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Fertilizer Prescription Based on Specific Yield of Rice in Inceptosol

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Abstract

A main fertility field experiment was conducted to investigate correlation between the soil test values as well as fertilizer doses of nitrogen, phosphorus and potassium with the crop response of rice in Persiya village, Chandauli district in an Inceptisoil. The fertilizer adjustment equations are derived by All India Coordinated Research Project, Institute of Agricultural Science, Banaras Hindu University, Varanasi centre. Results revealed that targeted yield of rice (38 q ha^{-1}) and (43 q ha^{-1}) have been achieved by using the plant nutrients on the basis of targeted yield concept (soil test crop response technology). The percent of highest in yield was 12.75 and 27.77 % over general recommendation dose of fertilizer. The maximum highest net returns of rice (Rs.34695.00 and Rs.43360.00) were obtained in treatment where plant nutrients applied as per soil test value (STCR treatment). This technology also maintained the soil available plant nutrients. Thus, for obtaining maximum gain and sustain the soil fertility, application of plant nutrients as per soil test value (STCR technology) is essential. The fertilizer doses were validated for attaining yield targets of 38 and 43 q ha^{-1} in farmer's fields. Rice yield within 10% deviation was attained, which indicated that soil test based fertilizer dose was superior. This approach could be adopted for regions with similar soil and agro-climatic conditions in other parts of the world to increase rice yields.

Key words: Target yield, soil test crop response, economics and B:C ratio etc.

Introduction

Rice is life for almost half of the global population and majority (60%) of the Indian populace, who are also highly vulnerable to inflationary pressure due to high rice price. The living and livelihood of majority of the Indian farming population also depends on growing rice. Rice production increased almost three-fold over the last five decades and contributes handsomely to the nutritional security of the country. In India, the annual compounded growth rate (ACGR) of rice production has declined from 3.55% during 1981-1990 to 1.74% during 1991-2000. Although an all-time high production of 99.50 million tons of rice with a productivity of 2.20 tons per hectare was achieved during the year 2008-2009. Rice is grown in almost all the states of the country. West Bengal, Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, Andhra Pradesh, Assam, Tamilnadu, Punjab, Maharashtra and Karnataka are major rice growing states and contribute to a total 92% of area and production. India is still amongst the countries with the lowest rice yields. Seventy percent of the 414 rice-growing districts report yields lower than the national average, clearly indicating that well after the advent of high yield technology, a sizable area is categorized as low producing. Sixty percent of the low productivity rice areas are in Bihar, Orissa, Assam, West Bengal, and Uttar Pradesh. Surprisingly, 32% of the irrigated rice areas produce low yields[12]. Rice based

cropping systems are the major production systems contributing to food production. Current crop production systems are characterized by inadequate and imbalanced uses of fertilizers e.g. blanket fertilizer recommendations over large domains with least regard to the variability in soil fertility and productivity. Future gains in productivity and input use efficiency require soil and crop management technologies that are tailored to specific characteristics of individual farms or fields. Farm research demonstrated existence of large field variability in terms of soil nutrient supply, nutrient use efficiency, crop responses etc. Management of this variability is a principal challenge for further increasing crop productivity of intensive Rice crop systems[7].

Materials and Methods

The on farm testing trials were conducted in village–Parsiya, block - Naugarh of Chandauli district, Uttar Pradesh, India during year Rabi 2022-23 on alluvial soil (Inceptisol). Soil samples (0-15 cm in depth) were collected, dried and passed through 2 mm sieve and analyzed for physico chemical properties as described[3]. Available nitrogen, by the alkaline permanganate method[11], available phosphorus, by Olsen method[5] and available potassium, by the ammonium acetate method[2] as described. Five fertilizers treatments viz., Control, Farmers practice, General recommendation dose of fertilizer, Soil test crop response (STCR) for 38 q ha^{-1} and Soil test crop response (STCR) for 43 q ha^{-1} in Rice variety of test crop was **(**HUR-917, Malviya Sugandha Dhan 917), 38 q ha^{-1} and 43 q ha^{-1} targeted yield were taken. The targeted yield of crop was decided as per yield potential of varieties. Pre sowing soil samples were analyzed according to the standard procedures. Soil resource inventory of the study area in given in the table 1. Quantities of nitrogen, phosphorus and potassium were calculated with the help of fertilizer adjustment equations as follow (Singh *et al* 2014, a) [8].

$$FN = 4.74\ T - 0.49\ SN - 0.34\ ON$$

$$FP_2O_5 = 1.53\ T - 0.09\ SP - 0.06\ OP$$

$$FK_2O = 2.92\ T - 0.35\ SK - 0.11\ OK$$

Where - T = Yield target (t ha^{-1}) Where, FN, FP_2O_5 and FK_2O are fertilizers N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T=Grain yield target in q ha^{-1}; SN, SP and SK are available N, P and K through soil in kg ha^{-1}, respectively; ON, OP and OK are N, P and K . The treatments imposed were as follows: (i) Control, (ii) Farmer's Practices, (iii) General Recommended Dose, (iv) STCR based fertilizer dose for an yield target of 38 q ha^{-1} (v) STCR based fertilizer dose for an yield target of 43 q ha^{-1}. Based on the initial soil test values of available N, P and K and the quantities of N, P_2O_5 and K_2O supplied fertilizer doses were calculated and applied for STCR treatments for various yield targets.

The crop received one third N and full dose of P_2O_5 and K_2O as basal application and remaining half N were applied and 27 days after sowing in rice crop. Remaining nitrogen was applied at panicle initiation stage. Nitrogen was applied through urea and phosphorus through single super phosphate and potassium through muriate of potash. The rice variety of test crop was **(**HUR-917, Malviya Sugandha Dhan 917). The same variety was used in STCR treatment and other treatments.

Results and Discussion

Soil characteristics

The soil was alluvial (Inceptisol) in reaction with pH varying from 7.50 - 7.65. The organic carbon content varied from 0.33-0.37 soils were medium in available nitrogen (ranging from 209.00-210.80 kg ha^{-1}), low to medium in available phosphorus (ranging from 16.70-17.10 kg ha^{-1}) and medium to high in available potassium (ranging from 183.90-155.90 kg ha^{-1}) in table 1. Though these soils are considered to be most fertile, they are deficient in nitrogen and humus but moderately supplied with phosphorus and potassium.

Table 1 Physico-chemical properties of the experimental area

Locations	Physico chemical properties			Fertility status		
	pH	EC (dSm^{-1})	OC (%)	Av-N (kg ha^{-1})	Av-P (kg ha^{-1})	Av-K (kg ha^{-1})
Location-I	7.50	0.37	0.48	210.80	17.1.0	183.90
Location-II	7.65	0.33	0.42	209.00	16.70	185.00

***** Av = Available

Table 2 Economics of Verification Trails for Rice (HUR-917, Malviya Sugandha Dhan 917)

Treatments	Fertilizer dose NPK (kg ha^{-1}) and FYM (t ha^{-1})	Actual mean yield (kg ha^{-1})	Additional yield (kg ha^{-1})	Value of additional yield (Rs.)	Cost of fertilizer (Rs.)	Net benefit (Rs.)	B/C ratio
	Location - I: Name – Smt. Phuleshari W/O. Sri. Bhagwandas, Village- Parsiya						
T_1-Control	0-0-0	1648	-	-		-	-
T_2 - FP	100-35-35	2380	732	14640	4626.85	10013.15	2.16
T_3 - GRD	120-60-60	3295	1647	32940	7037.40	25902.60	3.68
T_4 – 38q/ha	74-56-46-2	3715	2067	41340	6644.82	34695.18	5.22
T_5 - 43q/ha	98-64-60-2	4210	2562	51240	7879.82	43360.18	5.50
	Location - II: Name – Smt. Phulmati devi W/O. Sri. Jayshankar, Village- Parsiya						
T_1-Control	0-0-0	1622	-	-		-	-
T_2 - FP	100-35-35	2418	796	15920	4626.85	11293.15	2.44
T_3 - GRD	120-60-60	3265	1643	32860	7037.40	25822.60	3.67
T_4 – 38q/ha	74-56-66-2	3764	2142	42840	6644.82	36195.18	5.45
T_5 - 43q/ha	98-64-60-2	4297	2675	53500	7879.82	45620.18	5.79

Note: Rice@Rs.20.00/kg, N@Rs.17.39/kg P_2O_5@Rs.56.25/kg, K_2O@Rs.26.66/kg.

A miner modification was made in the ready reckoner, FP: Farmers practice i.e. the fertilizer doses the farmers generally applied in the area, GRD: General recommendation of agricultural department of the district on the basis of soil test value, B: C ratio: benefit cost ratio

Yield targeting of Rice based on soil test

Experimental data on follow up trails as frontline demonstration, for each location during the period 2022-23 were conducted in farmers field and are given in Table 2. From the field experiment the basic data on nutrient requirement for producing one quintal grain yield of rice, percent contribution of nutrients from soil (%CS) and fertilizer (%CF) were evaluated. These basic parameters were used for developing the fertilizer prescription equations under NPK alone. The nutrient requirement of N, P_2O_5 and K_2O were 6.26, 1.12 and 3.78 kg q ha^{-1} of grain yield, respectively. The percent contribution of nutrients from soil and fertilizers were found to be 25.41 and 117.03 for N, 40.99 and 35.42 for P_2O_5 and 19.67 and 45.47 for K_2O, respectively. It was noted that contribution of potassium from fertilizer for wheat was higher in comparison to soil. This high value of potassium could be to the interaction effect of higher doses of N, P coupled with 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[6]. Similar type of higher efficiency of potassic fertilizer was also reported for Rice [1] in alluvial soils.

Target yield of 38 and 43 q ha^{-1} has been achieved with comparatively lower application of N and P_2O_5 fertilizers but higher application of K_2O, in comparison to doses applied in farmer's practice and soil based recommendations. As for example in the alluvial soil of West Bengal, In the winter season highest Rice yield was 6.0 t ha^{-1} regardless of the N level used but could be raised to 7.4 t ha^{-1} with increased application of K fertilizers[12] . This is probably due to the higher N use efficiency as well as increased N recovery by crop under increased K application[4]. Yield targets of 38 and 43 q ha^{-1} for Rice **(**HUR-917, Malviya Sugandha Dhan 917) were achieved in table 2, from the expected yield targets in all the cases. In all sites, grain yields of rice through general recommendation (GRD) of fertilizers lagged behind the yield obtained at 38 and 43 q ha^{-1} fixed target[9, 10]. Between the two targets tried, targeting for 43 q ha^{-1} recorded relatively higher response ratio than with 38 q ha^{-1} though it has also recorded higher yields. This might be due to the better use efficiency of applied NPK fertilizers at low yield target levels[9,10].

3.2 Post harvest soil fertility status

Post harvest soils value revealed that a sufficient build up and maintenance of SN, SP and SK are found under STCR study compare to farmer practices and general recommended dose. Despite removal of higher amount of nutrient in STCR treatment due to getting a higher yield, higher post harvest soil fertility was observed in STCR plot. Highest post harvest soil nitrogen was found in STCR for 38 and 43 q ha^{-1} in location-1, Smt. Phuleshari W/O. Sri. Bhagwandas, Village- Parsiya (240.00 and 233.00 kg ha^{-1}), soil potassium in location-2, Smt. Phulmati devi W/O. Sri. Jayshankar, Village- Parsiya (215 and 210 kg ha^{-1}), soil phosphorus in location-1, Smt. Phuleshari W/O. Sri. Bhagwandas, Village- Parsiya (19.5 and 18.1 kg ha^{-1}) in table 3. The greater build up of nutrient in STCR treatment was due to balance application of chemical fertilizer in conjunction with organic manure. Combined application of inorganic fertilizers improved the chemical

and physical properties, which may lead to enhanced and sustainable production. Greater profit consistent with maintenance of soil fertility status was realized when fertilizer was applied for appropriate yield targets in succession over years using STCR concept[8].

Table 3 Post harvest soil fertility status of various treatments under different locations of Villege- Persiya, Naugarh block in district Chandauli.

Treatments	Location 1			Location 2		
	N	P	K	N	P	K
Control	209	17.5	206	218	17.4	194
Farmer's practice	228	16.1	188	226	18.3	181
GRD	232	17.2	198	231	19	191
STCR 38 q ha^{-1}	240	18.1	208	233	16.5	210
STCR 43 q ha^{-1}	245	19.5	212	239	18.5	215
CD at 5%	1.30	1.05	0.53	0.59	1.05	0.71

Where: GRD – General recommended dose and STCR-Soil teat crop response

However for efficient utilization of applied fertilizer some other parameters like soil pH, organic carbon status etc. should also be considered, since these are the major determining factors of soil nutrient retention. This is for the development of an effective fertilizer schedule as well as nutrient supply source in view of the better nutrient absorption and assimilation by the plants.

The study will help to make guidelines for the amount of fertilizer used in rice cultivation. The specific yield equation based on soil health will not only ensure sustainable crop production but will also steer the farmers towards economic use of costly fertilizer inputs depending on their financial status and prevailing market price of the crop under consideration.

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