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Response of Chemical Fertilizers and Integrated Nutrient Management on Physico-Chemical Properties of Soil and Yield of Rice (*Oryza sativa* L.) in Inceptisol

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Abstract

A field experiment was conducted on medium duration rice during *kharif* season of 2006-2007 and 2007—2008 on Inceptisol consisting of 12 treatment combinations arranged in randomized block design and replicated three times with different nutrient management practices in which chemical i.e. T_1 (control), T_2 (RDF_{50}) and T_3 (RDF_{30}), T_4 (RDF_{75}) and T_5 (RDF_{100}) and integrated nutrient management i.e. T_6 (RDF_{50} + FYM_{50}), T_7 (RDF_{75} + FYM_{25}), T_8 (RDF_{50} + RR_{50}), T_9 (RDF_{75} + RR_{25}), T_{10} (RDF_{50} + GM_{50}), T_{11} (RDF_{75} + GM_{25}) and T_{12} (farmers's practices). Among the chemical fertilizer and integrated nutrients management practices T_{10} (RDF_{50} + GM_{50}) recorded significantly higher availability and uptake of N (272 kg/ha), P (29.45 kg/ha), K (294.67 kg/ha) and grain yield (61.06 q/ha). While the nutrient use efficiency of N in respected of agronomic efficiency (57.70), physiological efficiency (80.08), recovery efficiency (106.01) and factor productivity index (116.07) was significantly higher in T_4 (RDF_{75}), T_{12} (farmers' practices), T_{10} (RDF_{50} + GM_{50}) and T_3 (RDF_{50}), respectively.

Key words : Chemical fertilizer, Integrated nutrient management, Nutrient use efficiency, Grain yield, Uptake of NPK.

In India rice is grown in an area 44.6 million hectare in four major ecosystems : Irrigated (21 m ha), rainfed lowland (14 m ha), rainfed upland (6 m ha) and flood prone (3 m ha). In central part of India, the Chhattisgarh state is called rice bowl of country because it is a principal crop, which covered 78% area during *kharif*. The Chhattisgarh consists of three agro-climatic zones namely, Chhattisgarh plains, Northern hills and Baster plateau. Rice is grown in area of 3.46 million hectare with its 5.2 million tonne production (1). More than 75% of farmers of the state are living in the villages and cultivate paddy as main crop. In Chhattisgarh, average yield of rice is only 1,522 kg/ha which is far below the national average 3,007 kg/ha owing to number of biotic and abiotic factors (2). The chemical fertilizer is costly input for for crop cultivation. In 2005, farmers of Chhattisgarh used 58 kg/ha NPK fertilizers in the *kharif* season in 2005. However, the most of the India farmers and they cannot afford high amount of fertilizers. When we harvest a tonne (1,000 kg) of rice grain, we remove from soil about 10—31 kg N, 1—5 kg P and 8—35 kg K and 1—3 kg S/ha (3).Unbalanced fertilization has resulted in micronutrient deficiencies. The FYM is common source of plant nutrients amongst the farmers of Chhattisgarh, which is prepared easily and contains substantial amount of plant nutrients. Rice residues also a good source of organic manures, is sustaining soil productivity. Additionally, residue incorporation improves physical and biological conditions of the soil and prevents soil degradation, which is used in the farm itself. Green manures are well know for its in improving soil fertility and significantly ameliorate the physico-chemical properties of soil. Amongst the various green manuring, sunnhemp *(Crotolaria juncea)* finds an important place in rice based cropping, as it contains substantial quantities of N, P, K and micronutrient.

Methods

A field experiment was conducted on medium duration rice at research farm of IGKV, Raipur during *kharif* season of 2006-2007 and 2007-2008 on

Table 1. Effect of chemical fertilizer and integrated nutrient management on available nutrient and nutrient use efficiency of N viz., agronomic efficiency (AE), physiological efficiency (PE), recovery efficiency (RE) and factor productivity index (FPI). Pooled data of two years.

Treatments	Availability of nutrients (kg/ha)			Nutrient use efficiency			
	N	P	K	AE	PE	RE	FPI
T_1 Control	180.00	12.33	190.22	-	-	-	-
T_2 50% RDF (40 : 30 : 20)	219.00	21.67	228.00	59.30	65.58	56.66	100.56
T_3 50% RDF	236.00	22.73	232.12	74.81	67.32	65.00	116.07
T_4 75% RDF	253.00	25.45	248.30	57.70	58.96	78.90	85.21
T_5 100% RDF	261.33	27.52	279.32	54.89	55.59	99.46	75.52
T_6 50% RDF + 50% FYM	265.67	32.37	289.67	55.06	59.82	93.97	75.69
T_7 75% RDF + 25% FYM	258.23	28.82	283.67	50.69	57.28	90.97	71.32
T_8 50% RDF + 50% RR	255.67	24.92	264.73	46.61	63.64	79.10	67.24
T_9 75% RDF + 25% RR	253.79	22.39	259.52	48.42	59.99	84.82	69.05
T_{10} 50% RDF + 50% GM	272.33	29.45	294.67	55.70	51.92	106.01	76.33
T_{11} 75% RDF + 25% GM	268.00	25.72	283.67	52.55	54.80	97.52	73.18
T_{12} Farmer's practices (50:30:20)	233.33	23.33	266.25	52.46	80.08	56.92	85.47
SE ±	5.42	1.79	5.87	4.36	7.63	3.10	3.80
CD (P = 0.05)	15.90	5.26	17.21	12.79	22.37	9.10	11.15

Inceptisol consisting of 12 treatment combinations arranged in randomized block design and replicated three times with the soil of the experiment was sandy loam in texture, neutral in pH, low in available N (230 kg/ha), medium in available P (20 kg/ha) and exchangeable K (278 kg/ha). The different nutrient management practices namely, chemical i.e. T_1 control (no chemical fertilizer application), T_2 RDF_{50} (50% recommended dose of fertilizer) and T_3 80:60:40 (RDF_{50}), T_4RDF_{75} (75% recommended dose of fertilizer) and T_5 RDF_{100} (100% recommended dose of fertilizer) and integrated nutrient management i.e. T_6 RDF_{50} + FYM_{50} (farm yard manure 50%), T_7 RDF_{75} + FYM_{25} (farm yard manure 25%), T_8 RDF_{50} + RR_{50} (rice residues 50%), T_9 RDF_{75} + RR_{25} (rice residues 25%), T_{10} RDF_{50} + GM_{50} (green manure 50%), T_{11} RDF_{75} + GM_{25} (green manure 25%) and T_{12} (farmers' practices). A medium duration high yielding rice variety Mahamaya was taken as a test crop of recommended seed rate and planted also at a spacing of 15 × 10 cm with 2 seedling/hill.

Results and Discussion

Effect of Chemical Fertilizer and INM on Availability and Nutrient Use Efficiency of N

The different nutrient management practices of rice significantly affected the availability of nutrients their uptake, nutrient use efficiency and finally grain yield and harvest index of rice (Table 1). Application of chemical fertilizer along with green manure RDF_{50} + GM_{50} showed significantly higher available N (272.33 kg/ha) and K (294.67 kg/ha), which might be due to the residual effect of green manure at later stage in the form of mineralize N. While the T_{11} (268 kg/ha) was significantly superior followed by T_6 (265.67 kg/ha), T_7 (258.23 kg/ha), T_8 (255.67 kg/ha) and T_9 (253.79 kg/ha), respectively. The availability of P found significantly higher under T_6 (32.37 kg/ha), it may be due to release of organic acids during microbial decomposition of farm yard manure that have helped in solubility of native phosphorus. Similar result was also reported by Singh et al. (4). Application of 100% recommended dose of fertilizer T_5 (27.52 kg/ha) was significantly higher over all the treatments through chemically applied fertilizers. However, the K availability was higher under T_{10} (294.67 kg/ha). The reason may be increased available K through green manure application was the result of additional K supplied through it, the solubilization action of certain organic acid production during decomposition and its greater capacity to hold K in available form in soil. Similar result was also reported by Sharma et al. (5). Among the nutrient use efficiency of N, the agronomic efficiency (AE), that predict additional yield obtained per unit of nutrient applied was found significantly higher under treatment T_2 RDF_{50} (74.81%) as 50% urea applied over all treatments (Table 1). Among integrated nutrient practices, T_{10} gave the superior results as

Table 2. Effect of chemical fertilizer and integrated nutrient management on grain yield, harvest index and nutrient uptake. Pooled data of two year.

Treatments		Grain yield (q/ha)	Harvest index (%)	Nutrients uptake (kg/ha) N	P	K
T_1	Control	16.50	47.50	21.11	3.42	70.15
T_2	50% RDF (40:30:20)	40.22	48.93	57.18	11.48	211.38
T_3	50% RDF	46.43	49.06	65.51	14.09	244.82
T_4	75% RDF	51.12	49.12	79.24	15.88	275.4
T_5	100% RDF	60.42	49.18	99.71	19.68	329.21
T_6	50% RDF + 50% FYM	60.55	49.20	94.23	22.32	341.17
T_7	75% RDF + 25% FYM	57.05	49.20	91.23	19.11	308.91
T_8	50% RDF + 50% RR	53.79	50.23	79.35	18.69	281.14
T_9	75% RDF + 25% RR	55.24	49.16	85.08	18.22	300.33
T_{10}	50% RDF + 50% GM	61.06	48.88	106.27	23.95	344.12
T_{11}	75% RDF + 25% GM	58.55	49.14	97.77	20.8	327.32
T_{12}	Farmers' practices (50:30:20)	42.73	48.93	57.33	13.11	226.47
	SE ±	2.21	2.11	5.27	0.93	14.71
	CD (P = 0.05)	6.47	NS	15.46	2.74	43.17

compared to other treatments. Data calculated for physiological efficiency (PE) is the biological yield obtained per unit of nutrient uptake indicated that the application of T_{12} (farmers' practices) give significantly higher over all the treatments. Recovery efficiency of N that explained how much N applied was recovered and taken up by the crop was significantly higher in integrated nutrient management treatment $RDF_{50} + GM_{50}$ (106.01%) followed by T_5 RDF_{100} (99%), T_{11} (97.52%), T_6 (93.97%) and T_7 (90.97%), respectively. The low nutrient recovery efficiency in farmers' practices (56.92%) is associated with loss of applied nutrient by leaching, volatilization, denitrification and soil erosion. Similar result was reported by Fageria et al. (6). The factor productivity index of N explained the yield produced for each kg of N applied and it included to the indigenous (soil N) and fertilizer N was higher under treatment of (116.07 kg grain/kg N added).

Effect of Chemical Fertilizers and INM on Grain Yield and Nutrients Uptake

The different nutrient management practices and chemical and INM practices significantly affect the grain yield, harvest index and nutrient uptake of rice (Table 2). The grain yield of rice significantly increased with increasing levels of chemical fertilizers from RDF_{50} to RDF_{100}, irrespective of the source (chemical fertilizers or INM). Among the chemical fertilizer T_5 (100% recommended dose of fertilizer) produced significantly higher grain yield (60.42 q/ha), and nutrient uptake and N (99.7 kg/ha), P (19.68 kg/ha) and K (329.21 kg/ha) followed by 75% recommended dose of fertilizer, 50% RDF, 50% RDF (40:30:20) and farmers' practices. Among all the treatments like chemical and INM practices, RDF_{50} + GM_{50} produced significantly higher grain yield (61.06 q/ha) and nutrient uptake (kg/ha) and N (106.27 kg/ha), P (23.93 kg/ha) and K (344.12 kg/ha) due to higher nutrient use efficiency. The N, P and K uptake by grain was also increased due to increased concentration of the nutrients and though INM practices was also reported by Makarim and Shuartatik (7). Among INM practices, T_6 (60.55 q/ha) was found significantly higher grain yield followed by T_{11} (58.55 q/ha) and T_7 (57.05 q/ha), but at with T_5 (60.42 q/ha). It might be due to the organic manure as farm yard manure provides regular supply of N by releasing it slowly resulting in increased yield of rice. The treatment of T_9 $RDF_{75} + RR_{25}$ and T_8 $RDF_{50} + RR_{50}$ treatments had carry over effect of rice residue due to slow mineralization on amount of wide C/N ratio might have resulted gradual release of nutrient besides improve soil quality and thus reflected in higher grain yields and uptake of N and K over inorganic alone (RDF_{50} and RDF_{75}). This ultimately led to increased grain yield. The harvest index was found to be highest in T_8 $RDF_{50} + RR_{50}$ (50.23%) followed by T_7 (49.20%), T_5 (49.16%), T_{11} (49.14%) and T_4 (49.12%), respectively due to less grain yield.

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