecosystems by enhancing soil microbial health, where microorganisms play a key role in nutrient cycling and sustaining soil productivity. Natural farming relies on fermented bio-inputs such as Beejamrutham, Dravajeevamrutham, Ghanajeevamrutham, and Panchagavya, which are enriched with beneficial microbes to boost plant growth, vegetative development, yield, and quality. Among small millets, foxtail millet (*Setaria italica* L.) stands out as one of the oldest cultivated crops, playing a vital role in food and nutritional security, especially in rainfed and marginal agro-ecosystems of arid and semi-arid regions, thanks to its short growth duration, low water requirements, efficient water use, and ability to escape terminal drought. In India, known locally as Kakun or Kangni, it serves as a staple with exceptional nutritional value providing 331 kcal energy, 60.9 g carbohydrates, 12.3 g protein, 4.3 g fat, 6.7 g dietary fiber, and rich minerals like 290 mg phosphorus, 81 mg magnesium, 250 mg potassium, 31 mg calcium, 2.8 mg iron per 100 g, along with B-complex vitamins (0.59 mg thiamine, 0.11 mg riboflavin, 3.2 mg niacin) and its low glycaemic index makes it ideal for managing lifestyle disorders while supporting digestive health and metabolic regulation. Globally, it occupies 0.79 million hectares with 2.11 million tonnes production at 2688 kg/ha (FAO, 2021) ^[14], while in India, southern and central states like Andhra Pradesh (major districts: Kurnool, Kadapa, Anantapur), Karnataka, Tamil Nadu, and Telangana account for 90% of the area under mostly rainfed conditions, though average productivity remains low at 828 kg/ha amid declining cultivation due to commercial crops, yet renewed focus on nutritional security is reviving interest. Crop performance and grain quality in foxtail millet hinge on nutrient management, particularly nitrogen for vegetative growth, grain

development, and protein synthesis; under natural farming, indigenous inputs like Fish amino acid and Saptha Dhanyakura kashayam, alongside organic manures (farmyard manure, poultry litter, vermicompost), stimulate microbial activity, nutrient uptake, root development, soil organic carbon, structure, and water-holding capacity, ultimately improving yield, quality, mineral composition, and economic viability. Despite rising adoption of natural farming in Andhra Pradesh, region-specific evidence on growth, yield, quality, soil fertility, and economics for foxtail millet remains limited, necessitating research to standardize organic input quantities for optimal production and soil health enhancement. This article investigates the productivity and quality of foxtail millet under natural farming by evaluating various natural organic manures' effects on crop performance, soil fertility, and returns.

2. Materials and Methods

The experiment was conducted during *kharif*, 2025 at the College Farm, Agricultural College, Mahanandi, Andhra Pradesh, situated at 15.51° N latitude and 78.61° E longitude with an altitude of 233 m above mean sea level under semi-arid tropical conditions. The region experiences scarce rainfall with moderate temperature and humidity during the cropping period. The experiment was laid out in a Randomized Block Design (RBD) with nine treatments replicated thrice. The treatments consisted of different combinations of natural farming inputs including Ghanajeevamrutham, Dravajeevamrutham, fish amino acid, Saptha Dhanyakura Kashayam, and enriched farmyard manure along with Panchagavya. Prior to sowing, composite soil samples were collected randomly from 0–30 cm depth, air dried, ground, and passed through a 2 mm sieve for analysis. The soil was sandy loam in texture with 68.3% sand, 21.4% silt, and 10.3% clay. It was neutral in reaction (pH 7.38), low in organic carbon (0.41%) and available nitrogen (136.7 kg ha^{-1}), and high in available phosphorus (36.2 kg ha^{-1}) and potassium (554.6 kg ha^{-1}). Each plot was demarcated properly with bunds and irrigation channels as per layout. Beejamrutham seed treatment were uniformly followed for all treatments except the organic package treatment and mulching was practiced commonly for all treatments. The variety SiA 3159 of foxtail millet was sown on 31st of August at spacing of 30 cm × 10 cm. All the natural organic manures were prepared in site and applied as per treatment. The crop was sown on 31-07-2025 and harvested on 01-11-2025. Pre and post-harvest observations were recorded and data was subjected to statistical analysis.



Fig 1: Preparation of Ghanajeevamrutham



Fig 2: Preparation of Dravajeevamrutham

3. Results

3.1 Effect on crop growth

Growth attributes viz., plant height, drymatter production, leaf area index, SPAD chlorophyll content, number of tillers plant⁻¹ were significantly influenced by application of different doses of natural organic manures at all crop growth intervals.

Significantly taller plants with higher drymatter production, leaf area index, SPAD chlorophyll content and number of tillers plant⁻¹ were observed with the application of Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + foliar spray of fish amino acid 1% spray (T_6) and it was found to be on par with Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + foliar spray of Saptha Dhanyakura Kashayam spray @ 25 l ha^{-1} at panicle initiation and grain filling stage (T_8). Significantly lower growth attributes were noticed with Ghanajeevamrutham @ 500 kg ha^{-1} (T_1), which was comparable with the application of enriched farmyard manure and foliar spray of Panchagavya 5% at 30 DAS and 45 DAS treatment (T_9). similar findings were reported by Priyanka *et al.* (2019) [10], Atish *et al.* (2020) [3] and Bindu *et al.* (2024) [5].

Influence of different doses of natural organic manures was found to be non-significant on initial and final plant population, days to reach different phenological stages.

3.2 Effect on Yield Attributes

Among the different natural organic manure treatments, the highest values of yield attributes viz., number of panicles m⁻², Panicle length, panicle weight and Single panicle grain weight at harvest was reported with the application of Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS (T_6) and it was statistically on par with Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + foliar spray of Saptha Dhanyakura Kashayam @ 25 l ha^{-1} at panicle initiation and grain filling stages (T_8). Both treatments were significantly superior to the remaining treatments. The lowest yield attributes were recorded with Ghanajeevamrutham @ 500 kg ha^{-1} (T_1), which was comparable with the control treatment comprising enriched farmyard manure @ 5 t ha^{-1} + foliar spray of Panchagavya @ 5% at 30 DAS and 45 DAS (T_9). However, 1000 grain weight was not significantly influenced by the application of different doses of natural organic manures. These results are in line with the findings of Priya *et al.* (2019) [9] and Manduri *et al.* (2021) [6].

3.3. Effect on grain and straw yield

Grain yield and straw yield of foxtail millet was significantly influenced by the application of different natural organic manure treatments. Among the different doses of natural organic manures, the highest grain yield was recorded with Ghanajeevamrutham @ 1000 kg ha^{-1} + Dravajeevamrutham @ 1000 l ha^{-1} + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS (T_6), which was statistically comparable with

Ghanajeevamrutham @ 1000 kg ha⁻¹ + Dravajeevamrutham @ 1000 l ha⁻¹ + foliar spray of Saptha Dhanyakura Kashayam @ 25 l ha⁻¹ at panicle initiation and grain filling stages (T₈). Both treatments were significantly superior to the remaining treatments. In contrast, the lowest grain and straw yield was observed under Ghanajeevamrutham @ 500 kg ha⁻¹ (T₁), which remained on par with the control treatment comprising enriched farmyard manure @ 5 t ha⁻¹ + foliar spray of Panchagavya @ 5% at 30 DAS and 45 DAS (T₉). Harvest index was not significantly influenced by different natural organic manure treatments. Aravind *et al.* (2018) ^[2], Manjunatha *et al.* (2021) ^[7] and Tamilkanth *et al.* (2024) ^[12].

3.4. Effect on Economics

The data regarding economics was presented in Table 4.0 and the results revealed that highest values of gross returns, net returns and B:C ratio were recorded in treatment receiving application of Ghanajeevamrutham @ 1000 kg ha⁻¹ + Dravajeevamrutham @ 1000 l ha⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS (T₆) and this was followed by Ghanajeevamrutham @ 1000 kg ha⁻¹ + Dravajeevamrutham @ 1000 l ha⁻¹ + foliar spray of Saptha Dhanyakura Kashayam @ 25 l ha⁻¹ at panicle initiation and grain filling stages (T₈). The lowest values were recorded with Ghanajeevamrutham @ 500 kg ha⁻¹ (T₁), which remained on

par with the control treatment comprising enriched farmyard manure @ 5 t ha⁻¹ + foliar spray of Panchagavya @ 5% at 30 DAS and 45 DAS (T₉). A similar trend was reported by Ananda *et al.* (2018) ^[1] and Ramsheena *et al.* (2025) ^[11].

The enhanced growth and yield of foxtail millet under higher doses of natural organic manures may be attributed to improved nutrient availability, increased microbial activity, and better synchronization of nutrient release with crop demand. The combined application of Ghanajeevamrutham, Dravajeevamrutham, fish amino acid, and Saptha Dhanyakura Kashayam likely promoted nutrient mineralization, root growth, chlorophyll synthesis, and photosynthetic efficiency, resulting in greater plant height, dry matter production, leaf area index, tiller production, and biomass accumulation. Improved nutrient uptake and assimilate translocation from source to sink might have enhanced panicle development, grain filling, and yield attributes, leading to higher grain and straw yields. Furthermore, improved soil physical properties and moisture retention under these organic inputs could have created a favourable environment for crop growth under rainfed conditions, thereby enhancing the overall productivity of foxtail millet. Similar findings were reported by Upendranaik *et al.* (2018) ^[13], Bhadu *et al.* (2021) ^[4], Nadekar *et al.* (2024) ^[8].

Table 1: Growth attributes of foxtail millet as influenced by different natural organic manures

Treatment	Plant height			Drymatter production			Leaf area index (LAI)			Number of tillers plant ⁻¹
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	
T ₁ : Ghanajeevamrutham @ 500 kg ha ⁻¹	20.7	79.5	101.7	183	872	1322	0.89	1.22	1.18	3.6
T ₂ : Ghanajeevamrutham @ 1000 kg ha ⁻¹	24.3	86.3	103.5	235	1567	2463	1.16	1.71	1.26	4.2
T ₃ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 500 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	25.9	91.8	104.6	258	2291	3296	1.22	1.52	1.35	5.1
T ₄ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	26.4	96.4	106.8	269	2307	3779	1.25	1.80	1.41	5.8
T ₅ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 500 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	27.8	99.6	110.7	277	2903	4353	1.27	1.89	1.47	6.2
T ₆ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	29.5	104.9	113.2	283	3671	5581	1.36	2.53	1.73	8.6
T ₇ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of Saptha Dhanyakura Kashayam @ 25 l ha ⁻¹ at panicle initiation and grain filling stage	27.3	96.9	106.5	274	2953	4155	1.25	1.81	1.44	6.1
T ₈ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of Saptha Dhanyakura Kashayam @ 25 l ha ⁻¹ at panicle initiation and grain filling stage	28.7	101.4	112.1	276	3411	5374	1.31	2.43	1.71	8.2
T ₉ : Organic package – Enriched farmyard manure @ 5 t ha ⁻¹ + foliar spray of Panchagavya 5% at 30 DAS and 45 DAS	21.5	87.9	104.3	201	1014	1873	0.99	1.49	1.20	4.1
SEm ±	0.55	1.94	1.15	6.63	203.9	251.2	0.068	0.081	0.077	0.11
CD (P=0.05)	1.7	5.6	3.4	19.8	596	729	0.20	0.24	0.23	0.3
CV (%)	10.6	12.2	11.4	11.0	10.7	9.8	9.5	10.4	11.0	9.7

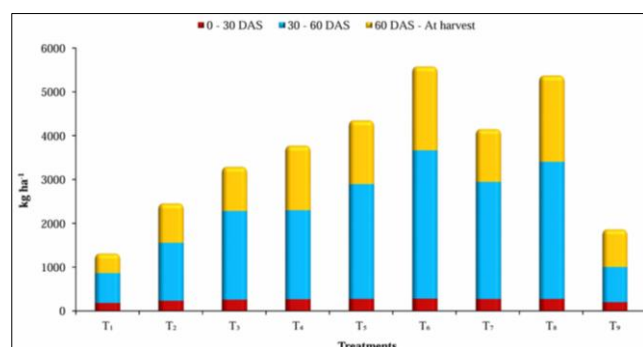
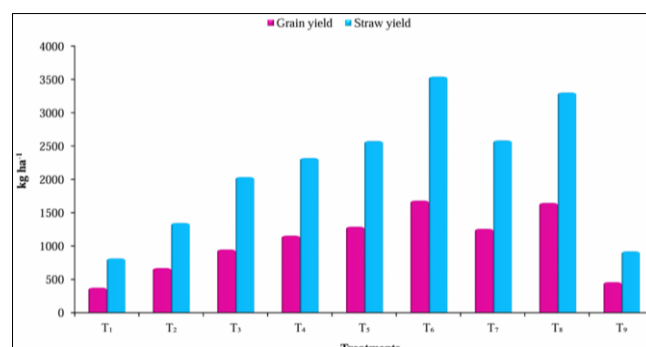
Table 2: Yield attributes of foxtail millet as influenced by different natural organic manures

Treatments	Number of panicles m ⁻²	Panicle length (cm)	Panicle weight (g)	Single panicle grain weight (g)
T ₁ : Ghanajeevamrutham @ 500 kg ha ⁻¹	43.3	6.32	7.43	2.43
T ₂ : Ghanajeevamrutham @ 1000 kg ha ⁻¹	48.3	7.28	9.28	2.45
T ₃ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 500 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	51.6	7.31	10.09	2.87
T ₄ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	53.2	8.43	12.46	3.31
T ₅ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 500 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	55.7	8.61	13.31	3.43
T ₆ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	73.5	9.75	15.75	4.13
T ₇ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of Saptha dhanyakura kashayam @ 25 l ha ⁻¹ at panicle initiation and grain filling stage	55.2	8.52	13.04	3.48

T ₈ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of Saptha dhanyakura kashayam @ 25 l ha ⁻¹ at panicle initiation and grain filling stage	61.8	9.53	15.43	4.06
T ₉ : Organic package – Enriched FYM @ 5 t ha ⁻¹ + foliar spray of Panchagavya 5% @ 30 DAS and 45 DAS	46.5	6.72	8.09	3.31
SEm ±	2.98	0.31	0.64	0.18
CD (P=0.05)	9.0	0.9	1.9	0.5
CV (%)	9.5	10.6	11.0	9.9

Table 3: Yield of foxtail millet as influenced by different natural organic manures

Treatments	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index (%)
T ₁ : Ghanajeevamrutham @ 500 kg ha ⁻¹	377	822	32.01
T ₂ : Ghanajeevamrutham @ 1000 kg ha ⁻¹	676	1352	33.92
T ₃ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 500 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	955	2039	32.52
T ₄ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	1162	2323	33.91
T ₅ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 500 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	1296	2578	34.12
T ₆ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	1686	3541	32.91
T ₇ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of Saptha dhanyakura kashayam @ 25 l ha ⁻¹ at panicle initiation and grain filling stage	1264	2586	33.42
T ₈ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of Saptha dhanyakura kashayam @ 25 l ha ⁻¹ at panicle initiation and grain filling stage	1652	3303	33.92
T ₉ : Organic package – Enriched FYM @ 5 t ha ⁻¹ + foliar spray of Panchagavya 5% @ 30 DAS and 45 DAS	462	927	33.71
SEm ±	62.3	140.0	7.64
CD (P=0.05)	188	423	NS
CV (%)	9.7	10.7	9.6

**Fig 3:** Drymatter production of foxtail millet at different crop growth intervals as influenced by different natural organic manures**Fig 4:** Grain yield and straw yield of foxtail millet as influenced by different natural organic manures**Table 4:** Economics of foxtail millet as influenced by different natural organic manures

Treatments	Gross returns (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	B: C ratio
T ₁ : Ghanajeevamrutham @ 500 kg ha ⁻¹	12475	939	1.08
T ₂ : Ghanajeevamrutham @ 1000 kg ha ⁻¹	22308	9272	1.71
T ₃ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 500 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	31580	16544	2.10
T ₄ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	38346	21810	2.32
T ₅ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 500 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	42761	26225	2.59
T ₆ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS	55723	37687	3.09
T ₇ : Ghanajeevamrutham @ 500 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of Saptha dhanyakura kashayam @ 25 l ha ⁻¹ at panicle initiation and grain filling stage	41741	24205	2.38
T ₈ : Ghanajeevamrutham @ 1000 kg ha ⁻¹ + Dravajeevamrutham @ 1000 l ha ⁻¹ + foliar spray of Saptha dhanyakura kashayam @ 25 l ha ⁻¹ at panicle initiation and grain filling stage	54516	35480	2.86
T ₉ : Organic package – Enriched FYM @ 5 t ha ⁻¹ + foliar spray of Panchagavya 5% @ 30 DAS and 45 DAS	14784	1753	1.13
SEm ±	672	494	0.119
CD (P=0.05)	2016	1482	0.36
CV (%)	9.7	9.7	9.7

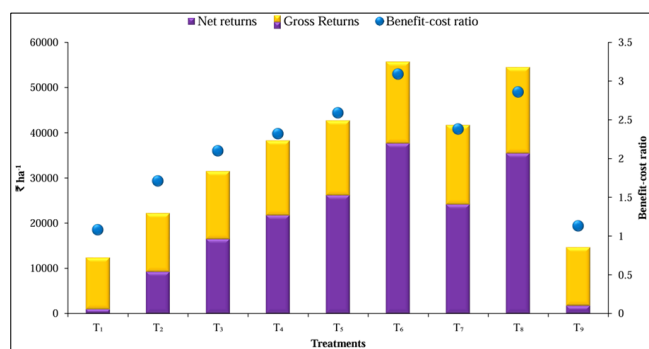


Fig 5: Economics of foxtail millet as influenced by different natural organic manures

Conclusion

The present study demonstrated that natural organic manures significantly enhanced the growth, yield attributes, and productivity of foxtail millet under natural farming conditions. Application of Ghanajeevamrutham @ 1000 kg ha⁻¹ + Dravajeevamrutham @ 1000 l ha⁻¹ + foliar spray of fish amino acid 1% at 30 DAS and 45 DAS or Ghanajeevamrutham @ 1000 kg ha⁻¹ + Dravajeevamrutham @ 1000 l ha⁻¹ + foliar spray of Saptha Dhanyakura Kashayam @ 25 l ha⁻¹ at panicle initiation and grain filling stages proved most effective in improving crop growth, grain and straw yield, therefore, the application of higher doses of Ghanajeevamrutham and Dravajeevamrutham supplemented with fish amino acid or Saptha Dhanyakura Kashayam can be recommended as an efficient and sustainable nutrient management strategy for enhancing the productivity and profitability of foxtail millet under natural farming conditions.

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