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Integrated Nutrient Management by Using Target Yield Equation for Rice-Pea Cropping System in an Inceptosol

Y. V. Singh, S. K. Singh and Pradip Dey
AICRP on STCR, Department of Soil Science and Agricultural Chemistry,
Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221005 (Uttar Pradesh)

Abstract

Field studies on target yield equation (TYE) based on integrated nutrient management in rice (2 t ha^{-1}) and pea (2 t ha^{-1}) was conducted to investigate its value in achieving target yields and soil nutrient status. The study was conducted in 2017-18 under farmer's field. Growing rice variety sudha in sequence with pea variety malviya-pea-15 in kharif and rabi seasons. Requirement of nitrogen (N), phosphorous (P) and potassium (K) for achieving target yield of 5t ha^{-1} for rice and 2t ha^{-1} for pea was estimated following a soil test crop response (STCR) based TYE. Two sets of treatments (T_4 and T_5) included chemical fertilizers with farm yard manure (FYM) as organic source in rice and pea crops were applied, compared with an untreated crop (control) usually followed in farmer's practice and general recommendation dose of fertilizers. Results showed marginal deviation from specified target yield, achieving 101% of the target yield in rice and 99% in pea. Integrated nutrient management resulted insignificantly higher yield of both rice (5.05 t ha^{-1}) and pea (1.98 t ha^{-1}), in treatment T_5. A benefit: cost ratio was also derived, showing a maximum of 7.71 in rice pea cropping system in treatment T_5, compared with 4.65 with the application of farmer practice (T_5). Nutrient uptake was also higher in crops in treatment T_5 due to improved available NPK status of soil.

Key words: *Integrated nutrient management, target yield, nutrient uptake, soil NPK, rice, pea, B:C ratio.*

Introduction

The need based estimation of N, P, and K requirements may call for soil test crop response (STCR) based nutrient management, which can be represented in a linear relationship, correlating their requirement with a specified target yield depending on their native soil status. This 'target yield equation' (TYE) is considered as a soil and fertilizer based precision farming strategy to meet nutrient demands for a specified yield. Simultaneously, this TYE could ensure nutrient application to fill dynamically the deficit between rice needs and native fertility status to maintain soil productivity. Another crop management issue addressed in this study was the need for integrated nutrient management in a rice pea cropping system. Applying fertilizer alone may initially boost rice productivity[2,3]. However, chemical fertilization alone has a negative impact on conservation of soil quality. Even a soil nutrient resilience mechanism would be severely affected by disrupting dynamic bio equilibrium in soil-plant continuum and by disintegrating soil strata. The present experiment was conducted under a farmer's field to evaluate the appropriateness of estimating N, P, and K requirements by using a 'soil test crop response (STCR)based 'target yield equation (TYE)' for enhancing crops and nutrient productivity as well as soil nutrient balance.

Materials and Methods

Field experiments on integrated nutrient management in rice and pea under rainfed conditions were conducted during 2017-18, consecutively, in a farmer's field at Majhagawan Naugarh, Chandauli (U.P.), India. The location's soil profile characteristics at 15 cm depth were analyzed to determine its textural class as well as its fertility status. The texture of the soil was alluvial sandy loam. The soil contained 0.71% organic carbon, 185.00 kg ha^{-1}available N, 12.50 kg ha^{-1} available P, and 178.00 kg ha^{-1} available K with EC 0.30 dSm^{-1} and pH 7.00 this status found in 2017 before sowing of rice. Doses of N, P_2O_5 and K_2O calculated on soil test basis by using following equations:

For rice (Regar and Singh, 2014)

Nitrogen dose ($kgha^{-1}$) =4.40T-0.49 SN-0.34ON

Phosphorus dose (kg ha^{-1}) = 1.53T-1.14 SP-0.09OP

Potassium dose (kg ha^{-1}) =2.92T-0.35 SK-0.11OK

For pea(Kumar *et al.*, 2017)

Nitrogen dose (kg ha^{-1}) =4.15T- 0.27SN-.09ON

Phosphorus dose (kg ha^{-1}) = 3.18T- 2.08 SP-0.12OP

Potassium dose (kg ha^{-1}) = 4.31T-0.32K-0.14OK

Where, T= Yield target; FN, FP and FK is fertilizer N, P_2O_5 and K_2O (kg ha^{-1}), respectively; SN, SP and SK are available N P and K of soil ($kgha^{-1}$) and ON, OP and OK are available N P and K of farm yard manure (%), respectively.

Five nutrient management practices viz. T_1- Control, T_2- Farmer's practices of fertilizer *i.e.* for rice100 kg N, 35 kg P_2O_5 and 35 kg K_2O ha^{-1} and for pea 10 kg N, 15 kg P_2O_5 and 20 kg K_2O ha^{-1}, T_3 - GRD (General recommended Dose) fertilizer *i.e.* for rice 120 kg N, 55 kg P_2O_5 and 55 kg K_2O ha^{-1} and for pea 20 kg N, 40 kg P_2O_5 and 30 kg K_2O ha^{-1}, T_4- Fertilizer dose according to soil test crop response equation with 2 t ha^{-1} FYM on Target yield ofrice–4.0 t ha^{-1} and for target yield of pea 1.5.t ha^{-1}, T_5-Fertilizer dose according to soil test crop response equation with 2 t ha^{-1} FYM on Target yield for rice – 5.0 t ha^{-1} and for target yield for pea2.0 t ha^{-1}, FYM were tested in randomized block design with three replications for rice and pea in T_4 andT_5. Rice variety sudha' was sown in the second week of July and pea variety 'malviya-pea 15' was sown in second week of November with recommended package and practices. The grain yield in rice and pea crop was recorded after harvesting of crop. The experiment was laid out in a RBD design with three replications. Each micro plot size was 6 m X5 m and the net harvested area in each plot was 5.5 m X4.5 m leaving 0.5 m boarder zone around periphery of each plot. Nutrient uptake was determined by analyzing the entire plant sample collected randomly from each plot at harvest. Plant nutrient uptake and nutrient content were analyzed following the standard methods of N, P, and K analysis. The economics in term of benefit cost ratio was also calculated at price prevailing in nearest market The grain yields of rice and pea, and other parameters of nutrient dynamics were subjected to standard analysis of variance (ANOVA), and treatment differences were tested following tests of least significant difference (LSD).

Results and Discussion

Rice and Pea Yield and Production Economics

Overall results showed that rice grown with TYE based integrated nutrient management produced a 'near target' grain yield, consistently over the years as compared with other treatments. This was enhanced further by the application of fertilizer dose according to soil test crop response equation with 2 t ha^{-1} farm yard manure producing 5.05 t ha^{-1} grain yield, significantly higher than that (3.62 t ha^{-1}) under100% estimated fertilizer N P K, treatment T_3 similar results were reported earlier[1]. None the less, previous pea with this fertilizer dose according to soil test crop response equation with 2 t ha-1farm yard manure also produced significantly higher pea yield 1.98t ha^{-1} in table 1. Therefore, fertilizer dose according to soil test crop response equation with 2 t ha^{-1} farm yard manure ensured 99.50% of the target grain yield of rice achieved in treatment T_4, compared with the 91.68% with the application of 100% fertilizer NPK, treatment T_3. The corresponding values in pea were 98.00 and 70.70 %, respectively. As a result, system productivity aggregating yield of rice and pea also remained highest with the application of fertilizer dose according to soil test crop response equation with 2 t ha^{-1} farm yard manure (T_5), estimating 7.03 t ha^{-1}[6]. Subsequently, the production economics of the system also determined fertilizer dose according to soil test crop response equation with 2 t ha^{-1} farm yard manure in treatment T_5 more profitable, deriving a maximum benefit: cost ratio of 7.51 compared with the 100% fertilizer NPK application in treatment T_3 (7.34). Overall performance of rice and pea grown with INM, which resulted in higher yield, was better than that treated with fertilizer NPK alone. Balanced nutrition due to adequate nutrients uptake following INM promoted rice growth and subsequent development of yield attributes appreciably. The achieving higher system productivity, the benefit: cost ratio was also higher in rice-pea with INM in either of the proportions used[5].

Table 1 : Rice-pea yield, percent achievement of target yield, system productivity and benefit: cost ratio under rice-pea cropping system in an Inceptosol

Treatmnets Fertilizer dose N, P_2O_5, K_2O (kg ha^{-1}) - FYM (t ha^{-1})	Grain yield of Rice (tha^{-1})	% achieve -ment of yield	Treatmnets Fertilizer dose N, P_2O_5, K_2O (kg ha^{-1}) - FYM (t ha^{-1})	Grain yield of Pea (t ha^{-1})	% achieveme-nt of yield	System productiv-ity (t ha^{-1})	B:C
T_1-0-0-0	1.68	33.26/42.21#	T_1-0-0-0	0.94	47.47/63.94#	2.62	
T_2-100-35-35	2.56	51.69/64.32#	T_2-10 -20 – 15	1.06	53.53/ 72.10#	3.62	2.80/1.95
T_3-120-55-55	3.62	71.68/90.95#	T_3-20 - 40 – 30	1.40	70.70/95.23#	5.02	4.86/4.44
T_4-119-52-64-2	3.98	99.50	T_4-19-27-20 -2	1.47	98.00	5.45	6.10/8.19
T_5-193–60-79-2	5.05	101.00	T_5-40-43- 41-2	1.98	99.00	7.03	6.49/8.93
LSD (P=0.05)	0.95	6.38	-	1.09	2.69	0.87	-

Note: Achievable yield of higher target i.e. rice 4.0 and 5.0 (t ha^{-1}) and pea 1.5 and 2.0(t ha^{-1})

Nutrient Uptake

INM also promoted nutrient utilization, accounting for better NPK uptake in rice pea cropping system. N, P, and K uptake were higher in rice with fertilizer dose

according to soil test crop response equation with 2 t ha^{-1} farm yard manure (T_5), estimated at 108.56, 56.33 and 78.28 kg ha^{-1}, compared with 101.30, 48.30 and 66.10 kg ha^{-1} of N, P, and K uptake, respectively, in rice with 100% fertilizer NPK application in treatment T_4 (Table 2). A similar trend in results was also noticed in pea with fertilizer dose according to soil test crop response equation with 2 t ha^{-1}farm yard manure, estimated at 114.30, 22.30 and 96.36 kg ha^{-1} in treatment T_5, compared with 102.30, 17.60 and 83.56 kg ha^{-1} of N, P, and K uptake in treatment T_4, respectively. The mechanism of nutrient uptake pattern depends on soil and rice-pea environment, as well as on the method of crop and nutrient management. Use of fertilizer dose according to soil test crop response equation with 2 t ha^{-1} farm yard manure, significantly promoted higher N, P, and K uptake in rice and pea[4].

Soil NPK Status

INM in the rice pea cropping system promoted considerable improvement in soil fertility parameters as show none year cropping system application following the TYE based precision nutrient management strategy. Soil available N, P, and K after one year of study was estimated 252.50, 32.60 and 216.60 kg ha^{-1}, respectively, in plots treated with fertilizer dose according to soil test crop response equation with 2 t ha^{-1} farm yard manure (T_5), as compared with the irinitial value of 185.0, 1 2.5, and 178 kg ha^{-1} at the beginning of the program. Even significant improvement in soil available N, P, and K was also in plot streated with fertilizer dose according to soil test crop response equation with 2 t ha^{-1} farm yard manure (T_4 andT_5),. TYE-based integrated nutrient management promoted sustainable development in soil quality status[1]. Growing crops sequentially under intensive crop systems with fertilizer alone results indepleting soil nutrients reserve. Balanced nutrition of the soil, through integrated management using both organic and chemical nutrient sources appears to be essential.

Table 2 : Nutrient uptake and soil nutrient status in the final year of rice-pea cropping system in an Inceptosol

Treatmnets	Rice Nutrient Uptake (kg ha^{-1})			Pea Nutrient Uptake(kg ha^{-1})			Available nutrient Status after One year of cropping system (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
T_1	30.15	13.16	21.28	65.46	10.23	40.43	212.20	20.01	183.02
T_2	86.80	40.43	53.08	78.48	13.73	53.53	220.60	24.05	192.20
T_3	92.21	44.48	60.31	91.40	15.33	67.85	224.60	26.06	202.10
T_4	101.30	48.30	66.10	102.30	17.60	83.36	233.50	29.06	212.50
T_5	108.36	56.33	78.28	114.30	22.33	96.36	252.50	32.60	216.60
LSD (P=0.05)	3.12	1.99	2.79	1.20	0.92	1.06	2.05	0.73	1.74

Conclusion

The study pointed out the deleterious impact of an individual application of fertilizer on both the crops and soil nutrient status. Even the cost of cultivation increased with fertilizeral one. Concurrently, our findings suggest the need for balanced nutrition in rice-pea, which could be accomplished with INM instead of chemical fertilizer alone. Additionally, we stress the need for prior estimation of major

plant nutrients like N, P, and K as per the demand of a particular crop for a specified yield. Our results confirmed the validity of TYE based nutrient management to supplement plant demand for nutrients (other than those available from the soil). As a consequence, results showed progressive development in soil fertility status as well as an increase in total system productivity, which is the major concern in a sustainable rice-pea production system. Concurrently, production economics of the entire crop system improved with a higher benefit: cost ratio. Therefore, our study could promote target yield based combine duse of both organic and chemical nutrient sources for improving crop productivity, enhancing nutrientutilization, and increase soil nutrientresilience.

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