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Targeted yield approach under integrated nutrient management for assessing fertilizer requirement of rice

Poonam Gautam*, Ajaya Srivastava, Sobaran Singh and Anil Kumar Saxena
G.B.Pant University of Agriculture and Technology, Pantnagar-263145, Distt. U.S. Nagar, Uttarakhand.

ABSTRACT

Response of rice to the selected combinations of four levels of N, P, K and three levels of FYM with simultaneous variations in initially available soil forms of these three nutrients were studied under soil test crop response calibration in aquic hapludoll. Grain and straw yield and soil analysis data were utilized to formulate the prescription equations for fertilizer doses under integrated nutrient management system with varying yield targets at different fertility levels. Besides, follow up trials were conducted to test the validity of these equations. Results of these trials clearly indicate the superiority of yield target approach over other approaches.

Key words: *rice, soil test, crop response, yield target, fertilizer prescription equation*

Rice contributes about 43% of total food grain production and 46% of total cereal production in India (Mahapatra, 2005). Farmers are inclined to the excess use of chemical fertilizers to get more and more yield, but the decision on fertilizer use requires knowledge of the expected crop yield response to nutrient application, which is a function of crop nutrient needs, supply of nutrients from indigenous sources and the short and long term fate of fertilizer applied (Dobermann *et al*., 2003). Dumping of fertilizers by the farmers in the fields with out information on soil fertility status and nutrient requirement by crop causes adverse effects on soil and crop regarding both nutrient toxicity and deficiency either by over use or inadequate use (Ray *et al*., 2000). Managing the location specific variability in nutrient supply is a key strategy to overcome the current mismatch of fertilizer rates and crop nutrient demand in irrigated rice environments (Dobermann and Cassman, 2002).Soil test based application of plant nutrient helps to realize higher response ratio and benefit :cost ratio as the nutrients are applied in proportion to the magnitude of the deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization (Rao and Srivastava, 2000). Location specific fertilizer recommendations are possible for soils of varying fertility, resource conditions of farmers and levels of targeted yield for similar soil classes and environment (Ahmed *et al.,* 2002).Field specific balanced amounts of N,P,K'were prescribed based on crop based estimates of the indigenous supply of N,P,K and by modelling the expected yield response as a function of nutrient interaction was done by many workers (Dobermann and White,1998.,Witt *et al.,*1999). Therefore, the present investigation was undertaken to study the relationship between the nutrient supplied by the soil and added fertilizers, their uptake and yield of paddy and to develop a guideline for judicious application of fertilizer under integrated nutrient management system.

MATERIALS AND METHODS

Field experiment was conducted at G.B. Pant University of Agriculture and Technology, Pantnagar on a silty clay loam soil which was classified as Aquic Hapludoll (Deshpande *et al.*, 1971). Prior to this experiment, fertility gradient was created through graded doses of N, P and K fertilizers to obtain appreciable variation in soil fertility in the same field. Fertility gradient was created by dividing the experimental area into three equal strips and the application of 150 Kg N- 60 Kg P_2O_5- 40 Kg K_2O ha^{-1} in second and 300 Kg N- 120 Kg P_2O_5- 80 Kg K_2O ha^{-1} in third strip was done while first strip was kept unfertilized (control). Wheat was grown during dry season 2005 as a preparatory crop so that fertilizer could interact with soil, plant and microbes and thus become a part of soil system. After the exhaust of preparatory crop experiment on rice variety Pant Dhan-4 was conducted in subsequent wet season 2006. Each strip was divided in to 24 equal sized (4 m X 3 m) plots. Twenty one selected fertilizer treatments constituted of different combinations of four levels of N (0, 100,150 and 200 Kg ha^{-1}), P_2O_5 (0, 30, 60 and 120 Kg ha^{-1}), K_2O (0, 20,40 and 60 Kg ha^{-1}) and 3 levels of FYM (0, 5, 10,tons ha^{-1}). These treatments were randomly distributed in each strip with three control plots interspaced. Fertilizers used were urea, single super phosphate and muriate of potash. Full dose of $P_2O_5$and K_2O were applied as basal while nitrogen was applied in two equal splits, half as basal and remaining half was applied 30 days after transplanting. Before fertilizer application soil samples from individual plots were collected at 0-15 cm depth and analyzed for alkaline $KMnO_4$-N (Subbiah and Asija, 1956), Olsen's-P (Olsen et al., 1954) and ammonium acetate extractable-K (Hanwey and Heidal, 1952). At physiological maturity grain and straw samples were collected and processed. These samples were analyzed for total N, P and K content (Jackson, 1973) and uptake was calculated. The data on grain yield, N, P, K uptake by rice, soil available N, P, K and fertilizer N, P, K applied were used for calculation of basic data (Sonar, 1984) *viz.* nutrient requirement (NR), per cent contribution from soil (CS) and per cent contribution from fertilizer (CF) and were transfered in to workable adjustment equation (Rao and Srivastava, 2000).

FD= [(NRxTx100)/CF]-[(CS/CF)xSTV]

Where, FD= Fertilizer dose (Kg ha^{-1}), T= Yield Target (q ha^{-1}), STV= Soil test value for available N, P, K (Kg ha^{-1})

Five follow up trials were conducted on the same soil type with four treatments *viz.* Farmer's practice (FP), General recommended dose (GRD), Yield target 4.0 t ha^{-1} (TY1) and Yield target 4.5t ha^{-1} (TY2) to test the validity of these equations for rice crop. FYM was applied in all the treatments @ 10 tones ha^{-1}.

RESULTS AND DISCUSSIONS

In the present investigation the soil test values ranged from 171.5 to 221.5, 38.4 to 52.3 and 183.1 to 231.1 with the mean values of 192.8, 45.2 and 204.6 for N, P and K Kg ha^{-1} respectively. Grain yield varied between 2.39 to 6.85 t ha^{-1} with mean of 4.81 tha^{-1}(Table 1). Perusual of the basic data indicated that 1.78, 0.37 and 2.11 Kg of N, P and K are required to produce one quintal of rice grain (Table 2). The utilization efficiency of soil for N, P and K was 31.09, 28.39 and 37.21 percent. Values for fertilizer efficiency were 31.63, 40.50 and 180.81 percent with FYM. Values of percent contribution from applied FYM were 30.01, 9.13 and 54.74, respectively. These results indicate that nutrient contribution from fertilizer sources was greater than that from the soil source. The findings are closely in accordance with those reported by Meena *et al* (2001).Contribution of potassium for rice was observed to be more than 100 %.This high value of K could be due to the interaction effect of higher doses of N, P

Table 1. Range and mean values of yield (t ha^{-1}) and soil test values (Kg ha^{-1}) of rice variety Pant Dhan- 4 under different fertility strips.

Particulars	Strip	Mean	Strip II	Mean	Strip III	Mean
Grain yield (t ha^{-1})	2.39-6.35	4.38	3.31-6.58	(4.86)	4.02-6.85	5.20
Alkaline $KMnO_4$-N (Kg ha^{-1})	171.5-186.3	180.2	174.5-201.1	(188.6)	181.3-221.5	209.5
Olsen's-P (Kg ha^{-1})	38.4-48.4	43.9	39.4-49.3	(44.8)	43.1-52.3	46.7
Ammonium acetate extractable-K (Kg ha^{-1})	183.1-205.4	194.5	194.5-212.8	(202.5)	205.4-231.1	216.8

Table 2. Basic data for calculating fertilizer dose for target yield of rice under INM.

Particulars	N	P	K
Nutrient required (Kg/ q)	1.78	0.37	2.11
Contribution from soil* (%)	31.09	28.39	37.21
Contribution from fertilizer (%)	31.63	40.50	180.81
Contribution from applied FYM (%)	30.01	9.13	54.74

*Soil test values at (0-15 cm depth) alkaline $KMnO_4$-N ($Kgha^{-1}$), Olsen's-P ($Kgha^{-1}$) and ammonium acetate extractable-K ($Kgha^{-1}$).

and the priming 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).

Table 3. Nitrogen requirement for targeted yield of rice under INM

Soil test values alkaline $KMnO_4$-N (Kg ha $^{-1}$)	Fertilizer dose (Kg ha $^{-1}$) Grain yield of rice (t ha^{-1})			
	4.0	4.5	5.0	5.5
150	62.2	90.4	118.6	146.8
170	42.6	70.8	99.0	127.2
190	23.0	51.2	79.4	107.6
210	3.4	31.6	59.8	88.0
230	-	12.0	40.2	68.4

Nitrogen dose (Kg ha^{-1}) = 5.64 T- 0.98 SN- 0.95 FYM N
Where, T = Yield target, SN = alkaline $KMnO_4$-N (Kg ha $^{-1}$) and FYM N=Contribution of Nitrogen from FYM

Similar type of higher efficiency of potassic fertilizer was also reported for rice by Ahmed *et al*. (2002) in alluvial soils and for maize by Reddy *et al* . (2000) in

Table 4. Phosphorus requirement for targeted yield of rice under INM.

Soil test values Olsen's-P (Kg ha $^{-1}$)	Fertilizer dose (Kg ha $^{-1}$) Grain yield of rice (t ha^{-1})			
	4.0	4.5	5.0	5.5
35	9.4	14.10	18.7	23.3
45	2.6	7.11	11.6	16.4
55	-	0.15	4.7	9.5
65	-	-	-	2.3
75	-	-	-	-

Phosphorus dose (Kg ha^{-1}) = 0.92 T- 0.70 SP- 0.23 FYM P
Where, T = Yield target, SP = Olsen's-P (Kg ha^{-1}) and FYM P=Contribution of Phosphorus from FYM

Table 5. Potassium requirement for targeted yield of rice under INM

Soil test values ammonium acetate extractable-K (Kg ha $^{-1}$)	Fertilizer dose (Kg ha $^{-1}$) Grain yield of rice (t ha^{-1})			
	4.0	4.5	5.0	5.5
150	9.9	15.8	21.6	27.5
165	6.8	12.6	18.5	24.3
180	3.6	9.5	15.3	21.2
195	0.5	6.3	12.2	18.0
210	-	3.2	9.0	14.9

Potassium dose (Kg ha^{-1}) = 1.17 T- 0.21 SK- 0.30 FYM K
Where, T = Yield target, SK = ammonium acetate extractable-K (Kg ha^{-1}) and FYM K=Contribution of Potassium from FYM

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Final computations by using the basic data simple fertilizer prescription equations for targeted yield of rice were worked out. These equations were transformed into ready reckoners for the prescription of fertilizer dose for four different yield targets i.e. 4.0, 4.5, 5.0 and 5.5 t ha^{-1} of rice on soils with varying soil test values (Table 3, 4 and 5). Fertilizer rates increased with increasing yield targets of rice and decreased with increasing the soil test values. The results are in conformity with the results observed by Saxena *et al*, (2008) for onion and Raghaviah *et al*., (2008) for castor crop. It is obvious from findings that there was net savings of fertilizers for each target.

Validity of these equations developed for rice was tested by conducting follow up trials on the same soil type. Results of the trials showed that there is fairly close similarity between the yield target and those actually obtained (Table 6). The variation in yield obtained from the targeted yield ranged from -2.52 to -3.47 % which were within -10% variation of the yield targets. These results accorded with the findings of

Table 6. Economics of follow up trials for rice (variety Pant Dhan -4)

Treatments	Fertiliser dose N-P-K (Kg ha^{-1})	Actual Mean yield (t ha^{-1})	Additional yield (t ha^{-1})	Value of additional yield (Rs.)	Cost of fertilizer (Rs.)	B:C ratio	Net benefit (Rs.)	Response ratio	Yield deviation
FP	140-30-20	3.08	0	0	0	0.00	0.0	0	0
GRD	150-60-40	3.65	0.56	8538	2968.20	1.88	5569.8	2.3	0
TY1	70.1-35.4-4.7	3.89	0.81	12168	1424.37	7.54	10743.6	7.4	-2.78
TY2	83.0-46.5-11.6	4.34	1.25	18846	1812.57	9.40	17033.4	8.9	-3.47

FP - Farmers' practice, GRD - General recommended dose, TY1- Yield target 4.0 t ha^{-1}, TY2 - Yield target 4.5 t ha^{-1}

Ray *et al*., (2000). The farmer's practice of fertilizer application was least efficient in producing grain yield of rice. Mean yield, net benefit and benefit cost ratio was higher in treatments where fertilizer was applied on the basis of target yield approach than the farmer's practice and general recommended dose treatments. Highest response and benefit cost ratio were found to be with yield target 4.5 t ha^{-1}. There was also increase in profit over farmer's practice with increasing yield targets from 4.0 to 4.5 t ha^{-1} which might be due to efficiency factor increase in crop yield (Sekhon *et al.*, 1977). The results are in conformity with the results observed by Milapchand *et al.* (2006).

Therefore, targeted yield approach will not only ensure sustainable crop production but will also steer the farmers towards economic use of costly fertilizers depending on their financial status and prevailing market price of the crop under consideration. However, some other soil parameters which affect the soil nutrient retention should also be considered.

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