EFFECT OF OPTIMAL, SUB-OPTIMAL AND INTEGRATED NUTRIENT MANAGEMENT ON SOIL PROPERTIES AND NUTRIENT UPTAKE ON RICE (*ORYZA SATIVA*)

Chandra Shekhar Khare*, S. Chitale, Kamal Narayan, Jitendra Kumar Khare and Hemkanti

Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)
**Email.-khare.chandrashekhar@rediffmail.com*

Abstract: The present investigation entitled "Effect of optimal, sub optimal and integrated nutrient management on soil properties and nutrient uptake on rice (*Oryza sativa*)" was carried out at the Research Cum Instructional Farm IGKV., Raipur (C.G.) during *kharif* season of 2010. The soil of experimental field was '*Inceptisols*' locally known as *Matasi*. It was neutral in reaction, low in nitrogen, medium in available phosphorus and potassium. The experiment was laid out in randomized block design with 3 replications. The results revealed that amongst the different optimal, sub-optimal and integrated nutrient management practices using green manure, farmyard manure and chemical fertilizers, T_{10} consisting of 50% RDF + 50% N through green manuring recorded the highest growth , energy output (178.38 MJ x 10^3) and NPK content in soil. Application of 100% RDF (80:60:40 kg NPK ha^{-1}) also proved superior over other integrated nutrient management systems consisting farmyard manure and rice residues for energy output (176.75 MJ x 10^3). Sub-optimal doses of nutrients failed to provide considerable yield advantage and build-up of nutrients in soil as compared to optimal level or integrated nutrient management options.

Keywords: Nutrient management, Nutrient uptake, Soil properties, Energy

INTRODUCTION

Rice-wheat is the super most cropping system adopted in Indian sub continent spreading over 13.5 million ha. In Chhattisgarh rice is the predominant crop grown in approximately 3.50 m. ha, which is around 77 % of the net cultivated area. The state is considered as "rice bowl" and the livelihood of almost 83% of rural population is depending only on rice cultivation. Although, during favorable monsoon years, the state relishes good production of with an ever time record of 60 lakh tones and 1.7 $t.ha^{-1}$ productivity in the year 2010-11; the long-term productivity of rice in the state is remained low (1.3 $t.ha^{-1}$) below to the national average. The main reasons for low productivity even in irrigated areas are application of inadequate and unbalanced quantity of fertilizers to this nutrient exhaustive crop, which not only resulted in low yield (Sharma *et al*., 2003) but also consequently declined the soil organic carbon and soil health.

Application of organic manure not only improves the soil organic carbon for sustaining the soil physical quality but also increases the soil N. Crop residues have potential for improving soil and water conservations, sustaining soil productivity and enhancing crop yields (Das *et al*., 2003). The most effective mean of arranging natural supply of N and organic matter to soil is *in situ* cultivation of legumes and their incorporation at appropriate stages of crop growth. The use of green manure in combination with chemical fertilizer tends to increase the fertility of rice field. Although green manure, is well known for its role in soil fertility and it supplies a part of nutrient requirement of the rice crop, at present the use of the green manure is became limited. Amongst the different green manure crop, *Sesbania aculeata* and sun hemp (*Crotolaria juncea*) find an important place in the rice based cropping system because of faster growth, low C: N ratio, high N (ranging from 80 to 220 kg ha^{-1}) and P, K and micronutrients contents.

The replacement of external inputs *viz.*, chemical fertilizers by farm-derived organic inputs normally leads to a reduction in variable input costs under organic management. In Chhattisgarh, by virtue of using less quantity of chemical fertilizers, integration of organic manures being an available sources of nutrients, could have better opportunity towards high remuneration with inherent lesser cost advantage. Therefore, keeping these points in view, a field experiment was carried out at Research cum Instructional farm, I.G.K.V., Raipur, during *kharif* season of 2010.

MATERIAL AND METHOD

The present investigation entitled "Effect of optimal, sub optimal and integrated nutrient management on soil properties and nutrient uptake on rice (*Oryza sativa*)" was carried out at the Research Cum Instructional Farm IGKV., Raipur (C.G.) during *kharif* season of 2010. The soil of experimental field was '*Inceptisols*' locally known as *Matasi*. It was neutral in reaction, low in nitrogen, medium in available phosphorus and potassium. The experimental area comes under dry moist to sub humid climatic condition. The region receives on an average of 1200-1400 mm rainfall annually, out of which about 87 percent received during the rainy season (June to September) and the rest of 13 percent during winter season (October to February). January is the coolest and May is the hottest month. The maximum temperature ranges from 26.7^0Cto 42.5^0C. The soil of experiment field was '*Inceptisols*' which is locally known as '*Matasi*'. The soil was neutral in reaction and medium in fertility having low N, medium P and K. The experiment was laid out in randomized block design with three replications. The 12 treatments consisted of different nutrient levels some of them having integrated nutrient management.

Physico-chemical properties of the experimental site (initial in 1991-92)

No.	Particulars	Values	Rating	Methods used
A. Textural properties				
1.	**Mechanical composition**			
	Sand (%)	23		International pipette method (Black, 1965)
	Silt (%)	46	Silty clay	
	Clay (%)	31	(*Inceptisol)*	
B. Chemical composition				
1.	Organic carbon (%)	0.51	Medium	Walkey and Black's rapid titration method (Black, 1965)
2.	Available N (kg ha^{-1})	234	Medium	Alkaline permanganate method (Subbiah and Asija, 1956)
3.	Available P (kg ha^{-1})	11.5	Medium	Olsen's method (Olsen, 1954)
4.	Exchangeable K (kg ha^{-1})	280	Medium	Flame photometric method (Jackson, 1967)
5.	pH (1:2.5, Soil : water)	7.36	Neutral	Glass electrode pH meter (Piper, 1967)
6.	Electrical conductivity (m mhos m^{-1} at 25°C)	0.20	Normal	Solubridge method, (Black, 1965)
C. Physical composition				
3.	Bulk density (Mg m^{-3})			Soil Core Method (Black, 1965)
	0-15 cm, soil depth	1.12		
	15-30 cm, soil depth	1.28		

Treatment details of the experiment

No	***Kharif* (Rice)**	**Notation**
T_1	No fertilizer, no organic manure (control)	No fertilizer, no manure (control)
T_2	50% recommended NPK dose through fertilizers(40:30:20)	50% RDF
T_3	50% recommended NPK dose through fertilizers.	50% RDF
T_4	75% recommended NPK dose through fertilizers	75% RDF
T_5	100% recommended NPK dose through fertilizers (80:60:40)	100% RDF
T_6	50% recommended NPK dose through fertilizers +50%N through farmyard manure	50% RDF+50% N (FYM)
T_7	75% recommended NPK dose through fertilizers +25%N through farmyard manure	75% RDF+25% N (FYM)
T_8	50% recommended NPK dose through fertilizers +50% N through composted rice residue	50% RDF+50% N (RR)
T_9	75% recommended NPK dose through fertilizers +25% N through composted rice residue	75% RDF+25% N (RR)
T_{10}	50% recommended NPK dose through fertilizers +50% N through green manure	50% RDF+50% N (GM)
T_{11}	75% recommended NPK dose through fertilizers +25% N through green manure	75% RDF+25% N (GM)

T_{12}	Conventional farmer's practice (50:30:20)	Farmers' practice 50:30:20 NPK kg ha^{-1}

- RDF: 80:60:40 N:P_20_5:K_2O kg/ha.

RESULT AND DISCUSSION

1. Uptake studies

It is very clear from the data given in the Table-1&2 that NPK content and uptake in rice grain and straw at harvest was significantly affected by different optimal, sub-optimal and integrated nutrient management system. The higher yields enhanced the nutrient uptake.

1.1 Uptake of nitrogen

It is evident from the Table-2 that total uptake of N by rice was the minimum under control treatment, but increased significantly by applying fertilizers with different levels and/or supplemented with different organic manures such as FYM (T_6 and T_7), rice straw residue (T_8 and T_9) and GM (T_{10} and T_{11}). The total N uptake was maximum (97.21 kg ha^{-1}) with 50% N through GM + 50% RDF, closely followed by 100% NPK through RDF (96.90 kg ha^{-1}) and 50% N through FYM + 50% RDF (90.78 kg ha^{-1}). Application of nutrients as per farmers' practice also showed significantly more N uptake than the control. Higher uptakes of N with 100% RDF were also reported by Kumari *et al*. (2010) and with integrated nutrient management by Gupta *et al*. (2006).

1.2 Uptake of phosphorus

As regards to the uptake of P in rice grain and straw it is clear from the data presented in Table -1&2 that the P uptake by rice grain was recorded significantly highest under 50% N through GM + 50% RDF i.e. T_{10} over control (T_1), sub-optimal doses of nutrients (T_2, T_3 and T_4) and over T_8 and T_9 where N was supplemented through composted rice residues. While, uptake of P by rice straw and total P uptake (grain + straw) was recorded significantly maximum under 100% RDF where optimum dose of nutrients was applied. Sub-optimal doses of nutrients (T_1, T_2, T_3 and T_4) and N supplementation through composted rice residues (T_8 and T_9) failed to record higher uptake due to lesser amount of soil applied P and lower yield. P uptake in grains by the treatments having N supplementation through FYM and GM was higher to that of 100% RDF treatment.

Table -1: N, P and K content (%) in grain and straw of rice under different nutrient supply system in rice

Treatment		N		P		K	
		Grain	Straw	Grain	Straw	Grain	Straw
T1	No fertilizer, no manure (control)	0.90	0.31	0.17	0.037	0.160	1.72
T2	50% RDF	0.95	0.35	0.18	0.040	0.187	1.71
T3	50% RDF	0.99	0.35	0.18	0.047	0.193	1.78
T4	75% RDF	0.97	0.37	0.19	0.043	0.197	1.75
T5	100% RDF	1.20	0.40	0.23	0.060	0.233	1.94
T6	50% RDF+50% N (FYM)	1.16	0.35	0.24	0.040	0.200	1.89
T7	75% RDF+25% N (FYM)	1.13	0.32	0.22	0.040	0.200	1.83
T8	50% RDF+50% N (RS)	1.10	0.31	0.21	0.040	0.190	1.79
T9	75% RDF+25% N (RS)	1.06	0.33	0.20	0.047	0.187	1.76
T10	50% RDF+50% N (GM)	1.13	0.44	0.23	0.040	0.227	1.91
T11	75% RDF+25% N (GM)	1.10	0.38	0.21	0.040	0.190	1.85
T12	Farmers' practice 50:30:20 NPK kg ha^{-1}	0.97	0.32	0.19	0.037	0.173	1.78
SEm±		0.05	0.06	0.009	0.006	0.008	0.04
CD 5%		0.14	0.22	0.029	0.017	0.028	0.11

1.3 Uptake of potassium

Like P, the total uptake of K by rice was significantly increased with the use of 100% RDF (T_5) or in combination with organic manures like FYM (T_6 and T_7), composted rice residue (T_8 and T_9) and green manures (T_{10} and T_{11}) over sub-optimal doses, control and farmers' practice (T_{12}). The total K uptake was the maximum with the treatment T_5 (161.28 kg ha^{-1}, total uptake) followed by 50% N-substitution through GM +50% RDF (159.35 kg ha^{-1}). The results are in conformity with the findings of Gupta *et al*. (2006).

Table -2: N, P and K uptake (kg ha^{-1}) in grain and straw of rice under different nutrient supply system in rice

Treatment		Nitrogen			Phosphorus			Potassium		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T1	No fertilizer, no manure (control)	12.22	7.06	19.34	2.27	0.83	3.10	2.18	39.09	41.27
T2	50% RDF	32.85	17.66	50.51	6.25	2.00	8.25	6.48	85.62	92.10
T3	50% RDF	39.10	18.30	57.28	7.00	2.42	9.42	7.66	92.29	99.95
T4	75% RDF	41.45	22.81	64.28	8.23	2.65	10.88	8.37	106.84	115.21
T5	100% RDF	66.04	30.87	96.90	12.69	4.59	17.28	12.88	148.40	161.28
T6	50% RDF+50% N (FYM)	63.92	26.87	90.78	13.22	3.07	16.29	11.02	145.05	156.07
T7	75% RDF+25% N (FYM)	60.54	23.71	84.24	11.75	2.96	14.71	10.68	135.29	145.97
T8	50% RDF+50% N (RR)	59.54	22.68	82.21	11.22	2.89	14.11	10.32	129.29	139.60
T9	75% RDF+25% N (RR)	56.58	23.61	80.15	10.71	3.33	14.04	9.99	125.98	135.97
T10	50% RDF+50% N (GM)	63.49	33.65	97.21	12.74	3.07	15.80	12.74	146.61	159.35
T11	75% RDF+25% N (GM)	60.13	29.29	89.43	11.63	3.08	14.71	10.36	142.65	153.00
T12	Farmers' practice 50:30:20 NPK kg ha^{-1}	29.26	15.65	44.87	5.75	1.80	7.55	5.25	87.46	92.71
	SEm±	3.30	1.52	3.32	0.66	0.42	0.66	0.65	3.68	3.62
	CD 5%	9.68	4.47	9.73	1.94	1.24	1.94	1.91	10.80	10.62

Table -3: Soil organic carbon and Available nutrients (kg ha^{-1}) under different nutrient supply system in rice

Treatment		OC (%)	N	P	K
T1	No fertilizer, no manure (control)	0.48	172	11.60	172
T2	50% RDF	0.52	208	18.33	220
T3	50% RDF	0.60	232	20.13	230
T4	75% RDF	0.61	246	20.60	241
T5	100% RDF	0.69	263	27.87	276
T6	50% RDF+50% N (FYM)	0.66	260	24.73	280
T7	75% RDF+25% N (FYM)	0.66	256	26.33	285
T8	50% RDF+50% N (RS)	0.59	253	23.07	263
T9	75% RDF+25% N (RS)	0.57	247	20.13	260
T10	50% RDF+50% N (GM)	0.70	272	29.47	297
T11	75% RDF+25% N (GM)	0.69	265	25.27	280
T12	Farmers' practice 50:30:20 NPK kg ha^{-1}	0.59	228	21.00	241
	Initial value	0.51	234	11.5	232
	SEm±	0.01	5	1.01	5
	CD 5%	0.04	15	2.95	16

2. Soil properties

Continuous application of green manuring or adding of rice residues or FYM over a long period of time offer the twin benefits of soil quality and fertility enhancement while meeting a part of nutrient need of crops, not only sustain the higher yields of crop but also cut the expensive fertilizers on the other hand.

2.1 Organic Carbon

Data presented in Table-3 clearly reveal that exclusion / omission of inorganic fertilizers from system (control plots) lowered the organic carbon (0.48%) even it was remained lesser than the initial values (0.51%) as compared to all the other treatments. Incorporation of FYM, RR or GM in conjunction with fertilizer increased significantly organic carbon (OC) content of surface soil. While, among the inorganic fertilizer treatments, only 100% RDF was found capable to those which have received integrated nutrient management practices and improved the OC content (0.69%) even more than 50% or 75% N through RR. Application of FYM (50% RDF + 50%N through FYM and 75% RDF + 25%N through FYM in T_6 and T_7 respectively), composted RR (50% RDF + 50% N through RR and 75% RDF + 25% N through RR in T_8 and T_9 respectively) and GM (50% RDF + 50% N through GM and 75% RDF + 25% N through GM in T_{10} and T_{11} respectively) significantly improved the organic carbon over initial status. Improvement in OC status in FYM/RR/GM treated plots after a continuous 31 cropping cycles was also reported by Sharma *et al*. (2007).

2.2 Available N

Available N content of surface soil varied significantly with application of FYM/RR/GM in combination with fertilizers over initial status. The highest available nitrogen in surface soil (272 kg ha^{-1}) was recorded with *in situ* application of GM for 50% N supplementation + 50% of RDF (T_{10}) followed by 25% N through GM + 75% of RDF (T_{11}) (265 kg ha^{-1}). Adding *Sesbania aculeata* as green manure favoured the soil conditions and might have helped in the mineralization of soil N leading to build-up of increased available N (Bajpai *et al*., 2006). On the other hand, increase in supply of available nitrogen from 50% to 75% FYM (T_7) and RR (T_9) failed to adding of nitrogen to the available pool of the soil and did not recorded the comparable values to that of GM. Among the inorganic fertilizer treatments, 100% RDF have maintained the available N level of soil. It was significantly improved the N status (263 kg ha^{-1}) over suboptimal doses as well as to those of T_7, T_9 and the initial values of 234 kg ha^{-1}. This also indicates that if balanced fertilizer is used or integrated with manures rationally, substantial improvement in soil health can be expected (Table - 3).

2.3 Available P

Incorporation of 50% N through GM + 50% RDF (T_{10}) and 100% RDF (T_5) recorded significantly higher available P (29.47 and 27.87 kg ha^{-1} respectively) than farmers' practice, T_2, T_3, T_4, T_6, T_8, T_9 and off-course over control (Table-3). Available P content of the soil was also increased with incorporation of varying level of FYM (both 25 and 50% N) and added comparable P to that of T_{10} and T_5. Incorporation of RR at both 25 and 50% N substitution with chemical fertilizer not succeeded to improve P status markedly as compared to sub-optimal and farmers' practice might be due to lesser P content of RR which failed to add more P in the soil. It is an established fact that crops only use 25 to 30% of applied phosphorus and rest remains in soil. Increase in available P with FYM application might also be due to solubilization of the native P in the soil through release of various organic acids. This is more pronounced at the higher moisture level under irrigated conditions. Organic manures enhanced the labile P in soil through complexation of cations like $Ca^{2+}$and Mg^{2+} which are mainly responsible for fixation of P when it is applied in combination with inorganic fertilizer. Tolanur and Badanur (2003) also supported that organic matter like FYM and GM with inorganic fertilizer had the beneficial effect on increasing the phosphate availability.

2.4 Available K

The available K content of surface soil in rice in rice-wheat crop rotation differed significantly due to various levels of organic manures in combination with inorganic sources of nutrients. GM in conjunction with fertilizer (50% N + 50% of RDF) could only increase the available potassium (297 kg ha^{-1}) significantly over other treatments and to that of initial status (Table-3). Interestingly, like N and P status, 100% RDF level (T_5) could not maintain comparable K level as much to that of T_{10}. Even, incorporation of FYM to meet 25% N + 50% RDF recorded the significantly higher available K over sub-optimal dose of fertilizers, rice residue integration and slightly over 100% RDF level. Increase in available potassium due to GM application may be attributed to the direct addition of potassium to the available pool of the soil. Kharub and Chander (2010) also reported less negative K balance where organic sources of nutrients applied in parts or full. The beneficial effect of GM and FYM on available potassium may be ascribed to the reduction of potassium fixation and release of potassium due to interaction of organic matter with clay, besides the direct potassium addition to the potassium pool of the soil. But, the available K content in the soil could not rise in RR incorporation over control and graded inorganic fertilizer treatments as in GM/FYM. This could be attributed to more K removal than small addition in rice in rice-wheat cropping system (Kumar *et al*., 2008).

3. Energy analysis

The data related to energy input, energy output and energy parameters viz. energy output -input ratio and energy productivity are presented in Table- 4. The data revealed that energy output and energy parameters of rice were significantly affected due to different nutrient management options used. The lowest values of all energy parameters were obtained under control where rice was grown without fertilizers and manures.

As regard to the response of energy parameters to different optimal, sub-optimal and integrated nutrient management adopted in rice, in general, owing to the higher yields the total output energy, recorded significantly the maximum (178.38 MJ x 10^3) where integration of 50% N through GM with 50% RDF (T_{10}) were opted and closely followed by 50% N integration with FYM (T_6) and 75% N through GM (T_{11}). However, in case of 100% RDF level (T_5), input: output energy ratio was significantly lower (9.50) as compared to integrated nutrient management options due to higher energy input in terms of inorganic fertilizers. Interestingly, despite of lowest grain and straw yield and output energy recorded, the input; output ratio and energy productivity were significantly maximum under T_1 as compared to all the other optimal, sub-optimal and integrated treatments due to not applying any of the nutrient under this treatments which resulted in smaller amount of energy.

Table- 4: Energy analysis of different nutrient management systems

Treatment		Input energy (MJ x 10^3)	Output energy (MJ x 10^3)	Input: output energy ratio	Energy productivity
T1	No fertilizer, no manure (control)	3.58	48.44	13.55	381.12
T2	50% RDF	11.09	113.61	10.25	313.83
T3	50% RDF	11.09	123.18	11.11	357.43
T4	75% RDF	14.84	139.06	9.37	286.93
T5	100% RDF	18.60	176.75	9.50	296.74
T6	50% RDF+50% N (FYM)	16.29	176.94	10.86	338.19
T7	75% RDF+25% N (FYM)	17.45	171.10	9.81	306.20
T8	50% RDF+50% N (RR)	16.29	170.26	10.45	333.20
T9	75% RDF+25% N (RR)	17.45	168.01	9.63	306.92
T10	50% RDF+50% N (GM)	16.29	178.38	10.95	344.84
T11	75% RDF+25% N (GM)	17.45	176.50	10.12	312.41
T12	Farmers' practice 50:30:20 NPK kg ha^{-1}	12.39	105.80	8.54	244.36
SEm±		-	3.23	0.30	18.66
CD 5%		-	9.48	0.90	54.74

REFERENCES

Bajpai, R.K. and Tripathi, R.P. (2006). Evaluation of non puddling under shallow water tables and alternative tillage methods on soil and crop parameters in a rice wheat system in uttar Pradesh. *Soil and Tillage Research* 55: 99-106.

Bajpai, R.K., Chitale, S., Upadhyay and Urkurkar, J.S. (2006). Long-term studied on soil physic-chemical properties and productivity of rice-wheat system as influenced by integrated nutrient management in inceptisol of Chhattisgarh. *Journal of the Indian Society of Soil Science* 54 (1): 24-29.

Black, C.A. (1965). Method of Soil Analysis. *Amer. Agron. Inc. Madison*. Wisconsin, USA, pp 131-137.

Das, K., D.N. Medhi and Guha B. (2003). Application of crop residues in combination with chemical fertilizers for sustainable productivity in rice (*Oryza sativa*) -Wheat (*Triticum aestivum*) system. *Indian J. Agron*. 48(1): 8-11.

Gupta, Vikas, Sharma, R.S. Sharma and Vishwakarma, S.K. (2006). Long-term effect of integrated nutrient management on yield sustainability and soil fertility of rice(*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* 51(3): 81-96.

Kumari, N., Singh, A.K., Pal, S.K. and Thakur, R. (2010). Effect of organic nutrient management on yield, nutrient uptake and nutrient balance sheet in sented rice (*Oryza sativa*). *Indian Journal of Agronomy* 55(3): 220-223.

Kumar Balvinder, Gupta R.K. and Bhandari A.L. (2008). Soil fertility changes after long-term application of organic manures and crop residues under rice-wheat system. Journal of the Indian Society of soil Science 56(1): 80-85.

Kharub, A.S. and Chandar, S. (2010). Effect of organic farming on yield, quality and soil fertility status under basmati rice (*Oryza sativa*)-wheat

(*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* 55(3): 172-177.

Sharma, S.K. and Sharma, S.N. (2003). Balance sheet of nitrogen, phosphorus and potassium under different rice (*Oryza sativa*) – based cropping systems. *Indian Journal of Agronomy* 47(1): 6–11. Tolanur, S.L. and Badanur, V.P. 2003. Effect of integrated use of organic manure, green manure and fertilizer nitrogen on sustaining productivity of rabi sorghum-chickpea system and fertility of a Vertisol. *Journal of the Indian Society of Soil Science*. 51(1): 41-44.

Sharma, M. P., Bali, S.V. and Gupta, D.K. (2007). Soil fertility and productivity of rice wheat cropping system in an *Inceptisol* as influenced by integrated nutrient management. *Indian Journal. Agric. Sci.* 71(2): 80-82.

Tolanur, S.L. and Badanur, V.P. (2003). Effect of integrated use of organic manure, green manure and fertilizer nitrogen on sustaining productivity of rabi sorghum-chickpea system and fertility of a Vertisol. *Journal of the Indian Society of Soil Science*. 51(1): 41-44.