Original Research Article

VALIDATION OF TARGETED YIELD EQUATIONS FOR FINGER MILLET UNDER SOUTHERN DRY ZONE OF KARNATAKA

ABSTRACT

General usage of fertilizers resulted in less productive soils and not able to harvest the complete genetic potential of the crop. Hence, it's indispensable to follow a more scientific application of fertilizer nutrients *i.e*, Soil Test Crop Response (STCR) approach to meet the nutrient demand of the crop and to feed the increasing human population without compromising on limited land resources. Therefore, field experiments were carried out at Mandya and Mysore to validate the fertilizer prescription equation for targeted yield of finger millet developed through STCR approach. STCR target 40 q ha^{-1} through integrated approach had shown comparatively higher amount of grain yield (42.65 and 42.00 q ha^{-1} at Mandya and Mysore respectively) compared to all other treatments. Similarly, nutrient uptake of the aforesaid treatment had shown comparatively higher (101.97, 6.54 and 55.01 kg ha^{-1} of N, P and K respectively at Mandya and 99.41, 7.06 and 58.22 kg ha^{-1} of N, P and K respectively at Mysore) than other treatments. The higher economics in terms of value cost ratio was recorded from STCR treatments compared to soil test laboratory approach and general recommended dose thus proving the superiority of STCR approach over other approaches of fertilizer recommendation.

- *Keywords: STCR, Finger millet, Yield, Uptake, Economics.*

1. INTRODUCTION

The human population at the beginning of the 20th century was 1.4 billion, it has rose to nearly 8 billion by 2022, this increase of human population and increase in the demand for food has made human beings to look alternatives to grow more crops per unit area and produce more food per unit area.[1] Few of the alternatives found were usage of fertilizers and introduction of high yielding varieties and hybrids. Hence, fertilizer usage initiated during 1960-1970s in the course of green revolution, then the fertilizer use efficiency was 16 kg food grain per kilo gram use of NPK nutrients. But the nutrient use efficiency of fertilizers has come down drastically (6 kg food grain per kilo gram use of NPK nutrients) due to various reasons and one could be imbalanced, unscientific application of fertilizers and increasing deficiency of secondary and micronutrients in soil.[2] With the introduction of fertilizer responsive high yielding varieties and hybrids, the fertilizer consumption also increased. As the data presented in the Rajya Sabha by the Government of India, the usage of fertilizers was 8.00 lakh tonne in 1960 and it has mounted to 590 lakh tonne in 2020-2021. Therefore, for efficient and economic use, it is necessary to have information on the optimum dose of fertilizers and organics based on soil testing for different soils.

Study on nutrient uptake and efficiency of added nutrients by the crop may be helpful in formulating sound fertility evaluation programme. Soil Test Crop Response (STCR) approach is a novel approach, which is site and situation specific, wherein fertilizer recommendations are made by considering nutrient use efficiency of the crop, nutrient

contribution of the soil and added organic matter, and also yield target. The fertilizer dose can be altered based on the yield target, so that farmers can apply fertilizers based on their economic resources and requirement.[3] Therefore, in order to extrapolate the STCR equations to other situations (Zones), one should evaluate the equation for its suitability.
Finger millet is the fourth important small millet crop grown globally after sorghum, pearl millet and foxtail millet. In India, it is the sixth important cereal after rice, wheat, maize, sorghum and pearl millet. In Karnataka, finger millet occupies an area of 1.02 million hectares with a production of 1.86 million tonnes, accounting for 53.95 per cent area and 44.94 per cent production compared to the whole country. Unscientific use of fertilizers in intensive cropping system poses serious problems to soil fertility and results in harmful effects on soil physico-chemical and biological properties that deter sustainable crop production. The objective of this work is to validate the developed STCR equation of Eastern Dry Zone of Karnataka at Southern Dry Zone.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

Field experiments were conducted to validate the targeted yield equations developed by AICRP on STCR, University of Agricultural Sciences, GKVK, Bangalore for finger millet crop under Southern Dry Zone of Karnataka at two different locations *viz.,* Zonal Agricultural Research Station, VC Farm, Mandya district (Location 1) and Krishi Vigyan Kendra, Suttur, Mysuru district (Location 2). Composite soil samples were collected from each plot after laying out the plan and before sowing and analyzed for soil pH. organic carbon content [4], alkaline $KMnO_4$-N [5], Olsens-P_2O_5[6] and NH_4OAc-K [7]. The soils of Zonal Agricultural Research Station, VC Farm, Mandya were neutral in reaction with EC of 0.06 dSm^{-1} and organic carbon ranging from 0.85 – 0.90%. The available nitrogen (N), phosphorus (P) and potassium (K) was ranging from 390.32 – 420.56 kg ha^{-1}, 9.30 – 10.95 kg ha^{-1} and 132.97 – 144.58 kg ha^{-1}, respectively. The soils of Krishi Vigyan Kendra, Suttur, Mysuru district were neutral in reaction with EC of 0.15 dSm^{-1} and organic carbon ranging from 0.36 – 0.42%. The available nitrogen (N), phosphorus (P) and potassium (K) was ranging from 285.62 – 295.63 kg ha^{-1}, 3.73– 5.61 kg ha^{-1} and 284.69 – 290.56 kg ha^{-1}, respectively.

The experiment was laid out in randomized complete block design (RCBD) with twelve treatments comprising T_1: STCR target 40 q ha^{-1} through Inorganics (NPK alone) T_2: STCR target 40 q ha^{-1} through Integrated (NPK + FYM), T_3: STCR target 30 q ha^{-1} through Inorganics, T_4: STCR target 30 q ha^{-1} through Integrated, T_5: Soil test laboratory (STL) approach, T_6: General Recommended Dose (GRD) T_7: Absolute control. The yield targets should not exceed 20 – 30% of yield mentioned in package of practice as the yield depends on genetic potentiality of the crop. The following STCR fertilizer adjustment equations were used for fertilizer application to STCR treatments. The STCR equations used for this experiment is as follows.

FN = 3.29 T -71.17 (% OC) - 0.00281 OM.

FP= 1.798 T - 0.189 (SP)- 0.00173 OM.

FK = 1.775 T - 0.15 (SK) - 0.0015 OM.

Where, FN, FP and FK are fertilizer N, Pand K in kg ha^{-1}, respectively; T is the yield target in q ha^{-1}; %OC, SP and SK are organic carbon content in per cent, available P and NH_4OAc-K in kg ha^{-1}, respectively and OM is amount of FYM added in t ha^{-1}.

Based on the soil test values NPK fertilizer nutrients were applied for specific yield target in STCR and STL approach. The quantity of nutrients applied per hectare through different approaches as per the treatments are presented in Table I. The grain and straw yields were recorded and plot-wise grain and straw samples from each plot were analyzed for total N [8], P and K [9] contents and uptake of N, P and K by finger millet were computed.

Table I: Quantity of fertilizer nutrients per hectare through different approaches as per the treatment

Treatment details	Location 1			Location 2		
	N	P	K	N	P	K
T_1:STCR target 40 q ha^{-1} through Inorganics (NPK alone)	67.50	29.67	38.99	106.00	30.72	16.23
T_2:STCR target 40 q ha^{-1} through Integrated (NPK+FYM)	33.75	20.82	10.98	53.00	16.42	0.00
T_3:STCR target 30 q ha^{-1} through Inorganics (NPK alone)	34.58	21.82	24.26	73.08	22.86	1.49
T_4:STCR target 30 q ha^{-1} through Integrated (NPK+FYM)	17.29	17.28	15.65	36.54	13.04	0.00
T_5: Soil test laboratory (STL) approach	87.50	27.31	41.50	100.00	21.85	41.50
T_6: General Recommended Dose (GRD)	100.00	21.85	41.50	100.00	21.85	41.50
T_7: Absolute control	-	-	-	-	-	-

Note: FYM at 10 t ha^{-1} was added to treatment T_2, T_4, T_5 and T_6.

Using the data recorded from the experiment, the following parameters were calculated as furnished below [10]:

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

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

$$\text{Nutrient uptake} = \frac{[\text{Nutrient content (\%)} \times \text{Dry weight (kg ha}^{-1})]}{100}$$

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

Experimental data generated in the verification trial was subjected to statistical analysis adopting Fisher's method of analysis of variance [11].

3. RESULTS AND DISCUSSION

3.1 Grain yield

The grain yield of finger millet at both the locations *i.e.,* Zonal Agricultural Research Station, VC farm, Mandya district and Krishi Vigyan Kendra, Suttur, Mysore district was significantly higher in treatment receiving fertilizers through STCR integrated approach for the targeted yield of 40 q ha^{-1} (42.65 and 42.00 q ha^{-1}) compared to General recommended dose (38.03 and 33.33 q ha^{-1}) and Soil test laboratory approach (36.67 and 34.03 q ha^{-1}) (Table II).

However, it was found on par with the other STCR treatments. The STCR treatments recorded higher yield than the target fixed and STCR integrated approach recorded higher yield compared to the respective inorganic approach at the targeted yield of 40 and 30 q ha^{-1} and at location 1 and 2. The enhanced nutrient uptake and increased nutrient use efficiency under STCR approach over STL and GRD would have resulted in positive effect on growth and yield attributes that have enabled higher yield. Also, there might be favorable complementary influence of organics and inorganics on soil properties under STCR integrated approach would have resulted in higher yield. [12] The higher grain yield in STCR treatments could also be attributed to the ability of targeted yield approach to supply the nutrient demand of crop more efficiently as it considers the nutrient requirement of the crop and contribution of nutrients from soil, fertilizers and organic manures and it discourages lop sized application of nutrient or over fertilization.[13] Even though lower dose or no potassium fertilizer was applied in STCR treatments at both the targets as per the equations due to sufficient quantity of potassium in soils, the higher yield was recorded compared to Soil test laboratory approach and General recommended dose receiving higher amount of potassium fertilizer which clearly indicate that higher K application can be avoided by applying only the required quantity of fertilizer based on soil test and targeted yield approach of fertilizer recommendation so that unnecessary over-dose application at high available potassium soils can be restricted.[14]

3.2 Per cent Deviation

The percent deviation indicated the yield variation from the target fixed (Table II). The per cent (%) deviation in the present study from the fixed target was found to be positive in STCR target of 35 q ha^{-1} through integrated (29.43% and 37.00% at location 1 and 2, respectively) and inorganic approach (27.23% and 35.53% at location 1 and 2, respectively) followed by STCR target of 40 q ha^{-1} through integrated (6.62% and 5.00% at location 1 and 2, respectively) and inorganic approach (3.75% and 3.33% at location 1 and 2, respectively) where the yield obtained was higher than the fixed targets. However, the higher negative deviation was noticed in soil test laboratory approach and general recommended dose indicating that the crop could not achieve the genetic potential yield in these treatments. The per cent deviation of ± 10.00 will be generally considered as a best equation otherwise the equations will be modified.[15]

3.3 Value Cost Ratio

The higher value cost ratio (VCR) of 7.68 was recorded where fertilizer nutrients were applied through STCR integrated approach for a yield target of 40 q ha^{-1} (T_2) followed by 6.11 under STCR target of 35 q ha^{-1} through integrated approach (T_4) at location 1. Similarly, the higher VCR of 8.72 was recorded under STCR targeted yield of 35 q ha^{-1} through inorganic approach (T_3) followed by 6.20 under STCR target of 40 q ha^{-1} through inorganics (T_1). The lower value cost ratio of 2.78 was recorded in soil test laboratory approach at location 1 and 1.55 under general recommended dose at location 2. The higher VCR under inorganic approach at location 2 could be attribute to no application of potassium fertilizer as the soils were high in available potassium content. The results are in conformity with the findings of Basavaraja*et al.*[16] who have reported that higher VCR in STCR treatments could be mainly due to lower levels of NPK fertilizer application compared to STL/ GRD approach associated with higher yields.

Table II: Influence of different approaches of fertilizer recommendation on yield, per cent deviation, yield response and VCR of finger millet

Treatments	Yield (q ha^{-1})		Per cent deviation		VCR	
	Location 1	Location 2	Location 1	Location 2	Location 1	Location 2
T_1:STCR target 40 q ha^{-1} through Inorganics (NPK alone)	41.5	41.33	3.75	3.33	5.76	6.20
T_2:STCR target 40 q ha^{-1} through Integrated (NPK+FYM)	42.65	42.00	6.62	5.00	7.68	6.08
T_3:STCR target 30 q ha^{-1} through Inorganics (NPK alone)	38.17	40.66	9.06	16.17	6.07	8.72
T_4:STCR target 30 q ha^{-1} through Integrated (NPK+FYM)	38.83	41.10	10.94	17.43	6.11	6.15
T_5: Soil test laboratory (STL) approach	36.67	34.03	-8.33	-14.93	2.78	1.68
T_6: General Recommended Dose (GRD)	38.03	33.33	-4.93	-16.68	3.95	1.55
T_7: Absolute control	29.67	29.00	-	-	-	-
S.Em±	**1.50**	**1.44**	-	-	-	-
CD @ 5%	**4.50**	**4.29**	-	-	-	-

3.4 Nutrient uptake

Significantly higher uptake of nitrogen, phosphorus and potassium were recorded with application of nutrients through STCR integrated approach for the targeted yield of 40 q ha^{-1} at both the locations as compared to soil test laboratory approach, general recommended dose and other STCR treatments except STCR target of 40 q ha^{-1} through inorganics which is on par. Application of nutrients considering the crop requirement with and without FYM based on soil test values for the targeted yield of finger millet recorded significantly higher uptake of nitrogen, phosphorus and potassium over that of soil test laboratory approach and general recommended dose which could be attributed to higher yield and balanced application of fertilizer doses that enables the higher availability of nutrients in the rhizosphere soil thereby proliferous growth of root system leads to ease in absorption of nitrogen, phosphorus and potassium resulted in higher uptake. Similar findings were reported by Basavaraja*et al* [16] who concluded that significantly higher NPK uptake was recorded in STCR-targeted yield with IPNS approach (30 q ha^{-1}) in finger millet crop which was on par with package of practice (POP) approach. The higher uptake and the availability of these nutrients were due to higher availability of nutrients and high dry matter production.

Table III: Influence of different approaches of fertilizer recommendation on nutrient uptake by finger millet

Treatments	Location 1			Location 2		
	N	P	K	N	P	K
	(kg ha^{-1})					
T_1:STCR target 40 q ha^{-1} through Inorganics (NPK alone)	98.825	6.02	50.02	96.53	6.88	54.18
T_2:STCR target 40 q ha^{-1} through Integrated (NPK+FYM)	101.97	6.54	55.01	99.41	7.06	58.22
T_3:STCR target 30 q ha^{-1} through Inorganics (NPK alone)	88.38	5.84	45.32	84.53	6.22	49.12
T_4:STCR target 30 q ha^{-1} through Integrated (NPK+FYM)	89.65	5.90	46.67	89.63	6.42	48.62
T_5: Soil test laboratory (STL) approach	85.23	5.51	46.16	70.28	5.64	45.06
T_6: General Recommended Dose (GRD)	90.21	5.42	44.28	65.26	5.55	43.69
T_7: Absolute control	35.79	3.61	25.07	28.56	3.51	25.16
S.Em±	**2.50**	**0.29**	**2.90**	**2.68**	**0.32**	**2.03**
CD @ 5%	**7.24**	**0.89**	**8.62**	**7.88**	**0.86**	**7.68**

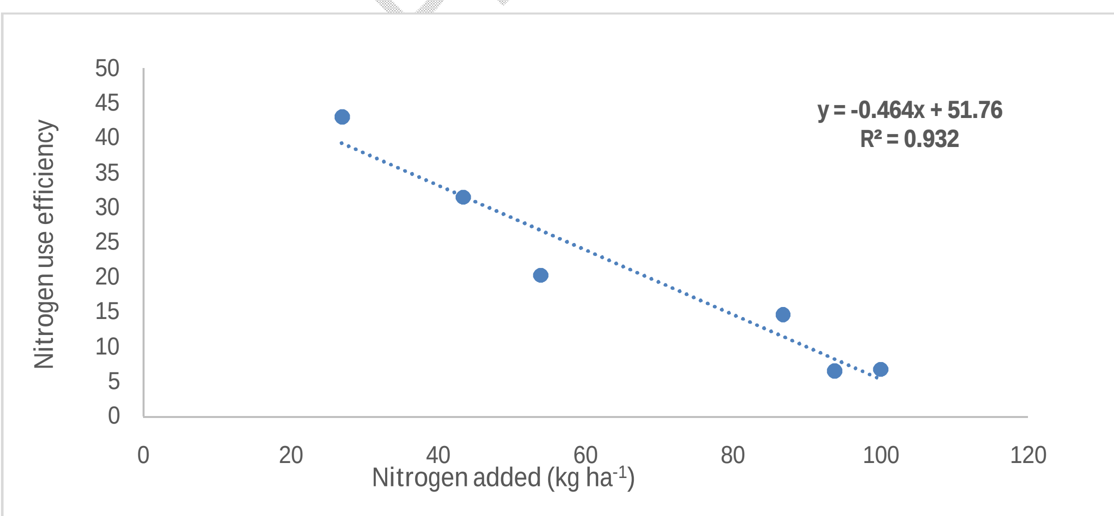
3.5 Nutrient use efficiency

The higher nitrogen use efficiency at location 1 (52.98 kg kg^{-1}) and location 2 (33.11 kg kg^{-1}) was recorded in treatment receiving fertilizers based on STCR approach for the targeted yield of 30 q ha^{-1} through integrated followed by STCR target of 40 q ha^{-1} through inorganics. Among STCR treatments integrated approach recorded higher use efficiency compared to their inorganics and lower targeted yield recorded higher use efficiency which could be attributed to the higher yield associated with lower dose of fertilizers based on targeted yield equations. Whereas, the lower use efficiency was recorded in soil test laboratory approach (8.00 and 5.03 kg kg^{-1} at location 1 and 2, respectively) and general recommended dose (9.16 and 4.33 kg kg^{-1} at location 1 and 2, respectively). Similarly, the higher use efficiency of phosphorus (11.90 kg kg^{-1}) and potassium (81.43 kg kg^{-1}) at location 1 was noticed in treatment T_2 (STCR target 40 q ha^{-1}integrated) and the lower use efficiency was recorded in soil test laboratory approach (4.89 and 11.62 kg ka^{-1} of P and K, respectively). The potassium use efficiency at location 2 was higher (537.66) in treatment T_3 (STCR target 35 q ha^{-1}inorganics) which could be attribute to higher yield associated with application of only 1.80 kg ha^{-1} of potassium fertilizer. However, the K use efficiency could not be worked out for treatment T_2 and T_4 as K fertilizer was not applied to these treatment as per targeted yield equations. The results are in accordance with the findings of Prakash *et al* [17]who reported that use efficiency of N, P and K was progressively increased in rice with incremental doses of respective nutrients due to balanced application of nutrients, increased nutrient uptake and utilization of indigenous nutrients, and by increasing the efficiency with which applied nutrients are taken up by the crop and utilized to produce higher grain yield.

A positive quadratic association between nutrient use efficiency and total nutrient applied in finger millet was observed (Fig. I). Total nutrient applied accounted to 93.22 per cent, 50.76 per cent and 74.50 percent of the variability of nitrogen, phosphorus and potassium use efficiency respectively.

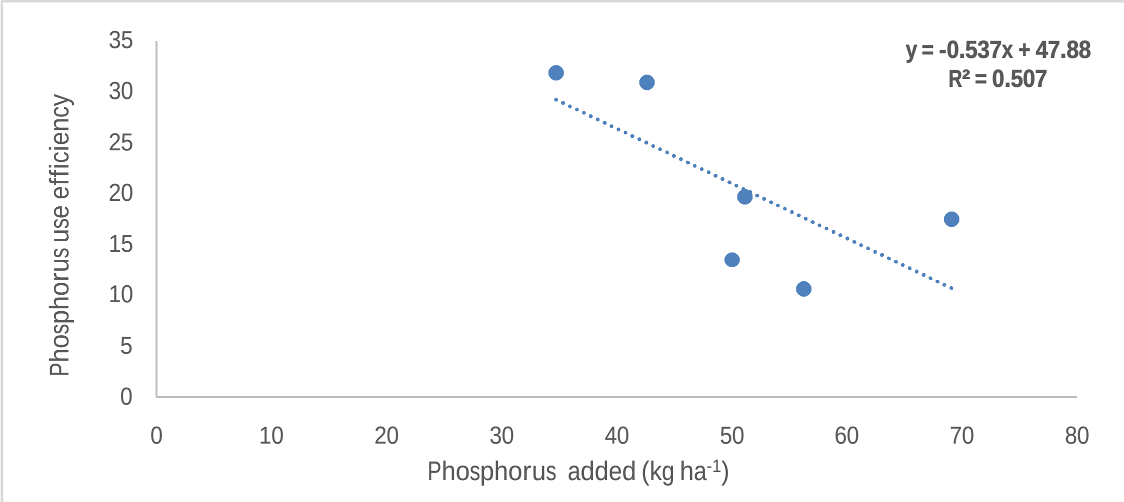
Table IV:Influence of different approaches of fertilizer recommendation on nutrient use efficiency by finger millet

Treatments	Location 1			Location 2		
	N	P	K	N	P	K
	(kg kg^{-1})					
T_1:STCR target 40 q ha^{-1} through Inorganics (NPK alone)	17.53	7.61	20.90	11.63	7.66	52.35
T_2:STCR target 40 q ha^{-1} through Integrated (NPK+FYM)	38.46	11.90	81.43	24.53	15.12	-
T_3:STCR target 30 q ha^{-1} through Inorganics (NPK alone)	24.58	7.44	24.14	15.96	9.74	537.66
T_4:STCR target 30 q ha^{-1} through Integrated (NPK+FYM)	52.98	10.12	40.31	33.11	17.72	-
T_5: Soil test laboratory (STL) approach	8.00	4.89	11.62	5.03	4.40	8.35
T_6: General Recommended Dose (GRD)	9.16	8.01	15.21	4.33	3.78	7.19
T_7: Absolute control	-	-	-	-	-	-



a)

b)



c)

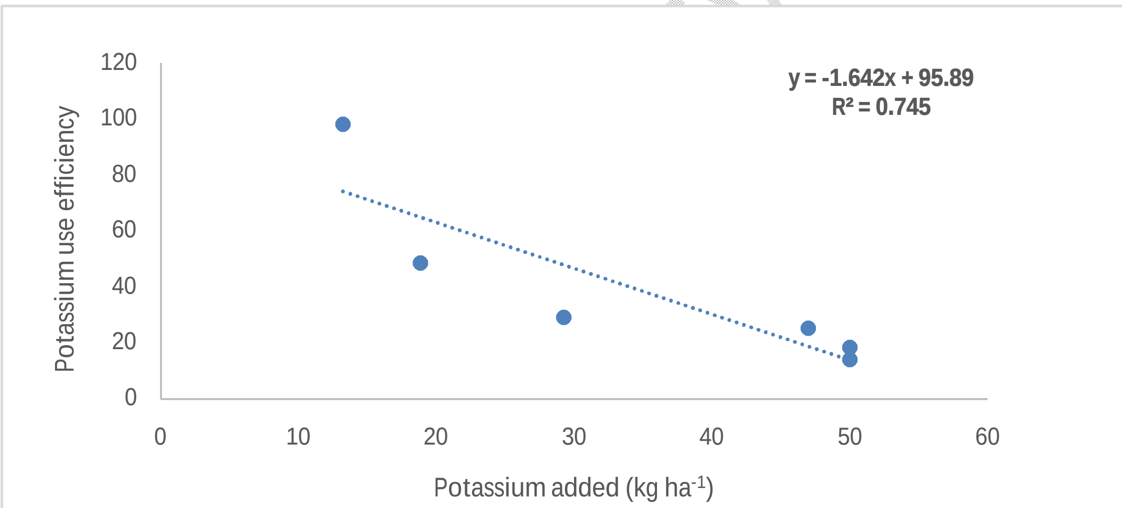


Figure I: Relationship between nutrient use efficiency and nutrient applied for a) Nitrogen b) Phosphorus and c) Potassium.

4. CONCLUSION

Based on this study, it can be concluded that the STCR targeted yield equations developed for Finger millet crop is most suitable for southern dry zone of Karnataka for getting higher yield compared to all other approaches of fertilizer nutrient recommendation. The STCR integrated approach have recorded the higher yield, nutrient uptake, use efficiency and economics. Therefore, this approach of nutrient management can be recommended as an effective tool for balanced fertilization.

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