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RESEARCH ARTICLE

Evaluation of Different Approaches of Fertilizer Recommendations on Yield, Nutrient Uptake, and Use Efficiency of Finger Millet (*Eleusine Coracana* L. Garten)

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ABSTRACT

The effect of fertilizer application based on "fertilizing the soil versus fertilizing the crop," which ensures real balance between the applied and available soil nutrients, is urgently needed. Hence, the present study was conducted during *Kharif* 2022 at Zonal Agricultural Research Station, Mandya to assess the effect of imbalance and balance fertilization based on initial soil test values and targeted yields, and to determine the effect of different approaches of fertilizer recommendation on yield, nutrient uptake and use efficiency of finger millet crop. The experiment was laid out in a randomized complete block design comprising seven treatments. The results revealed that significantly higher grain yield (46.30 q ha^{-1}), straw yield (67.90 q ha^{-1}), total uptake of nitrogen (218.49 kg ha^{-1}), phosphorus (24.75 kg ha^{-1}) and potassium (165.74 kg ha^{-1}) of finger millet was observed in STCR based NPK + FYM application for the targeted yield of 45 q ha^{-1} based on actual soil test values which was superior compared to general recommended dose (GRD) and soil fertility rating approach (SFR) approach. The higher apparent recovery efficiency (ARE), agronomic nutrient use efficiency (ANUE) of NPK, and partial factor productivity (PFP) of N and K were recorded in the STCR approach compared to SFR and GRD. Whereas the PFP of phosphorus was noticed to be higher in the soil fertility rating approach, and the IUE of NPK was recorded as higher in the absolute control. Further, the higher economics in terms of benefit cost ratio (BCR) was recorded in treatment with the STCR NPK alone application for yield target of 45 q ha^{-1} based on soil test value compared to other treatments, thus proving the superiority of the STCR approach over other approaches of fertilizer recommendation.

Keywords: *Soil test crop response, Finger millet, Soil fertility rating, General recommended fertilizer, Nutrient use efficiency*

INTRODUCTION

Finger millet (*Eleusine coracana* L. Garten) is one of the oldest cultivated cereals in India, with a history dating back over 2000 years. It was a staple food in ancient Indian diets and was even mentioned in ancient Indian texts like the Yajurveda. It is India's

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third most crucial millet, besides sorghum and pearl millet. It can be cultivated under adverse soil and climatic conditions, mainly as a rainfed crop. It is rich in protein, calcium, phosphorus, iron, fibre, and vitamin content (Mathyam Prabhakar *et al*., 2023). Out of the total minor millets produced, finger millet (*Eleusine coracana* L. Garten.) accounts for about 85% of production in India. The crop is cultivated over an area of 1.19 million hectares with a production of 1.98 million tons, giving an average productivity of 1661 kg ha^{-1}. Karnataka accounts for 56.21% and 59.52% of the area and finger millet production, followed by Tamil Nadu (9.94% and 18.27%). Unfortunately, the land area cultivated with this crop has decreased, displaced by maize and rice. Reversing this trend will involve achieving higher yields, including improvements in crop nutrition, and synchronizing nutrient supply with crop demand, which is essential to maximize yield and fertilizer use efficiency.

Fertilizer nutrients are the primary and important inputs in modern agriculture to fulfill the needs of the ever-increasing population of India. However, Indian agriculture is operating on a net negative balance of plant nutrients, and fertilizer recommendation plays an important role to improve it. It also helps meet crop requirements and obtain better yields. General recommended dose, Soil fertility rating approach, Targeted yield concept, and Site-Specific Nutrient Management are some approaches for fertilizer recommendation.

Achieving the potential yields of high-yielding crop varieties require applying optimum nutrient doses. However, using inadequate and imbalanced fertilizers without knowledge of the inherent soil capabilities and crop requirements hinders the ability to harness the potential yield of crops, deteriorates soil health, and leads to economic losses for farmers (Krishna Murthy *et al*., 2024a). Therefore, a comprehensive approach that considers soil tests, field research, and profitability should be employed for fertilizer use. Thus, the soil test crop response (STCR) methodology can be adopted to calculate nitrogen (N), phosphorus (P), and potassium (K) requirements for crops. NPK requirements are linearly correlated with the target yield (TY), depending on the soil test values (STVs). As a result, precise fertilizer recommendations can be made using this approach, as it uses data from soil and plant analysis (Krishna Murthy *et al*., 2024b). A higher economic return and yield response are observed when nutrient application is based on crop demand, and soil nutrient imbalances can be corrected (Ramasamy Arulmani *et al*., 2025).

Considering the above facts, the experiment was conducted to validate the developed soil test crop response-targeted yield equations for finger millet at various locations, along with other fertilizer recommendation approaches.

MATERIALS AND METHODS

Soil Test Crop Response field investigation was conducted during Kharif season 2022 at Zonal Agricultural Research Station, Vishweshwaraih Canal Farm, Mandya, located in the Southern Dry Zone of Karnataka at 12° 34' 6.58'' N latitude, 76° 49' 11.10'' E longitude with an altitude of 695 meters above mean sea level. The climate condition of this area is a dry tropical savanna environment characterized by fairly hot summers and relatively cool winters. The annual precipitation level recorded at the site was 943.9 mm. The area is well-drained red soil at the research site, which belongs to the taxonomically defined large group known as Typic Kandic Paleustalfs, a member of the fine mixed Isohyperthermic family.

Before the initiation of the investigation, the EC and pH of the soil were 7.20 and 0.30 dS m^{-1}. The textural soil class was sandy loam with 68.00% sand, 8.00 % silt and 24.00% clay determined using the international pipette method (Black 1965). The soil's potassium dichromate oxidizable organic carbon content was 3.20 g kg^{-1}. Soil available nitrogen, phosphorus, and potassium were 232.73-286.12 kg ha^{-1}, 38.44-57.48 kg ha^{-1}, and 196.08-214.70 kg ha^{-1}, respectively.

Fertilizer prescription equations for finger millet

Development of fertilizer prescription equations based on the STCR approach involves two consecutive field experiments, the fertility gradient experiment and the test crop experiment. A fertility gradient experiment was conducted to create variations in soil nitrogen, phosphorus, and potassium levels within the experimental field (Ramamoorthy *et al*., 1970). After confirming the variation in soil fertility with respect to available NPK, a test crop experiment was conducted to develop the targeted yield equation for finger millet. The data on basic parameters for the development of targeted yield equations *viz*., nutrient requirement, contribution of nutrients from soil, fertilizer, and organic manure, were computed from the main experiment. Fertilizer recommendations were provided separately for the use of chemical fertilizers alone (NPK) and for the integrated application of chemical fertilizers and organic manure (NPK + FYM), based on the following STCR fertilizer adjustment equationsF.N = 3.29 T - 71.17 S (OC %) - 0.00281 OM

F. P_2O_5 = 1.798 T - 0.189 SP_2O_5 - 0.00173 OM

F.K_2O = 1.775 T - 0.150 SK_2O - 0.0015 OM.

Where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively, OM is percent contribution of nutrients from FYM, T is the yield target in q ha^{-1}; S(OC), SP_2O_5 and SK_2O respectively are organic carbon, Olsen-P and NH_4OAc-K in initial soil.

Experimental design and treatments

The field experiment consists of seven fertilization treatments and one absolute treatment, arranged in a randomized complete block design with three replications. The treatment comprised *viz.,* T_1: STCR NPK TY 45 q ha^{-1}, T_2: STCR NPK + FYM TY 45 q ha^{-1}, T_3: STCR NPK TY 40 q ha^{-1}, T_4: STCR NPK + FYM TY40 q ha^{-1}, T_5: General recommended dose, T_6: Soil fertility rating, and T_7: Absolute control. The experimental layout was prepared, and soil samples were collected from a depth of 0-20 cm to determine the available nitrogen, phosphorus, and potassium for each plot before sowing and after harvest. Farmyard manure (FYM) was applied 15 days before sowing and it contains 0.57% N, 0.34% P and 0.51% K, and half of the nitrogen, as well as the full amount of phosphorus and potassium, were applied as a basal dose through urea, single super phosphate and muriate of potash respectively. The fertilizer dose added under each treatment is presented in Table 1. The crop was cultivated following the standard package of practices and harvested at full maturity.

The response yard stick (RYS), percent deviation, and value cost ratio (VCR) were computed via the standard formulae shown below (Ramamoorthy *et al.*, 1967).

$$\text{RYS} = \frac{\text{Yield response } (\text{kg ha}^{-1})}{\text{Total nutrient applied } (\text{kg ha}^{-1})}$$

$$\text{Percent deviation} = \frac{[\text{Actual yield obtained } (\text{kg ha}^{-1}) - \text{Targeted yield } (\text{kg ha}^{-1})]}{\text{Targeted yield } (\text{kg ha}^{-1})} \times 100$$

$$\text{VCR} = \frac{[\text{Yield in treated plot } (\text{kg ha}^{-1}) - \text{Yield in control plot } (\text{kg ha}^{-1})]}{\text{Cost of fertilizers and FYM applied to treated plot}} \times \text{Cost kg}^{-1} \text{ of seed}$$

Analysis of soil and plant samples

The soil samples were air-dried and sieved through a 2 mm mesh. Bulk density was determined using rings with a known volume, and soil cores were dried in an oven at 105°C for 48 hours. Bulk density was calculated by dividing the weight of the dried soil by the core's volume (Veihmeyer and Hendrickson, 1948). The soil pH was measured in a 1:2.5 soil-to-water suspension using a glass electrode, and electrical conductivity was determined in the supernatant liquid of a 1:2.5 soil-to-water suspension using a conductivity meter (Jackson 1973). Soil organic carbon was determined using 1N $K_2Cr_2O_7$ and back titrated with 0.5 N FAS (Walkley and Black 1934). Available nitrogen was estimated using the alkaline $KMnO_4$ method (Subbiah and Asija, 1956), available phosphorus was extracted with Bray's extractant (0.025 M HCl and 0.03 M NH_4F) and measured

Table 1. Quantity of nutrients applied for different approaches of fertilizer recommendation and finger millet yield

Treatments	Nutrients applied (kg ha^{-1})			Yield (q ha^{-1})	
	N	P_2O_5	K_2O	Grain	Straw
T_1: STCR NPK TY 45 q ha^{-1}	125.28	72.56	48.44	46.07	66.47
T_2 STCR NPK + FYM TY 45 q ha^{-1}	97.18	54.68	34.82	46.30	67.90
T_3 STCR NPK TY 40 q ha^{-1}	108.83	63.25	39.37	42.48	64.14
T_4 STCR NPK + FYM TY 40 q ha^{-1}	80.73	45.71	24.18	41.23	56.93
T_5 General recommended dose	100.00	50.00	50.00	42.20	60.90
T_6 Soil fertility rating approach	100.00	37.50	50.00	41.96	58.21
T_7 Absolute control	0.00	0.00	0.00	20.00	20.96
S.Em. ±	-	-	-	1.72	2.17
C.D. @ 5%	-	-	-	5.04	6.38

colorimetrically by the ascorbic acid method (Bray and Kurtz, 1945), and available potassium was extracted with 1 N ammonium acetate (pH 7.0) and measured using a flame photometer (Page *et al*., 1982).

Plant samples were collected from each treatment, dried in shade and then in a hot air oven at 65°C, and were ground in a Willey mill. The micro Kjeldahl method determined nitrogen content in plant samples (Piper 1966). Di-acid extract was prepared using a 9:4 mixture of HNO_3:$HClO_4$ (Jackson 1973) to determine P and K content in the plant samples. The sample was pre-digestion using 10 mL of HNO_3 g^{-1} of sample. Phosphorus was determined spectrophotometrically by vanadomolybdate phosphoric acid yellow colour method (Jackson 1973), and potassium was estimated using a flame photometer (Jackson 1973). From the chemical analytical data, the uptake of each nutrient was calculated.

Nutrient uptake (kg ha^{-1}) = Nutrient content (%) × dry weight in kg ha^{-1} / 100

Nutrient Use Efficiency

Nutrient (N/P/K) use efficiency parameters *viz.,* Agronomic nutrient use efficiency (AE), Recovery efficiency (RE), Partial factor productivity (PFP), and Reciprocal internal utilization efficacy (RIUE) were calculated using the following formulae, as per Singh *et al* (2021):

$$AE(kg\ kg^{-1}) = \frac{[\text{Grain yield in treated plot } (kg\ ha^{-1}) - \text{Grain yield in control plot } (kg\ ha^{-1})]}{\text{Fertilizer nutrient applied } (kg\ ha^{-1})}$$

$$RE(kg\ kg^{-1}) = \frac{[\text{Nutrient uptake in treated plot } (kg\ ha^{-1}) - \text{Nutrient uptake in control plot } (kg\ ha^{-1})]}{\text{Fertilizer nutrient applied } (kg\ ha^{-1})}$$

$$PFP\ (q\ ha^{-1}) = \frac{[\text{Yield obtained in treated plot } (q\ ha^{-1})]}{\text{Fertilizer nutrient applied } (kg\ ha^{-1})}$$

$$RIUE(\%) = \frac{\text{Nutrient uptake by grain } (kg\ ha^{-1})}{\text{Grain yield } (Mg\ ha^{-1})}$$

Statistical Analysis

Descriptive statistics were used for the gradient and test crop experiment using SPSS 16.0 software. Data recorded in verification experiments were analyzed using the ANOVA technique (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Grain and straw yield

The grain yield of finger millet was significantly higher in the treatment receiving fertilizers through STCR NPK + FYM application for the targeted yield of 45 q ha^{-1} (46.30 q ha^{-1}) compared to STCR NPK + FYM TY 40 q ha^{-1} (41.23 q ha^{-1}), and absolute control (20.00 q ha^{-1}), respectively (Table 1). Similarly, significantly higher straw yield was recorded in STCR NPK + FYM TY 45 q ha^{-1} (67.90 q ha^{-}) compared to all other treatments. The lower grain and straw yields were recorded in absolute control plots.

Irrespective of the yield targets, the yield obtained in the STCR-based NPK + FYM application was higher when compared to the corresponding STCR-NPK application. Farmyard manure contributed relatively higher contents of available forms of most of the nutrient elements and better retention of moisture in the soil during crop growing seasons, which is also linked to increased photosynthetic accumulation, higher biomass output, and improved growth and yield attributes (Parvathi Sugumari *et al*., 2021). The grain yield under the 45 q ha^{-1} fixed yield target was 9.72 and 10.34% higher than the general recommendation dose and soil fertility rating approach, respectively. This might be due to balanced application of nutrients, which is based on soil analysis, amount of nutrients removed by crops, initial levels of soil fertility, efficiency of nutrients present in the soil, and added through fertilizers. These factors might have provided the optimum time for better uptake and ultimately resulted in higher dry matter production and yield (Suganya *et al*., 2025)

Nutrient uptake

Nutrient uptake data (Table 2) reveal that combined application of NPK and FYM for STCR targeted yield of 45 q ha^{-1} based on soil test value recorded significantly higher nitrogen (218.49 kg ha^{-1}), phosphorous (24.75 kg ha^{-1}) and potassium (165.74 kg ha^{-1}) uptake by finger millet compared to all the treatments. The lower uptake of nutrients (N: 64.27 kg ha^{-1}, P: 2.23 kg ha^{-1}, K: 23.47 kg ha^{-1}, respectively) was observed in the absolute control, where no fertilizer nutrients and FYM were applied. Whereas treatments receiving the general recommended dose and the soil fertility rating approach of fertilizer recommendation recorded lower uptake of NPK compared to the STCR approach, this might be due to the imbalanced application of fertilizer, which may lead to a loss of nutrients.

The greater nutrient uptake in STCR–IPNS treatments could be attributed to creating a conducive environment for crop growth through applying FYM by

Table 2. Influence of different approaches of fertilizer recommendation on major nutrients uptake in finger millet

Treatments	Nutrient uptake (kg ha^{-1})		
	N	P	K
$T_{1:}$ STCR NPK TY 45 q ha^{-1}	204.47	24.00	160.13
T_2 STCR NPK + FYM TY 45 q ha^{-1}	218.49	24.75	165.74
T_3 STCR NPK TY 40 q ha^{-1}	195.94	21.09	150.32
T_4 STCR NPK + FYM TY 40 q ha^{-1}	162.87	9.60	129.16
T_5 General recommended dose	175.51	10.36	131.27
T_6 Soil fertility rating approach	168.01	10.27	119.67
T_7 Absolute control	64.27	2.23	23.47
S.Em. ±	6.67	0.91	5.19
C.D. @ 5%	19.56	2.66	15.22

Table 3. Nutrient use efficiency in finger millet as influenced by different approaches of fertilizer recommendation

Treatment	Nitrogen use efficiency				Phosphorus use efficiency				Potassium use efficiency			
	ARE	AUE	PFP	IUE	ARE	AUE	PFP	IUE	ARE	AUE	PFP	IUE
	kg kg^{-1}			kg Mg^{-1}	kg kg^{-1}			kg Mg^{-1}	kg kg^{-1}			kg Mg^{-1}
T_1	20.81	1.12	36.77	22.53	35.93	0.30	63.49	191.99	53.82	2.82	95.11	28.77
T_2	27.06	1.59	47.64	21.19	48.10	0.41	84.67	187.04	75.53	4.09	132.97	27.94
T_3	20.66	1.21	39.03	21.68	35.54	0.30	67.16	201.42	57.10	3.22	107.90	28.26
T_4	26.30	1.22	51.07	25.32	46.44	0.16	90.20	429.47	87.80	4.37	170.51	31.92
T_5	22.20	1.11	42.20	24.04	44.40	0.16	84.40	407.41	44.40	2.16	84.40	32.15
T_6	21.96	1.04	41.96	24.97	58.56	0.21	111.89	408.41	43.92	1.92	83.92	35.06
T_7	0.00	0.00	0.00	31.12	0.00	0.00	0.00	897.34	0.00	0.00	0.00	85.21

ARE: Apparent recovery efficiency AUE: Agronomic use efficiency, PFP: Partial factor productivity IUE: Internal utilization efficiency

enhancing soil properties, nutrient retention and water holding capacity. This would mobilize the unavailable nutrients and also positively affect root growth, ensuring improved uptake of nutrients (Sugumari *et al*., 2021). Significantly higher NPK uptake in the STCR approach was recorded compared to other approaches due to the application of the required quantity of nutrients through inorganic fertilizers, resulting in higher uptake and high dry matter production because of higher availability of nutrients (Krishna Murthy *et al*., 2024c).

Agronomic nutrient use efficiency

The higher agronomic nitrogen use efficiency (28.12 kg kg^{-1}) was recorded in the treatment receiving STCR-based NPK + FYM application based on soil test values for a targeted yield of 45 q ha^{-1}, respectively (Table 3). Similarly, higher phosphorus use efficiency was also recorded in the same treatment. However, the higher potassium use efficiency was recorded in STCR-based NPK + FYM application for a targeted yield of 40 q ha^{-1} (87.80 kg kg^{-1}) based on soil test values. The lower agronomic nutrient use efficiency of NPK was noticed in treatments that recorded lower yield with higher application of fertilizer nutrients.

Apparent recovery efficiency

The higher apparent recovery efficiency in nitrogen (1.59 kg kg^{-1}) and phosphorus (0.41 kg kg^{-1}) was recorded in T_2 STCR NPK + FYM TY 45 q ha$^{-1,}$ but a higher apparent recovery efficiency of potassium was recorded in STCR NPK + FYM TY 40 q ha^{-1} (4.37 kg kg^{-1}). The lower apparent recovery efficiency of nitrogen (1.04 kg kg^{-1}) and potassium (1.92 kg kg^{-1}) was recorded in the soil fertility rating approach. At the same time, lower phosphorus recovery efficiency was recorded in absolute control (0.14 kg kg^{-1}).

Higher agronomic nutrient use efficiency and apparent crop recovery efficiency was recorded in treatment receiving STCR based NPK + FYM due to application of fertilizers as per the crop demand along with incorporation of 10 t ha^{-1} FYM which resulted in higher yield and uptake of nutrients per kg of fertilizer added, without any loss of nutrient due to excessive usage, there by increased ANUE and ARE in finger millet. It is also associated with lower fertilizer rate, cultural practices meant for promoting integrated nutrient management, which helped for effective saving in the amount of fertilizer nutrient applied to the crops and thereby improved fertilizer use efficiency (Rangaiah *et al*., 2023a).

Partial factor productivity

The higher partial factor productivity of nitrogen and potassium was recorded in STCR NPK + FYM TY 40 q ha^{-1} (51.07 kg kg^{-1}). However, the higher partial factor productivity of phosphorus was recorded in the soil fertility rating approach (111.89 kg kg^{-1}), which recorded a higher yield (41.96 q ha^{-1}) with a lower dose of phosphorus fertilizer (37.50 kg ha^{-1}) application.

Partial factor productivity was higher in the treatment, showing higher yields with respect to a lower fertilizer application rate (Karthika *et al*., 2024).

Internal utilization efficiency

The internal utilization efficiency of nitrogen, phosphorus, and potassium recorded a higher value in the absolute control plot than all treatments (Table 3). This may be attributed to the higher utilization efficiency of NPK, which was recorded with no fertilizer application compared to fertilized treatments. This signifies the deficiency of nutrients in the control plot (Krishna Murthy *et al*., 2023b).

Response Yard Stick

The response yard stick (RYS) indicates the yield obtained in kg per kg of NPK applied in that particular ratio of each treatment. The response yard stick was recorded at 14.10 kg kg^{-1} in STCR NPK + FYM with a yield target of 40 q ha^{-1} based on soil test values.

Response yard stick recorded higher in STCR based NPK + FYM application than compared general recommended dose and soil fertility rating approach it may be attributed to that fertilizers were applied along with FYM to crop in balanced manner by considering soil test values and nutrient requirement of the crop which was effectively utilized by the crop to achieve the target as compared to all other treatments (Bhavya *et al*., 2023) and organic manures also contain both micro and macronutrients, unlike NPK fertilizer that contains only N, P and K which contributed to the higher grain yield in crop (Spoorthishankar *et al*., 2025).

Per cent Deviation

The percent deviation indicated the yield variation from the targeted yield (Table 4). In the present study, it was found to be higher in STCR-based NPK + FYM application for the target of 40 q ha-1 based on soil test values (6.20%), where the yield obtained was higher than the fixed targets. All remaining treatments found positive deviation from the fixed target. Here, the higher negative deviation indicates that the crop could not achieve the genetic potential yield in these treatments. The per cent deviation of ± 10.00 will generally be considered the best equation; otherwise, the equations will be modified (Patel *et al*., 2001).

Table 4. Influence of different approaches of fertilizer recommendation on response yard stick, percent deviation and benefit cost ratio of finger millet

Treatments	RYS	% Deviation	BCR
T_1 STCR NPK TY 45 q ha^{-1}	10.59	2.38	2.93
T_2 STCR NPK + FYM TY 45 q ha^{-1}	14.09	2.89	2.38
T_3 STCR NPK TY 40 q ha^{-1}	10.63	6.20	2.81
T_4 STCR NPK + FYM TY 40 q ha^{-1}	14.10	3.08	2.12
T_5 General recommended dose	11.10	5.50	2.14
T_6 Soil fertility rating approach	11.71	4.90	2.12
T_7 Absolute control	-	-	1.39

Benefit Cost Ratio

The higher benefit cost ratio (BCR) of 2.93 was recorded where fertilizer nutrients were applied through STCR NPK alone for a yield target of 45 q ha^{-1} based on soil test values, followed by 2.81 in STCR NPK TY 40 q ha^{-1}. The lower benefit-cost ratio of 1.39 was recorded in the absolute control plot, where fertilizers and FYM were not applied.

The benefit-cost ratio was highest in STCR treatments with a purely inorganic approach compared to any other treatments. The highest BCR could be mainly due to lower levels of NPK fertilizer application associated with higher yield (46.07 q ha^{-1}) production compared to all other treatments. Even though higher yields were recorded in the STCR integrated approach, the BCR was lower, mainly due to the high cost of FYM (Krishna Murthy *et al*., 2023c). BCR was found to be 36.92 and 38.21% higher in fertilizer treatments based on STCR methodology as compared to the general recommended dose and soil fertility rating approach at both locations respectively, it may be attributed to the balanced application of nutrients based on crop requirement and contribution from soil, fertilizer and organic matter had reduced excess application of fertilizers thereby reduced cost of fertilizer application (Spoorthishankar *et al*., 2025).

CONCLUSION

Based on this study, it can be concluded that the STCR targeted yield equations developed for finger millet crop is most suitable for Zone-6 of Karnataka and Dhartimitra software can be used to prescribe fertilizer dose for finger millet where frequent soil testing could be avoided for getting higher grain and straw yield compared to all other different approaches of fertilizer recommendation. Even though BCR was recorded lower in STCR-based NPK + FYM application due to high cost of FYM, these treatments should be recommended for applying a balanced dose of fertilizer nutrients to encourage farmers to utilize their compost/FYM to reduce the cost of production and maintain soil sustainability.

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Originality and Plagiarism:

We hereby declare that the work presented in this manuscript is original and has not been published elsewhere, nor is it currently under consideration for publication by any other journal. All sources that have been used or quoted are properly cited and acknowledged. We affirm that the manuscript is free from plagiarism, including self-plagiarism, and complies with the ethical standards for academic publishing.

Data availability statement:

The data that support this study will be shared upon reasonable request to the corresponding author.

Conflict of interest:

The author reported no potential conflicts of interest.

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