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Effect of integrated sources of nutrient, puddling and irrigation schedule on productivity of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system

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ABSTRACT

A field experiment was conducted during 1999–2000 to 2001–2002 at Bilaspur, Chhattisgarh, to evaluate the effect of level of puddling along with integrated sources of nutrients and irrigation schedule to rice (*Oryza sativa* L.) and it residual effect on wheat (*Triticum aestivum* L. emend. Fiori & Paol.) productivity in rice–wheat cropping system. Conventional (3 passes with cultivator + 2 plankings) and reduced (through rice puddler) puddling had not much significant difference in yields. However, grain yields obtained with 80 kg N/ha (50% through green manure + 50% through urea) were comparable to 80 kg N/ha (50% through FYM + 50% through urea), but both were significantly higher than 80 kg N through urea. Similarly, irrigation schedule had a significant effect and it was found that 1 day drainage period after disappearance of 7 ± 2 cm ponded water recorded higher yield but comparable to 3 days drying period. However, 5 days drainage period resulted in significantly lower yield than 1 and 3 days. Level of puddling and irrigation shedule followed during the rainy-season rice had no residual effect on wheat yield, but integrated sources of nutrients (organic + inorganic) had residual effect on succeeding wheat yield and nutrient uptake of rice–whet system.

Key words : Organic and inorganic sources, Puddling, Irrigation Scheduling, Cropping system

Rice–wheat is one of the major cropping systems in the country. However, both rice and wheat are heavy feeder of nutrients. Due to escalation in the price of chemical fertilizers a greater emphasis has to be laid on supplementing the chemical fertilizers with cheaper sources of nutrients such as organics and bio-fertilizers. Application of organic materials along with inorganics fertilizers into soil leads to increase in productivity of the system and also sustained the soil health for longer period. Organic sources of nutrients applied to the preceding crop benefits the succeeding crop to a great extent (Hegde and Dwivedi, 1992) and system productivity becomes sustainable. It is well known that the organic sources cannot meet the total nutrients need of modern agriculture, integrated use of nutrients seems to be more appropriate. Incorporation of organic sources and later on its decomposition determines the availability of the nutrients.

Therefore, the approach of integrated nutrient management through the judicious mixing of organic as well as inorganic sources of nutrients is an appropriate, which will not only economize the use of chemical fertilizers but also improve the physico-chemical status of the soil. Hence, a study was conducted with a view to find out the optimum combination of organic and inorganic sources of nutrients and its residual effect under different puddling and irrigation levels in rice–wheat system.

MATERIALS AND METHODS

The experiment was conducted during 1999–2000 to 2001–2002 at Bilaspur. The soil of the experimental field was clay-loam with pH 7.3, organic carbon 0.46%, available nitrogen 239 kg/ha, available phosphorus 12 kg/ha and available potassium 416 kg/ha. The experiment was laid out in split-plot design, replicated thrice. Keeping the combination of level of puddling and integrated sources of nutrients in main plot and irrigation schedule in subplot. The treatments for rice included 2 levels of puddling, viz. P_1, conventional (cultivator 3 passes + 2 plankings) and P_2, reduced (puddling through rice puddler); 3 levels of integrated nitrogen management, viz. S_1, 80 kg N/ha (50% through green manure + 50% through urea); S_2, 80 kg N/ha (50% through farmyard manure (FYM) + 50% through urea) and S_3, 80 kg N/ha (through urea); and 3 levels of irrigation, viz. I_1, 1 day drainage after disappearance of 7 ± 2 cm ponded water (DAPW); I_2, 3 days; and I_3, 5 days after DAPW. *Sesbania rostrata* was used as

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green manure. It was grown on the field and 50 days old plants were incorporated well during the puddling 5 days before the transplanting of rice seedlings. Similarly, farm-yard manure (FYM) was also incorporated 5 days before transplanting of the rice seedlings. Different sources of organic materials were analyzed on dry-weight basis for determination of N, P, K content (FYM: 0.5, 0.25, 0.35% and sesbania: 2.32, 0.35, 2.10% respectively) and they were applied as per the treatments on fresh-weight basis. Twentyseven days old seedlings of 'Mahamaya' rice were transplanted in the second week of July during all the years. After rice harvest 'HD 2285' wheat was sown during last week of November with a common pre-sowing irrigation in the same layout to assess the residual effect of the treatments followed during rainy season (*kharif*) rice. Wheat crop was supplied with 100 kg N/ha in 3 splits (50% at sowing and 25% at crown root initiation + 25% at jointing) and phosphorus and potassium @ 40 and 30 kg/ha, respectively were applied to both the crops as basal dose. Wheat crop was irrigated at 0.9 IW : CPE ratio with 60 mm water in each irrigation, which is recommended for the region. Total water use of the sytem was worked out by summing of the number of irrigations and effective rainfall between transplanting or sowing and physiological maturity of the crops. Average number of irrigations under I_1, I_2 and I_3 was 7, 6 and 5, respectively, in rice while 5 irrigations including pre-sowing irrigation in wheat.

RESULTS AND DISCUSSION

Effect on physico-chemical properties of soil

Physical properties like bulk density, infltration rate and water-holding capacity differed appreciably due to incorporation of organic material after rice harvest. Incorporation of orgaic sources of nutrients decreased the bulk density and decreased the porosity and thus enhanced the infiltration rate and water-holding capacity (Table 1). Organic materials with higher C : N ratio like FYM is known to improve the soil physical properties. Favourable effects of crop residues and other organic materials on soil water-holding capacity were also reported by Yadav and Kumar (1993) and Das *et al.* (2001).

In general, there was positive improvement in fertility status of soil due to incorporation of organic sources (Table 1). But pH and electric conductivity of the soil did not differ appreciably, however incorporation of FYM or green manure along with chemical fertilizer invariably increased the organic carbon and available N, P and K in soil compared to application of chemical fertilizers alone (Table 1). The improvement could be attributed to addition of greater root biomass and organic matter through FYM and *Sesbania.* Availability of soil nutrients (NPK) is always influenced due to addition or depletion of such nutrients in the soil, but favourable response was more pronounced with integrated nutrient management than chemical fertilizers alone. Thus, addition of organic sources with chemical fertilizers improved the physico-chemical properties of soil after rice harvest compared to initial soil status.

Effect of rice yield

The level of puddling had no significant variation in the yield indicating that puddling through rice puddler not only produces same yield but the saving of energy consumed on field preparation than conventional puddling which requires more passes. The crop supplemented with organic sources like green manure and FYM gave significantly higher grain yield of rice than inorganic sources of nutrients alone (Table 2). However, yields obtained with green manure and FYM were at par. Increase in rice grain yield owing to green manure and FYM incorporation may be

Table 1. Effect of different treatments on physico-chemical properties of soil after rice harvest (mean of 3 years)

Treatment	Bulk density (g/cc)	Infiltration rate (cm/hr)	Maximum water-holding capacity (%)	Organic carbon (%)	Available nutrient (kg/ha)		
					N	P_2O_5	K_2O
Initial value	1.46	0.82	42.65	0.46	239	12.0	416
Puddling level							
P_1	1.43	1.87	43.70	0.48	248	15.2	438
P_2	1.42	2.05	44.82	0.49	250	15.9	440
Source of N							
S_1	1.40	2.12	45.80	0.50	264	16.4	441
S_2	1.42	2.05	44.32	0.48	253	15.9	455
S_3	1.44	1.80	42.78	0.46	230	13.8	424
Irrigation level							
I_1	1.42	1.96	44.30	0.48	250	15.0	438
I_2	1.42	1.96	44.10	0.47	259	15.7	440
I_3	1.43	1.93	44.02	0.47	248	15.9	442

Table 2. Yield and yield attributes of rice in rice–wheat cropping sytem (mean data of 3 years)

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Panicles/ m^2	Fertile spikelets/ panicle	1,000-grain weight (g)
Level of puddling					
P_1	5,274	5,894	277	104	28.0
P_2	5,429	5,960	279	106	28.5
CD (P=0.05)	NS	NS	NS	NS	NS
Source of N					
S_1	5,471	5,915	281	108	28.5
S_2	5,450	6,104	280	107	28.0
S_3	5,091	5,802	272	101	27.0
CD (P=0.05)	285	NS	7	5	0.5
Irrigation schedule					
I_1	5,467	5,920	282	107	28.0
I_2	5,343	6,012	278	107	28.0
I_3	5,095	5,815	274	102	28.5
CD (P=0.05)	241	NS	4	3	0.3

Table 3. Yield and yield attributes of wheat in rice–wheat cropping system (mean data of 3 years)

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Spikes/m row length	Grains/spike weight (g)	1,000-grain weight (g)
Level of puddling					
P_1	3,372	4,365	76	36	42.4
P_2	3,410	4,472	77	35	41.8
CD (P=0.05)	NS	NS	NS	NS	NS
Source of N					
S_1	3,595	4,365	78	36	41.7
S_2	3,516	4,520	77	36	42.2
S_3	3,150	4,305	74	35	42.4
CD (P=0.05)	251	NS	2	1.0	0.4
Irrigation schedule					
I_1	3,421	4,340	76	35	41.8
I_2	3,437	4,295	77	36	42.0
I_3	3,355	4,312	76	36	42.3
CD (P=0.05)	NS	NS	NS	0.8	NS

attributed to release of nutrients to soil slowly for longer duration after decomposition resulting in better plant growth and yield-contributing characters (Table 2).Patra *et al.* (2000) and Das *et al.* (2001) reported similar effects of organic matter management.

Significant variation in grain yield was recorded with variable irrigation schedule. It was observed that 1 day drainage after disappearance of ponded water recorded significantly higher yield but comparable to 3 days drying period. However, 5 days drainage period resulted in significantly less yield than 1 and 3 days drainage period. The significant low yield was attributed to lesser yield-attributing characters (Table 2).

Effect on wheat yield

Level of puddling and irrigation schedule followed during the *kharif* rice did not have any residual effect on succeeding wheat yield. Similarly, different organic sources of nutrients incorporated in rainy (*kharif*) season did not influence the grain yield of succeeding wheat crop during first year. However, it was increased with incorporation of organic sources during next 2 succeeding years. The plots receiving green manure and FYM in rainy (*kharif*) season recorded significantly higher grain yield of wheat than plots receiving only inorganic sources of nutrients (Table 3). The average increase in wheat yield was 14% and 11% with green manure and FYM over the inorganic source respectively. In general, the practice of supplementing inorganic sources of nutrients with organic sources improves organic carbon and NPK content in the soil (Table 1), which in turn results in better plant growth and development. It was reflected through significantly

Table 4. Nutrient uptake of rice in rice–wheat cropping system (mean data of 3 years)

Teatment	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Level of puddling									
P_1	74.36	31.81	106.17	14.76	4.71	19.47	22.15	88.94	111.09
P_2	75.46	31.59	107.05	14.66	4.17	18.83	23.34	89.40	112.74
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Source of N									
S_1	77.42	31.94	109.36	15.57	4.14	19.71	23.61	89.32	112.93
S_2	76.72	32.09	108.81	14.80	4.24	19.04	23.02	90.81	113.83
S_3	70.76	31.33	102.09	14.25	4.64	18.89	21.89	87.03	108.92
CD (P=0.05)	2.13	NS	2.42	NS	NS	NS	0.92	1.12	2.02
Irrigation schedule									
I_1	77.38	31.97	109.35	15.03	4.14	19.17	23.38	88.80	112.18
I_2	75.06	32.46	107.22	15.12	4.81	19.93	23.22	90.18	113.40
I_3	72.35	31.56	109.91	14.26	4.68	18.94	21.91	88.26	110.17
CD (P=0.05)	1.42	NS	1.92	NS	0.29	NS	NS	NS	1.02

Table 5. Nutrient uptake of wheat in rice–wheat cropping system (mean data of 3 years)

Treatment	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Level of puddling									
P_1	58.33	23.13	81.46	13.82	2.18	16.00	17.53	78.13	95.66
P_2	58.31	22.81	81.12	13.64	2.24	15.88	17.59	79.15	96.54
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Source of N									
S_1	61.47	22.70	84.17	14.74	2.18	16.92	18.33	77.70	96.03
S_2	60.47	23.05	83.52	14.42	2.71	17.13	17.58	80.00	97.58
S_3	54.49	22.82	77.31	12.62	2.15	14.75	16.38	77.06	93.44
CD (P=0.05)	1.82	NS	2.21	1.05	0.48	1.15	0.92	1.13	1.82
Irrigation schedule									
I_1	57.81	23.00	80.81	14.03	2.60	16.63	17.79	76.82	94.61
I_2	59.46	21.47	80.93	14.10	2.58	16.68	17.87	76.45	94.32
I_3	58.04	22.85	80.89	13.42	2.16	15.68	17.11	77.18	94.29
CD (P=0.05)	NS	0.62	NS	NS	0.23	NS	NS	NS	NS

higher yield-attributing characters (Table 3).

Total productivity of rice–wheat system

Total productivity of the system differed significantly with integrated management of nutrients. The plots receiving green manure recorded the highest grain yield, followed by FYM incorporation. The lowest total grain production was obtained with the application of inorganic sources of nutrients alone (Table 6). The increase in total grain production from the system was 10.25% and 9.16% with green manure and FYM incorporation, respectively, compared to inorganic source of nutrients. Irrigation schedule of 1 day drainage period after disappearance of 7 cm ponded water resulted in highest grain production, followed by 3 days drainage period. Level of puddling did not cause significant difference in total grain production from the system.

NPK uptake by rice

Total (in grain and straw) N, P, and K uptake by rice due to *Sesbania* incorporation was higher than inorganic source of N but comparable to FYM incorporation. Crop receiving green manure along with 50 kg N/ha through urea removed 109.36, 19.71 and 112.93 kg N, P and K/ha, respectively, followed by FYM incorporation. This might be due to increased and slow supply of nutrients for longer period of the crop growth. Irrigations applied 1 or 3 days after disappearance of 7 cm ponded water accrued higher N, P and K uptake than 5 days drainage period. However, there was no significant variation in nutrients uptake between the 2 levels of puddling (Table 4).

NPK uptake by wheat

The nutrients uptake was not significantly influenced by level of puddling and irrigation schedule followed during the *kharif* rice. However, incorporation of organic sources of nutrients had a significant residual effect on nutrient uptake by wheat. Nutrient status of soil after rice harvest indicated that incorporation of organic material increased the NPK content in soil compared to initial values and had a residual effect on wheat (Table 1). Total uptake of N, P and K by wheat grown in plots receiving green manure and FYM during *kharif* rice was significantly higher than plot receiving only inorganic nutrients (Table 5). The N, P and K uptake with green manure was 84.17, 16.92 and 96.03 kg/ha, respectively, whereas these values for FYM incorporation were 83.52, 17.83 and 95.58 kg/ha. Similar results were obtained by Bhandari *et al.* (1992) and Paikaray *et al.* (2001).

NPK uptake by rice–wheat system

Total NPK uptake in rice–wheat system was not influenced by level of puddling followed during *kharif* rice. However, it was significantly influenced due to incorporation of organic sources supplemented with inorganic source as compared to inorganic source alone (Table 6). *Sesbania* green-manured plots resulted in removal of 193.53 kg N, 36.83 kg P and 208.96 kg K/ha followed by FYM incorporation. The total removal of NPK with *Sesbania* and FYM supplemented with inorganic source was 439.12 and 439.91 kg/ha, respectively, while it was 415.40 kg/ha with inorganic source of nutrients alone.

Total water use and its efficiency of rice–wheat system

Total water use of the system increased with the increase in frequency of irrigation. It was noted that irrigation applied 1 day after disappearance of ponded water consumed more water followed by 3 days drainage period. The minimum water was used when 5 days drainage period was allowed after disappearance of ponded water. However, the WUE was highest with 5 days drainage period after disappearance of ponded water followed by 1 and 3 days drainage period (Table 7).

REFERENCES

Bhandari, A.L., Sood, A., Sharma, K.N. and Rana, D.S. 1992. Integrated nutrient management in a rice–wheat system. *Journal*

Table 6. Total grain production and nutrient uptake of rice–wheat system (mean data of 3 years)

Treatment	Grain yield (kg/ha)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	NPK uptake (kg/ha)
Level of puddling					
P_1	8,646	187.63	35.47	206.75	429.85
P_2	8,839	188.17	34.17	209.28	432.16
CD (P=0.05)	NS	NS	NS	2.05	NS
Source of N					
S_1	9,066	193.53	36.63	208.96	439.12
S_2	8,966	192.33	36.17	211.41	439.91
S_3	8,241	179.40	33.64	202.36	415.40
CD (P=0.05)	520	2.37	1.56	1.96	3.13
Irrigation schedule					
I_1	8,888	190.16	35.81	206.79	432.76
I_2	8,780	188.13	36.81	207.72	432.66
I_3	8,450	184.80	34.62	204.46	423.88
CD (P=0.05)	310	2.05	1.05	1.32	1.97

Table 7. Total water use and water-use efficiency (WUE) of rice–wheat system as influenced by irrigation schedule (mean data of 3 years)

Treatment	Water applied (Rice + wheat) (cm)	Effective rainfall (cm)	Total water use (cm)	WUE (kg/ha-cm)
I_1	86	43.40	129.40	68.69
I_2	72	48.73	120.73	72.72
I_3	65	51.33	116.33	72.66

of Indian Society of Soil Science **40** : 742–747.

Bindra, A.D. and Thakur, R.C. 1996. Inclurence of green manures alongwith fertilizer on nitrogen, phosphorus and potassium contents in rice. *Oryza* **33** : 143–145.

Das, K., Medhi, D.N. and Guha, B. 2001. Recycling effect of crop residues with chemical fertilizers on physico-chemical properties of soil and rice (*Oryza sativa*) yield. *Indian Journal of Agronomy* **46** : 648–653.

Hegde, D.M. and Dwivedi, B.S. 1992. Nutrient management in rice–wheat cropping system in India. *Fertiliser News* **37** : 27–41.

Paikaray, R.L., Mahapatra, B.S. and Sharma, G.L. 2001. Integrated nitrogen management in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **46** : 592–600.

Patra, A.K., Nayak, B.C. and Mishra, M.M. 2000. Integrated nutrient management in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **45** : 453–457.

Yadâv, D.S. and Kumar, A. 1993. System based integrated nutrient management for sustainable cropping system in Uttar Pradesh. *Fertiliser News* **38** : 45–51.