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Evaluation of different approaches of fertilizer recommendation on finger millet (*Eleusine coracana* L) yield, nutrient requirement and economics

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ABSTRACT

A field experiment was conducted at Zonal Agricultural Research Station, UAS, GKVK, Bengaluru, Karnataka to study the effect of different approaches of fertilizer application on yield and nutrient use efficiency of finger millet crop under dry land condition. The results revealed that the soil test crop response (STCR)-targeted yield (30 q/ha) with integrated plant nutrient system (IPNS) approach resulted in significantly highest grain yield (41.42 q/ha) whereas highest stover yield was noticed with package of practices (PoP) approach (70.82 q/ha). Similarly significantly higher nutrient uptake was recorded in STCR-targeted yield with IPNS approach (30 q/ha) which was on par with PoP approach. However the highest nutrient requirement (NR) was recorded in STCR treatment either with inorganics or IPNS. Similarly the better profit was also recorded (VCR: 15.45) in STCR-targeted yield (20 q/ha) with inorganic approach.

Keywords: STCR yield target; finger millet, nutrient requirement; value-cost ratio

INTRODUCTION

Soil fertility evaluation helps the farmers to use fertilizer nutrients according to the need of the crop. Therefore soil testing is now accepted as a procedure for the recommendation of doses and kind of fertilizer nutrients. Fertilizer nutrient recommendations are usually given for different crops by taking into consideration the soil available nutrient status which is being categorised as low, medium and high. Among the various methods of fertilizer recommendations the soil test crop response (STCR)-targeted yield approach is unique in the sense that this method not only indicates the soil test-based fertilizer dose but also the level of yield the farmer can hope to achieve if good agronomic practices are adopted in crop cultivation. However soil testing would become a useful tool when it is based on intimate knowledge of soil-crop-variety-fertilizer-climate and management practices interaction for a given situation (Kanwar 1971).

Finger millet (*Eleusine coracana* L) is the third most important millet in India (locally called as ragi) next to sorghum and pearl millet. In Karnataka

finger millet is extensively cultivated as a means of livelihood. Finger millet tastes good and is nutritionally rich (compared to cassava, plantain, polished rice and maize meal) as it contains high levels of calcium, iron and manganese while the finger millet straw is highly valued as feed for livestock and fuel. It contains a low glycemic index and has no gluten which makes it suitable for diabetics and people with digestive problems.

Karnataka is the state with second biggest area under rainfed lands. Under rainfed agro-ecosystems the best results in crop productivity can be achieved by adopting a holistic approach in which soil and water conservation measures are implemented along with sound nutrient management options (Wani et al 2003).

STCR-targeted yield approach can be used for individual field situation and is a better approximation for planning the requirement of fertilizers on area basis for a given level of crop production. Since fertilizer is a costly input the scientific and efficient utilization of this input is the call of the day. In this input utilization

STCR approach plays a vital role as a comprehensive approach of fertilizer utilization wherein fertilizer is applied based on yield target, site specification, crop specification and soil test values. However there is a need to evaluate the STCR-targeted yield approach in comparison with the other approaches for yield variation, nutrient uptake, nutrient requirement and economics so that its validity can be further scrutinized.

MATERIAL and METHODS

A field experiment was conducted to evaluate the different approaches of fertilizer application during Kharif season of 2013-14 at Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka. The experimental site belonging to Vijayapura series was classified as Kandic Paleustalf and was red laomy in texture and low in

organic carbon with slightly acidic pH (6.50). Available nitrogen was low (265.26-312.32 kg/ha), phosphorus high (65.91-103.20 P_2O_5 kg/ha) and potassium low (152.40-315.60 K_2O kg/ha). The experiment was laid out in randomized complete block design (RCBD) with seven treatments replicated thrice comprising T_1 (STCR-targeted @ 30 q/ha with purely inorganics), T_2 (STCR-targeted @ 30 q/ha with IPNS approach), T_3 (STCR-targeted @ 20 q/ha with purely inorganics), T_4 (STCR-targeted @ 20 q/ha with IPNS approach), T_5 (PoP or general recommendations), T_6 (Soil test laboratory (STL) approach), T_7 (Absolute control).

The following STCR fertilizer adjustment equation developed by AICRP on STCR, UAS, Bengaluru centre under dryland condition for Zone-5 was used for STCR treatments.

STCR equation for inorganics	STCR equation for IPNS
FN= 9.128239 T – 0.678209 STV	FN= 9.128239 T – 0.678209 STV – 0.00635104 OM
FP ₂ O ₅ = 1.603342 T – 0.342016 STV	FP ₂ O ₅ = 1.603342 T – 0.342016 STV – 0.00325642 OM
FK ₂ O = 2.329544 T – 0.174945 STV	FK ₂ O = 2.329544 T – 0.174945 STV – 0.00370249 OM

Using this fertilizer adjustment equation the quantity of fertilizer nutrients required with or without FYM for achieving the target of 20 and 30 q/ha grain yield of finger millet was worked out. The quantity of fertilizer nutrients (NPK) applied for each treatment is mentioned in Table 1.

After laying out the field plan soil samples were drawn from each treatment from experimental site. Based on the soil test values NPK fertilizers were applied in STCR and LMH approach. However in PoP recommended dose of FYM + NPK (50:40:25 kg NPK/ha) was applied. Fifty per cent of nitrogen recommended for each treatment was applied through urea and entire quantity of phosphorus through SSP (single super phosphate) and potassium through MoP (muriate of potash) were supplied at the time of transplanting as basal dose to each plot and remaining

50 per cent of nitrogen was applied 30 days after transplanting. At harvest net plot finger millet earheads were harvested and grains were separated, dried, weighed and computed to q/ha. Similarly straw from each plot was harvested, weighed and computed to q/ha. At harvest random grain and straw samples were collected, dried, powdered and used for analysing the concentration of NPK by adopting the standard procedures outlined by Jackson (1973). Soil samples collected from the experimental plots after crop harvest were processed and analysed for available nitrogen, phosphorus and potassium by following standard procedures (Jackson 1973). After analysing the major nutrient concentrations in grain and straw samples uptake of these nutrients by finger millet, nutrient requirement (NR), response yard stick (RYS) and value-cost ratio (VCR) were computed by using the standard formulae shown below:

$$\text{Nutrient requirement (NR) (kg/q)} = \frac{\text{Total uptake of NPK (kg/ha)}}{\text{Finger millet grain yield (q/ha)}}$$

The data collected with respect to yield, nutrient uptake and available nutrient status were subjected to statistical analysis. The level of significance used in F-

and t-test was $P = 0.05$. Critical difference (CD) values were calculated for $P = 0.05$ whenever F-test was found significant.

$$\text{Response yard stick (RYS)} = \frac{\text{Yield response}^*}{\text{Fertilizer applied}}$$

*Yield response= Treated yield - control yield

$$\text{Value-cost ratio (VCR)} = \frac{\text{Cost of grain yield above the control yield}}{\text{Cost of fertilizer and FYM added}}$$

RESULTS and DISCUSSION

The grain and straw yield was significantly influenced by various approaches (Table 2). Significantly highest grain yield (41.42 q/ha) was recorded in STCR-targeted (30 q/ha) with IPNS approach followed by package of practices (40.41 q/ha). STCR-targeted (30 and 20 q/ha) with IPNS approach recorded higher yield (39.42 and 34.93 q/ha respectively) compared to same target of STCR with purely inorganics. The STCR approaches gave higher yield than the target fixed in both inorganic and integrated approaches. The increase in yield due to application of fertilizers based on STCR approaches with or without FYM may be attributed to the increase in growth and yield attributing characters as a consequent of improved efficiency through balanced nutrient application. The increase in grain yield might be due to combined use of FYM and inorganic fertilizers in balanced way. Rao et al (2012) reported increased yield and grain protein content in finger millet due to N fertilizer application rates up to 40 kg/ha in Andhra Pradesh and claimed that the economic optimum rate of N fertilizer for finger millet was 43.5 kg/ha under rainfed conditions. Similarly Ryan et al (2012) suggested that application of NPK along with micronutrients and FYM (7.5-12.5 tonnes/ha) increased the finger millet yield.

Package of practices (PoP) treatment achieved significantly highest straw yield (70.82 q/ha) as compared to control (30.44 q/ha) and STCR 20 q/ha target (55.12 q/ha) with IPNS approach but it was on par with all other treatments. Increased straw yield in PoP and STCR treatments with IPNS may be ascribed to better plant growth due to improved nutrient supply and uptake of nutrients by crop with improvement in soil properties. Long-term use of fertilizers in crop production leads to soil organic matter (SOM) accumulation and soil health improvement through addition of increasing amount of litter and root biomass of the soil (Ladha et al 2011, Geiseller and

Scow 2014). Increase in vegetative growth could be due to increased nutrient availability with conjunctive use of organics responsible for better growth and dry matter accumulation in finger millet (Sankar et al 2011).

The data in Table 2 indicate the available nitrogen, phosphorus and potassium status of soil after harvest of finger millet crop as influenced by different approaches of fertilizer application. Significantly higher available nitrogen (288.96 kg/ha) was recorded in PoP approach over STCR-targeted with (30 q/ha) IPNS approach (251.97 kg/ha). However remaining all other treatments were on par with each other. The available phosphorus content was significantly higher (24.64 kg/ha) in STCR-targeted with (20 q/ha) IPNS approach (T_4) compared to STCR-targeted (30 q/ha) with purely inorganic approach (T_1). In this treatment (T_4) no P fertilizer was applied as per the STCR equation due to high level of initial soil phosphorus. These results clearly indicate that higher P application can be avoided by applying only the required quantity of phosphorus based on soil test and targeted yield approach of fertilizer application so that unnecessary over-dose application at high available phosphorus and under application in low phosphorus containing soils can be restricted (Basavaraja et al 2015). The higher available phosphorus in IPNS approach could be due to acidulation of soil by the applied organic matter which helped in solubilizing the fixed P thereby enhanced the available P. However lower available P at higher levels of P application in the present study might be due to conversion of relatively soluble forms of P into more complex and stable forms by adsorption and precipitation mechanism (Ashwini 2007). Available potassium content was significantly higher in all the treatments where IPNS approach was adopted. The treatments which received purely inorganic fertilizers recorded significantly lower potassium content (94.00 and 96.80 kg K_2O /ha) as compared to STCR-targeted (20 q/ha) with IPNS approach which received both inorganic fertilizers and FYM (117.60 kg/ha). The available phosphorus and potassium contents in soil had

Table 1. Details of initial soil test values and nutrients applied in finger millet crop

Treatment	Initial soil test values (kg/ha)			Nutrients applied (kg/ha)		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
T ₁	290.57	64.20	229.46	76.78	26.16	29.59
T ₂	293.33	52.60	214.80	70.08	5.70	29.46
T ₃	274.88	64.00	228.66	0.40	10.17	9.44
T ₄	285.22	66.60	210.80	0.00	0.00	9.24
T ₅	294.85	61.10	170.80	50.00	40.00	25.00
T ₆	280.59	52.60	186.80	53.33	27.50	24.94
T ₇	-	-	-	-	-	-

T₁: STCR-targeted @ 30 q/ha with purely inorganics, T₂: STCR-targeted @ 30 q/ha with IPNS approach, T₃: STCR-targeted @ 20 q/ha with purely inorganics, T₄: STCR-targeted @ 20 q/ha with IPNS approach, T₅: PoP or general recommendations, T₆: Soil test laboratory (STL) approach, T₇: Absolute control

Table 2. Influence of different approaches of fertilizer application on finger millet grain yield, straw yield, post-harvest soil nutrient status, nutrient uptake and nutrient requirement

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Post-harvest soil nutrient status (kg/ha)			Nutrient uptake (kg/ha)			Nutrient requirement (kg/q)		
			N	P ₂ O ₅	K ₂ O	N	P	K	N	P	K
T ₁	39.42	63.17	272.13	8.75	96.80	131.82	13.31	128.47	3.33	0.34	3.26
T ₂	41.42	66.49	251.97	19.82	117.60	136.97	14.97	137.85	3.30	0.36	3.34
T ₃	34.93	57.77	275.52	17.50	94.00	108.38	12.11	106.06	3.11	0.35	3.03
T ₄	36.50	55.12	271.79	24.64	116.80	108.68	13.49	121.02	2.97	0.37	3.32
T ₅	40.41	70.82	288.96	16.43	93.20	131.88	14.69	131.84	3.24	0.36	3.26
T ₆	36.53	61.80	277.76	18.39	113.20	111.37	13.42	113.80	3.05	0.37	3.11
T ₇	29.12	30.44	271.79	16.07	96.00	70.79	8.24	63.91	2.43	0.29	2.22
SEm±	0.67	4.82	9.86	3.73	6.70	9.66	0.70	9.13	0.25	0.02	0.24
CD _{0.05}	1.92	13.74	28.11	10.64	19.09	27.54	2.01	26.02	0.70	0.06	0.69

T₁: STCR-targeted @ 30 q/ha with purely inorganics, T₂: STCR-targeted @ 30 q/ha with IPNS approach, T₃: STCR-targeted @ 20 q/ha with purely inorganics, T₄: STCR-targeted @ 20 q/ha with IPNS approach, T₅: PoP or general recommendations, T₆: Soil test laboratory (STL) approach, T₇: Absolute control

a digressive trend during the three years of experimentation (Hanc et al 2008). Gil et al (2007) reported that available K was significantly increased in soil fertilized with compost plus mineral fertilizers whereas its concentration changed with mineral fertilization. Uma Devi (2005) reported similar existence of operational ranges of available N, P and K for carrot on ultisols. Santhosh (2013) reported the higher available nutrient status due to application of farmyard manure with 100 per cent NPK.

Nutrient uptake data (Table 2) reveal that combined application of NPK with FYM based on STCR-targeted (30 q/ha) with IPNS approach recorded significantly higher nitrogen, phosphorus and potassium (136.97, 14.97 and 137.85 kg/ha respectively) uptake by finger millet followed by PoP (131.88, 14.69 and

131.48 kg/ha respectively). Whereas STCR-targeted (20 q/ha) with purely inorganic and IPNS approach recorded lower uptake of NPK might be due to lower levels of NPK application based on STCR-targeted yield equation as these soils were high in NPK status. The STCR-targeted (20 q/ha) with purely inorganic and IPNS approach which received less or no fertilizer nutrients (0.40:10.17:9.44 and 0.00:0.00:9.24 kg/ha NPK) had direct influence on the uptake of nutrients. The lower NPK uptake was also observed in absolute control where no fertilizer nutrients were applied. The increased NPK uptake under PoP and STCR-targeted (30 q/ha) with purely inorganic approach could be due to application of required quantity of nutrients through inorganic fertilizers in STCR purely inorganic approach and inorganic fertilizers and through FYM in PoP treatment. The lower nitrogen uptake was observed in

STCR-targeted (20 q/ha) approach with purely inorganics and IPNS approach which received no N fertilizers as per STCR equation. Fertilizer doses increase with increasing yield target of finger millet and decrease with increase in soil test values. The results are in conformity with the findings of Saxena et al (2008) for onion and Chatterjee et al (2010) for potato crop. It is obvious from the findings that there was a net saving of fertilizers for each STCR-targeted yield.

The results of the present study reveal that nutrient requirement (NR) of nitrogen (kg/q) was 3.33 and 3.11 in STCR yield target of 30 and 20 q/ha respectively in inorganic treatments. Whereas with the same targets the nitrogen requirement was lowest (3.30 and 2.97 kg/q) with STCR-IPNS treatment compared to inorganic treatments. Yu (2011) found that quadratic equation could best fit the relationship between N requirement and rice yield. The phosphorus and potassium requirement for finger millet ranged from 0.29 (T_7) to 0.37 (T_4) and 2.22 (T_7) to 3.34 (T_2) kg/q respectively. In the present study the lowest P_2O_5 and K_2O requirement was observed in control plots whereas more phosphorus and potassium requirement was observed in IPNS treatments where higher yields were recorded compared to inorganic plots. Sonar et al (1982) stated that for production of one quintal of sorghum grain nutrient requirements were 3.34 kg N, 0.73 kg P_2O_5 and 3.99 kg K_2O . The strong instability in nutrient absorption occurred when gaining low grain yield however as yield increased the stability increased.

Yield response was worked out as the yield obtained above the control yield (Table 3). The yield response was found to be higher in STCR-targeted of

30 q/ha with IPNS approach (12.30) followed by PoP (11.29). This higher yield response was mainly due to highest grain yield obtained under STCR-targeted with IPNS approach. Response yard stick (RYS) worked out was found to be higher in STCR-targeted of 20 q/ha with IPNS approach (79.79) followed by STCR-targeted of 20 q/ha with purely inorganic approach (29.03). Highest RYS in 20 q/ha STCR target with IPNS approach indicated that the applied NPK fertilizer nutrients were effectively utilized by the crop at lower targets as compared to higher targets as well as in other treatments. This could be mainly because though the total NPK applied to this treatment was only 9.24 kg the crop effectively utilized the available nutrients from the soil compared to rest of the treatments. To effectively utilize the nutrients in manure their mineralization potential should be considered while determining the application rates (Eghball et al 2002).

Value-cost ratio (VCR) worked out was found to be highest (15.45) in STCR-targeted of 20 q/ha with purely inorganic approach compared to any other treatment. This highest VCR could be mainly due to lower levels of NPK fertilizer application associated with higher yield (34.93 q/ha) production compared to all other treatments. Even though higher yields were recorded in STCR integrated approach and STL treatments the VCR was lower mainly due to high cost of FYM applied to these treatments. STCR technology focused through frontline demonstrations at different locations at farmers' fields revealed that benefit-cost ratio was found to be much higher in fertilizer treatments based on this methodology as compared to the fertilizer doses based on general recommended dose or local farmers' practice (Reddy and Ahmed 2000, Gogoi et al 2011, Basavaraja et al 2015).

Table 3. Influence of different approaches of fertilizer application on finger millet grain yield, yield response, response yard stick (RYS) and value-cost ratio (VCR)

Treatment	Grain yield (q/ha)	Yield response	RYS	VCR
T_1	39.42	10.29	7.77	6.90
T_2	41.42	12.30	11.68	3.10
T_3	34.93	5.81	29.03	15.45
T_4	36.50	7.37	79.79	2.36
T_5	40.41	11.29	9.81	2.45
T_6	36.53	7.41	6.44	1.69
T_7	29.12	-	-	-

T_1 : STCR-targeted @ 30 q/ha with purely inorganics, T_2 : STCR-targeted @ 30 q/ha with IPNS approach, T_3 : STCR-targeted @ 20 q/ha with purely inorganics, T_4 : STCR-targeted @ 20 q/ha with IPNS approach, T_5 : PoP or general recommendations, T_6 : Soil test laboratory (STL) approach, T_7 : Absolute control

The study indicates that STCR approach of fertilizer application is superior over any other approach in getting higher economic yields as well as in sustaining the soil fertility status through balanced nutrition to the crop. However the yield targets under STCR approach should be fixed based on the genetic potentiality of the finger millet crop and maximum production potential of the crop in that particular zone.

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