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Integrated Fertilizer Prescription Equations for Finger Millet (*Eleusine coracana* L.) Through Inductive Cum Targeted Yield Model on an Alfisol

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A B S T R A C T

Studies on Soil Test Crop Response based Integrated Plant Nutrition System (STCR - IPNS) were conducted adopting the Inductive cum Targeted yield model, on Alfisols of GKVK, Bengaluru, during 2008–2012 in order to develop fertilizer prescriptions through IPNS for the desired yield targets of finger millet crop. For calculating the four important basic parameters *viz.*, nutrient requirement (NR), contribution of nutrients from soil (%CS), fertilizer (%CF) and organic matter (%C-OM) were computed using the field experimental data. Making use of these basic parameters, the fertilizer prescription equations were developed under NPK alone and under IPNS for the desired yield targets of finger millet for a range of soil test values. The magnitude of response was higher under IPNS approach as compared to inorganics alone. The per cent reduction in NPK fertilizers under IPNS also increased with increasing soil fertility levels with reference to NPK. This could be achieved by integrated use of FYM with NPK fertilizers. Thus the Inductive cum Targeted yield model used to develop fertilizer prescription equations provides a strong basis for soil fertility maintenance consistent with high productivity and efficient nutrient management in "Precision Farming" for sustainable and enduring Agriculture.

Introduction

Nutrient absorption pattern of the plant and its efficient utilization of applied nutrients are necessary for obtaining the economically profitable returns. Fertilizer use is a major contributing factor for higher crop production in India. The fertilizer requirement of a crop largely depends on native soil fertility and hence, the prescription of doses should always be made by examining the relationships of soil test values with applied fertilizer doses and crop yield (Velayutham *et al.*, 1976). Finger millet (*Eleusine coracana L.*) locally called as ragi in Karnataka, It is also known as poor man's food because of its long sustenance as it can be stored safely for many years without infestation by insects and pests. This millet can grow in almost all types of soils and climatic conditions including alkaline soils with pH as high as 11 and at an altitude of 2,500 m from sea level, with average annual rainfall ranging from 800 to 1,200 mm. The low yield in millets under rainfed conditions was mainly attributed to poor nutrient status of soil, limited use of fertilizer either through chemical or organic sources coupled with insufficient moisture during crop growth period. Distortion in soil fertility and deterioration in soil health is due to indiscriminate and imbalanced use of fertilizers, which can be corrected only by proper use of manures and fertilizers based on the soil fertility evaluation. In recent years much emphasis has been given for use of fertilizer nutrients to produce adequate amount of high quality food. Such nutrient supply system helps for maintenance and possibly improvement of soil fertility for sustaining crop productivity on long term basis (Babalad, 1999).

Fertilizer recommendation based on soil test crop response correlation (STCR) concept are more quantitative, precise and meaningful because combined use of soil and plant analysis is involved in it. At this junction, the unique inductive cum targeted yield model of Ramamoorthy *et al.,* (1967) is quite appropriate for determining a precise fertilizer prescription for finger millet crop. Hence, a present study has been taken on Alfisols of Southern Karnataka under dry land condition for finger millet crop to develop a STCR targeted yield equation with a farmer's friendly ready reckoner.

Materials and Methods

Treatment structure, soil and plant analysis

A field experiment was conducted with finger millet *var.*GPU-28 as test crop during 2008-09 and 2011-12 on *Kandicpaleustalfs* at Zonal Agriculture Research Station, GKVK, Bengaluru to develop the targeted yield equations by following the standard procedure as outlined by Ramamoorthy *et al.*, 1967. Prior to test crop experimentation, the variation in the soil fertility was created by adopting the "Inductive cum Targeted Yield Model" (Ramamoorthy *et al.*, 1967). The surface soil (0-20 cm deep) of the experimental field was red soil, well drained, sandy loam in texture with pH 6.13, electrical conductivity 0.23dSm^{-1}. The Initial soil organic carbon (OC %) 0.51 per cent, available alkaline potassium permanganate ($KMnO_4$-N) nitrogen, available Bray's phosphorus (P_2O_5) and ammonium extractable potassium (K_2O) were 181.38,90.85 and 187.20 kg ha^{-1} respectively. Fertility gradient experiment was conducted to develop wide variation in NPK fertility status in the same field by dividing experimental field into three rectangular strips (L_1, L_2 and L_3). The needed variation in soil fertility levels was deliberately created by dividing the field into three equal strips (L_1, L_2 and L_3) which were applied with ½ dose (37.5, 100 and 100 kg NPK ha^{-1}), standard dose (75, 200 and 200 kg NPK ha^{-1}) and double dose (150, 400 and 400 kg NPK ha^{-1}) in L_1, L_2 and L_3 strip respectively. An exhaustive crop of fodder maize was grown to enable the applied fertilizer nutrients to undergo transformation in the soil by plant and microbes. Fodder maize was harvested at 60 days after sowing (DAS) and recorded the fodder yield. Similarly soil samples were also collected and analysed for major nutrients to check the development of fertility gradient (Table 2).

This plot was used for conducting main experiment after establishment of fertility gradient. Each fertility strip was divided in to three blocks to impose three levels of FYM (F_1 – 0.0, F_2 – 7.5 and F_3 – 15.0 t ha^{-1}). Before applying FYM and NPK fertilizers for each plot, soil samples (0-20 cm) from all these plots were collected and analysed for alkaline - $KMnO_4$-N outlined by Subbaiah and Asija, 1956; Bray's-P and NH_4OAc-K method as described by Jackson (1973).The experiment was laid out in fractional factorial design comprising of 7 treated plots + 1 control plot in each FYM blocks covering twenty one treated plots and three control treatments in each strips covering totally seventy two plots which comprised of sixty three treated plots and nine control plots and finger millet crop was tested with four levels of N (0, 25, 50 and 75 kg ha^{-1}) P_2O_5 (0, 20, 40 and 60 kg ha^{-1}) and K_2O (0, 15, 25 and 40 kg ha^{-1}).

The IPNS treatments (NPK alone, FYM (7.5 t ha^{-1}) + NPK and FYM (10 t ha^{-1}) + NPK) were superimposed across the strips. Half dose of N fertilizer along with full dose of P and K were applied to finger millet at the time of sowing and remaining half dose of N was applied attillering stage as per package of practice. At harvest, grain and straw yield were recorded from all the plots, and expressed in kg ha^{-1}. Representative plant samples were collected from all the plots, washed thoroughly with running water followed by double distilled water. The plant samples including grain were then dried at 60^0 C to attain a constant weight, ground and analysed for nitrogen, phosphorus and potassium contents by following standard procedures outlined by Jackson (1973) and total nutrient uptake was computed.

Data computation

Initial soil data, grain and straw yield, and nutrient uptake by finger millet crop were used for calculating the four important basic parameters *viz.*, nutrient required to produce a quintal of grain yield (NR), contribution of nutrients from soil (% CS), contribution of nutrients from fertilizers (% CF) and contribution of nutrients from organic matter (C-OM) using following formulae (Ramamoorthy *et al.*, 1967).

$$\text{NR (kg q}^{-1}) = \frac{\text{Nutrient uptake (NPK) (kg ha}^{-1}) \text{ by grain + straw}}{\text{Grain yield or any economic produce (q ha}^{-1})}$$

$$\% \text{ CS} = \frac{\text{Nutrient uptake (NPK)(kg ha}^{-1}) \text{ by grain + straw in control plot}}{\text{Soil test values (Av.NPK) in control plot (kg ha}^{-1})} \text{ X 100}$$

$$\% \text{ CF} = \frac{\{\text{Nutrient uptake by grain + straw in treated plot}\} - \left\{\text{Soil test values in treated plot X } \frac{\text{\% Contribution (NPK) from soil}}{100}\right\}}{\text{Nutrient doses applied in treated plot (kg ha}^{-1})} \text{X100}$$

$$\% \text{ C} - \text{OM} = \frac{\{\text{Total uptake of NPK in organic plot (kg ha}^{-1})\} - \left\{\text{Soil test values in OM plot X } \frac{\text{\% Contribution (NPK) from soil}}{100}\right\}}{\text{Amount of FYM added in organic plots (kg ha}^{-1})} \text{X100}$$

These basic parameters were transformed into simple, workable fertilizer adjustment equations for calculating specific yield target based on soil test values by following the procedure of Ramamoorthy *et al.*, (1967).

Results and Discussion

Fodder yield and soil test values of gradient experiment

Maize had been found to develop fertility gradient for the three major nutrient elements in the experimental strips because of inherent capacity of maize, as an exhaustive crop, which leads to mining of plant available nutrients leaving relatively consistent nutrient sink in soil resulting a fine tuned fertility gradient.

The first year gradient experiment data revealed that the fodder yield varied from 7.16 to 8.56 t ha^{-1} in low to high fertility strip. Whereas, in second year lowest fodder yield (28.75 t ha^{-1}) was recorded in L_1 strip and the highest yield (44.31 t ha^{-1}) was recorded in L_3 strip. The soil status at harvest clearly depicted (Table 1), that fertility gradient was developed from L_1 to L_3.

Low yield of fodder maize was mainly due to moisture constraints but NPK fertilizer application was one of the major factor for variation in fodder yield.

The increase in fresh yield of forage under different dose fertilizer application can be attributed to the positive effect of fertilizer and efficiency of these fertilizers on all the parameters in this study. These findings are in conformity with the findings of Ellis *et al.*, (1956) and Singh *et al.*, (1992).

The soil data at harvest of fodder maize varied from 59.47 to 81.38 kg N ha^{-1}, 75.40 to 90.85 kg P_2O_5 ha^{-1} and 175.20 to 187.20 kg K_2O ha^{-1} in the first year. Similarly, in the second year, soil chemical properties after the harvest of maize crop indicated the increased fertility status from L_1, L_2 and L_3 strip, where available nitrogen increased from 288.00 to 599.00 kg N ha^{-1} strip, the available phosphorus increased from 61.32 kg P_2O_5 ha^{-1} (L_1) to 125.00 kg P_2O_5 ha^{-1} (L_2) and available potassium from 85.02 kg ha^{-1} (L_1) to 220.05 kg ha^{-1}(L_3) strips. The increase in availability of N, P and K status of soil was due to graded levels of fertilizer application, which created a fertility gradient in the respective strips. However, even though P was not applied, gradient was developed in P levels from L_1 to L_3, mainly due to residual P level from the earlier gradient experiment in the same yield In the present study all the needed soil fertility gradient (L_1, L_2 and L_3) was deliberately created in the same field by growing exhaustive maize crop for 60 days the result in conformity with the findings of Santhi *et al.,* (2011). Thamaraiselvi *et al.*, (2012) reported increased soil total N and available phosphorus due to FYM application.

Initial available NPK status, grain yield and nutrient uptake

The data on soil available nutrient status was depicted in table 3. The initial soil test values revealed that the available nitrogen ranged from 65.73 to 184.67 and 111.72 to 410.56 kg N ha^{-1} in I and II year respectively. The available phosphorus in strip I was lowest (40.81 kg P_2O_5 ha^{-1}) and highest was observed in strip III (455.20 kg P_2O_5 ha^{-1}) in 1st year, whereas in second year, lowest and highest (38.70 and 189.01 kg ha^{-1}) P_2O_5 content was recorded in strip I. The mean NH_4OAc–K_2O content in soil ranged from 128.78 to 286.35 in first year, whereas in second year mean available K ranged from 80.11 to 286.35 kg K_2O ha^{-1}.

The range and mean values indicated that the finger millet grain yield ranged from 864.00 kg ha^{-1} in absolute control to 6182.00 kg ha^{-1} in strip III where 75:40:40 kg NPK ha^{-1} + FYM @ 7.5 t ha^{-1} was applied in first year. Whereas, in second year same trend was followed with slight increase in grain yield in absolute control (1148.00 kg ha^{-1}) and treated plot (75:60:25 kg NPK ha^{-1}) recorded 6552.00 kg ha^{-1} grain yield.

Nutrient uptake by finger millet

Application of adequate amount of nutrients is a prerequisite for exploiting genetic potential of any crop. Across fertility gradient and FYM levels, application of different levels of N caused significant changes in uptake of N in both the year of study.

The N uptake in Strip I, II and III varied from 11.49 to 70.95, 19.50 to 71.90 and 33.67 to 102.60 kg N ha^{-1} and 28.05 to 167.21, 56.90 to 217.35 and 39.43 to 456.93 kg N ha^{-1} in 1st and 2nd year of study, respectively. The maximum nitrogen uptake was associated with the highest level of N applied plots but the minimum values were associated with the no N input. The phosphorus uptake by finger millet varied from 1.87 to 19.05 kg ha^{-1} and K uptake from 12.59 to 125.38 kg ha^{-1} in first year of study. In second year, the P uptake ranged from 13.56 to 101.17 kg ha^{-1} and K uptake ranged from 57.33 to 723.77 kg ha^{-1}. The application of higher levels of P and K fertilizers will influence on the uptake of P and K by finger millet crop.

The magnitude of P and K uptake due to application of different levels of P and K followed same trend as that of yield. The existence of operational range of soil test values for available N, P_2O_5 and K_2O status in the present investigation was clearly depicted from the initial soil available nutrient status and variations in the grain yield of finger millet and NPK uptake, which is a prerequisite for calculating the basic parameters and developing fertilizer prescription equations for calibrating the fertilizer doses for specific yield target of dry land finger millet. Uma Devi (2005) reported similar existence of operational ranges of available N, P and K for carrot crop on *Ultisol.*

Basic parameters

In the targeted yield model, the basic parameters for developing fertilizer prescription equations for dry land finger millet are nutrient requirement (NR) in kg per quintal of grain, per cent contribution of available NPK from soil (% CS), fertilizers (% CF) and organic manure (% C-OM). By making use of basic data's obtained from the main experiment *viz.,* Initial soil test values for available N, P_2O_5 and K_2O, doses of fertilizer N, P_2O_5 and K_2O applied, the grain yield of finger millet, total uptake of N, P_2O_5 and K_2O, the basic parameters *viz.* NR, CS, CF and C-OM were computed. Nutrient requirement per quintal of finger millet grain production were observed to be 2.764 and 3.587, 0.488 and 1.233 and 2.546 and 6.478 kg N, P_2O_5 and K_2O in first and second year respectively.

The per cent contribution of nutrients from soil (CS) to the total uptake was computed from the absolute control plots and it expresses the capacity of the crop to extract nutrients from the soil. In the present study contribution of nutrients as estimated from soil and fertilizer sources was higher (35.856%, 58.812%, 90.257 % and 37.547%, 48.984%, 155.787 % N, P_2O_5 and K_2O, respectively) in second year compared to first year (14.483%, 10.423%, 19.126% and 30.267, 30.476 and 109.329 % N, P_2O_5 and K_2O, respectively). These results indicate that nutrient contribution from fertilizer sources was greater than that from the soil source for both the years. The findings are closely accorded with those reported by Ray *et al.,* (2000) and Meena *et al.,* (2001). Similar trend of nutrient requirement for N, P_2O_5 and K_2O were reported by Smitha *et al.,* (2010) for Cabbage. Among the three major nutrients K_2O requirement is the highest, followed by N and P_2O_5. It is interestingly noted that contribution of K_2O for finger millet (Table 4) was observed to be more than 100% (155.78%).

This high value of K could be due to the interaction effect of higher doses of N, P and the primary effect of starter K doses in the treated plots, which might have caused the release of soil potassium form, resulting in the higher uptake from the native soil sources by the crop (Ray *et al.,* 2000). The contribution from fertilizers was higher than from the soil for all the three nutrients. The contribution of nutrients towards the growth of the crop was higher from fertilizers than that of soil for all the three nutrients (N, P_2O_5 and K_2O).

The per cent contribution from the organic manures (C-OM) to the total uptake was computed from the organic manure applied plots (F_1 @ 7.5 t ha^{-1} and F_2 @ 10 t ha^{-1}). The first year data showed that 19.23, 9.92, 40.47 per cent of N, P_2O_5 and K_2O towards the total uptake by finger millet. Whereas, in second year of study the per cent of N, P_2O_5 and K_2O was 0.348, 0.018 and 0.887 respectively. The results of the study are in conformity with the work of Vijayalakshmi (2008) for radish and Santhi *et al.,* (2011) for beetroot on *Typic haplustalf*. The findings also corroborated with the findings of Santhi *et al.,* (2002) and Saranya*et al.,* (2012).

Fertilizer prescription equations for finger millet crop under dry land

Soil test based fertilizer prescription equations for desired yield target of finger millet were formulated by relating the basic parameters obtained from the main experiment.

Fertilizer prescription targeted yield equations were developed as follows by further simplification of this relation.

Table.1 Graded dose of fertilizers applied, fodder yield obtained and soil test values after Harvest of maize crop in gradient experiment

Strip	Level of fertilizers			Input applied (kg ha^{-1})				Fodder Yield (t ha^{-1})	Soil test values after harvest (kg ha^{-1})		
				FYM	N	P_2O_5	K_2O		N	P_2O_5	K_2O
First year											
L_1	N_0	P_0	K_0	3.75	37.5	0.00	100	7.16	59.47	75.40	175.20
L_2	N_1*	P_1*	K_1*	7.50	75.00	0.00	200	8.30	68.86	78.60	182.40
L_3	N_2	P_2	K_2	15.00	150.00	0.00	400	8.56	81.38	90.85	187.20
Second year											
L_1	N_0	P_0	K_0	3.75	18.75	0.00	100	28.75	288.00	61.32	85.12
L_2	N_1*	P_1*	K_1*	7.50	37.50	0.00	200	39.35	373.00	88.85	164.89
L_3	N_2	P_2	K_2	15.00	75.00	0.00	400	44.31	599.00	125.0	220.05

* Recommended dose of nutrients to fodder maize

Table.2 Treatment structure

No.	Treatment combination			Levels of nutrients (kg ha^{-1})		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	2	1	0	40	15
5	1	1	1	25	20	15
6	1	1	2	25	20	25
7	1	2	1	25	40	15
8	1	2	2	25	40	25
9	2	0	2	50	0	25
10	2	1	1	50	20	15
11	2	1	2	50	20	25
12	2	2	0	50	40	0
13	2	2	1	50	40	15
14	2	2	3	50	40	40
15	2	2	2	50	40	25
16	2	3	2	50	60	25
17	2	3	3	50	60	40
18	3	1	1	75	20	15
19	3	1	2	75	20	25
20	3	2	1	75	40	15
21	3	2	3	75	40	40
22	3	3	1	75	60	15
23	3	3	2	75	60	25
24	3	3	3	75	60	40

* FYM levels: F_0 – 0 t ha^{-1}, F_1 – 7.5 t ha^{-1} and F_2 – 15 t ha^{-1}

Table.3 Pre-sowing soil available NPK content, grain yield and NPK uptake by finger millet crop

Year	Strip		Soil test values (kg ha^{-1})			Finger millet yield (kg ha^{-1})		Uptake (kg ha^{-1})		
			$KMnO_4$ - N	Bray's P_2O_5	NH_4OAc - K_2O	Grain yield	Straw yield	N	P	K
I	I	Min	102.50	40.81	96.00	864.00	455.00	11.49	1.87	12.59
		Max	184.67	112.00	193.20	4000.00	2473.00	70.95	10.60	70.99
		Mean	**141.60**	**75.30**	**128.78**	**2664.67**	**1511.92**	**42.87**	**7.53**	**52.18**
	II	Min	78.25	159.53	146.40	1273.00	655.00	19.50	3.89	28.75
		Max	122.15	261.14	291.60	4273.00	2155.00	71.90	13.82	84.86
		Mean	**102.22**	**209.25**	**203.88**	**3182.75**	**1638.58**	**50.60**	**9.67**	**61.61**
	III	Min	65.73	214.52	200.40	1909.00	1000.00	33.67	6.26	42.65
		Max	75.00	455.20	392.40	6182.00	3318.00	102.60	19.05	125.38
		Mean	**97.14**	**351.78**	**286.35**	**3255.08**	**2205.46**	**61.24**	**10.78**	**82.55**
II	I	Min	111.72	38.70	56.80	1148.00	220.50	28.05	13.56	57.33
		Max	367.08	189.01	120.00	5082.00	938.30	167.21	60.16	287.68
		Mean	**280.72**	**120.80**	**80.11**	**3310.00**	**590.90**	**85.87**	**34.52**	**180.51**
	II	Min	230.00	72.68	109.20	1471.00	328.70	56.90	18.20	93.39
		Max	331.97	180.30	334.80	5707.00	1079.90	217.35	56.39	351.11
		Mean	**279.91**	**127.71**	**184.62**	**3805.00**	**717.80**	**116.33**	**37.91**	**216.54**
	III	Min	224.50	81.20	108.00	1287.00	413.00	39.43	18.22	109.02
		Max	410.56	158.30	495.60	6552.00	2322.10	456.93	101.17	723.77
		Mean	**305.66**	**117.60**	**264.77**	**4417.00**	**1621.90**	**239.79**	**70.92**	**403.31**

Table.4 Nutrient requirement and contribution of nutrients from soil, fertilizers and Organic matter for finger millet

Parameters	Basic data					
	N		P_2O_5		K_2O	
	I Year	II Year	I Year	II Year	I Year	II Year
Nutrient requirement (NR) (kg q^{-1})	2.764	3.587	0.488	1.223	2.546	6.478
Contribution from soil (CS) (%)	14.483	35.856	10.423	58.812	19.126	90.257
Contribution from fertilizers (CF) (%)	30.287	37.547	30.476	48.984	109.329	155.787
Contribution from organic matter – (C-OM) (%)	19.235	0.348	9.924	0.018	40.478	0.887

Table.5 Ready reckoner for dryland finger millet for a yield target of 35 q ha^{-1}

--------- kg ha^{-1} -------			Without FYM			With 7.5 t FYM ha^{-1}			Reduction over NPK alone (%)		
STV $KMnO_4$ - N	STV P_2O_5	STV K_2O	F. Rq. N	F. Rq. P_2O_5	F. Rq. K_2O	F. Rq. N	F. Rq. P_2O_5	F. Rq. K_2O	N	P_2O_5	K_2O
250.00	15.00	110.00	95.62	69.40	81.81	86.43	65.01	71.61	9.61	6.33	12.47
260.00	17.00	120.00	86.07	67.00	76.02	76.88	62.61	65.82	10.68	6.55	13.42
280.00	19.00	125.00	66.97	64.60	73.12	57.78	60.21	62.92	13.72	6.80	13.95
290.00	21.00	130.00	57.42	62.20	70.22	48.23	57.81	60.03	16.00	7.06	14.51
300.00	23.00	140.00	47.87	59.80	64.43	38.68	55.40	54.23	19.20	7.36	15.83
320.00	25.00	150.00	28.77	57.40	58.64	19.58	53.00	48.44	31.94	7.67	17.39
340.00	30.00	160.00	9.67	51.39	52.84	0.48	47.00	42.64	95.04	8.54	19.30
400.00	32.00	170.00		48.99	47.05		44.60	36.85		8.96	21.68
440.00	35.00	180.00		45.39	41.26		41.00	31.06		9.67	24.72
480.00	38.00	200.00		41.79	29.67		37.40	19.47		10.50	34.38
520.00	41.00	220.00		38.19	18.08		33.79	7.88		11.52	56.42
560.00	44.00	240.00		34.58	6.49		30.19			12.70	
600.00	46.00	260.00		32.18			27.79			13.64	
	47.00	280.00		30.98			26.59			14.17	
	50.00	300.00		27.38			22.99			16.03	
	52.00	320.00		24.98			20.59			17.57	
	54.00	340.00		22.58			18.18			19.49	
	58.00	440.00		17.78			13.38			24.75	
	62.00			12.97			8.58			33.85	
To increase or decrease the yield target by one q ha^{-1}, the variations to be made in the fertilizer recommendations are as follows N = ± 9.55 kg ha^{-1} P_2O_5 = ± 2.50 kg ha^{-1} K_2O = ± 4.16 kg ha^{-1}											

NPK alone – Inorganic equation

2008-09

F.N = 9.128239 T - 0.678209 STV ($KMnO_4$-N)

F.P_2O_5 = 1.603342 T - 0.342016 STV (Bray's P_2O_5)

F.K_2O = 2.329544 T - 0.174945 STV (Am. Ac.K_2O)

2011-12

F.N = 9.55311 T - 0.954963 STV ($KMnO_4$-N)

F.P_2O_5 = 2.49750 T - 1.200641 STV (Bray's)

F.K_2O = 4.15833 T - 0.579362 STV (Am. Ace.)

Where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T is the yield target in q ha^{-1}; SN, SP and SK respectively are alkaline $KMnO_4$-N, Bray's-P_2O_5 and NH_4OAc-K in kg ha^{-1} and OM – organic matter or FYM in kg ha^{-1}.

Fertilizer response is denoted by the functional relationship between increase in crop yield and added fertilizers. It can be expressed graphically or algebraically by an equation. Milap Chand *et al.*, (2006) reported the superiority of the targeted yield concept over other approaches of fertilizer prescription for different crops as it gave higher yields, net benefit and optimal economic returns. Kasthuri and Natesan (2009) documented the formulation of fertilizer prescription equation for cauliflower crops through STCR targeted yield approach. The yield targets were achieved within reasonable limits when the fertilizer was applied on soil test basis in majority of the crops thus establishing the utility of the prescription equations for recommending soil test based fertilizer application to the farmers. In the present investigation, soil test based fertilizer prescription equations for desired yield target of finger millet was developed using the basic parameters obtained. The data clearly revealed that the fertilizer N, P_2O_5 and K_2O requirements decreased with increase in soil test values and increased with increase in yield targets.

Fertilizer prescription under IPNS for desired yield target of dry land finger millet

A ready reckoner (Table 5) was prepared using these equations for a range of soil test values and for a yield target of 35 q ha^{-1} for finger millet. For achieving a yield target of 35 q ha^{-1} of grain yield of finger millet with a soil test value of 250, 21 and 240 kg ha^{-1} of $KMnO_4$-N, Bray's-P_2O_5 and NH_4OAc-K_2O, the fertilizer N, P_2O_5 and K_2O doses required are 95.62, 62.20 and 6.49 kg ha^{-1}, respectively under NPK alone and 86.43, 57.81 and 0.0 kg ha^{-1} under IPNS approach, where FYM was applied @7.5 t ha^{-1} along with NPK fertilizers. Under IPNS, the fertilizer savings were 9.61, 7.06 and 56.42 per cent respectively when FYM was applied @7.5 t ha^{-1} along with NPK fertilizers. To increase additional one quintal (35+1 q ha^{-1}) of grain yield, the variation in nutrients application to be made as 9.55 kg N ha^{-1}, 2.50 kg P_2O_5 ha^{-1} and 4.16 kg K_2O ha^{-1}. To decreases the one quintal of grain yield same above values substituted should be from actual nutrient values.

In the present investigation, there was a marked response to the application of NPK fertilizers. The magnitude of response was higher under IPNS approach as compared to inorganics (NPK) alone. The per cent reduction in NPK fertilizers under IPNS also increased with increasing soil fertility levels with reference to NPK. This could be achieved by integrated use of FYM with NPK fertilizers. The role of FYM is multidimensional ranging from building up of organic matter, maintaining favourable soil physical properties and balanced supply of nutrients. Therefore, in the present study, soil test based fertilizer prescription for dry land finger millet was developed for Alfisol of Karnataka taking into account of the above factors which might have contributed for the yield enhancement in finger millet when NPK fertilizers were coupled with FYM.

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