

Original Research Article

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Fertilizer Prescriptions for Rice Based on STCR –IPNS

U. Bagavathi Ammal^{1*}, R. Sankar^{1*}, K. Coumaravel^{1*} and Pradip Dey²

¹Department of Soil Science and Agricultural Chemistry, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal-609603, India

²Project Coordinator, Indian Institute of Soil Science, Bhopal-462 038, India

*Corresponding author

ABSTRACT

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To develop fertilizer prescription equation for rice, a field experiment was conducted on an inceptisol of farmer's field at Arachikuppam village, Puducherry during 2015 by using integrated plant nutrient management system on the basis of STCR approach. The rice grain and straw yield was significantly increased with the soil test values and fertilizer doses of N, P and K. Based on the experiment, the nutrient requirement for producing 1 quintal of rice grain was 1.46 kg of N, 0.60 kg of P₂O₅ and 1.12 kg of K₂O, respectively. The percent nutrient contribution from soil was 20.18, 21.39 and 19.52, from fertilizer 39.04, 39.39 and 70.97 and from organic manure 23.06, 30.40 and 55.03 for N, P₂O₅ and K₂O respectively. By using the basic parameters the soil test based fertilizer adjustment equations for specific targets of rice grain yield of 7.0 and 8.0 t ha⁻¹ have been calibrated based on the targeted yield concept. These fertilizer prescription equations developed for Rice (var.) White Ponni can be used to estimate fertilizer doses formulated for the range of soil test values and desired yield targets under NPK alone and IPNS (NPK plus FYM).

Introduction

Rice (*Oryza sativa* L.) is central to the lives of billions of people around the world. At the global level, rice is the most widely grown crop which occupies an area of about 161.8 million hectares, of which Asia covers about 143.2 million hectares. Similarly, Out of the total world rice production of 701 million tons, Asia contributes approximately 633.7

million tons (FAO Statistical year book, 2013). The slogan 'Rice is life' is most appropriate for India; as this crop plays a vital role in our India's food security and is a mean of livelihood for millions of rural households (Ajaykumar *et al.*, 2016). In India, more than 44 million hectares area is occupied by rice under three major ecosystems, rainfed uplands (16% area), irrigated medium lands (45%) and rainfed lowland (39%), with a

productivity of 0.87, 2.24 and 1.55 tons per hectare, respectively (Tiwari *et al.*, 2013). The rice production largely depends upon the resource availability, varietal potential and nutrient management technologies. The nutrient management is one of the most important input in agriculture.

The annual consumption of fertilizers, in nutrient forms (N, P and K) has increased from 0.07 million tons in 1951-52 to more than 28 million tons in 2010-11 and per hectare consumption has increased from less than 1 kg in 1951-52 to the level of 135 kg in 2010-11 (Karsangla and Gohain, 2015), the nutrient use efficiency has gone down from 16 kg food grain produced per kg NPK applied during 1970's to 8 kg food grain produced per kg NPK applied during 1990's and around 6 kg now due to increasing deficiency of secondary and micronutrient (Tiwari *et al.*, 2013). The blanket fertilizer recommendation are based on crop responses without taking into account the spatial and temporal variability of the soils and the results is over / under use entailing economic / yield losses. Therefore, it is necessary to supplement crops with organic and inorganic fertilizers sources in order to maintain the nutrient supply and also to correct the deficiency of secondary and micronutrients. This can be offset only by adopting soil testing and applying integrated plant nutrient supply as has been enunciated as "The Law of Optimum", which has been demonstrated and validated in numerous farmer's field for obtaining targeted yield of crops under the All India Co-ordinated Research Project on Soil Test Crop Response (AICRP-STCR) project annual reports (Ramamoorthy and Velayutham, 2011, Tandan 2014 and Velayutham *et al.*, 2016).

The targeted yield approach wherein Ramamoorthy *et al.*, (1967) established the theoretical basis and experimental proof for

the fact that Liebig's law of minimum operates equally well for N, P and K. Among the various methods of fertilizer recommendation, the one based on yield targeting is unique in the sense that this method not only indicates soil test based fertilizer doses but also the level of yield the farmer can hope to achieve if good agronomic practices are followed in raising the crop. Targeted yield concepts strikes a balance between "Fertilizing the crop" and "Fertilizing the soil". The objective of this study was to develop the fertilizer prescriptions for rice crop in alluvial soil (Inceptisols) at different soil fertility levels under the conditions of fertilizer scarcity and to ensure maximum fertilizer use efficiency. The study also intended to find the relationship between nutrients supplied by the soil and added by organic and inorganic sources, their uptake and to develop a guideline for judicious application of fertilizer for desired yield target of rice by using STCR model.

Materials and Methods

A field experiment was conducted with rice as test crop during 2015 on alluvial soil (Inceptisol) of farmer's field at Arachikuppam village, Puducherry to develop targeted yield equation following the procedure of Ramamoorthy *et al.*, (1967). The field was divided into three strips of equal size and in each strip, The first strip received no fertilizer ($N_0P_0K_0$), the second and third received one ($N_1P_1K_1$) and two ($N_2P_2K_2$) times the standard dose of N, P_2O_5 and K_2O respectively were applied to develop a fertility gradient, and rice variety ADT 39 was grown as an exhaust crop during summer 2015 for stabilizing fertility gradient in the field. Crop was harvested at maturity. In the succeeding season, rice variety White Ponni was grown as test crop during rabi (2015) in the same field in which fertility gradient stabilizing experiment was

conducted. Each strip made (made in the fertility gradient stabilizing experiment in the previous season) was divided into 24 (21 treated and 3 control plots equal sized (4m x 4m) plots resulting in total of 72(24x 3) plots. Three blocks (A,B,C) comprising of 8 treatments were made within each strip randomized with farmyard manure (FYM) levels. The various levels of FYM (0.6.25 and 12.5 t ha⁻¹) and fertilizer [four levels of N (0, 50, 100 and 150 kg ha⁻¹), four levels of P₂O₅ (0, 25, 50 and 75 kg ha⁻¹) and four levels of K₂O (0, 25, 50 and 75 kg ha⁻¹)] were used. Treatments of N, P₂O₅, K₂O and FYM were used as shown in Table 1. Fertilizer used was urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP). Full dose of P₂O₅ and K₂O were applied as basal were N was applied in three equal splits, half as basal and remaining tillering, panicle initiation and flowering stages.

Plot-wise nutrient levels were tested before applying FYM and NPK. Soil samples (0-15cm) from all the 72 plots were collected and analyzed for available N by the alkaline permanganate method (Subbiah and Asija 1956); available P by 0.5 MNaHCO₃ (Olsen *et al.*, 1954) and available K by the ammonium acetate method (Stanford and English 1949) as described by Jackson (1973).

Rice grain and straw yield were recorded separately at maturity and plant samples were taken for estimation of N, P and K contents for working out uptake by the crop. Plot-wise soil test data, fertilizer doses, yield and uptake were used for obtaining NR (nutrient required to produce one tone of rice grain), %CS (per cent contribution of nutrients from soil) %CF (per cent contribution of nutrients from fertilizers) and % Cfym (per cent contribution of nutrients from organic matter), as per method described by Ramamoorthy *et al.*, (1967).

These parameters were used to develop equations for soil test based fertilizer recommendations for desired yield targets of rice under NPK alone as well as NPK plus FYM.

Results and Discussion

Soil available nutrients and grain yield

The range and mean values of soil available nutrients and grain yield of rice in treated and control plots are furnished in table 2. In the NPK treated plots (Plots that received NPK alone or NPK plus FYM) KMnO₄ -N increased from 159.6 kgha⁻¹ in strip 1 to 271.6 kgha⁻¹ in strip III with a mean value of 210.0kgha⁻¹. The Olsen-p ranged from 19.2 to 36.8kg P₂O₅ha⁻¹, while the NH₄OAc-K status varied from 107 to 161kgK₂Oha⁻¹

In the NPK treated plots that received NPK alone or NPK plus FYM, the yield of rice ranged from 3570 to 8010kgha⁻¹ with a mean value 5720 kgha⁻¹. In the overall control plot, the yield ranged from 2750 to 3250kgha⁻¹ with a mean value of 2983 kgha⁻¹.

In the overall control plot of three fertility gradients (Table 2), the KMnO₄ -N ranged from 176.4 to 193.2 kgha⁻¹ with a mean of 168.0 kg ha⁻¹, Olsen-P status ranged from 33.1 to 35.6 kgha⁻¹ with a mean value of 28.0 kgha⁻¹ and the NH₄OAc-K status varied from 141to 162 kg K₂O ha⁻¹ with a mean value of 114kg K₂O ha⁻¹. Though these soils are considered as fertile, they are low in N and high in P and medium in K.

The above data clearly indicate the existence of operational range of soil test values for available N, P and K status and yield of treated and control plots, which is prerequisite for calculating the basic parameters and fertilizer prescription equations for calibrating the fertilizer doses for specific yield targets.

The equations are

NPK Alone

FN= 3.75T-0.52SN
 FP₂O₅= 1.53T-1.24SP
 FK₂O=1.58T-0.33SK

NPK + FYM

FN = 3.75 T-0.52 SN -0.59 ON
 FP₂O₅ = 1.53 T-1.24 SP -1.77 OP
 FK₂O = 1.58 T-0.33SK-0.93 OK
 FN= Fertilizer N(kg ha⁻¹.)
 FP=Fertilizer P₂O₅ (kg ha⁻¹.)
 Fk=Fertilizer K₂O (kg ha⁻¹.)
 T= yield target (qha⁻¹)

Where, SN, SP, SK, respectively are alkaline KMnO₄ -N, Olsen-P and NH₄OAc-K in kg ha⁻¹ of soil and ON, OP and OK are the quantities of N, P and K in kg ha⁻¹ supplied through FYM respectively.

Basic parameters

The basic data viz., nutrient requirement for producing one quintal grain of Rice, per cent contribution of nutrients from soil(%CS),

fertilizer(%CF) and FYM(%Cfym) have been calculated (Table 3). These basic parameters were used for developing fertilizer prescription equations under NPK alone and NPK plus FYM. The nutrient requirement of N, P₂O₅ and K₂O were 1.46, 0.60 and 1.12 kg q⁻¹ of grain, respectively. The %CS and %CF were found to be 20.18 and 39.04 for N, 21.39 and 39.39 for P₂O₅ and 19.52 and 70.97 for K₂O. Similarly, the percent contribution of N, P₂O₅ and K₂O from FYM was 23.06, 30.04 and 55.03, respectively. It was noted that contribution from fertilizer for rice was higher in comparison to soil. The high value of potassium could be due to the interaction effect of higher doses of N, P coupled with priming effect of K doses in the treated plots, which might have caused the release of soil potassium, resulting in higher uptake from the native soil sources by the crop (Ray *et al.*, 2000). Similar type of higher efficiency of potassic fertilizers was also reported for rice by Ahmed and Reddy (2002) in alluvial soils. Among the three nutrients, the per cent contribution from soil was higher for P₂O₅ followed by N and K₂O. Similar trend of contribution of nutrients from soil to the total uptake was reported by Natesan *et al.*, (2007) for different rice varieties.

Table.1 Levels of Nitrogen, Phosphorous, potassium and FYM used in the experiment

N(kg ha ⁻¹)	P ₂ O ₅ (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)	FYM (t ha ⁻¹)
0	0	0	0
50	25	25	6.25
100	50	50	12.5
150	70	70	-

Table.2 Available nutrients in pre-sowing surface soil and yield of rice crop

Parameters	NPK treated plots		Control plots	
	Range	Mean	Range	Mean
KMnO ₄ -N (kgha ⁻¹)	159.6-271.6	210.0	176.4-193.2	168.0
Olsen-P (kgha ⁻¹)	19.2-36.8	28.6	33.1-35.6	28.0
NH ₄ OAc-K (kgha ⁻¹)	107 -161	130	141-162	114
Yield (kg ha ⁻¹)	3570-8010	5720	2750-3250	2983

Table.3 Basic data for fertilizer adjustment of Rice

Basic data	N	P ₂ O ₅	K ₂ O
Nutrient requirement (Kg q ⁻¹)	1.46	0.60	1.12
Soil efficiency(%) or %CS	20.18	21.39	19.52
Fertilizer efficiency(%) or %CF	39.04	39.39	70.97
Organic efficiency(%) or %Cfym	23.06	30.40	55.03

Table.4 Estimation of soil test based fertilizer recommendation for 7.0 t⁻¹ ha grain yield target of Rice crop

Soil Test values (kg ha ⁻¹)			Fertilizer Doses (kg ha ⁻¹) under NPK alone			Fertilizer doses (kg ha ⁻¹) under NPK + FYM@ 12.5 t ha ⁻¹		
SN	SP ₂ O ₅	SK ₂ O	FN	FP ₂ O ₅	FK ₂ O	FN	FP ₂ O ₅	FK ₂ O
160	10	100	180	95	77	134	69	42
200	12	120	159	92	71	113	66	36
240	14	140	139	90	64	93	64	29
280	16	160	118	87	57	75	61	25
320	18	180	100	85	51	60	59	25

An estimate of fertilizer doses was prepared based on these equations for a range of soil test values and for yield target of 7.0 tha⁻¹ of rice (Table 4). For achieving this target with the soil test values of 200:12:120 kg ha⁻¹ of KMnO₄ -N, Olsen-P and NH₄O Ac-K, the fertilizer N, P₂O₅ and K₂O doses required were 159, 92 and 71kg ha⁻¹, respectively, where FYM (0.51, 0.29 and 0.39% of N,P and K, respectively) was applied @ 12.5t ha⁻¹ along with NPK, the required fertilizer N,P₂O₅ and K₂O doses were 113, 66 and 36 kg ha⁻¹, respectively. Under IPNS system the required dose of fertilizer is low due to nutrient availability increased by FYM through mineralization. Singh *et al.*, (2015) also reported that under irrigated plant nutrient system, required dose of fertilizer to achieve desired yield target are reduced.

In conclusions, use of integrated plant nutrient management system resulted in saving of fertilizer nutrients in rice crop. Target yield

equations generated from STCR-IPNS technology ensures not only sustainable crop production but also economic use of costly fertilizer inputs. Generally, soil productivity and health may be more sustainable with the integrated application of FYM and inorganic fertilizers than with the use of inorganic fertilizer alone.

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