EFFECT OF OPTIMAL, SUB OPTIMAL AND INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD ATTRIBUTES OF RICE (*ORYZA SATIVA*) IN RICE-WHEAT CROPPING SYSTEM

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Abstract: The present investigation entitled "Effect of optimal, sub optimal and integrated nutrient management growth and yield attributes of rice (*Oryza sativa*) in rice-wheat cropping system" 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 12 treatments and 3 replications.

The treatments consisted of T_1 (No fertilizer, no organic manure, control), T_2 (50% recommended NPK dose through fertilizers, 40:30:20), T_3 (50% recommended NPK dose through fertilizers), T_4 (75% recommended NPK dose through fertilizers), T_5 (100% recommended NPK dose through fertilizers, 80:60:40), T_6 (50% recommended NPK dose through fertilizers +50%N through farmyard manure) and T_7 (75% recommended NPK dose through fertilizers +25%N through farmyard manure). T_8 (50% recommended NPK dose through fertilizers +50% N through composted rice residue). T_9 (75% recommended NPK dose through fertilizers +25% N through composted rice residue). T_{10} (50% recommended NPK dose through fertilizers +50% N through green manure). T_{11} (75% recommended NPK dose through fertilizers +25% N through green manure). T_{12} (Conventional farmer's practice (50:30:20) Table (i). 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 and yield attributing characters, grain yield of rice (56.19 q ha^{-1}) and maximum net return (Rs. 46,117 ha^{-1}). 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 yield (55.19 q ha^{-1}), net return (Rs. 44,962 ha^{-1}) and B:C ratio (2.52). 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: Rice, optimal, sub optimal and integrated nutrient management and yield attributes

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 and Sharma, 2003) but also consequently declined the soil organic carbon and soil health. In Chhattisgarh, the status of soil nitrogen is very low and addition of organic matter to the soil is not very much practiced and rice crop is completely depends upon soil and applied nutrient. Therefore to sustain as well as to increase the productivity of the crop, replenishment of nutrients drawn out from the soil system by the crop harvest becomes imperative. Incorporation of organic sources viz. green manures, FYM and recycling of crop residues along with NPK fertilizers in an integrated (nutrient) manner is effective in alleviating the nutrient deficiency in soil and enhances the yield potential as well. Moreover, such integration ameliorates the properties of the soil further for sustaining the productivity and profitability in a long-term basis. Hence, it is necessary to judiciously manage the inflow of organic sources of nutrients and their interaction with fertilizers in soil system.

MATERIAL AND METHOD

The present investigation on the "Effect of optimal, sub optimal and integrated nutrient management growth and yield attributes of rice (*Oryza sativa*) in rice-wheat cropping system" was conducted during *Kharif* season of 2010 at the Research Cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experimental area comes under dry moist to sub humid climatic condition. The region receives on an average of 1200-1400 mm rainfall annually. The maximum temperature ranges from $26.70^{C}$to 42.50^{C}. Relative humidity varies between 70 to 90 per cent from mid June to March. 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. All the

recommended package and practices were followed to grow healthy crop. 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. The recorded data were analyzed as suggested by Gomez and Gomez (1984) for analysis of variance.

Table (i) : Treatment details of the experiment

No	Treatments	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_2O_5:K_2O kg/ha.

Table 1: Effect of optimal, sub optimal and integrated nutrient management on growth attributes of rice

Treatment		Plant population (hills m^{-2})				Plant height (cm)				Leaf area index			Crop growth rate	
		30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	60 DAT	90 DAT
T_1	No fertilizer, no manure (control)	48	47	46	45	55.4	90.7	97.0	97.6	2.13	5.23	5.03	0.06	0.17
T_2	50% RDF	48	48	47	45	63.4	98.6	97.6	105.2	2.20	5.27	5.30	0.07	0.24
T_3	50% RDF	48	48	47	46	69.5	102.5	105.2	111.7	2.30	5.30	5.43	0.08	0.27
T_4	75% RDF	48	48	48	46	74.5	107.8	108.4	116.0	2.37	5.33	5.47	0.08	0.26
T_5	100% RDF	49	48	48	47	76.6	105.2	112.9	114.5	2.53	5.57	6.27	0.15	0.36
T_6	50% RDF+50% N (FYM)	49	48	47	47	70.3	105.0	113.1	113.7	2.50	5.50	6.13	0.13	0.34
T_7	75% RDF+25% N (FYM)	48	48	47	47	69.9	108.9	112.7	112.8	2.41	5.37	5.50	0.10	0.33
T_8	50% RDF+50% N (RR)	49	48	48	47	80.3	111.9	112.6	117.7	2.43	5.47	5.60	0.12	0.34
T_9	75% RDF+25% N (RR)	48	48	47	46	76.3	110.1	116.0	116.8	2.41	5.40	5.53	0.10	0.31

T_{10}	50% RDF+50% N (GM)	48	48	47	47	80.4	113.3	116.4	121.9	2.63	5.60	6.30	0.16	0.36
T_{11}	75% RDF+25% N (GM)	48	48	47	46	66.6	109.9	114.9	115.7	2.47	5.53	5.70	0.14	0.33
T_{12}	Farmers' practice 50:30:20 NPK kg ha^{-1}	48	47	47	46	65.8	102.7	103.7	113.9	2.30	5.10	5.27	0.06	0.24
CD at 5%		NS	NS	NS	NS	6.4	13.0	3.9	1.5	0.23	0.29	0.45	NS	0.04

Table 2: Effect of optimal, sub optimal and integrated nutrient management on yield and yield attributes of rice

Treatment		No of tillers m^{-2}				Panicle length (cm)	Weight of panicle (g)	Grain yield (q ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross Return (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit : cost ratio
		30 DAT	60 DAT	90 DAT	Effective tillers at harvest							
T_1	No fertilizer, no manure (control)	77	93	114	115	25.8	2.69	13.63	15,270	15,898	628	0.04
T_2	50% RDF	153	195	260	261	27.0	2.74	34.79	16,573	39,789	23,216	1.40
T_3	50% RDF	155	222	265	266	27.3	2.75	39.63	16,573	44,820	28,247	1.70
T_4	75% RDF	147	240	283	284	27.2	2.84	42.58	17,225	48,700	31,475	1.83
T_5	100% RDF	160	285	339	342	28.9	2.96	55.19	17,876	62,837	44,962	2.52
T_6	50% RDF+50% N (FYM)	156	260	334	337	28.8	2.95	55.10	18,173	62,779	44,606	2.45
T_7	75% RDF+25% N (FYM)	159	273	321	324	28.6	2.85	53.42	18,025	60,823	42,798	2.37
T_8	50% RDF+50% N (RR)	159	273	299	302	27.9	2.86	54.29	17,943	61,528	43,585	2.43
T_9	75% RDF+25% N (RR)	154	270	298	301	27.9	2.80	53.54	17,910	60,686	42,776	2.39
T_{10}	50% RDF+50% N (GM)	162	289	360	363	28.8	2.95	56.19	17,733	63,850	46,117	2.60
T_{11}	75% RDF+25% N (GM)	159	280	332	333	28.6	2.89	54.50	18,205	62,211	44,006	2.42
T_{12}	Farmers' practice 50:30:20 NPK kg ha^{-1}	151	175	263	264	27.0	2.87	30.27	16,694	35,175	18,481	1.11
CD at 5%		12	15	17	18	1.0	0.13	6.58	-	-	-	-

RESULT AND DISCUSSION

The present study was a part of the long-term permanent plot experiment on the integrated nutrient management in rice-wheat cropping system of All India Coordinated Research Project on Integrated Farming Systems, which is being conducted during *kharif* and *rabi* seasons with 12 pre-decided different nutrient management treatments both for rice and wheat since 1991-92. In view of the fact that, the present study is a part of the experiment and as the present study was carried for only *kharif* season crops and the *rabi* season crop i.e. wheat was not taken under the study, two of the treatments (T_2 and T_3) seems alike with each other because of different nutrient levels during *rabi*. Hence, the results are presented in the light of residual effects of permanent plots of different treatments on rice growth and yield and nutrient status of the soil.

1. Growth characters

1.1 Plant population and plant height (cm)

As the rice crop was grown under transplanted condition and seedling of rice properly placed in experimental field, the plant population was not influenced significantly due to the different treatments over entire crop growth period (Table- 1). In general, by virtue of vertical growth character of rice plants, their height increased with the advancement of crop age. But, the maximum increase was recorded during 0 to 30 and 30 to 60 DAT, while the pace of the growth was slowed down

after 60 DAT (Table-1). The increment in height was more in 100% RDF as well as integrated nutrient management options as compared to sub-optimal or unfertilized control treatments. Among the different integrated nutrient management treatments, application of 50% RDF + 50% N through GM (T_{10}) recorded significantly the maximum plant height as compared to rest of the treatments at 30, 60 and 90 DAT and at harvest. However, it was found to be at par with treatments of T_8, T_9, and T_5 at 30 DAT, but at 60 and 90 DAT, it was found to be at par with 100% RDF and all the integrated nutrient management treatments i.e. T_5, T_6, T_7, T_8, T_9 and T_{11} were significantly superior to rest of the sub-optimal treatments.

1.2 Leaf area index

Leaf area index is the ultimate expression of the photosynthetic activity of the plant, which may have a direct effect on growth and yield parameters during the developmental stages of crop. It is evident that, irrespective of the treatments, leaf area index was increased with the advancement of crop age. At 30 DAT, significantly the maximum leaf area was noted under the treatment T_{10} (50% recommended NPK dose through fertilizers + 50% N through green manure).

Overall, T_{10} (50% RDF +50% N through green manure) was resulted in higher leaf area index in all the stages of growth followed by 100% RDF through inorganic fertilizers and substitution of 50%N through farmyard manure. This might be due to better uptake and utilization of nutrients under $T_{10,}$ which might have resulted in greater canopy coverage per unit ground area under these treatments.

1.3 Crop growth rate

The crop growth rate progressively increased with increasing crop age up to harvest. The data presented in Table -1 showed no significant variation between, the treatments at 30-60 DAT. While at 60-90 DAT stage, significant variation was found in crop growth rate due to different treatment under study. The higher growth rate was noted under T_{10} (50% RDF +50% N through GM) which was at par with T_5 (100% RDF), T_6 (50% RDF +50%N through farmyard manure), T_7 (75% RDF + 25% N through farmyard manure), T_8 (50% RDF +50% N through RR), and T_{11} (75% recommended NPK dose through fertilizers + 25% N through green manure), whereas least value for crop growth was noted under T_1 (No fertilizer, no organic manure). Results are in accordance with the findings of Singh *et al.* (2001).

2. Yield attributing characters and yield

2.1 No. of tillers m^{-2}

Data presented in Table-2 clearly illustrate that the number of tillers of rice was significantly influenced due to different nutrient management options. However, at 30 DAT, interestingly it was similar among all the integrated nutrient supply treatments and also similar to that of recommended doses of inorganic fertilizer but significantly lower numbers of tillers was recorded with control. This was might be due to the effect of initial nutrient doses applied to the soil except control. But with the advancement of crop growth, the integrated nutrient management treatment particularly N substitution through GM showed their considerable effect on tillers and it was the maximum under T_{10} (50% RDF+ 50 % N through GM) which was significantly superior over all the treatments except T_5 and T_{11} at 60 DAT irrespective of nutrient management level at 90 DAT and at harvest. Treatments having N substitution (both 25 and 50%) through farmyard manure (T_6 and T_7) or composted rice residue (T_8 and T_9) and 100% NPK by inorganic fertilizers (T_5) have also recorded significantly more numbers of effective tillers at harvest over sub-optimal and farmers' practice as well as control treatment.

2.2 Panicle length (cm) and weight of panicle (g)

It is also depicted through the Table-2 that the panicle length and weight of panicle were statistically similar under optimal and integrated nutrient supply and significantly superior over unfertilized control, sub-optimal and under farmers' practice treatments. However, longest panicle (28.9 cm) and heaviest panicle (2.95 g) was observed under 100% RDF application followed by 50% RDF + 50% N through GM.

2.3 Grain yield (q ha^{-1})

The data presented in Table-2 clearly revealed that the yield of rice increased with increasing the levels of nitrogen from 50 to 100 % of RDF. Treatment T_{10} consisting of 50% RDF + 50% N as received from green manuring registered significantly highest grain yield of rice (56.19 q ha^{-1}) which was significantly superior to the sub optimal doses of 50 % of RDF (T_2 and T_3), farmers' practice (T_{12}) and the control treatment (T_1). Painkray *et al*. (2001) also obtained significantly higher rice yield with *Sesbania* green manure Higher yield attributes *i.e.* number of effective tillers m^{-2}, grains $panicle^{-1}$ panicle length (cm) and panicle weight (g) in 100% RDF and/or integrated nutrient treatments led to differential yield of the various treatments (Kumari *et al*. 2010). The rice grain yield of other integrated nutrient treatments using GM or FYM or RR was also similar amongst them and was found to be significantly higher over farmer's practice with respect to rice yield. Integration of organic manure with inorganic fertilizer either with FYM at 50% N level (T_6) or with GM at 25% N level (T_{11}) or with rice residues of 50% N under T_8 and 25% N under T_9 respectively produced grain yield comparable to that of 100% chemical fertilizer treatment (T_5).

Superiority of combined application of urea and FYM over recommended fertilizer application was

also reported by Choudhary and Thakur (2007). Even, the inorganic fertilizers treatment (50% dose of fertilizer under T_3) performed significantly to that of farmer's practice might be due to the residual effects of 100% NPK dose in wheat in same treatment during previous *rabi* season. While, the lowest yield of rice (13.63 q ha^{-1}) was recorded with no manures and fertilizers i.e. control. These findings indicated that integrated use of chemical fertilizers with FYM or GM or RR facilitates to curtail the use of expensive chemical fertilizers up to 50% and is a better alternative to use of full dose of recommended fertilizers (Gupta *et al*., 2006, Gill *et al*., 2008).

2.4 Economics

It is revealed from the data presented in Table -2 that the cost of cultivation of rice varied from Rs. 17,733 to Rs. 18,205 ha^{-1} owing to the use of different sources of optimal/integrated nutrient management. Among all the treatments, highest net return (Rs. 46,117 ha^{-1}) and benefit: cost ratio (2.60) was obtained with 50% of RDF + 50% N through GM. Owing to the higher yields recorded under this treatment as discussed earlier (Table-2) fetched Rs. 2000/- more over 50% RDF+ 50% N through FYM (Rs 44,606 ha^{-1}) and Rs. 3000/- over 50% RDF+ 50% N through RR (Rs 43,585 ha^{-1}). Comparatively higher cost incurred for supplementing N through FYM/RR is another reason for less remuneration from capital invested in the later treatments. On the other hand, the results also showed that the comparable total net returns (Rs. 44,962 ha^{-1}) and benefit: cost ratio (2.52) was achieved with 100% of RDF. Sub-optimal doses of nutrients failed to register as good as amount of net return to that of integrated/100% RDF treatments. Lowest net return was recorded under control. These results are in agreement with the findings of Gupta *et al.* (2006).

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