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FERTILIZER PRESCRIPTIONS THROUGH INDUCTIVE CUM TARGETED YIELD MODEL FOR RICE ON ALFISOLS OF KASHMIR

UZMA BASHIR*, PRADIP DEY, JA WANI, MA DAR AND FOZIA QURESHI

Sher-i-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar - 190 025, Jammu and Kashmir, India

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Abstract

Soil test crop response correlation involving integrated plant nutrition system (STCR-IPNS) studies on nitrogen (N), phosphorus (P) and potassium (K) in rice on Alfisols in Srinagar Kashmir were carried out following Ramamoorthy's 'inductive cum targeted yield model'. After establishment of marked fertility gradient with respect to soil available N, P and K, four levels of fertilizer N, P, K and three levels of farm yard manure (FYM) were randomized in three fertility strips each having 24 plots. Soil and plant analysis data were further used to compute basic parameters required for development of nutrients prescription equation. The nutrient requirement for producing one quintal of rice yield was worked out as 2.31 kg of N, 0.61 kg of P_2O_5 and 2.91 kg of K_2O. Soil available pool contribution 47.81, 67.92 and 66.31% of total N, P and K uptake, respectively; contribution from applied fertilizer were 44.34, 51.37 and 264.98% and contribution of applied FYM were 14.09, 13.64 and 19.73% to total N, P and K uptake, by rice. Using basic data fertilizer prescription equation and ready reckoner were developed for range of soil test values and desired yield targets for IPNS (NPK with FYM).

Introduction

In the era of precision agriculture, application of fertilizers based on soil testing is an essential tool to prescribe nutrient doses for crop besides assessing the soil health. Although fertilizer use over the years in the quantitative sense is impressive, ensuring greater fertilizer use efficiency by farmers at large is still to be realized. Further, the escalation in fertilizer prices has caused a serious setback for balanced fertilization (Santhi and Natesan 2011)**.** Hence exclusive dependence on either mineral fertilizers or organic sources is neither economically viable nor environmentally acceptable (Mahajan *et al*. 2013)**.** Further, signs of soil fertility fatigue are now discernible in intensive crop production systems. At present an annual net negative balance of about 10 million tones of nutrients is reported in India (Santhi *et al.* 2012)**.** This distortion in soil fertility and deterioration in soil health is due to indiscriminate and unbalanced use of fertilizers, and it can be corrected only with proper manure fertilizer schedule based on soil fertility evaluation (Santhi *et al.* 2011)**.** Sakarvadia *et al.* 2012) found yield targeting approach effective in soil fertility built up. Khosa *et al.* 2012) also reported the superiority of the target yield concept over other practices for different crops as it gave higher yield and optimal economic returns. Additional of Integrated Plant Nutrition System (IPNS) to this concept ensure balanced fertilization by application of inorganic and organic sources of nutrients. Use of moong straw to improve nutrient status and soil properties in rice-wheat cropping system (Gongola *et al.* 2012), farm yard manure to enhance recovery and productivity of wheat (Bhaduri and Gautam 2012) and higher rice productivity and optimum biological activities (Bhatt *et al.* 2012) has been successfully demonstrated in recent literatures. Such recommendations are helpful in maintenance and enhancing soil fertility simultaneously with improving crop production and nutrient use efficiencies.

*Author for correspondence: <druzmass@gmail.com>.

Rice (*Oryza sativa* L.) is an important cereal crop grown all over the country and cultivated in Kashmir in an area of 256.87 ha with a production of 531.4 MT, the average productivity is about 24961.86 q/ha (Rather 2014). As the average productivity is less than the world's average, the productivity of rice crop has to be enhanced through improved technologies in which prescription of nutrient doses based on soil test and targeted yield of rice gains importance. At this juncture, the unique inductive cum targeted yield model of (Ramamoorthy *et al.* 1967) is quite appropriate for determining a prescise fertilizer prescription for rice. The study aims (i) to develop basic data of nutrient requirement and contribution of nutrients to develop uptake from different sources and (ii) to develop fertilizer N, P and K prescription equation and farmer friendly ready reckoner to prescribe fertilizer in rice crop.

Materials and Methods

Soil test crop response correlation studies on rice var. *Jhelum* was conducted on Alfisols at Research Farm of Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Shalimar, Srinagar.

Surface soil (0 - 15 cm) of the experimental field is silty clay loam in texture, with pH 6.8, electrical conductivity (EC) 0.28 dS/m, and cation exchange capacity of 12.21 cmol (p^+)/kg. The initial organic carbon, soil available alkaline potassium permanganate ($KMnO_4$) nitrogen (N), Olsen’s phosphorus (P) and ammonium acetate (NH_4OAC) K were 198.50, 39.33, 155.77 kg/ha, respectively.

The inductive cum fertility gradient approach was followed for conducting the experiment (Ramamoorthy *et al.* 1967). Three fertility gradients were created by dividing the experimental field into three equal strips which were fertilized with $N_0P_0K_0$, $N_1P_1K_1$ and $N_2P_2K_2$ levels. These fertility gradients were fertilized as L_0 : no, $N_0P_0K_0$, L_1 : $N_{90}P_{60}K_{30}$ and L_2 : $N_{180}P_{120}K_{60}$ respectively. Maize var (C_6) as an exhaust crop was grown so that the fertilizers could go transformation in the soil with plant and microbial agencies. By growing the exhaust crop the operational range of soil fertility was created in the fertility strip which was evaluated in term of variations in yield, uptake and soil test value. After the harvest of exhaust crop, the main experiment on rice was conducted. Each strip was divided in 24 equal size plots. Twenty one selected fertilizer treatments $N_0P_{60}K_{30,}$ $N_{100}P_{40}K_{10,}$ $N_{100}P_{40}K_{30,}$ $N_{100}P_{60}K_{10,}$ $N_{100}P_{60}K_{30,}$ $N_{120}P_{40}K_{10,}$ $N_{120}P_0K_{30,}$ $N_{120}P_{40}K_{30}$, $N_{120}P_{60}K_{0,}$ $N_{120}P_{60}K_{10,}$ $N_{120}P_{60}K_{30,}$ $N_{120}P_{60}K_{50,}$ $N_{120}P_{80}K_{30,}$ $N_{120}P_{80}K_{50,}$ $N_{140}P_{40}K_{10,}$ $N_{140}P_{60}K_{10,}$ $N_{140}P_{60}K_{30,}$ $N_{140}P_{80}K_{10,}$ $N_{140}P_{80}K_{30,}$ $N_{140}P_{60}K_{50,}$ $N_{140}P_{80}K_{50}$ constituted of different combinations of four levels of N (0, 100, 120 and 140 kg/ha) four levels of P_2O_5 (0, 40, 60 and 80 kg/ha) and four levels of K_2O (0, 10, 30 and 50 kg/ha) were randomly distributed in each strip along with three control plots $N_0P_0K_0$. The FYM levels 0, 10 and 15 t/ha were superimposed across each fertility gradient strips. The initial soil samples before transplanting of rice from each plot were collected and analyzed for alkaline $KMnO_4$ – N (Subbiah and Asija 1956), Olsens P (Olsen *et al.* 1954) and NH4OAC – K (Stanford and English, 1949). The crop was grown till maturity and grain yield were recorded from each plot, grain and strover samples were collected, processed and analyzed for N (Humphries 1956), P and K content (Jackson 1973) and NPK uptake by rice was computed using the dry matter yield.

Making use of the data on nutrient uptake, yield, pre sowing soil available nutrient and applied fertilizer doses, the basic parameters *viz.*, nutrient requirement (NR) and contribution of nutrient from soil (Cs) fertilizers (Cf), and farm yard manure (Cfym) were calculated as outlined by (Ramamoorthy *et al.* 1967).

These parameters were used for developing fertilizer prescription equation for deriving fertilizer doses, and the soil-test-based fertilizer recommendations were prescribed in the form of a ready table for the desired yield target for rice under NPK alone as well as under IPNS.

Results and Discussion

The mean grain yield of rice was 57.88, 62.72 and 60.30 kg/ha, respectively in strip (1, 2 and 3). The N uptake varied 132.27 to 148.10 kg/ha, P uptake varied from 31.85 to 40.32 kg/ha, K uptake varied from 121.48 to 141.15 kg/ha in strip 1 - 3, respectively. The data on initial soil test values revealed that the mean $KMnO_4$ – N values were 177.44 kg/ha in strip 1, 194.57 kg/ha in strip 2 and 223.55 kg/ha in strip 3. The mean Olsen's P values were 30.82. 40.33 and 46.85 kg/ha in strip 1 - 3, respectively. For NH_4OAC-K, the mean values were 145.57, 150.44 and 171.44 in strip 1 - 3, respectively (Table 2).

Table 1. Mean value of available nutrients in the pre-sowing surface soil samples, grain yield and nutrient uptake by grain yield.

Parameters	Strip 1	Strip 2	Strip 3
Soil test values (kg/ha)			
$KMnO_4$ - N	177.44	194.57	223.55
Olsen - P	30.82	40.33	46.85
NH_4OAC - K	145.57	150.44	171.44
Grain yield (kg/ha)			
Total	57.88	62.72	60.30
N uptake	132.27	148.10	140.12
P uptake	31.85	40.32	38.31
K uptake	121.48	141.15	135.31

Table 2. Nutrient requirements and contribution of nutrient from soil, fertilizer and farm yard manure for grain yield.

Parameter	Basic data		
	N	P_2O_5	K_2O
Nutrient requirement (kg/q)	2.31	0.61	2.91
Contribution from soil (Cs) (%)	47.81	67.92	66.31
Contribution from fertilizer (Cf) (%)	44.34	51.37	264.98
Contribution from farm yard manure (Cfym) (%)	14.09	13.64	19.73

The existence of operational range of soil test values for available N, P and K status in the present investigation was clearly depicted from the initial soil-available nutrient status and the variations in the grain yield of rice and NPK uptake, which is a prerequisite for calculating the basic parameters and fertilizer prescription equations for calibrating the fertilizer doses for specific yield target. Parveena *et al*. 2013 also reported existence of operational range of soil test values after fertility gradient experiment with preliminary crop pearlmillet for development of soil test based fertilizer recommendation to obtain economic yield of wheat crop

In the targeted yield model, making use of the data on grain yield of Rice, uptake of N, P_2O_5 and K_2O applied, the basic parameters were computed. The basic parameters for developing fertilizer prescription equations for rice are (i) nutrient requirement in Kg per quintal of rice (NR) and percentage contributions from soil available nutrients (Cs), fertilizer nutrients (Cf) and organic manure (Co) .

The results of the present investigation revealed that rice grain requires 2.31 kg of N, 0.61 kg of P_2O_5 and 2.19 kg of K_2O for producing one quintal of rice (Table 3). Among the three nutrients the requirement of N is the greater, followed by K_2O and P_2O_5. The requirement of N is 0.79 times greater than K_2O and 3.78 times greater than P_2O_5.

Table 3. Soil Test based fertilizer prescription under IPNS for 60 q/ ha target yield of rice (kg/ha).

Parameters	NPK alone (kg/ha)	IPNS			
		NPK(kg/ha) + FYM 10 t/ha	Reduction over NPK alone (%)	NPK(kg/ha) + FYM 15 t/ha	Reduction over NPK alone (%)
$KMnO_4$-N (kg/ha)					
110	205	196	4.28	192	6.43
120	183	174	4.79	170	7.18
140	162	153	5.42	148	8.14
160	140	131	6.26	127	9.39
180	119	110	7.39	105	11.09
200	97	88	9.03	84	13.54
220	75	67	11.59	62	17.39
Olsen P (kg/ha)					
10	57	55	3.3	54.0	4.95
13	53	51	3.54	50.0	5.31
16	49	47	3.82	46.0	5.74
19	45	43	4.15	42.0	6.23
22	41	39	4.55	38.0	6.83
25	37	35	5.03	34.0	7.55
28	33	31	5.62	30.0	8.43
NH_4OAC-K (kg/ha)					
90	27	24	10.32	22	15.49
100	24	21	11.37	20	17.06
110	22	19	12.66	17	18.99
120	19	16	14.28	15	21.42
130	17	14	16.37	12	24.55
140	14	11	19.17	10	28.76
150	12	9	23.14	7	34.71

The percentage contribution of nutrients from soil (Cs) to the total uptake was computed from the absolute control. In the present study, it was found that the soil has contributed 47.81 of available N, 67.92 of available P, and 66.31 of available K, respectively toward the total N, P_2O_5 and K_2O uptake by rice. Among the three nutrients, the percentage contribution from soil was greater for P followed by N and K. With regard to N and K_2O, comparatively lower Cs was recorded which might be due to the preferential nature of rice towards the applied N and K_2O then the native N and K. This is in accordance with Popat *et al.* (2012**)** on kharif cotton in Maharashtra. Similar trend of nutrient requirements for N, P_2O_5 and K_2O was reported by (Santhi *et al.* 2011) for beet root.

With regard to fertilizer nutrients, the contribution was computed from NPK applied plots and values were 44.34, 51.37 and 264.98%, respectively in N, P_2O_5 and K_2O in which contribution from applied fertilizer followed the order $K_2O > P_2O_5 > N$. The estimated Cf clearly revealed that the magnitude of contribution by fertilizer K_2O was 5.15 times greater than P_2O_5 and 5.97 times that of nitrogen. The contribution from fertilizers was higher than from the soil for all the three nutrients. The findings are closely accorded with those reported by (Anon. 2012) for transgenic cotton BRAHMA on black calcareous soil.

The percentage contribution of nutrients from farm yard manure (Cfym) to the total uptake was computed from the farm yard manure applied plots. It was found that farm yard manure has contributed 8.99% of N, 7.62% of P_2O_5 and 10.56% of K_2O, respectively toward the total N, P and K uptake by rice followed the order $K_2O > N > P_2O_5$. As a component of IPNS, 27.92, 11.21 and 17.66% of the total nutrient uptake was contributed by FYM N, P and S (Mahajan *et al.* 2013)**.** The present findings corroborated with finding of (Saranya *et al*. 2012)**.**

Soil-test-based fertilizer equations for desired yield target of rice were formulated using the basic parameters

NPK alone

$$FN = 5.22\,T - 1.08\,SN$$

$$FP_2O_5 = 1.18\,T - 1.32\,SP$$

$$FK_2O = 0.83\,T - 0.25\,SK$$

NPK with FYM

$$FN = 5.22\,T - 1.08\,SN - 0.22\,ON$$

$$FP_2O_5 = 1.18\,T - 1.32\,SP - 0.19\,OP$$

$$FK_2O = 0.83\,T - 0.25\,SK - 0.14\,OK$$

where FN, FP_2O_5 and FK_2O are fertilizers N, P_2O_5 and K_2O in kg/ha, respectively. T is the yield target in q/ha. SN, SP and SK, respectively are alkaline $KMnO_4$ – N, Olsen P, and NH_4OAC-K in kg/ha and ON, OP and OK are the quantities of N, P and K supplied through FYM in kg/ha. Santhi *et al*. (2012) and Praneena *et al*. (2013) documented in hand book the soil test and yield target based fertilizer prescriptions under IPNS for 25 crops comprising cereals, millets, pulses, oilseeds, sugarcane, cotton, vegetable, spices and medicinal crops on 14 soil series for Tamil Nadu.

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