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FERTILIZER RECOMMENDATION BASED ON SOIL TESTING FOR THE TARGETED YIELD OF RICE IN EASTERN PLAIN ZONE OF UTTER PRADESH

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ABSTRACT

A field experiment was conducted on rice crop under soil test crop response correlation studies in Varanasi region of Utter Pradesh during *kharif* 2011. Multiple regressions have been calibrated for predicting rice yield through soil and fertilizer nutrients and their interactions. The models were found to have a high and significant predictability value. Using the data, fertilizer adjustment equations have also been developed for prescribing optimum fertilizer doses for attaining different yield targets. The nutrient requirements (kg $q^{\bullet 1}$) of N, P_2O_5 and K_2O for producing one quintal of rice yield in Inceptisol were found to be 2.56, 0.56 and 2.21, respectively. The per cent contributions of nutrient from soil, fertilizers and FYM were 26.35, 51.17 and 26.14; 54.03, 36.35 and 75.68; and 18.59, 3.10 and 8.56 of N, P and K nutrients, respectively. The fertilizer adjustment equations and a ready reckoner of optimum fertilizer doses at varying soil test values for attaining yield target of 40 and 50 q ha^{-1} of rice yield have been calibrated based on the targeted yield concept.

INTRODUCTION

Fertilizer is one of the costliest inputs in agriculture and the use of right amount of fertilizer is fundamental for farm profitability and environmental protection (Kimetu *et al.,* 2004). To enhance farm profitability under different soil-climate conditions, it is necessary to have information on optimum doses for crops. Traditionally, to determine the optimum fertilizer doses of most appropriate method is to apply fertilizer on the basis of soil test and crop response studies. During 1956-57 the semi-quantitative soil test calibrations were evolved and advocated for the use. Subsequently in India the quantitative refinements in the fertilizer recommendations based on the soil and plant analysis were made (1967-68) through the All India Coordinated Research Project for Investigation on Soil test crop response correlation (STCRC). The ICAR project on soil test crop response correlation used the targeted yield approach to develop relationship between crop yields on the one hand and soil test values and fertilizer inputs on the other.

Rice fulfills 43 percent of calories requirement of more than 70 percent of the Indian population. To meet the demands of increasing population and to maintain self-sufficiency, the present production level of 102 million tones needs to be increased upto 125 million tonnes by the year 2020 (Sridevi *et al.*, 2011). This signifies the contribution of rice in meeting food requirements of the hungry mouth of country. But now day crop yield stagnation as well as no further increment in crop yield is emerging challenge for researchers. One of the reasons for lower production of rice is imbalanced fertilization of N, P and K nutrients. (Reddy and Ahmed, 2000). The most comprehensive approach of fertilizer application by incorporating soil test values, nutrient requirement of the crop, contribution of nutrients from soil, manures, fertilizers and fixing yield-targets is possible only through Soil Test Crop Response (STCR) approach. Keeping this in view, the present investigation was carried out to develop fertilizer schedule based on soil test values for attaining different yield targets of rice in Inceptisol of Varanasi region of Utter Pradesh.

MATERIALS AND METHODS

A field experiment was conducted based on STCR methodology on rice with the variety 'Saryau-52' at Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University in Varanasi during *kharif* 2011 after harvest of wheat experiment during Rabi 2010-11. The field was prepared without any disturbance to the already created three fertility gradient strips (0X, X, 2X). Then each strip was sub divided into 24 plots of equal size. A set of 24 treatments out of which 21 treatments in combination with four levels of nitrogen (0, 50, 100 and 150 kg ha^{-1}), four levels of phosphorus (0, 40, 80 and 120 kg ha^{-1}) four levels of potassium (0, 40, 80 and 120 kg ha^{-1}) and three levels of FYM (0, 5, 10 t ha^{-1}) and three controls were superimposed to different plots in each strip and the experiment was conducted in a randomized

block design (RBD). Initial soil samples were collected from each sub-plot (0-15cm) before superimposition of 21 fertilizer treatments and three controls were analyzed for organic carbon by Walkey and Black method (1934), available nitrogen by alkaline potassium permanganate method as proposed Subbiah and Asija (1956), available phosphorus by Olsen's method (Olsen *et al*., 1954) and available potassium by ammonium acetate method (Hanway & Heidal, 1952) as described by Jackson (1973). The plant samples grain as well as straw sample collected at harvesting stage has been analyzed for N, P and K and the plant uptake of nutrients was calibrated by using grain and straw yield data. Using the grain yield and nutrient uptake data, soil test values and applied fertilizer does of treated and control plots, the basic data viz. nutrient requirement (kg q^{-1}), soil, fertilizer and organic manure efficiencies (%) for making fertilizer recommendation have been estimated by following the conventional procedure as discussed by Ramamoorthy *et al*. (1967).

The experiment was conducted on the basis of whole field method in which the data of all plots were used in deriving the estimates. The soil efficiency was estimated from only unfertilized plots, while the fertilizer and organic manure efficiency was estimated from fertilized plots. The nutrient requirement was estimated from both the fertilized and unfertilized plots. The computational procedure of basic data is well discussed in Ramamoorthy *et al*. (1967). The estimates of basic data were used for developing fertilizer adjustment equations for deriving optimum fertilizer doses for achieving different yield targets. The soil test based fertilizer recommendations can be prescribed in the form of a ready reckoner for different yield targets.

RESULTS AND DISCUSSION

The range and mean of soil test values and yield of treated and control plots are presented in Table 1. The results showed that the organic carbon percent ranged from 0.32 to 0.51 with a mean of 0.39, available nitrogen between 145 and 265 with a mean of 194 kg ha^{-1}, available phosphorus from 13 to 36 with a mean of 22 kg ha^{-1}, and available potassium between 136.5 and 245 with a mean of 182 kg ha^{-1}. The harvested grain yield in treated and control plots was found to range from 3208 to 4740 and 1989 to 2580 kg ha^{-1}, respectivily. It is evident from the above data with a wide variability has existed in the soil test values and grain yield of treated and control plots which is essential for developing a multiple regression model, basic data and targeted yield equations for calibrating the optimum fertilizer dose.

Prediction equation using soil and fertilizer variables and their interactions

Apart from fertilizer doses, soil test values of N, P and K and their interactions would influence rice yield. Hence, a multiple regression equation of grain yield through soil and fertilizer N, P and K variables and their interactions has been calculated and is as fallows.

$Y = 18.50 – 0.03833\ SN + 0.498251^*\ SP + 0.013634\ SK + 0.058434^*\ FN + 0.082766\ FP + 0.088757^*\ FK - 0.000092\ FN^2 – 0.000336\ FP^2 - 0.000454\ FK^2 - 0.00042\ SNFN - 0.000383$ SPFP - 5.653 SKFK ($KMnO_4$-N, Olsen's-P, Ammonium Acetate K) $R^2 = 0.82$

It is obvious from the above equation that soil P, fertilizer N and fertilizer K are important variables as they have significantly contributed to the grain yield. Although all other variables are non-significant, still the complete model has to be calibrated since the grain yield is the resultant of both the soil and fertilizer nutrient variables in the study. On differentiating the above equations partially with respect to fertilizer N, P and K nutrients, we get fertilizer adjustment equations for deriving fertilizer dose for maximum yield, maximum profit and a desired rate of return.

Soil test based fertilizer calibrations for attaining targeted yields

The basic data viz., the nutrient requirement (kg q^{-1}) for producing one quintal of rice yield, soil, fertilizer and organic manure efficiencies or the percent contribution from soil, fertilizer nitrogen, phosphorus, potassium and FYM have been calculated from each plot based on the data of whole field. The estimates of nutrient requirement (kg q^{-1}) values of fertilizer nitrogen, phosphorus and potassium based on whole field method were 2.56, 0.56 and 2.21, respectively. The percent nutrient contribution from soil, fertilizer and FYM in an Inceptisol were found to be 26.35, 51.17 and 26.14; 54.03, 36.35 and 75.68; and 18.59, 3.10 and 8.56 for nitrogen, phosphorus and potassium, respectively under whole field method which is given in Table 2. These results indicate that N and K nutrient contributions from the fertilizer source are more than from the soil source but P nutrient contribution from soil is more than from fertilizer sources. Bhargava (2001) Reported that the nutrient requirements for the production of one quintal of rice grain were 1.57 kg N, 0.35 kg P_2O_5, and 3.8 kg K_2O in Vertisols. Further reported that the fertilizer use efficiencies by rice were 37, 10, and 180% for N, P_2O_5, and K_2O, respectively and in soil those were 17, 18, and 22% for N, P_2O_5, and K_2O, respectively. Similar result also found by Rao *et al*. (2001) was conducted a field experiment to evolve soil test based fertilizer recommendation for N at Karimnagar district of Andhra Pradesh.

Using fertilizer adjustment equations derived under whole field method, a ready reckoner showing optimum N, P and K fertilizer doses at varying soil test values for attaining yield targets of 40 and 50 q ha^{-1} grain yield of rice is given in Table 3.The result clearly indicate that the fertilizer dose require for attaining a specific yield targets of rice yield are decreasing with increasing soil test values as shown in the figers 1 for N, 2 for P_2O_5 and 3 for K_2O. The optimum fertilizer doses required

Table1: The range and mean of soil test values and yield of treated and control plots

Variable	Range	Mean
Organic carbon (%)	0.32-0.51	0.39
Soil test values (kg ha^{-1})		
Alkaline permanganate N	145-265	194
Olsen's P	13-36	22
Ammonium acetate K	136.5-245	182
Grain yield (kg ha^{-1})		
Treated plots	3208-4740	3858
Control plots	1989-2580	2242

Table 2: Basic data and fertilizer adjustment equations for rice in Inceptisol

Nutrients	Basic data				Fertilizer adjustment equations
	NR (kg q^{-1})	CS (%)	CF (%)	CFYM (%)	
N	2.56	26.35	54.03	18.59	FN = 4.76T-0.49SN-0.34FYM-N
P	0.56	51.17	36.35	3.10	FP_2O_5 = 1.53T-1.41SP-0.09FYM-P
K	2.21	26.14	75.68	8.56	FK_2O = 2.92T-0.35SK-0.11FYM-K

NR = Nutrient requirement in kg per quintal of grain production; CS = Percent nutrient contribution from soil (soil efficiency); CF = Percent nutrient contribution from fertilizer (fertilizer efficiency); CFYM = Percent nutrient contribution from FYM (organic manure efficiency); T = Yield target (q ha^{-1}); SN, SP and SK = Soil available nitrogen, phosphorus and potassium in kg ha^{-1}; FN, FP_2O_5 and FK_2O = Fertilizer nitrogen, phosphorus and potassium required in kg ha^{-1}; FYM-N, FYM-P and FYM-K = Applied organic manure provides nitrogen, phosphorus and potassium in kg ha^{-1}

Table 3: Ready reckoner of fertilizer doses at varying soil test values for specific yield targets of rice using 10 tonnes FYM in Inceptisols

Available nutrients (kg ha^{-1})			Fertilizer nutrients required (kg ha^{-1}) for yield target of					
			40 q ha^{-1}			50 q ha^{-1}		
N	P	K	N	P_2O_5	K_2O	N	P_2O_5	K_2O
160	10	140	95.00	44.40	63.40	142.60	59.70	92.60
180	15	160	85.20	37.35	56.40	132.80	52.65	85.60
200	20	180	75.40	30.30	49.40	123.00	45.60	78.60
220	25	200	65.60	23.25	42.40	113.20	38.55	71.60
240	30	220	55.80	16.20	35.40	103.40	31.50	64.60
260	35	240	46.00	9.15	28.40	93.60	24.45	57.60
280	40	260	36.20	2.10	21.40	83.80	17.40	50.60
300	-	280	26.40	-	14.40	74.00	-	43.60
320	-	300	16.60	-	7.40	64.20	-	36.60
340	-	-	6.80	-	-	54.40	-	-

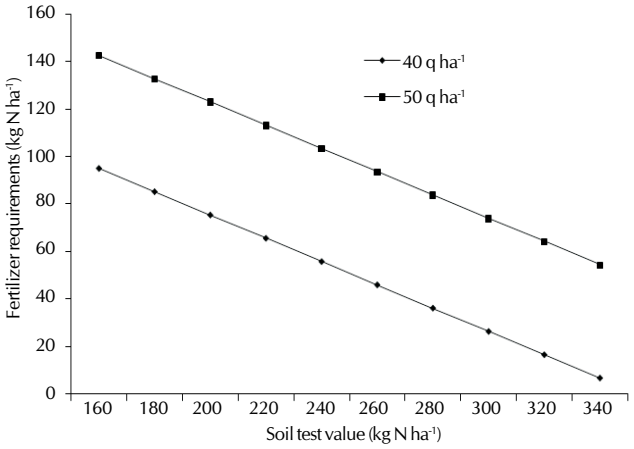

Figure 1: Fertilizer (N) requirement (kg ha^{-1}) for the targeted yield (40 and 50 q ha-1) of rice

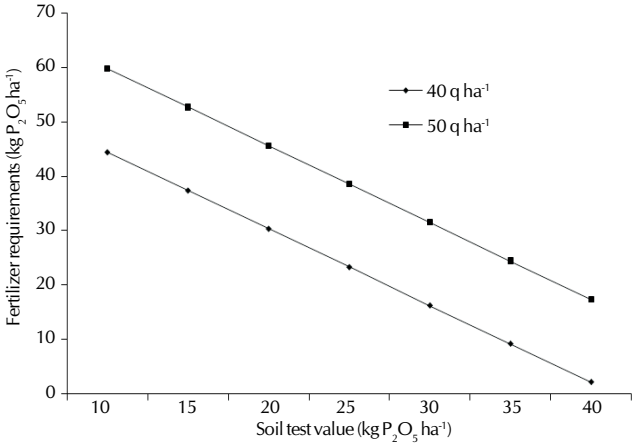

Figure 2: Fertilizer (P_2O_5) requirement (kg ha^{-1}) for the targeted yield (40 and 50 q ha-1) of rice

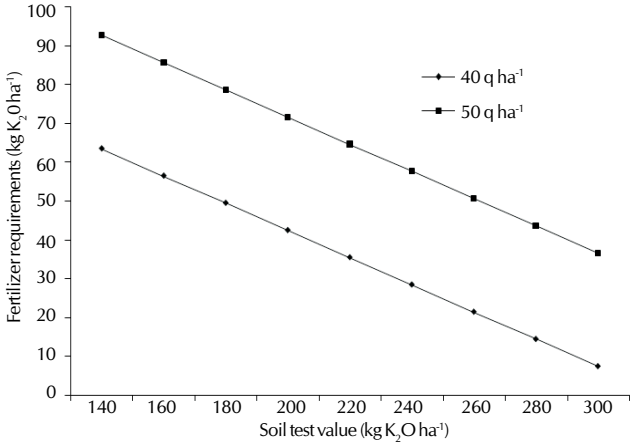

Figure 3: Fertilizer (K_20) requirement (kg ha^{-1}) for the targeted yield (40 and 50 q ha-1) of rice

at the average soil test values of the field experiment (194 kg N, 22 kg P, and 182 kg K) were found to be 126, 44 and 78 kg ha $^{-1}$ of N, P_2O_5 and K_2O, respectively for producing 50 q ha^{-1} of rice yield in an Inceptisol. There is no need of fertilizer N, P and K if Fertilizer nutrients requirement (NR) in kg ha^{-1} is obtained zero from fertilizer adjustment equations for producing of 40 and 50 q ha^{-1} of rice yield. According to Karem *et al*. (2012) findings showed that inorganic fertilizer application based on targeted yield along with organic manure (FYM) i.e. Integrated Plant Nutrient System (IPNS) approach, that consisted of application of 98 N: 103 P_2O_5: 27 K_2O kg ha^{-1} through chemical fertilizers + 46 N: 36 P_2O_5: 45 K_2O kg ha^{-1} through 5 t FYM ha^{-1} as organic manure, resulted in higher grain yield 4.04 t ha^{-1} of rice. Deshmuka *et al*. (2012) revealed that targeted yield of paddy (40 q ha^{-1}) have been achieved by using the plant nutrients on the basis of targeted yield concept (soil test crop response Technology). The per cent increase in yield was 38.24% over local check

which was 30.02 q ha^{-1}. Similar result also found by Srinivas *et al*. (2001) conducted soil test crop response (STCR) field experiments on 'Surekha' paddy with the objective of developing optimum fertilizer doses at varying soil test values for attaining different yield targets. Based on the study, the fertilizer doses were found to be ranging from 63 to 156 kg N ha^{-1}, 0 to 98 kg P_2O_5 ha^{-1} and 1 to 16 kg K_2O ha^{-1} at soil test values of 300 to 175, 35 to 10 and 825 to 700 kg ha^{-1} of N, P and K nutrients, respectively, for attaining an yield target of 50 q ha^{-1} in kharif 1988. Srinivasan and Angayarkanni (2010) were conducted a Soil test crop responses (STCR) studies with rice cv. ADT 43 and revealed that when the initial soil available NPK status were 200, 10, 250 kg ha^{-1}, the FN, FP_2O_5, FK_2O recommendations to get 60 t ha^{-1} were 233:100:107 kg ha^{-1} for fertilizers alone application.The fertilizer recommendations for the application of fertilizers + FYM + Azospirillum, for the same yield target were 185:86:82 kg ha^{-1} due to balanced fertilization.

REFERENCES

Bhargava, G. P. 2001. Nutrient management for rice, based on targeted yield concept in mediam black soil of Satpura and Kaymore plateau in madhya Pradesh. *JNKVV Research Journal*. **35(1/2):** 8-11.

Deshmuka, K. K., Bisen, N. K. and Singh, N. K. 2012. Effect of soil test crop response technology on productivity and economics of major crops of Seoni district of Madhya Pradesh. *Journal of Soils and Crops*. **22(1):** 54-57.

Hanway, T. J. and Heidal, H. 1952. Soil analysis methods as used in Iowa state soil testing laboratory. *Iowa Agriculture*. **57:** 1-31

Jackson, M. L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd, New Delhi.

Karem, K. S., Puri, G. and Sawarkar, S. D. 2012. Soil test based fertilizer recommendation for targeted yield of rice-wheat cropping sequence and its validation in vertisol. *Journal of Soils and Crops*. **22(2):** 302-308.

Kimetu, M., Mugendi, D. N., Palm, C. A., Mutuo, P. K., Gachengo, C. N., Nandwa, S. and Kungu, B. 2004. African network on soil biology and fertility (http://www.ciat.cgiar.org/#afnecbook). pp. 207-224.

Olsen, S. R., Cole C. V., Watanabe F. S. and Dean L. A., 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. USDA Circular. 1. p. 939.

Ramamoorthy, B., Narasimham, R. L. and Dinesh, R. S. 1967. Fertilizer application for specific yield target of sonara-64 wheat. *Indian Farming*. **17(5):** 43-45.

Rao, B. R. B. and Shantaram, M.V. 2001. Soil test based fertilizer recommendation for rice (Oryza sativa) for alfisols of Karimnagar district of Andra Pradesh. *Indian Journal of Dryland Agricultural Research and Development*. **16(2):** 97-103.

Reddy, K. C. and Ahmed, S. R. 2000. Soil test based fertilizer recommendation for maize grown in inceptisols of Jagtiyal in Andra Pradesh. *Journal of Indian Society of Soil Science*. **48(1):** 84-89.

Sridevi, V., Chellamuthu, V. and Jeyaraman, S. 2011. System of rice intensification - A review. *Agri. Review*. **32:** 120-126.

Srinivas, A., Rao, B. R. C. P., Reddy, K. C. K. and Sankar, G. R. M. 2001. Soil test based fertilizer recommendations for attaining different yield targets of rice under rice-rice crop sequence in Vertisols. *Journal of Research ANGRAU*. **29:** 69-74.

Srinivasan S. and Angayarkanni A. 2010. Fertilizer recommendation based on soil test crop response for high targeted yield. ORYZA - *An International Journal on Rice*. **47(4):** 287-290.

Subbiah, B. V. and Asija, G. L. 1956. A rapid procedure for assessment of available nitrogen to rice plots. *Current Science*. **31:** 196-200.

Troug, E. 1960. Fifty years of soil testing. Transactions of 7th International Congress of Soil Science, Vol. **3**, Commission IV, Paper No. 7, 46-53.

Walkley, A. and Black, I. A. 1934. An examination of the Degtijariff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*. **37:** 29-38.