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FERTILIZER PRESCRIPTION EQUATIONS FOR TARGETED YIELD OF RICE (*Oryza Sativa L*) AND THEIR VALIDATION UNDER AEROBIC CONDITION

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Abstract- Field experiments were conducted in soils (*Typic Rhodostalfs*) of Mandya (Zone 6), Karnataka by adopting the inductive cum targeted yield model, and fertilizer requirements were quantified for rice crop under puddled condition based on soil test crop response correlations. The data obtained from main experiment were used to compute nutrient required to produce a quintal of grain (NR), per cent contribution of nutrients from the soil (% CS), per cent contribution of nutrients from fertilizers (% CF) and per cent contribution of nutrients from organic matter (% C-OM). From these basic parameters fertilizer prescription equation was developed under an integrated plant nutrient system. The developed equation was verified under aerobic condition in the same zone. The results revealed that grain yield was significantly higher (65.73 q ha^{-1}) in STCR integrated approach with 75 q ha^{-1} target. The same trend was observed with an agronomic nutrient efficiency of nitrogen, phosphorus and potassium. However, higher value cost ratio (VCR) was observed in STCR inorganic approach with 50 q ha^{-1} target was due to application of lower doses of NPK without FYM application, which reduced the cost of inputs and the cost of cultivation which in turn directly influenced the VCR. The study clearly indicated targeted yield equation developed under puddled condition can be well adopted for both wet land and aerobic conditions of Karnataka.

Keywords- Rice, Soil test crop response, STCR-Equation.

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Introduction

Rice is the staple food crop for some three billion people in Asia and staple food for 60 per cent of the world population. Around 700 million of the world's poor live in rice growing areas in Asia [1]. In Asia alone rice consumes half of the 90 per cent fresh water divested to agriculture. Rice is the staple food of Karnataka, India, cultivated in an area of 2.1 million hectares producing 7.2 million tons. About 75 per cent of the world rice produced from 79 million hectares of irrigated lowland that together receives an estimated 24-30 per cent of the worlds developed water resources. The high productivity of irrigated lowland rice, however, is threatened by increasing water scarcity. In the next 25 years, 15-20 million hectares of lowland rice in Asia are projected to suffer from water scarcity. Several water saving technologies have been developed to cope with water scarcity in lowland rice areas, such as alternate wetting and drying, continuous soil saturation and ground cover rice production system, in which lowland rice was cultivated without a standing water during the entire life cycle or growth period. A new approach to reduce water requirement in rice production is aerobic rice. The water requirement by aerobic rice system is very less (935 mm) as compared to that of the lowland rice system. This varies from 1650 to 3000 mm. A new technology to respond to more severe water strategies is the aerobic rice system, in which specially developed, input response rice varieties developed locally with aerobic adoption are grown in well drained, non-puddle and non saturated soil without standing water.

By comparison with the large increase in yield that resulted from the introduction of green revolution technology in India, future yield and productivity increases in irrigated rice are likely to occur in smaller increments by fine tuning nutrient and crop management. The increasing rate of population growth in India (1.3 % in 2012), necessitate production of additional crops from the shrinking land areas without deteriorating soil health. This, in turn, requires extensive research for development of the scientific basis for enhancing and sustaining food production as well as soil productivity with minimum environmental degradation. In order to attain study state of productivity, the amount of nutrients removed from the soil to be replaced through judicious use of manures and fertilizers.

Application of fertilizer by the farmer without information on soil fertility status and nutrient requirement by crop, soil and crop will be affected adversely. Soil testing is one of the best scientific means for quick and reliable estimation of soil fertility status. Greater economy in fertilizer use can be made, if fertilizers are applied on the basis of soil test. This practice ensures balanced fertilization, higher yield and more profitability. The fertility gradient field experimental technique of Ramamoorthy *et al.* (1967) [2] for evolving soil test and targeted yield based fertilizer recommendation (STCR) to crop is unique in the sense that response of crops to applied nutrient is studied on representative soils, where variations in soil fertility had been created earlier by applying different amount of fertilizer nutrients to the preceding crop. The approach circumvents the effect of soil heterogeneity, management practices and climatic conditions on the response through native and fertilizer nutrients.

Fertilizer recommendation based on soil test crop response correlation (STCR) concept is more quantitative, precise and meaningful because the combined use of soil and plant analysis is involved in it. While developing the STCR targeted yield equation contribution of nutrients from soil, fertilizer and organics are taken in to consideration. Similarly, by taking these into consideration nutrient requirement (NR) to produce a quintal of grain or any economic produce are considered. It gives a real balance between applied nutrients and the available nutrients already present in the soil. Besides, it takes into account the farmer's ability to invent for raising the crops.

Besides balanced nutrition of growing crops, this approach gives due consideration to soil fertility and strikes a real balance between the nutrients already available in the soil and those required by the crops to achieve a predetermined yield target. The present studies were, therefore, under taken with a view of evolving soil test and targeted yield based fertilizer recommendation for wetland rice and test their adoptability for aerobic rice under field condition.

MaterialsandMethods

A field experiment was carried out at the Zonal Agriculture Station, Mandya, India to develop a scientific basis for prescribing fertilizer recommendations for rice with fodder maize as gradient and rice (*Oryza sativa.L*) as test crop and their validation was done for aerobic rice. The soil of the experimental site was sandy clay loam in texture. pH was 7.80 with medium level of organic carbon (0.55 %), The initial status of available N, P and K was 156.80, 64.70 and 103.20 kg ha^{-1}, respectively.

Treatment structure, soil and plant analysis

The field experiment *viz.,* fertility gradient experiment with exhaustive fodder maize (*var.* African tall), the test crop experiment with rice (Tanu) and the test verification with aerobic rice (MAS-946-1) were conducted at Zonal Agricultural Research Station (Zone 6), V.C. Farm, Mandya on *Typic Rhodostalfs* during 2010-11. The details of the crops and important cultural operations carried out in the experiment are described below. The treatment structure and layout design as followed in the All India coordinated Research Project for investigations on soil test crop response correction (AICRP-STCR) based on "Inductive cum Targeted Yield Model" [2] was adopted for the experimentation.

Gradient experiment

Prior to the test crop experimentation, the fertility gradient experiment was conducted by dividing the experimental field into three rectangular strips (L_1, L_2 and L_3). The layout of the experiment was based on the fertility gradient approach developed by Ramamoorthy *et al.* (1967) [2]. 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, 20 and 100 kg ha^{-1}) standard dose (75, 40 and 200 kg ha^{-1}) and double dose (150, 600 and 400 kg ha^{-1}) of NPK were applied in L_1, L_2 and L_3 strip respectively. An exhaustive crop of fodder maize was grown to enable the applied fertilizer to undergo transformation in the soil by plant and microbes. Fodder maize was harvested at 60 DAS and recorded the fodder yield. Similarly, soil samples were also collected and analysed to check the fertility gradient developed.

Test crop experiment

After the establishment of fertility gradient in the experimental field, each fertility strip was divided into three blocks to impose three levels of FYM (F_1 – 0.00, F_2 – 10.00 and F_3 – 15.00 t ha^{-1}). Each block was again divided into eight plots so that totally 72 plots will be made. Before applying the FYM and NPK, soil samples (0-20 cm) from all these plots were collected and analysed for alkaline-$KMnO_4$-N outlined by Subbaiah and Asija, 1956[3]; Olsen's-P and NH4OAC-K method as described by Jackson (1973) [4]. The experiment was laid out in fractional factorial design comprising of 21 treated plots and 3 control treatments in each strips covering totally 72 plots which comprised of 63 treated plots and 9 control plots and rice crop was tested with four levels of N (0, 50, 100 and 150 kg ha^{-1}) P (0, 25, 50 and 75 kg ha^{-1}) and K (0, 25, 50 and 70 kg ha^{-1}). The experiment was conducted as per the approved guidelines of All India Co-ordinated Research Project (AICRP) on Soil Test Crop Response Correlations (STCR). A half dose of N fertilizer along with a full dose of P and K was applied at rice transplanting and remaining half dose of N was applied in two splits.

At harvest, grain and straw yield was recorded from all the plots, and expressed in kg ha^{-1}. Representative plant samples were collected from the test crops, washed thoroughly with running water followed by double distilled water. The plant samples were then dried at 60^0 C to attain a constant weight, ground and analysed for nitrogen, phosphorus and potassium contents by following standard procedure outlined by Jackson (1973)[4] and nutrient uptake was computed.

Data computation

Initial soil data, yield and nutrient uptake by the crop were used for obtaining nutrient required to produce a quintal of grain yield (NR), contribution of nutrients from the soil (% CS), contribution of nutrients from fertilizers (% CF) and contribution of nutrients from organic matter (C-OM) using following formulae [2].

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

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

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

$$\%\ \text{C} - \text{OM} = \frac{\{\text{Total uptake of NPK in organic plot (kg ha}^{-1}\text{)}\} - \left\{\frac{\text{[Mean CF of control plot] X [STV in organic plot (kg ha}^{-1}\text{)]}}{100}\right.}{\text{Amount of NPK added through FYM (kg ha}^{-1}\text{)}}\ \text{X100}$$

These basic parameters were transformed into simple, workable fertilizer adjustment equations for calculating specific yield target based on soil test values following the procedure of Ramamoorthy *et al.* (1967)[2].

Results and Discussion

Results showed that a regular increase in fodder yield was observed in gradient experiment [Table-1]. The lowest fodder yield was noticed in L_1 (39.15 t ha^{-1}) strip and the highest was observed in L_3 (87.13 t ha^{-1}) strip which received one and a half per cent of the recommended dose of NPK fertilizers. Optimum supply of plant nutrients is always imperative for better growth and development of a crop. However, yield and quality parameters are greatly affected by inadequate availability of plant nutrients. The low yield of fodder maize was due to many constraints, but NPK fertilizer application was one of the major factors. The increase in fresh yield of forage under 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) [5,6]. The dry matter contents increased with increasing P application rates. The results are also in line with the findings of Singh and Bishnoi, (1993) [7] who observed that there was a significant increase in dry matter yield of maize upto @ 40 kg P_2O_5 ha^{-1} application. Similarly, soil chemical properties after the harvest of maize crop indicated that as the fertility gradient increases (L_1 to L_3 strip), the available nitrogen content increased from 159.47 kg N ha^{-1} to 381.38 kg N ha^{-1} strip. The available phosphorus content increased from 25.40 kg P_2O_5 ha^{-1} (L_1), 48.60 kg P_2O_5 ha^{-1} (L_2) and 90.85 kg P_2O_5

ha^{-1} (L_3) in different strips. Whereas, available potassium content in soil varied from 135.20 kg ha^{-1} (L_1) to 287.20 kg ha^{-1} (L_3) strips. The increase in availability of N, P and K status of the soil was due to graded levels of fertilizer application, which created a fertility gradient in the respective strips. 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 an exhaustive maize crop for 60 days. Thamaraiselvi *et al.* (2012) [8] reported increased soil total N and available phosphorus due to FYM application.

Maize had been found to develop a 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 a relatively consistent nutrient sink in the soil resulting a fine tuned fertility gradient.

Rice grain yield

Out of 63 treated plots, the highest rice grain yield (8.70 t ha^{-1}) was recorded in low fertility strip (L_1), where 3-1-1 levels of NPK were applied along with 15 t FYM ha^{-1} (F_3). The lowest grain yield (3.48 t ha^{-1}) was recorded in both L_1 and L_2 strips where 3-3-2 levels of NPK with 0 t FYM ha^{-1} (F_1) and 3-1-1 NPK levels with 10 t FYM ha^{-1} (F_2) were applied. This was due to the application of one and half dose of nitrogen (150 kg ha^{-1}) with 15 t FYM ha^{-1} (F_3) in low fertility strip (L_1), which increased the availability of nutrients as compared to medium and high fertility strips [Table-2]. The only required dose of phosphorus and potassium (RDF) is required to meet higher yields in any fertility stip. This might be due to the direct effect of decomposition and mineralization of nutrients from various organic manures and indirectly due to rhizosphere effect in increasing the microbial activity and its impact on the available nutrient content in flooded soil. Peng *et al.* (2009)[9] ascribed the increased grain yield to the favourable effects of improved leaf N concentration, photosynthetic rate of flag leaves and increased filled grain percentage. A better response for N dose up to 130 kg N ha^{-1} in rice was also reported by Dobermann *et al.* (2003) [10]. Organic manures were often superior to inorganic fertilizer as they exhibit dual benefits of improving the physical environment of soil and also supply the plant nutrients, which might have contributed to the increased nutrient uptake and ultimately the higher grain yield.

Among the 9 control plots higher grain yield (78.89 ha^{-1}) was recorded in medium fertility strip (L_2) where 15 t ha^{-1} of FYM (F_3) with no NPK fertilizer application. The lowest grain yield (23.20 q ha^{-1}) was recorded in the high fertility strip (L_3) where 0 t FYM ha^{-1} (F_1) was applied without NPK fertilizer. Bodruzzaman *et al.* (2010) [11] stated that FYM application on a preceding rice crop had a residual effect on the yield of a succeeding wheat crop. Thus, improvements in soil N and P nutrient status due to FYM application could sustain high rice crop yields ensuring long term sustainability of the system. In line with the present findings, the N and P replenishment through FYM with chemical fertilizer was enough to balance N and P removal by rice. Tiwari *et al.* (2010) [12] also reported similar findings that N and P balances were negative when only inorganic fertilizers were applied.

Nutrients uptake by rice crop

Nutrient uptake by rice crop was depicted in [Table-3]. Highest total nitrogen (264.81 kg N ha^{-1}) uptake was noticed in treated plot with application of 3-1-1 levels of NPK in low fertility strip (L_1) where 0 t FYM ha^{-1} (F_1) was applied. Whereas, lowest nitrogen uptake (76.75 kg N ha^{-1}) was observed in L_2 strip where 0 t FYM ha^{-1} (F_1) with 0-2-2 levels of NPK were applied. The highest total P (47.65 kg P ha^{-1}) and total K uptake by rice crop was noticed in L_1 strip where 0 t FYM ha^{-1} (F_1) was applied with 3-2-1 levels of NPK and 15 t FYM ha^{-1} (F_3) with 3-1-1 levels of NPK application in low fertility strip respectively. Increasing the available nitrogen in the soil by increasing the percentage of mineral N in fertilization led to a clear increase in nitrate accumulation in the plants. Esawy Mahmoud *et al.* (2009) [13] indicated that nitrate content in the plots treated with 45 t FYM ha^{-1} decreased by 31 per cent. This was attributed to the supply of readily available nitrate from mineral N to the plants while, in the FYM treated plots, nitrate release was comparatively low. The nitrate concentration increased with the inorganic nitrogen addition.

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})		
				N	P_2O_5	K_2O		N	P_2O_5	K_2O
L_1	N_0	P_0	K_0	37.5	20.00	100	39.15	159.47	25.40	135.20
L_2	$N_{1/2}$*	P_1*	K_1*	75.00	40.00	200	63.47	268.86	48.60	182.40
L_3	N_2	P_2	K_2	150.00	60.00	400	87.13	381.38	90.85	287.20

* Recommended dose of fodder maize

Table-2 *Rice grain yield (t ha^{-1}) in treated and control plots in STCR main experiment at ZARS, Mandya*

Strip	Treated plots: Lowest		Treated plots: Highest	
L_1	F_1, 3-3-2	3.48	F_3, 3-1-1	8.70
L_2	F_2, 3-1-1	3.48	F_3, 3-3-1	7.34
L_3	F_1, 0-2-2	4.06	F_3, 1-2-2	7.96
Control plots				
	Lowest		Highest	
L_1	F_1, 0-0-0	3.48	F_3, 0-0-0	5.57
L_2	F_2, 0-0-0	4.64	F_3, 0-0-0	7.89
L_3	F_1, 0-0-0	2.32	F_3, 0-0-0	7.54

Table-3 *Nitrogen, phosphorus and potassium uptake (kg ha^{-1}) by transplanted rice crop in STCR main experiment at ZARS, Mandya*

	Treated plots: Lowest		Treated plots: Highest	
Total N	L_2- F_1, 0-2-2	76.75	L_1- F_1, 3-2-1	264.81
Total P_2O_5	L_1- F_3, 0-2-2	17.41	L_1- F_1, 3-2-1	47.65
Total K_2O	L_1- F_3, 3-1-1	108.41	L_1- F_3, 3-1-1	354.19
Control plots				
	Lowest		Highest	
Total N	L_3- F_1, 0-0-0	54.34	L_2- F_3, 0-0-0	107.81
Total P_2O_5	L_3- F_1, 0-0-0	11.06	L_2- F_2, 0-0-0	22.55
Total K_2O	L_1- F_2, 0-0-0	62.94	L_3- F_2, 0-0-0	108.19

However, the control plots recorded lower levels of total NPK uptake by rice crop. The higher N (107.81 kg ha^{-1}), P (22.55 kg ha^{-1}) and K (108.19 kg ha^{-1}) uptake was noticed in L_2 strip with 15 t FYM ha^{-1} (F_3), L_2 strip with 10 t FYM ha^{-1} (F_2) and L_3 strip with 10 t FYM ha^{-1} (F_2), with 0-0-0 levels of NPK fertilizer application, respectively. The lowest nitrogen (54.34 kg ha^{-1}) and phosphorus (11.06 kg ha^{-1}) uptake by rice crop was observed in L_3 strip where 0 t ha^{-1} FYM (F_1) was applied. Whereas, total K uptake was lowest in low fertility strip which received 10 t FYM ha^{-1} (F_2). The mineral N content was significantly higher with application of 15 t FYM ha^{-1} as compared to lower doses of FYM, which reflects better utilization of available nitrogen at this dose [14]. Total highest P_2O_5 and K_2O uptake in control plots were recorded with application of 10 t FYM ha^{-1} with no fertilizers. Similarly, a significant effect on the content of available potassium in soil was also noted for FYM fertilization, especially with a dose of 60 and 80 t FYM ha^{-1} by Ladha *et al.* (2003) [15]. Long-term FYM application will increase the content of exchangeable and active potassium and, to a much lesser extent, available potassium.

Initial soil test values

The available nitrogen content in treated plot was highest (262.76 kg ha^{-1}) where 3-3-2 levels of NPK were applied with 10 t FYM ha^{-1} (F_2), in low fertility strip (L_1). In medium fertility strip (L_2) with application of 15 t FYM ha^{-1} (F_3) with 3-3-3 and 0 t FYM ha^{-1} (F_1) with 3-2-2 levels of NPK applied plots have recorded highest available P_2O_5 (231.72 kg ha^{-1}) and K_2O (427.68 kg ha^{-1}), respectively. This clearly indicates that application of graded levels of NPK fertilizers has increased the availability of NPK content in soil.

In control plots lowest available N & P_2O_5 was noticed in high fertility strip in F_1 (0 t ha^{-1}), and F_3 (15 t ha^{-1}), blocks where no NPK were applied. The higher N (187.80 Kg ha^{-1}) was observed in low fertility strip with 10 t FYM ha^{-1} (F_2) was applied. The higher available P_2O_5 & K_2O was noticed in the medium strip (L_2) which received 15 t FYM ha^{-1} (F_3) 229.42 kg P_2O_5 ha^{-1} and 327.32 kg P_2O_5 ha^{-1}, respectively. These details clearly indicated the presence of variation in soil available NPK status in the initial soil, variation in rice yield, NPK nutrient uptake by rice crop, which is a prerequisite for calculating basic parameters and fertilizer prescription equation for calculating the quantity of fertilizer nutrient required for specific yield target. Similar, wide ranges were obtained by Santhi *et al.* (2011) [16], while developing targeted yield equation for carrot and beet root.

Soil test calibration for targeted yield

The pre-sowing soil nutrient status, yield and nutrient uptake by rice crop were used to calculate the basic parameters *viz.,* nutrient requirement (NR) in kg for producing one quintal of rice, per cent contribution from soil (% CS), per cent contribution from fertilizer (% CF) and per cent contribution of nutrient from organic matter (% C-OM). The average nutrient requirement to produce 100 kg of dry matter yield of rice was 3.12, 0.61 and 2.09 kg of N, P_2O_5 and K_20, respectively [Table-5]. The results are in conformity with the findings of Bera *et al.* (2006)[17]. The contribution of N, P_2O_5, K_2O from soil, FYM and fertilizer sources were 48.11, 20.47 and 38.58; 60.24, 65.24 and 112.24 per cent, respectively. The results showed that the nutrient contribution from fertilizer sources was greater than that from the soil and organic matter alone. The findings were in agreement with those reported by Ray *et al.* (2000) and Bera *et al.* (2006)[17,18] who stated that the contribution of K from fertilizer for maize was higher in comparison to soil. It was observed that the contribution of K from fertilizer was more than 100 per cent (112.25 %). The higher K values of K could be due to interaction effect and primary effect of starter K doses in the treated plot, which might have caused the release of K from soil pools, resulting in the higher uptake from the native soil sources by the crop [18]. Similar type of higher efficiency of potassium fertilizer was also reported in rice by Ahmed *et al.* (2002)[19].

These parameters are used to relate with yield (y), soil nutrient (SN) and fertilizer nutrient (FN) as follows:

$$NR(y) = (\%CS)(SN) + (\%CF)\,(FN)$$

From this equation fertilizer nutrient (FN) can be calculated as follows:

$$FN = \frac{NR(y) - (\%CS)(SN)}{(\%CF)}$$

By simplification of the above equation individual nutrient requirement (fertilizer nutrient doses) can be calculated for specific targeted yield as follows:

$$FN = \left(NR\;X\;T - \frac{CS}{100}\;X\;SN\right)\frac{100}{CF} = \frac{NR}{CF}\;X\;100\;X\;T - \frac{CS}{CF}\;X\;SN$$

$$FP_2O_5 = \left(NP_2O_5\;X\;T - \frac{CF}{100}XSP_2O_5\right)\frac{100}{CF} = \frac{NR}{CF}\;X100\;X\;T - \frac{CS}{CF}SP_2O_5$$

$$FK_2O = \left(\frac{NR}{CF}\;X\;100\;X\;T - \frac{CS}{CF}XSK_2O\right)$$

By using the data of above basic parameters the fertilizer prescription equation was developed as presented below.

FN = 5.166 T- 0.799 S.N (% O.C) – 0.00967 OM

FP_2O_5 = 1.636 T – 0.256 SP_2O_5 (Olsen) – 0.000770 OM

FK_2O = 2.31T – 0.493 5.K_2O (Am. Ac.) – 0.00114 OM.

Where,

F_N, F_P and F_K - Fertilizer N, P and K required (kg ha^{-1})

T- Yield Target (100 kg ha^{-1})

OM – Organic matter (1000 kg ha^{-1})

Table-4 *Initial soil test values (kg ha^{-1}) of transplanted rice crop grown plots*

	Treated plots			
	Lowest		Highest	
Available N	L_3 - F_2, 1-1-2	81.38	L_1 - F_2, 3-2-2	262.76
Available P_2O_5	L_1 - F_1, 2-0-2	87.34	L_2 - F_3, 3-3-3	231.12
Available K_2O	L_1 - F_2, 2-2-0	161.16	L_2 - F_1, 3-2-2	427.68
	Control plots			
	Lowest		Highest	
Available N	L_3 - F_1, 0-0-0	100.00	L_1 - F_2, 0-0-0	187.80
Available P_2O_5	L_3 - F_3, 0-0-0	89.15	L_2 - F_3, 0-0-0	229.42
Available K_2O	L_1 - F_2, 0-0-0	151.07	L_2 - F_3, 0-0-0	327.32

Table-5 *Basic parameters of targeted yield equation for transplanted rice.*

Parameters	Basic Data		
	N	P_2O_5	K_2O
Nutrient requirement (NR) (Kg nutrient/100 kg dry matter yield)	3.12	0.61	2.09
Contribution from soil (CS %)	48.11	20.47	35.58
Contribution from fertilizer (CF %)	60.24	65.24	112.25
Contribution from organic matter (C-OM %)	58.23	35.25	70.46

Table-6 *Influence of different approaches of fertilizer application on 5 plants observations and available soil nutrient status after the harvest of rice crop*

Treatments	5 Plants observations				Available macronutrients (kg ha^{-1})		
	Plant height (cm)	No. of tillers	Grain weight (g)	Straw weight (g)	N	P_2O_5	K_2O
RDF	84.07	15.93	21.87	59.73	209.02	26.21	74.29
STCR (50 q ha^{-1}) approach	85.53	18.20	25.27	62.67	202.92	34.14	73.57
STCR (75 q ha^{-1}) approach	90.73	19.00	25.27	76.20	204.76	32.68	74.64
STCR (50 q ha^{-1}) Integrated approach	85.40	19.07	26.73	66.80	212.88	32.65	71.37
STCR (75 q ha^{-1}) Integrated approach	89.60	20.00	28.63	76.40	205.12	40.45	77.50
Control	74.20	15.20	17.53	38.47	198.86	24.79	65.36
SEm±	1.59	0.84	1.03	4.58	8.25	3.74	24.49
CD @ 5%	4.99	2.64	3.25	14.42	25.98	11.77	NS

Verification of targeted yield equation under aerobic condition.

The above targeted yield equation, which was developed for transplanted rice was verified for its suitability under aerobic condition under the Cauvery command area. For this purpose a verification trial was taken at ZARS, Mandya by conducting a follow up trial with 6 treatments *viz.,* T_1 – Recommended dose of fertilizer (RDF), T_2 – STCR (50 q ha^{-1}) approach, T_3 - STCR (75 q ha^{-1}) approach, T_4 -STCR (50 q ha^{-1}) Integrated approach, T_5 - STCR (75 q ha-^{1}) Integrated approach and T_6–Control and replicated trice. The results of the study showed that the plant height was significantly influenced by various treatments. Significantly higher plant height of 90.73 cm was recorded in STCR inorganic treatment with 75 q ha^{-1} target. It was mainly due to only fertilizer, which increases photosynthesis, and increases the vegetative growth of plants. Five plant observations on number of tillers (20.00), grain weight (28.63 g) and straw yield (76.40 g) was significantly increased with application of organics along with fertilizer through STCR approach at 75 q ha^{-1} targeted yield. This may be attributed to the increased supply of nutrients to rice crop under aerobic condition.

The results of the present study showed that higher yield target may be achieved through STCR integrated approach through the supply of nutrients from different sources, indicating the importance of balanced nutrition of crops.

Grain yield of rice was significantly higher (65.73 q ha^{-1}) in STCR integrated approach with 75 q ha^{-1} target. However, it was on par with the STCR integrated approach with 50 q ha^{-1} target [Table-7]. The lowest grain yield was recorded in control plot (45.66 q ha^{-1}) where no fertilizers were applied. Similarly, higher straw yield (212.61 q ha^{-1}) was recorded where STCR approach with 75 q ha^{-1} target either with only inorganic or integrated approach, compared to all other treatments. Addition of organic matter will directly help in enhancing the activity of microorganisms and release of nutrients into soil pool, which in turn helps in better growth and production of crops. Nitrogen, phosphorus and potassium uptake by rice crop was significantly higher in STCR integrated approach (75 q ha^{-1} target) followed by STCR inorganic (75 q ha^{-1} target).

The highest nitrogen (61.54 %) use efficiency (ANUE) was observed in treatment which received only 78 kg N ha^{-1} in T_5 - STCR 75 q ha^{-1} target with the IPNS approach, whereas in RDF (100 kg N ha^{-1}) and in T_2 (133 kg N ha^{-1}) recorded lower ANUE (13.75 and 16.85 % respectively). The nitrogen use efficiency gradually decreases with increase in N application rates [20]. With an increase in the application of phosphorus 50 kg ha^{-1} (ANUE – 12.05 %) from 93 kg ha^{-1} (ANUE – 76.61 %) which significantly influences the nutrient use efficiency in rice crop. The same trend was noticed with respect to potassium. The plots which received organic and inorganic with STCR approach have recorded higher yield response (20.07 and 15.37 in STCR 75 and 50 q ha^{-1} targets) whereas lowest yield response was observed in RDF (7.95 %) treatment.

The higher Value cost ratio VCR was noticed in STCR inorganic approach with 50 q ha^{-1} target plot (4.47) was due to application of lower doses of NPK and no FYM application which reduced the cost of inputs and the cost of cultivation which directly influenced the VCR. In other treatments, addition of the huge amount of FYM (15 t ha^{-1}) has greatly reduced the VCR due to high cost (900 Rs t^{-1}) of FYM, which directly increased the cost of cultivation.

From the present study, it concluded that, soil test based fertilizer prescription equation developed by taking into account the nutrient requirement and contribution of nutrients from fertilizer and organic manures for rice crop under puddled condition can be well adopted. The equation was validated under zone 6 of Karnataka, it was quite apparent that soil test and yield target based nutrient recommendation could help in improving the rice yield under both puddled and aerobic conditions in Cauvery command of Karnataka.

Table-7 *Influence of different approaches of fertilizer application on rice yield, nutrient uptake and nutrient use efficiency*

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Nutrient Uptake (kg ha^{-1})			Nutrient Use Efficiency (%)		
			N	P	K	N	P	K
RDF	53.60	164.53	65.75	22.84	81.09	13.75	12.05	11.60
STCR (50 q ha^{-1}) approach	56.93	175.21	74.41	23.42	82.76	16.85	11.31	10.13
STCR (75 q ha^{-1}) approach	57.54	212.61	98.00	37.52	110.28	29.30	40.04	28.21
STCR (50 q ha^{-1}) Integrated approach	61.03	177.35	76.70	30.58	96.33	37.42	50.53	43.44
STCR (75 q ha^{-1}) Integrated approach	65.73	212.61	100.00	41.62	125.78	61.54	76.61	79.05
Control	45.66	108.97	52.00	19.21	68.73			
SEm±	2.50	8.85	13.31	5.79	16.88			
CD @ 5%	7.95	27.80	41.9	18.23	53.16			

Table-8 *Aerobic rice yield and VCR as Influenced by different approaches of fertilizer application*

Treatments	Nutrients applied (kg ha^{-1})			Yield (q ha^{-1})	Yield Response	Per cent deviation	VCR
	N	P_2O_5	K_2O				
RDF	100.00	50.00	50.00	53.60	+ 7.95	-	0.95
STCR (50 q ha^{-1}) approach	133.00	65.00	65.00	56.93	+ 11.28	13.84	4.47
STCR (75 q ha^{-1}) approach	157.00	99.00	83.00	57.54	+ 11.88	-23.28	3.48
STCR (50 q ha^{-1}) Integrated approach	66.00	59.00	57.00	61.03	+ 15.37	+22.06	2.46
STCR (75 q ha^{-1}) Integrated approach	78.00	93.00	74.00	65.73	+ 20.07	-12.36	2.57
Control	00.00	00.00	00.00	45.66	-	-	-

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