



# Effect of Organic Amendments and Micronutrient Foliar Application on Finger Millet (*Eleusine coracana* L.) Productivity under Calcareous Soil of Tamil Nadu

Jawahar V <sup>a\*</sup>, Mohanapriya R <sup>a</sup>, Udhaya Kumar K <sup>a</sup>,  
Balaganesh B <sup>b</sup> and Samyuktha C <sup>a</sup>

<sup>a</sup> Division of Agronomy, Karunya Institute of Technology and Sciences, Coimbatore (Tamil Nadu), India.

<sup>b</sup> Division of Soil Sciences and Agricultural Chemistry, Karunya Institute of Technology and Sciences, Coimbatore (Tamil Nadu), India.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

## Article Information

DOI: <https://doi.org/10.9734/ijpss/2025/v37i45385>

## Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://pr.sdiarticle5.com/review-history/133716>

Original Research Article

Received: 28/01/2025

Accepted: 01/04/2025

Published: 05/04/2025

## ABSTRACT

**Aims:** To study the effect of organic amendments and micronutrient foliar sprays on the growth and yield of finger millet in calcareous soils, which suffer from low organic matter and limited availability of essential micro and macro nutrients, hindering crop growth and productivity.

\*Corresponding author: E-mail: [jawaharv95@gmail.com](mailto:jawaharv95@gmail.com);

**Cite as:** V, Jawahar, Mohanapriya R, Udhaya Kumar K, Balaganesh B, and Samyuktha C. 2025. "Effect of Organic Amendments and Micronutrient Foliar Application on Finger Millet (*Eleusine Coracana* L.) Productivity under Calcareous Soil of Tamil Nadu". *International Journal of Plant & Soil Science* 37 (4):31-40. <https://doi.org/10.9734/ijpss/2025/v37i45385>.

**Study Design:** Factorial Randomised Block Design.

**Place and Duration of Study:** The field experiment was carried out during the rabi season from September 2024 – December 2024 at Instructional south farm in Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu.

**Methodology:** The field trial was laid out with three replications, and the treatments comprised soil amendments in factor (S) viz., S<sub>1</sub>- Pongamia seed cake @ 1.46 t ha<sup>-1</sup> +100 %RDF, S<sub>2</sub> - Neem seed cake @ 1.25 t ha<sup>-1</sup> + 100 % RDF, S<sub>3</sub>- Castor seed cake @ t ha<sup>-1</sup> + 100 % RDF, S<sub>4</sub> - FYM @ 12.5 t ha<sup>-1</sup> + 100 % RDF, S<sub>5</sub>- 100% RDF alone (Control) and foliar application of micronutrients in factor F viz., F<sub>1</sub>- Fe-EDTA 0.2% @ 30 and 45 DAS, F<sub>2</sub>- Zn-EDTA 0.5% @ 30 and 45 DAS, F<sub>3</sub>- Mn-EDTA 0.5% @ 30 and 45 DAS, F<sub>4</sub>- No spray (Control).

**Results:** The results showed that the application of Pongamia seed cake @ 1.46 t ha<sup>-1</sup>+100% RDF + Fe-EDTA 0.2% @ 30 and 45 DAS significantly improved the physiological parameters, such as RGR and NAR, and the growth characteristics, such as LAI, number of leaves per plant, and stem girth, with higher grain yield (2891 kg ha<sup>-1</sup>) and straw yield (5752 kg ha<sup>-1</sup>).

**Keywords:** Fe- EDTA; growth; nitrification inhibitors; Pongamia cake; yield.

## 1. INTRODUCTION

Finger millet, a staple food crop in Asia and Africa, is a nutritious cereal with 8.1% protein, 1.5% fat, and 68.1% starch. It contains 22% total dietary fibre, 1.9% mineral content, and 65-75% carbohydrates (Shobana et al., 2006). India is the world's largest finger millet producer, with 2 million tons produced in 2021, followed by Ethiopia. With 19.85 lakh metric tonnes and a productivity rate of 1724 kg ha<sup>-1</sup>, Karnataka (64.8%) dominates production, followed by Tamil Nadu (7.1%) and Maharashtra (5.4%) (Milletstats, 2022). Calcareous soils, found in dry and semi-arid climates, cover 1.5 billion acres and account for 17% of global soils. In India, they cover 69.4% of the country's total area, with Tamil Nadu covering 6-8% of its 13 million hectares (Bolan et al., 2023). High calcium carbonate levels in calcareous soils limit the availability of phosphorus, iron, and zinc, leading to lime-induced iron chlorosis, reduced seed germination, and poor water retention. Hardpan formation further restricts root growth and water infiltration, exacerbating soil degradation (Taalab et al., 2019; Virto et al., 2018). In such condition synthetic fertilizers are less effective due to nitrogen loss through ammonia volatilization and phosphorus fixation into insoluble forms. Application of organic amendments help mitigate these issues by stabilizing soil pH, improving soil structure, increasing porosity, and enhancing water-holding capacity. They also enrich humus carbon pools, boost labile carbon fractions, and enhance cation exchange capacity, improving nutrient availability. Additionally, organic amendments contribute to reducing excess calcium carbonate, further enhancing soil fertility and plant growth (Zaki et al., 2011; Li et al.,

2023). EDTA formulations effectively manage micronutrients, alleviating plant stress in calcareous soils. They enhance chlorophyll content, promote photosynthesis, and reduce nutrient stress, enhancing plant resilience and boosting crop growth (Shalini et al., 2023). Organic fertilizers enhance soil health and microbial activity, while chelated micronutrients address iron chlorosis in calcareous soils. Combining organic amendments with chelated micronutrients boosts crop growth and yields (Zaki et al., 2011).

## 2. MATERIALS AND METHODS

### 2.1 Location of the Experimental Site

The field experiment was conducted at Instructional South farm, Karunya Institute of Technology and Sciences, Coimbatore. The experimental site is geographically located in the western zone of Tamil Nadu at 10° N latitude and 76° E longitude at an altitude of 474 m above mean sea level.

### 2.2 Season and Crop Varieties

The study was conducted during the season of *rabi* from September 2024 to December 2024. The variety selected as finger millet was ATL 1 with a duration of 95-110 days.

### 2.3 Experimental Design

The field trial was laid out in factorial randomised block design with three replications the treatments comprised of soil amendments in factor (S) viz., S<sub>1</sub> -Pongamia seed cake @ 1.46 t ha<sup>-1</sup> +100 %RDF, S<sub>2</sub> - Neem seed cake @ 1.25 t ha<sup>-1</sup> + 100 % RDF, S<sub>3</sub>- Castor seed cake @ t ha<sup>-1</sup>

+ 100 % RDF, S<sub>4</sub>- FYM @ t ha<sup>-1</sup> + 100 % RDF, S<sub>5</sub>- 100 % RDF alone (Control), respectively in factor S and foliar application of micronutrients in factor F viz., F<sub>1</sub>- Fe-EDTA 0.2% @ 30 and 45 DAS, F<sub>2</sub>- Zn-EDTA 0.5% @ 30 and 45 DAS, F<sub>3</sub>- Mn-EDTA 0.5% @ 30 and 45 DAS, F<sub>4</sub>- No spray (Control).

## 2.4 Soil Characteristics

The experimental field soil is clay loam with an initial pH of 8.63 (1:2 soil-water suspension), EC of 0.23 dS m<sup>-1</sup> with Jackson (1973), organic carbon of 0.24% with Walkley & Black (1934). Available N 210.75 kg ha<sup>-1</sup> Alkaline permanganate method for available N suggested by Subbiah and Asija (1956), Olsen method for available P 12.24 kg ha<sup>-1</sup> (Olsen et al., 1954), K 174.36 kg ha<sup>-1</sup> by Neutral normal ammonium acetate method (Stanford and English, 1949) and free CaCO<sub>3</sub> of 12.5% and estimated with rapid titration method (Piper, 1966).

## 2.5 Application of soil Organic Amendments and Micronutrients

Organic amendments were applied one week before crop transplanting, based on nutrient equivalent rates. Pongamia cake, neem cake, and castor seed cakes were evenly distributed and irrigated to improve soil fertility. This approach promotes steady fertilizer release and sustainable nutrient management. A foliar spray of Fe-EDTA, Zn-EDTA, and Mn-EDTA was also given at the vegetative stage and flowering stage of crop.

## 2.6 Experimental Observations

### 2.6.1 Leaf area index

Leaf area was measured at 30, 60 DAS, and harvested using a leaf area meter. Leaf Area Index (LAI) was calculated using formula (Williams, 1946).

$$\text{Leaf Area Index} = \frac{\text{Leaf Area}}{\text{Ground area occupied by the crop}}$$

### 2.6.2 Number of leaves

The number of leaves per plant of finger millet was recorded at 30, 60 DAS and at harvest stage.

### 2.6.3 Stem girth

The stem girth of finger millet was measured with with digital Vernier caliper at 30, 60 DAS and harvest stage.

### 2.6.4 Relative growth rate

RGR assesses each observational stage was calculated by incorporating the corresponding dry matter accumulation values for that stage (Radford, 1967).

$$\text{RGR} (g g^{-1} day^{-1}) = \frac{\ln W_2 - \ln W_1}{T_2 - T_1}$$

### 2.6.5 Net assimilation rate

Net Assimilation Rate (NAR) is the rate of biomass gain per unit of leaf area, representing the efficiency of leaves in producing dry matter through photosynthesis over a specific time period (Watson, 1958).

$$\text{NAR} (g m^{-2} day^{-1}) = \left( \frac{W_2 - W_1}{T_2 - T_1} \right) \left( \frac{\ln LA_2 - \ln LA_1}{LA_2 - LA_1} \right)$$

### 2.6.6 Yield

The crop was harvested once the seeds turned brown, the earheads were dried to 15% moisture, threshed manually, cleaned, and then further dried to 12% moisture.

## 2.7 Statistical Analysis

The statistical analysis was carried out by AGRES software at 5% significant level of significance.

## 3. RESULTS AND DISCUSSION

### 3.1 Leaf Area Index

The impact of soil amendments with micronutrients on leaf area index of finger millet was depicted in Fig. 1. Leaf area index recorded higher with the soil application of Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF at 30 DAS and 60 DAS (2.03 and 2.86) and harvest with the Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF (4.10) followed by Neem cake @ 1.36 t ha<sup>-1</sup> + 100% RDF and lower leaf area index recorded in 100% RDF alone (1.60, 2.1 and 3.02). Nitrification inhibitors slow down the conversion of ammonium nitrogen to nitrate, ensuring a prolonged supply of ammonium nitrogen. This extends nitrogen availability supports improved protein synthesis, chlorophyll production, cell expansion, and an increase in dry matter, as reported by Chitte et al. (2016) and Sarkar et al. (2011). Among foliar sprays, Fe-EDTA 0.2% @ 30 and 45 DAS had the highest leaf area index at 30 DAS and harvest (2.11 and 3.8), while no

spray was the lowest (1.52 and 3.24). At 60 DAS, Fe-EDTA 0.2% @ 30 and 45 DAS high leaf area index of (2.7), followed by Zn-EDTA 0.5% @ 30 and 45 DAS, and lower LAI was observed under no spray (2.13). According to Das et al. (2016) and Meghana et al. (2019) Iron fertilization enhanced the photosynthesis and root growth, increasing leaf expansion and canopy development, leading to a higher LAI.

### 3.2 Number of Leaves

Fig. 2 illustrates the effect of soil amendments and micronutrients foliar application on the number of leaves per plant in finger millet. Soil application of organic amendments significantly increased the number of leaves per plant at different stages of crop 30 DAS, 60 DAS and harvest with Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF (13, 21 and 21 leaves) which is remained at par with neem seed cake @ 1.25 t ha<sup>-1</sup> + 100% RDF. Lower number of leaves recorded in 100% RDF alone (11, 18 and 18 leaves). Pongamia cake stimulates metabolic processes which promote leaf establish and growth by improving cell division and expansion. This results in more leaves, which enhances attributes of growth and the overall development of the plant reported by Biswas et al., (2023) and similarly reported by Chitte et al., (2016). At 30 DAS, 60 DAS and harvest number leaves per plant significantly increased with the foliar application of Fe-EDTA 0.2% @ 30 DAS and 45 DAS (12, 21 and 21 leaves) which was statistically superior with Zn-EDTA 0.5% @ 30 DAS and 45 DAS and lower number of leaves per plant significantly observed in No spray (11, 18 and 18 leaves) (Fig. 2). Due to the foliar application of micronutrients, particularly iron, Akthar et al. (2019) found a significant enhancement in chlorophyll content and leaf growth, leading to improved plant development. Similarly, Setyoningsih et al. (2024) reported that the application of Fe-EDTA as a foliar spray increased the availability of Fe<sup>2+</sup> in leaves, boosting photosynthesis and growth parameters, including the number of leaves.

### 3.3 Stem Girth

As shown in Fig. 3, the stem girth of finger millet is influenced by soil amendments and the foliar application of micronutrient. Application of Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF increased the stem girth at different stages of crop 30 DAS, 60 DAS and harvest (3.11 mm, 4.28 mm and 3.11 mm). stem girth significantly

lower in 100% RDF alone (2.2 mm, 3.17 mm and 2.23 mm). Chitte et al. (2016) reported that an ongoing nitrogen supply enhances cambial activity, promoting stem girth development and increasing dry matter production. This suggests a direct correlation between nitrogen availability and structural growth in plants. Foliar application of micronutrient significantly improved the crop growth and stem girth at 30 DAS, 60 DAS and harvest were Fe-EDTA 0.2% @ 30 DAS and 45 DAS (3.01 mm, 3.92 mm and 3.01) and lower stem girth significantly observed in No spray (2.31 mm, 3.49 mm and 2.31 mm). Akhtar et al. (2019) found that Fe-EDTA significantly enhanced the bioavailability of Fe<sup>2+</sup> in plants, thereby boosting chlorophyll production and enzyme activity, crucial for plant development thus increases the stem girth crucially.

### 3.4 Relative Growth Rate

Table 1 shows the influence of soil amendments and foliar nutrition on relative growth rate. RGR significantly increased at 30 DAS, 60 DAS and harvest by the soil application of Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF (0.056 g g<sup>-1</sup> d<sup>-1</sup>, 0.087 g g<sup>-1</sup> d<sup>-1</sup> and 0.046 g g<sup>-1</sup> d<sup>-1</sup>). Lower RGR significantly reduced in 100% RDF alone (0.049 g g<sup>-1</sup> d<sup>-1</sup>, 0.08 g g<sup>-1</sup> d<sup>-1</sup> and 0.038 g g<sup>-1</sup> d<sup>-1</sup>). Chitte et al., (2016) noted that Pongamia cake releases essential micro-nutrients, supporting chlorophyll synthesis and enzymatic activities crucial for vegetative growth, which promotes consistent cell division, tiller formation, and dry matter accumulation. Foliar application of micronutrient significantly increased the RGR with Fe-EDTA 0.2% @ 30 DAS and 45 DAS (0.055 g g<sup>-1</sup> d<sup>-1</sup>, 0.084 g g<sup>-1</sup> d<sup>-1</sup> and 0.044 g g<sup>-1</sup> d<sup>-1</sup>). The lowest RGR was significantly recorded in the no-spray treatment, with values of 0.05 g g<sup>-1</sup> d<sup>-1</sup>, 0.08 g g<sup>-1</sup> d<sup>-1</sup>, and 0.04 g g<sup>-1</sup> d<sup>-1</sup>. The catalytic role of iron in enzymatic reactions, hormone production, and protein synthesis enhanced cell division and metabolic activity, leading to sustained growth, as also reported by Baishya et al. (2016).

### 3.5 Net Assimilation Rate

The impact of soil amendments and foliar nutrition on the net assimilation rate is displayed in Table 1. There is a significant increased NAR at 30, 60 DAS and harvest with the Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF (0.075 g m<sup>-2</sup> d<sup>-1</sup>, 0.024 g m<sup>-2</sup> d<sup>-1</sup> and 0.0049 g m<sup>-2</sup> d<sup>-1</sup>). Significantly lower NAR recorded in Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF (0.059 g m<sup>-2</sup> d<sup>-1</sup> and 0.016 g m<sup>-2</sup> d<sup>-1</sup>). Similarly, Paramasiva

et al. (2020) noted that Pongamia cake releases essential micro-nutrients, supporting chlorophyll synthesis and enzymatic activities crucial for vegetative growth. It doesn't show any significant improvement in NAR at 30DAS. No significant improvement in NAR was observed at 30 DAS. However, at 60 DAS, Fe- EDTA0.2% @ 30 & 45 DAS recorded a significantly higher NAR ( $0.2 \text{ g m}^{-2} \text{ d}^{-1}$ ), whereas the lowest NAR ( $0.019 \text{ g m}^{-2} \text{ d}^{-1}$ )

was observed under no spray. At harvest, no significant difference in NAR were recorded. The increased RGR due to Fe-EDTA application can be attributed to its role in enhancing chlorophyll synthesis and photosynthetic efficiency, which improves the interception of photosynthetically active radiation and promotes higher dry matter accumulation, as reported by Das et al. (2016) and Rakesh et al. (2012).

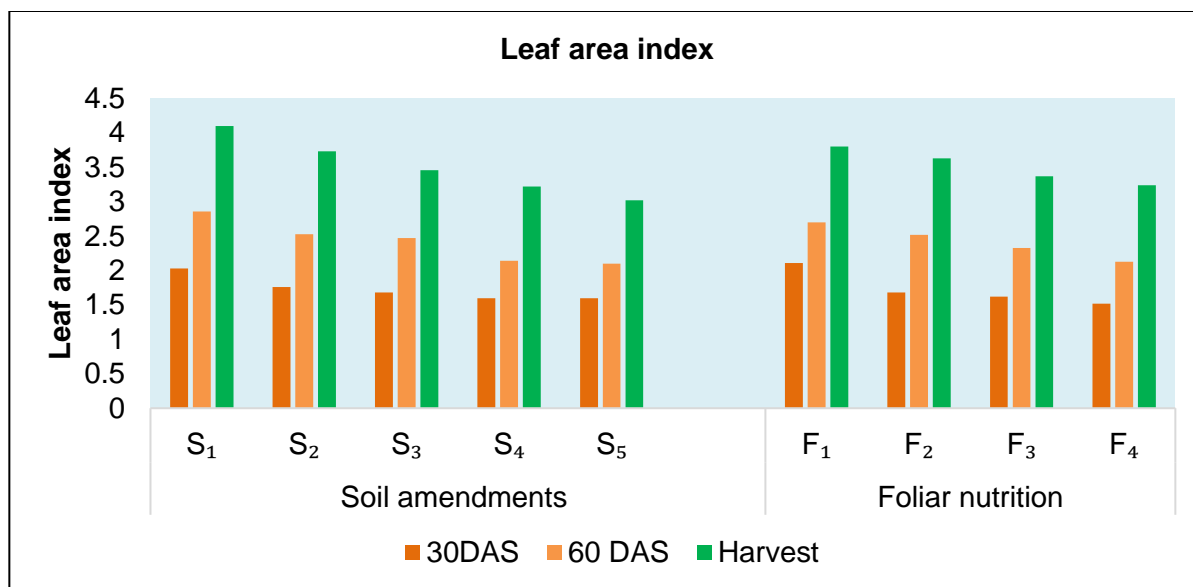


Fig. 1. Effect of soil organic amendments and micronutrients foliar on leaf area index of finger millet

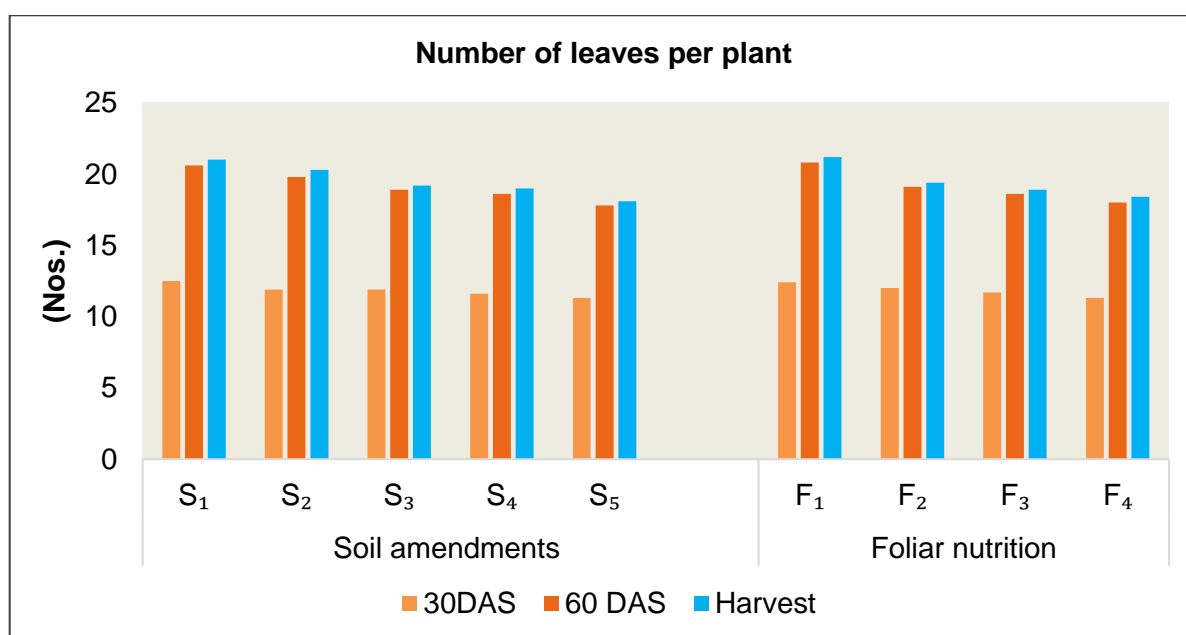


Fig. 2. Effect of soil organic amendments and micronutrients foliar on number of leaves per plant of finger millet

**Table 1. Effect of soil amendments and foliar nutrition on relative growth rate, net assimilation rate of finger millet**

Treatments	Relative growth rate (g g <sup>-1</sup> day <sup>-1</sup> )			Net assimilation rate (g m <sup>-2</sup> day <sup>-1</sup> )		
	0-30 DAS	30-60 DAS	60 DAS - Harvest	0-30 DAS	30-60 DAS	60 DAS -Harvest
<b>Soil amendments (S)</b>						
S <sub>1</sub> - Pongamia seed cake @ 1.46 t ha <sup>-1</sup> +100 %RDF	0.056	0.087	0.046	0.075	0.024	0.0049
S <sub>2</sub> - Neem seed cake @ 1.25 t ha <sup>-1</sup> + 100 % RDF	0.052	0.085	0.042	0.067	0.019	0.0047
S <sub>3</sub> - Castor seed cake @ 1.45 t ha <sup>-1</sup> + 100 % RDF	0.051	0.081	0.042	0.062	0.018	0.0047
S <sub>4</sub> - FYM @ 12.5 t ha <sup>-1</sup> + 100 % RDF	0.050	0.080	0.040	0.059	0.018	0.0044
S <sub>5</sub> - 100 % RDF alone (Control)	0.049	0.080	0.038	0.059	0.016	0.0045
Sed	0.001	0.001	0.001	0.003	0.001	0.0002
CD (P=0.05%)	0.002	0.003	0.002	0.005	0.002	NS
<b>Foliar nutrition (F)</b>						
F <sub>1</sub> - Fe-EDTA 0.2% @ 30 and 45 DAS	0.055	0.084	0.044	0.066	0.02	0.0048
F <sub>2</sub> - Zn-EDTA 0.5% @ 30 and 45 DAS	0.052	0.083	0.041	0.065	0.02	0.0047
F <sub>3</sub> - Mn-EDTA 0.5% @ 30 and 45 DAS	0.051	0.083	0.041	0.063	0.017	0.0046
F <sub>4</sub> - No spray (Control)	0.05	0.08	0.04	0.062	0.019	0.0044
Sed	0.001	0.001	0.001	0.002	0.001	0.0021
CD (P=0.05%)	0.002	0.003	0.002	NS	0.002	NS

Level of significance at 5%, DAS- Days After Sowing, RDF- Recommended Dose of Fertiliser, EDTA- Ethylene Diamine Tetraacetic Acid

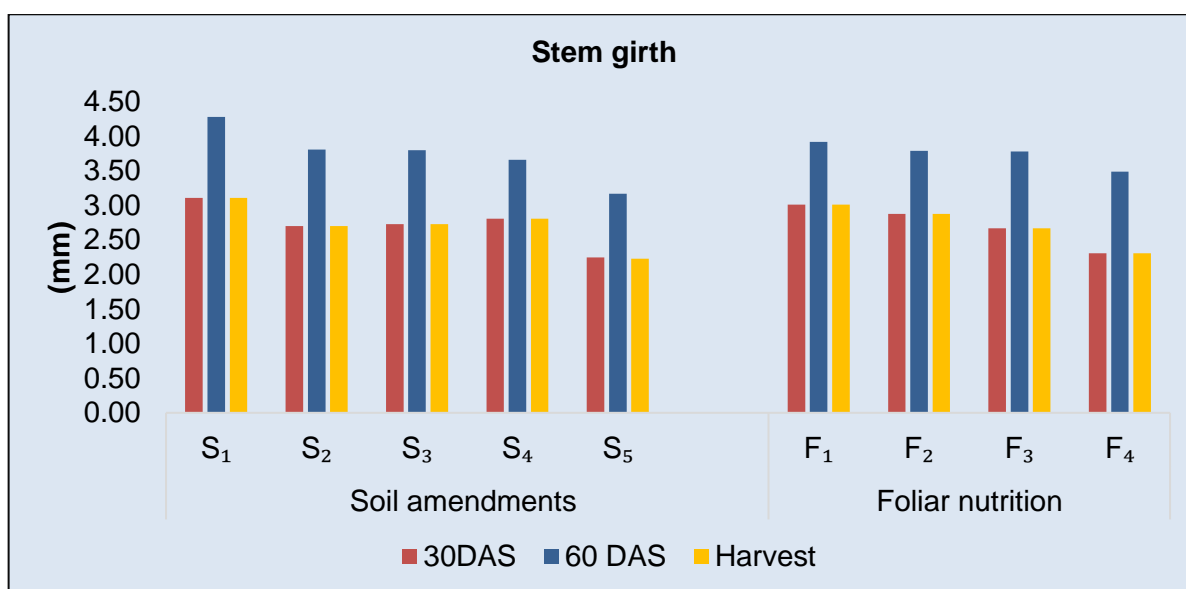


Fig. 3. Effect of soil organic amendments and micronutrients foliar on stem girth (mm) of finger millet

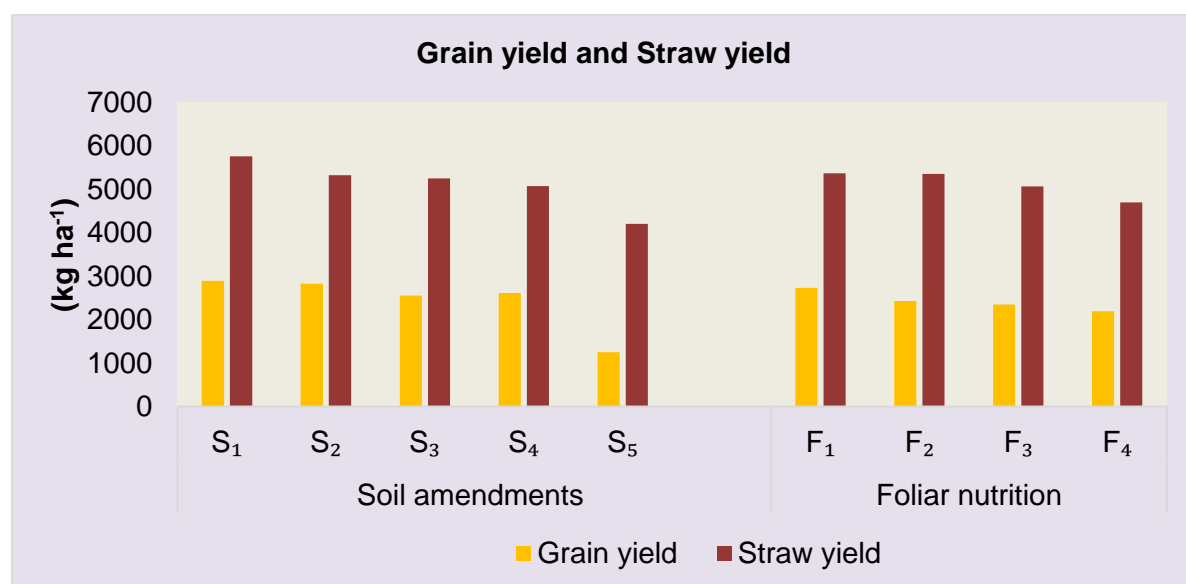


Fig. 4. Effect of soil organic amendments and micronutrients foliar on grain yield (kg ha<sup>-1</sup>) and straw yield (kg ha<sup>-1</sup>) of finger millet

### 3.6 Yield

Fig. 4 illustrates the effect of soil amendments and micronutrients foliar application on the yield of finger millet. Grain yield is significantly increased by the application of soil organic amendments with Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF were 2891 kg ha<sup>-1</sup> superior with Neem seed cake @ 1.25 t ha<sup>-1</sup> + 100% RDF, lower grain yield recorded in 100% RDF alone of 1246 kg ha<sup>-1</sup>. Nitrification inhibitors improve yield by reducing nitrogen losses,

ensuring a slow and steady nutrient release, and enhancing nutrient absorption, which collectively boost photosynthetic efficiency and dry matter production. The findings are consistent with those of Osmon et al. (2009), Biswas et al. (2023), and Chitte et al. (2016). Foliar application of micronutrients significantly enhanced grain yield, with Fe- EDTA 0.2% @ 30 & 45 DAS recording 2729 kg ha<sup>-1</sup>, while lowest yield of 2188 kg ha<sup>-1</sup> was observed in the no spray treatment. According to Meghana et al., (2019) and Bhatti et al. (2024), foliar feeding ensures

timely nutrient availability, enhances cell division, and boosts physiological processes, thereby improving crop productivity.

Soil application of organic amendments significantly enhanced straw yield, with Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF recording 5752 kg ha<sup>-1</sup>, whereas the lowest straw yield of 4203 kg ha<sup>-1</sup> was observed under 100% RDF alone. Organic amendments support active microflora, facilitating nutrient availability and suppressing pathogens, thereby reducing disease pressure and promoting plant growth, ultimately leading to higher straw yield, as reported by Barnwal et al., (2007). Foliar application of micronutrients also had a significant effect on straw yield, with Fe-EDTA 0.2% @ 30 & 45 DAS yielding 5367 kg ha<sup>-1</sup>, followed by Zn-EDTA 0.5% @ 30 & 45 DAS, which resulted 5350 kg ha<sup>-1</sup>. The lowest straw yield of 4695 kg ha<sup>-1</sup> was recorded in the no-spray treatment. Fe-EDTA foliar application enhances straw yield by improving iron uptake efficiency, which accelerates photosynthesis, increases chlorophyll content, and enhances metabolic activities, ultimately promoting plant growth (Vikashkumar et al., 2015).

#### 4. CONCLUSION

The study revealed that soil application of with Pongamia seed cake @ 1.46 t ha<sup>-1</sup> + 100% RDF significantly enhanced growth parameters, including leaf area index, number of leaves, stem girth, relative growth rate, and net assimilation rate. This treatment also achieved the highest grain and straw yields. Foliar application of Fe-EDTA 0.2% @30 & 45 DAS at critical growth stages further improved growth attributes and resulted in increased grain and straw yields. These treatments outperformed neem seed cake combined with RDF and other foliar sprays, highlighting the synergistic benefits of organic amendments and micronutrient foliar applications in improving plant growth and yield under calcareous soil conditions.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

We hereby declare that no generative AI technologies have been used during the writing or editing of this manuscript.

#### ACKNOWLEDGEMENTS

The authors express their gratitude to the Division of Agronomy, School of Agricultural

Sciences, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu – 641 114, for their support and contributions.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

- Akhtar, S., Bangash, N., Iqbal, M. S., Shahzad, A., Arshad, M., & Fayyaz-ul-Hassan. (2019). Comparison of foliar and soil applications for correction of iron deficiency in peanut (*Arachis hypogaea* L.). *Pakistan Journal of Botany*, 51(3), 1121–1127. [https://doi.org/10.30848/PJB2019-3\(13\)](https://doi.org/10.30848/PJB2019-3(13))
- Baishya, L. K., Sarkar, D., Ansari, M. A., Singh, K. R., Meitei, C. B., & Prakash, N. (2016). Effect of micronutrients, organic manures and lime on bio-fortified rice production in acid soils of Eastern Himalayan region. *Ecology of Environmental Conservation*, 22(1), 199–206.
- Barnwal, M. K., Agarwal, B. K., & Prasad, S. M. (2007). Effect of different levels of nitrogen and karanj cake in relation to occurrence of diseases and yield of rice. *Journal of Plant Protection and Environment*, 4(2), 122–125.
- Bhatti, S. M., Mari, Z. A., Bughio, Z. U., Depar, N., Rajpar, I., Siddiqui, M. A., & Rajput, I. S. (2024). Enhancing iron concentration in bread wheat through Fe-EDTA fortification. *Eurasian Journal of Soil Science*, 13(1), 52–58.
- Biswas, S., Dey, R., & Thakur, R. (2023). Influence of organic nitrogen sources on aromatic rice (*Oryza sativa* L.) cultivation in the Eastern Plateau and Hill Region of India. *Environment and Ecology*, 41(3B), 1767–1772.
- Bolan, N., Srivastava, P., Rao, C. S., Satyanaraya, P. V., Anderson, G. C., Bolan, S., Nortjé, G. P., Kronenberg, R., Bardhan, S., Abbott, L. K., Zhao, H., Mehra, P., Satyanarayana, S. V., Khan, N., Wang, H., Rinklebe, J., Siddique, K. H. M., & Kirkham, M. B. (2023). Distribution, characteristics and management of calcareous soils. *Advances in Agronomy*, 182, 81-130. <https://doi.org/10.1016/bs.agron.2023.07.002>

- Chitte, H., Chorey, A., & Tijare, B. (2016). Influence of fertilizer levels and organic nitrification inhibitors on yield, uptake of nutrients in cotton. *International Journal of Current Research in Life Sciences*, 5(2), 541–544.
- Das, L., Kumar, R., Kumar, V., & Kumar, N. (2016). Effect of moisture regimes and levels of iron on growth and yield of rice under aerobic condition. *The Bioscan*, 11(4), 2475–2479.
- Himanshu, C. M., Sonawane, S. K., & Arya, S. S. (2018). Nutritional and nutraceutical properties of millets: A review. *Clinical Journal of Nutrition and Dietetics*, 1(1), 1–18.
- Jackson, M.L. (1973). *Soil Chemical Analysis*. Prentis Hall of India Pvt. Ltd., New Delhi.
- Li, S., Wei, W., & Liu, S. (2023). Long-term organic amendments combined with nitrogen fertilization regulates soil organic carbon sequestration in calcareous soil. *Agronomy*, 13(2), 291. <https://doi.org/10.3390/agronomy13020291>
- Meghana, S., Kadalli, G. G., Prakash, S. S., & Fathima, P. S. (2019). Effect of micronutrients mixture on growth and yield of aerobic rice. *International Journal of Chemical Studies*, 7(2), 1733–1735.
- Milletstats. (2022). Finger millet (Ragi) production in India.
- Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate, Circular U.S. Department of Agriculture. 939.
- Paramasiva, I., Rajasekhar, P., Harathi, P. N., & Vineetha, U. (2020). Incidence of insect pests of rice as affected by organic and inorganic fertilizers. *Journal of Entomology and Zoology Studies*, 8(4), 638–641.
- Piper, C.S. (1966). *Soil and plant analysis* (pp. 51–74). Inter Science Publisher Inc.
- Radford, P. J. (1967). Growth analysis formulae: Their use and abuse. *Crop Science*, 7(3), 171–175.
- Rakesh, D., Reddy, P. R. R., & Pasha, M. L. (2012). Response of aerobic rice to varying fertility levels in relation to iron application. *Journal of Research ANGRAU*, 40(4), 94–97.
- Sarkar, A., Sarkar, S., & Zaman, A. (2011). Growth and yield of potato as influenced by combination of organic manures and inorganic fertilizers. *Potato Journal*, 38(1), 78–80.
- Setyoningsih, A. R., Samanhudi, S., Sakya, A. T., Supriyono, S., & Setyawati, A. (2024). The growth of biofortified mustard green plants with iron and zinc through foliar spray. *Earth and Environmental Science*, 1362, 012055.
- Shobana, S., & Malleshi, N. G. (2007). Preparation and functional properties of decorticated finger millet (*Eleusine coracana*). *Journal of Food Engineering*, 79, 529–538.
- Stanford S, English L. Use of flame photometer in rapid soil tests for K and Ca. *Agronomy Journal*. 1949;41(7):446 447.
- Subbaiah, B.V. and Asija, G.L. (1956). A rapid procedure for the determination of available nitrogen in soils. *Current Science*. 25: 259-260.
- Taalab, A. S., Ageeb, G. W., Siam, H. S., & Mahmoud, S. A. (2019). Some characteristics of calcareous soils: A review. *Middle East Journal of Agriculture Research*, 8(1), 96–105.
- Vikashkumar, V., Kumar, D., Singh, Y. V., & Raj, R. (2015). Effect of iron fertilization on dry matter production, yield and economics of aerobic rice (*Oryza sativa*). *Indian Journal of Agronomy*, 60(4), 547–553.
- Virto, I., Anton, R., Apesteguia, M., & Plante, A. (2013). Soil management and climate change & role of carbonates in the physical stabilization of soil organic matter in agricultural Mediterranean soils. *Plant Elsevier Incorporated, Besloten Vennootschap*, 128.
- Walkley, A. & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*, 37(1), 29–38.
- Watson, D. J. (1958). The dependence of crop growth rate on plant dry weight. *Annals of Botany*, 23, 37–54.
- Williams, R. F. (1946). The physiology of plant growth with special reference to the concept of net assimilation rate. *Annals of Botany*, 10(37), 41–72. <http://www.jstor.org/stable/42906970>
- Zaki, R. N., & Habashy, N. R. (2011). The role of de-oiled seed cakes as organic sources of nutrient applied to

sunflower and maize crops grown in a  
calcareous soil. Research Journal of

Agriculture and Biological Sciences, 7(1),  
23–31.

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of the publisher and/or the editor(s). This publisher and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

---

© Copyright (2025): Author(s). The licensee is the journal publisher. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*

<https://pr.sdiarticle5.com/review-history/133716>