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Integrating Organic Amendments with Chelated Micronutrients for Improving Finger Millet (*Eleusine coracana* L.) Productivity under Calcareous Soil Condition

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ABSTRACT

Background: Calcareous soils, covering 1.5 billion acres globally, which is around 17% of the country's geographical area of which India is having about 229 million hectares. Excessive $NaCO_3$ and $CaCO_3$ levels form water-impermeable caliche layers which limits mineralization and water retention in soil causes phosphorous fixation and ammonia volatilization. Under these condition plant experiences the iron chlorosis, poor germination and micro nutrient deficiencies. Synthetic fertilisers are avoided in calcareous soil due to nitrogen loss *via* volatilization and phosphorous fixation into insoluble form. To overcome these constraints addition of organic amendments along with chelated micronutrients are crucial for enhancing soil properties, nutrient uptake and crop productivity under calcareous condition.

Methods: In this context a field experiment was conducted at Karunya Institute of Technology and Sciences, Coimbatore during *rabi* 2023-24 to study the effect of organic amendments and foliar nutrition under calcareous soil condition. The experiment was laid out in Factorial randomised block design with three replications. The treatments comprised of different organic amendments as a soil application and chelated micronutrient as a foliar application.

Result: Results indicated that the application of *Pongamia* seed cake @ 1.46 t ha^{-1}+100 % RDF + Fe-EDTA 0.2% @ 30 and 45 DAS significantly improved growth characteristics *viz* plant height and DMP and the physiological parameters *viz,* SPAD value, CGR with higher grain yield (2891 kg ha^{-1}), straw yield (5752 kg ha^{-1}), biological yield (8643 kg ha^{-1}) with higher B:C ratio. The same treatment combination recorded higher crop nutrient uptake and soil available nutrients with maximum NUE.

Key words: Calcareous soil, Finger millet, Micronutrients, Nutrient use efficiency, Organic amendments.

INTRODUCTION

Finger millet contains 7.3% protein, 19.1% dietary fibre and 102 mg/100 g total phenol (Saldivar, 2003). Globally India is the largest millet producer, with a production potential of 10.91 MT in 2021-22, contributing 30-35 M ha under worldwide millet cultivation (World Atlas, 2023). In 2024, Karnataka is the leading finger millet producer with 8,65,000 tonnes, followed by Tamil Nadu 1,89,000 tons and Uttarakhand 1,01,000 tonnes (Statista, 2024). Calcareous soils cover about 1.5 billion acres globally, accounting 17% of the world's soils. In India is around 229 million hectares, representing 69.4% of the country's geographical area (Pal *et al.,* 2000). High $CaCO_3$ reduces nutrient availability, lowering phosphorus levels and causing iron, zinc and manganese deficiencies due to decreased solubility at alkaline pH. Synthetic fertilizers are avoided in calcareous soils due to nitrogen loss from ammonia volatilization and phosphorus fixation into insoluble forms. Organic amendments in calcareous soil improve pH stability, structure, porosity and water holding capacity (Zaki and Habashy, 2011), while their integration with inorganic fertilizers enhances yield and soil health; high C:N residues are less effective (Gupta and Bordoloi, 2024). Chelated micronutrient enhances nutrient uptake in calcareous soil through foliar by preventing micronutrient precipitation and plant absorption. Organic amendments outperform with inorganic fertilizers with residual benefits and combining them with chelated micronutrients boosts crop growth and yields (Taalab *et al.,* 2019).

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MATERIALS AND METHODS

The experiment was conducted at Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu (latitude is 10°56′N and the longitude is 76°45′E and 474 m MSL) during *rabi* 2023-24. The experiment was laid out in a factorial randomized block design consisting of five soil amendments S_3-*Pongamia* seed cake @ 1.46 t ha^{-1} +100% RDF, S_2-Neem seed cake @ 1.25 t ha^{-1} +100 % RDF, S_3 - Castor seed cake @1.45 t ha^{-1} +100 % RDF, S_4- FYM @ 12.5 t ha^{-1} +100 % RDF, S_5 -100 % RDF alone (Control) and four foliar nutrition *viz*., F_1 -Fe-EDTA 0.2% @ 30 and 45 DAS, F_2-Zn-EDTA 0.5 % @ 30 and 45 DAS, F_3-Mn-EDTA 0.5% @ 30 and 45 DAS, F_4- No spray (Control). The statistical analysis was performed using AGRES software at a 5% significance level of significance.

Growth parameters were recorded periodically at 30, 60 DAS and at harvest while yield was measured at harvest. Physiological parameters were determined using the following procedures.

Crop growth rate

CGR was determined using the formula proposed by Watson (1958) and is expressed in g m^{-2} day^{-1}.

$$\text{CGR (g m}^{-2}\text{ day}^{-1}) = \frac{W_2 - W_1}{P\,(T_2 - T_1)}$$

W_1 and W_2 = Plant dry weight (g) at time t_1 and t_2 respectively.

$(T_2 - T_1)$ = Time interval (days).

P = Spacing occupied by the plant (m^2).

SPAD value

The greenness of the leaves was measured using a SPAD 502 Plus chlorophyll meter between 11 AM and 12 PM.

Nutrient use efficiency

Agronomic use efficiency (AUE)

AUE measures the increase in crop yield per unit of nutrient applied, indicating the effectiveness of applied nutrients in improving crop productivity (Donald, 1963).

$$\text{AUE} = \frac{\text{(Grain yield in fetilized plot (Kg)} - \text{Grain yield inun-fertilized plot (kg)}}{\text{Quantity of nutrient applied (kg)}}$$

Recovery use efficiency (RUE)

RUE reflects the proportion of applied nutrients that are taken up by the plant, indicating nutrient uptake efficiency (Dobermann, 2005).

$$\text{RUE} = \frac{\text{(Nutient updake in fertilized plot (Kg)} - \text{Nutient updake in unfertilized plot (kg)}}{\text{Quantity of nutrient applied (kg)}}$$

Biological use efficiency (BUE)

BUE quantifies the biomass or yield produced per unit of nutrient taken up by the crop, reflecting nutrient utilization efficiency (Moll *et al.,*1982):

$$\text{BUE} = \frac{\text{Crop yield (kg)}}{\text{Applied nutrient (kg)}}$$

Economic use efficiency (EUE)

EUE measures the economic return per rupees of nutrient applied, highlighting the profitability of nutrient inputs (Timsina, 2021).

$$\text{EUE} = \frac{\text{Gross return (`)}}{\text{Per rupees of nutrient applied (`)}}$$

Chemical analysis

The physico-chemical characteristics of initial and final soil samples were estimated as per the standard procedures and the values are presented in Table 1. To estimate nutrient uptake, the plant samples were collected at harvest, oven-dried at 65±5°C and powdered by using willey mill. N was estimated using Micro kjeldhal method given by Humphries (1956), P using colorimetric method (Jackson,1973) and K by flame photometric method (Jackson,1973). The nutrient uptake was computed using the following formula:

Nutrient uptake (kg ha^{-1}) =

$$\frac{\text{Nutrient content (\%)}}{100} \times \text{ dry weight of the plant (kg ha}^{-1}\text{)}$$

The micronutrient content of plant samples at harvest was estimated using an atomic absorption spectro photometer and the nutrient uptake was computed using the formula (Lindsay and Norvell, 1978):

Nutrient uptake (kg ha^{-1}) =

$$\frac{\text{Nutrient g ha}^{-1}}{100} \times \text{ dry weight of the plant (kg ha}^{-1}\text{)}$$

Economics

For each treatment, the total cost of cultivation, including all expenses was calculated and expressed in ` ha^{-1}.

Gross returns (`ha$^{-1}$) = Monetary value of the grain (`kg^{-1}) + straw (`kg^{-1})

Net returns (`ha$^{-1}$) = Gross return (`ha^{-1}) -Total cost of cultivation (`ha^{-1})

$$\text{B:C ratio} = \frac{\text{Gross returns (`ha}^{-1}\text{)}}{\text{Cost of cultivation (`ha}^{-1}\text{)}}$$

Partial budgeting (`ha^{-1}) = (added income or reduced cost) - (increased or reduced income).

RESULTS AND DISCUSSION

Growth analysis

The impact of soil amendments with micronutrients on growth and physiological parameters of finger millet was depicted in Fig 1 and 2. *Pongamia* seed cake @ 1.46 t ha^{-1} + 100% RDF recorded highest plant height (108 cm), DMP (6,457 kg ha^{-1}), SPAD (25.8) and CGR (4.5 g m^{-2}day^{-1}) followed by neem seed cake @ 1.25 t ha^{-1} + 100% RDF. Adequate nitrogen supply promoted cell division and multiplication, leading to an increase in plant height due to enhanced growth and development. The slow nitrogen release over time steadily increased DMP reported by Osman *et al.* (2009) and Biswas *et al.* (2023). The lowest values of plant height (88 cm), DMP (4,967 kg ha^{-1}), SPAD (24.08) and CGR (3.017 g m^{-2} day^{-1}) were observed in 100% RDF alone. Among foliar nutrition, Fe-EDTA 0.2% @ 30 and 45 DAS recorded highest plant height (104 cm), DMP (6049 kg ha^{-1}), SPAD (27.31) and CGR (4.16 g m^{-2} day^{-1}) followed by Zn-EDTA 0.5% @ 30 and 45 DAS. Application of Fe-EDTA boosts SPAD value by providing readily absorbed Fe^{2+}, crucial for chlorophyll synthesis and preventing oxidation of Fe^{3+} to Fe^{2} and thus improve chlorophyll content. The results are in line with Akhtar *et al.* (2019). The lowest values of plant height (93 cm), DMP (5171 kg ha^{-1}), SPAD

Table 1: Physico-chemical characteristics of initial soil.

Particulars	Values	Methods
pH	8.63	1:2.5 soil water suspension (Jackson, 1973)
Electrical conductivity	0.23	
Organic carbon (%)	0.24	Chromic wet acid digestion (Walkleyand Black, 1934)
Available N (kg ha^{-1})	210.7	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P (kg ha^{-1})	12.24	0.5 M Sodium bicarbonate Calorimetric method (Olsen *et al.*,1954)
Available K (kg ha^{-1})	174.3	Flame photometer (Stanford and English, 1949)
Iron (mg kg^{-1})	3.42	DTPA Extraction method (Lindsay and Norvel, 1978)
Zinc (mg kg^{-1})	0.42	
Manganese (mg kg^{-1})	14.88	
Free $CaCO_3$ (%)	14.25	(Piper, 1966)

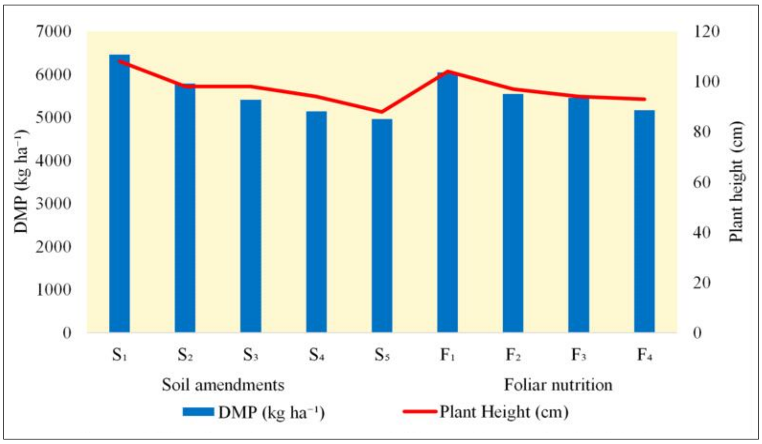

Fig 1: Effect of organic amendments and foliar nutrition on plant height(cm) and DMP (kg ha^{-1}).

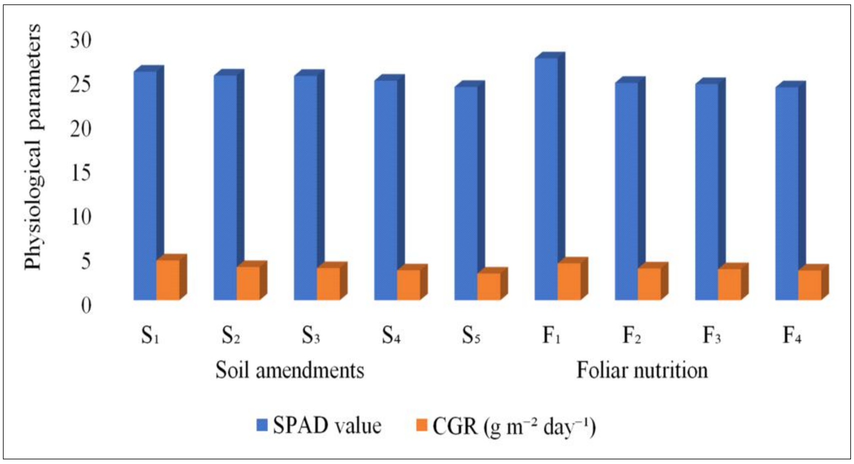

Fig 2: Effect of organic amendments and foliar nutrition on SPAD value and CGR (g m^{-2} day^{-1}).

value (24.04) and CGR (3.36 g m^{-2} day^{-1}) were observed in control (no spray) this is due to lack of organic amendments and micronutrients reduced nutrient availability, impairing photosynthesis and transpiration, thus limiting plant growth (Ramzani *et al.,* 2016).

Grain and straw yield

The data on grain and straw yield are presented in Table 2. *Pongamia* seed cake @ 1.46 t ha^{-1} +100% RDF recorded the highest grain yield (2891 kg ha^{-1}), straw yield (5752 kg ha^{-1}) and biological yield of 8643 kg ha^{-1}, which was statistically comparable with neem seed cake @ 1.25 t ha^{-1} +100% RDF. While significantly lower grain yield (1239 kg ha^{-1}), straw yield (4203 kg ha^{-1}) and biological yield (5442 kg ha^{-1}) were observed in 100% RDF alone. Nitrification inhibitors reduce nitrogen loss, enabling slow release, better absorption, improved photosynthesis, higher dry matter and yield. The results confirm with Chitte *et al.* (2016) and Biswas *et al.* (2023). Among foliar nutrition Fe-EDTA 0.2% @ 30 and 45 DAS recorded highest grain yield (2724 kg ha^{-1}), straw yield (5367 kg ha^{-1}) and biological yield (8091 kg ha^{-1}), which were statistically on par with Zn-EDTA 0.5%. Foliar feeding enhances cell division, physiological processes and timely nutrient supply, thereby improving

Table 2: Effect of organic amendments and foliar nutrition on grain yield, straw yield and biological yield of finger millet.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Soil amendments (S)			
S_1- *Pongamia* seed cake @ 1.46 t ha^{-1} +100 %RDF	2891	5752	8643
S_2- Neem seed cake @ 1.25 t ha^{-1} + 100 % RDF	2824	5321	8145
S_3- Castor seed cake @ 1.45 t ha^{-1} + 100 % RDF	2550	5246	7796
S_4- FYM @ 12.5 t ha^{-1} + 100 % RDF	2607	5074	7681
S_5- 100% RDF alone (Control)	1239	4203	5442
SEd	89.2	166.1	215.4
CD (P=0.05%)	181.3	337.7	437.7
Foliar nutrition (F)			
F_1- Fe-EDTA 0.2% @ 30 and 45 DAS	2724	5367	8091
F_2- Zn-EDTA 0.5% @ 30 and 45 DAS	2428	5350	7777
F_3- Mn-EDTA 0.5% @ 30 and 45 DAS	2349	5065	7415
F_4- No spray (Control)	2188	4695	6883
SEd	79.8	148.6	192.6
CD (P=0.05%)	162.2	302	391.5

Level of significance at 5%, DAS- Days after sowing, RDF- Recommended dose of fertiliser, EDTA- Ethylene diamine tetraacetic acid.

Table 3: Effect of organic amendments and foliar nutrition on plant nutrient uptake at harvest of finger millet.

Treatments	Macronutrients			Micronutrients		
	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})	Iron (g ha^{-1})	Zinc (g ha^{-1})	Manganese (g ha^{-1})
Soil amendments (S)						
S_1- *Pongamia* seed cake @ 1.46 t ha^{-1} +100 %RDF	116	22	59	2354	366	144
S_2- Neem seed cake @ 1.25 t ha^{-1} + 100 % RDF	114	21	54	2233	355	136
S_3- Castor seed cake @ 1.45 t ha^{-1} + 100 % RDF	112	19	52	2052	318	131
S_4- FYM @ 12.5 t ha^{-1} + 100 % RDF	112	18	48	1928	248	125
S_5- 100 % RDF alone (Control)	109	17	44	1404	210	117
SEd	2.3	0.4	1.9	48.1	9.5	2.8
CD (P=0.05%)	4.7	0.9	4	97.8	19.4	5.6
Foliar nutrition (F)						
F_1- Fe-EDTA 0.2% @ 30 and 45 DAS	116	21	55	2216	312	138
F_2- Zn-EDTA 0.5% @ 30 and 45 DAS	112	20	52	2038	303	131
F_3- Mn-EDTA 0.5% @ 30 and 45 DAS	111	19	50	1978	296	133
F_4- No spray (Control)	110	18	48	1745	286	122
SEd	2	0.3	1.7	43	8.5	2.5
CD (P=0.05%)	4.1	0.8	3.5	87.4	17.3	5

Level of significance at 5%, DAS- Days after sowing, RDF- Recommended dose of fertiliser, EDTA-Ethylene diamine tetraacetic acid.

yield parameters (Chitte *et al.,* 2016). Whereas, lowest grain yield (2188 kg ha^{-1}), straw yield (4695 kg ha^{-1}) and biological yield (6883 kg ha^{-1}) was recorded in control.

Nutrient uptake by plant

Values on plant uptake at harvest were presented in Table 3 shows *Pongamia* seed cake @ 1.46 t ha^{-1} + 100% RDF

Table 4: Effect of organic amendments and foliar nutrition on soil available nutrients.

Treatments	Macronutrients			Micronutrients		
	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})	Iron (g kg^{-1})	Zinc (g kg^{-1})	Manganese (g kg^{-1})
Soil amendments (S)						
S_1- *Pongamia* seed cake @ 1.46 t ha^{-1} +100 %RDF	188	20	280	4.33	1.78	14.36
S_2- Neem seed cake @ 1.25 t ha^{-1} + 100 % RDF	185	17	269	4.11	1.64	13.28
S_3- Castor seed cake @ 1.45 t ha^{-1} + 100 % RDF	182	16	266	3.63	1.50	12.86
S_4- FYM @ 12.5 t ha^{-1} + 100 % RDF	158	16	258	3.58	1.19	12.91
S_5- 100 % RDF alone (Control)	146	14	233	3.15	1.11	12.12
SEd	3.78	0.55	5.58	0.21	0.15	0.50
CD (P=0.05%)	7.69	1.13	11.34	0.43	0.30	1.02
Foliar nutrition (F)						
F_1- Fe-EDTA 0.2% @ 30 and 45 DAS	177	19	270	3.97	1.68	13.80
F_2- Zn-EDTA 0.5% @ 30 and 45 DAS	174	17	262	3.93	1.58	13.36
F_3- Mn-EDTA 0.5% @ 30 and 45 DAS	169	16	257	3.64	1.46	12.84
F_4- No spray (Control)	166	14	255	3.50	1.07	12.42
SEd	3.38	0.49	5.1	0.19	0.13	0.45
CD (P=0.05%)	6.88	1.01	10.14	0.38	0.27	0.91

Level of significance at 5%, DAS- Days after sowing, RDF- Recommended dose of fertiliser, EDTA- Ethylene diamine tetraacetic acid.

Table 5: Effect of organic amendments and foliar nutrition on nutrient use efficiency of finger millet.

Treatments	AUE			RUE			BUE			EUE		
	N	P	K	N	P	K	N	P	K	N	P	K
S_1F_1	11.73	11.23	32.82	0.75	1.77	0.07	17.81	17.06	49.84	95.8	58.4	75.03
S_1F_2	8.42	8.06	23.56	0.77	1.79	0.08	14.50	13.89	40.58	79.2	48.3	62.04
S_1F_3	8.27	7.92	23.15	0.77	1.79	0.10	14.36	13.75	40.17	78.4	47.8	61.43
S_1F_4	7.16	6.85	20.03	0.79	1.81	0.14	13.24	12.68	37.05	71.8	43.7	56.21
S_2F_1	11.49	11.12	33.06	0.79	1.78	0.08	17.51	16.94	50.39	93.2	57.4	75.09
S_2F_2	7.99	7.74	23.01	0.80	1.79	0.12	14.02	13.56	40.34	76.6	47.2	61.75
S_2F_3	7.79	7.54	22.44	0.83	1.81	0.16	13.82	13.37	39.76	74.9	46.1	60.39
S_2F_4	6.57	6.36	18.9	0.84	1.82	0.16	12.59	12.18	36.24	68.3	42.1	55.08
S_3F_1	8.48	7.87	24.27	0.79	1.88	0.11	14.56	13.52	41.69	79.6	47.0	63.81
S_3F_2	7.69	7.14	22.02	0.82	1.89	0.14	13.77	12.79	39.43	74.9	44.3	60.03
S_3F_3	6.51	6.05	18.65	0.81	1.89	0.18	12.59	11.70	36.06	68.4	40.4	54.87
S_3F_4	5.83	5.42	16.71	0.84	1.90	0.19	11.92	11.07	34.12	64.6	38.2	51.81
S_4F_1	7.89	7.17	13.53	0.73	1.93	0.60	13.98	12.69	23.98	76.1	44.0	32.88
S_4F_2	7.82	7.1	13.42	0.85	1.94	0.64	13.91	12.63	23.85	75.1	43.4	32.47
S_4F_3	7.36	6.68	12.62	0.81	1.95	0.65	13.44	12.21	23.05	72.7	42.0	31.43
S_4F_4	6.64	6.03	11.38	0.83	1.95	0.67	12.72	11.55	21.82	68.9	39.8	29.77
S_5F_1	0.65	0.45	1.7	0.17	1.70	0.02	9.86	6.86	25.72	55.9	24.7	40.79
S_5F_2	0.70	0.48	1.82	0.14	1.71	0.06	9.71	6.75	25.32	55.7	24.7	40.68
S_5F_3	0.64	0.44	1.66	0.25	1.71	0.08	9.63	6.70	25.12	55.0	24.3	40.16
S_5F_4	-	-	-	-	-	-	9.00	6.26	23.48	52.1	23.1	38.04

*Data not statistically analysed; AUE -Agronomic use efficiency, RUE- Recovery use efficiency, BUE- Biological use efficiency, EUE- Economic use efficiency.

recorded the highest N (116 kg ha^{-1}), P (22 kg ha^{-1}), K (59 kg ha^{-1}), Fe (2,354 g ha^{-1}), Zn (366 g ha^{-1}) and Mn uptake (144 g ha^{-1}) followed by neem seed cake @ 1.25 t ha^{-1} + 100% RDF. This might be attributed directly to the ammonium, readily absorbed by roots, boosts nitrogen uptake and assimilation when nitrification is inhibited (Majumdar, 2008). Similar findings were reported by Biswas *et al.* (2023). Application of organic amendments improving NPK uptake and seed nutrition were noted by Haiguipeung *et al.* (2025).

Whereas, the lower soil available nutrients were recorded in 100% RDF alone. Comparing various foliar nutrition, the higher N (116 kg ha^{-1}), P (21 kg ha^{-1}), K (55 kg ha^{-1}), Fe (2,216 g ha^{-1}), Zn (312 g ha^{-1}) and Mn uptake (138 g ha^{-1}) was observed under Fe-EDTA 0.2% @ 30 and 45 DAS. Fe-EDTA 0.2% @ 30 and 45 DAS than control. Foliar Fe-EDTA application bypasses soil limitations, reduces Zn antagonism and enhances Fe uptake and utilization. Fe-EDTA improves its availability for physiological functions, indirectly boosting Zn assimilation, yield and grain micronutrient content (Ram *et al.,* 2014).

Soil available nutrients

Table 4 shows the influence of soil amendments and foliar treatment on post-harvest nutrient status. *Pongamia* seed cake @ 1.46 t ha^{-1} + 100% RDF recorded highest soil available N (188 kg ha^{-1}), P (20 kg ha^{-1}), K (280 kg ha^{-1}), Fe (4.33 mg kg^{-1}), Zn (1.78 mg kg^{-1}) and Mn (14.36 mg kg^{-1}) followed by neem seed cake @ 1.25 t ha^{-1} + 100% RDF and lower N (146 kg ha^{-1}), P (14 kg ha^{-1}), K (233 kg ha^{-1}), Fe (3.15 mg kg^{-1}), Zn (1.11 mg kg^{-1}) and Mn (12.12 mg kg^{-1}) were estimated in 100% RDF alone. It seems to be due to the nitrification inhibitors slow down the conversion of ammonium (NH_4^+) to nitrate (NO_3^-) which enhancing ammonium persistence in soil (Majumdar, 2008). Organic amendments stabilize soil pH through microbially produced enzymes, thereby enhancing available NPK in the soil were reported by Kumar *et al.* (2023). This reduces nitrogen losses, improving nitrogen availability in soil. The control had lower levels of Fe and Zn because it lacked nutrient amendments, which were necessary to enhance nutrient bioavailability and uptake by plants reported by Ramzani *et al.* (2016) and Gowda *et al.* (2004). In foliar nutrition, Fe-EDTA 0.2% @ 30 and 45 DAS resulted in the highest soil available N (177 kg ha^{-1}), P (19 kg ha^{-1}), K (270 kg ha^{-1}), Fe (3.97 mg kg^{-1}), Zn (1.68 mg kg^{-1}) and Mn (13.80 mg kg^{-1}). The retention of Fe in soil by foliar Fe-EDTA is linked to adsorption by inorganic colloids (oxides, hydroxides, carbonates, phosphates) and organic colloids (Bhatti *et al.,* 2024). Whereas, the lower soil available nutrients were recorded in control.

Nutrient use efficiency

The impact of amendments and micronutrient on NUE were presented in Table 5. *Pongamia* seed cake @ 1.46 t ha^{-1} + 100% RDF + Fe-EDTA 0.2% @ 30 and 45 DAS showed the higher AUE for NPK (11.73, 11.2 and 33.0%) over control. Nitrification inhibitors regulate nitrogen release, ensuring sustained nutrient availability throughout the cropping

Table 6: Effect of organic amendments and foliar nutrition on economics and partial budgeting of finger millet.

Treatments	Cost of cultivation (` ha^{-1})	Gross return (` ha^{-1})	Net return (` ha^{-1})	B:C Ratio	Added cost (` ha^{-1})	Added return (` ha^{-1})	Net gain /loss (` ha^{-1})
S_1F_1	48945	129389	80444	2.64	20440	81834	61394
S_1F_2	50565	106988	56423	2.12	22060	59433	37373
S_1F_3	52365	105930	53565	2.02	23860	58375	34515
S_1F_4	48165	96936	48771	2.01	19660	49381	29721
S_2F_1	50651	127185	76534	2.51	22146	79630	57484
S_2F_2	52251	104572	52321	2.00	23746	57017	33271
S_2F_3	52651	102272	49621	1.94	24146	54717	30571
S_2F_4	49851	93271	43420	1.87	21346	45716	24370
S_3F_1	55228	107514	52286	1.95	26723	59959	33236
S_3F_2	56828	101148	44320	1.78	28323	53593	25270
S_3F_3	57228	92452	35224	1.62	28723	44897	16174
S_3F_4	54428	87294	32866	1.60	25923	39739	13816
S_4F_1	66090	102757	36667	1.55	37585	55202	17617
S_4F_2	67690	101460	33770	1.50	39185	53905	14720
S_4F_3	68090	98208	30118	1.44	39585	50653	11068
S_4F_4	65290	93043	27753	1.43	36785	45488	8703
S_5F_1	29305	50986	21681	1.74	800	3431	2631
S_5F_2	30905	50844	19939	1.65	2400	3289	889
S_5F_3	31305	50205	18900	1.60	2800	2650	-151
S_5F_4	28505	47555	19050	1.67	-	-	-

*Data not statistically analysed.

season which increased nutrient uptake, enhanced yield attributes, yield and improved NUE for crops (Chitte *et al.,* 2016). The highest RUE was recorded for N (0.85) in FYM @ 12.5 t ha^{-1}+ Zn-EDTA 0.5% @ 30 and 45 DAS and for P (1.95) and K (0.67) in FYM @ 12.5 t ha^{-1} + no spray. It is due to the variable rate of nutrient uptake by finger millet under calcareous soil condition. *Pongamia* seed cake @ 1.46 t ha^{-1} +100% RDF+ Fe-EDTA 0.2% @ 30 and 45 DAS recorded the highest BUE for NPK was 17.81, 17.0 and 49.8 %, as well as the highest EUE for NPK was 95.8, 58.4 and 75.0 % over 100% RDF alone + no spray.

Economics

The economic returns and partial budgeting were furnished in Table 6. *Pongamia* seed cake @ 1.46 t ha^{-1} + 100 % RDF + Fe-EDTA 0.2% @ 30 and 45 DAS, which achieved highest net return (` 80,444 ha$^{-1}$), B:C ratio (2.64) and net gain (` 61,394 ha^{-1}) with the cost of cultivation of ` 48,945. Similar findings stated by Osman *et al.* (2009). The lower net return (` 27,753 ha^{-1}) and B:C ratio (1.43) was recorded under FYM @ 12.5 t ha^{-1} +100% RDF + no spray. The net loss of ` 151 ha^{-1} was observed in 100% RDF Alone + Mn-EDTA 0.5% @ 30 and 45 DAS.

CONCLUSION

The study found that combining organic amendments with chelated micronutrients registered significantly increased growth components, physiological parameters, yield and economics at harvest. It also improved crop nutrient uptake, post-harvest soil available nutrients with higher nutrient use efficiency in finger millet. Hence it is concluded that application of *Pongamia* seed cake @ 1.46 t ha^{-1} +100% RDF+ Fe-EDTA 0.2% @ 30 and 45 DAS highlighting the essential role of proper nutrient management for improving finger millet productivity and soil fertility under calcareous soil condition.

Conflict of interest

All authors declared that there is no conflict of interest.

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