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Effect of integrated nutrient management on yield and nutrient uptake of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system in lowlands of eastern Uttar Pradesh

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ABSTRACT

A field experiment was conducted during 1999-2002 at Crop Research Station, Ghaghraghat, Bahraich to study the effect of integrated nutrient supply on yield, yield attributes, nutrient uptake and economics of rice (*Oryza sativa* L.)–wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] cropping system and soil fertility. Application of 25% recommended dose of N (RDN) through pressmud and the rest 75% NPK through inorganic fertilizers to both crops increased the grain yield of rice and wheat by 51.1 and 56.2% respectively over no NPK treatment. Addition of zinc with 100% of recommended NPK through inorganic fertilizers gave higher grain and straw yields of both rice and wheat over 100% of recommended NPK alone. The rice-equivalent yield and total uptake of N, P and K by rice-wheat system were highest with 25% RDN through pressmud + 75% RDF through inorganic fertilizers, followed by 50% RDN through pressmud + 50% RDN through inorganic fertilizers. The net income and benefit : cost ratios were also highest with 25% of recommended N through pressmud and the rest 75% NPK through inorganic fertilizer. The content of organic carbon and available phosphorus in soil improved in all integrated nutrient-management practices than its initial soil status. The value of potassium, bulk density, pH and electrical conductivity decreased in all the integrated nutrient-management practices compared with its initial soil status.

Key words : Integrated nutrient management, rice-wheat cropping system, Lowlands, Eastern U.P.

Rice (*Oryza sativa*)–wheat (*Triticum aestivum*) system plays a significant role in food security, contributing 76% to the total foodgrain production of the country. This system occupies 9.7 million ha in India (Jhoshi and Tripathi, 2006), out of which Uttar Pradesh accounts for 4.0 million ha. In lowlands area, the excess moisture remains in the soil after harvest of rice, which delays the sowing of winter season (*rabi*) crops like lentil, linseed, Indian mustard and pea, resulting in poor productivity. Under such a situation growing of wheat is the only option. Both crops in rice-wheat system are fertility exhaustive, and result in decline of soil-organic carbon and deterioration in soil health. Continuous and imbalanced use of inorganic fertilizers leads to decline or stagnation in productivity due to limitation of one or more nutrients. The results of long-term fertilizer experiments revealed that sustainable production of rice-wheat cropping system could be achieved only by maintaining a balance between supply and demand of nutrients by integration of inorganics, and organic sources of nutrients like farmyard manure, pressmud and crop residues. The present investigation was therefore taken up to study the effect of various organic manures and inorganic fertilizers on productivity of both the crops and on soil fertility after rice-wheat cropping system in lowlands.

MATERIALS AND METHODS

A field experiment was conducted during 1999-2002 at Crop Research Station, Ghaghraghat (Bahraich). The soil was sandy-loam, with pH (1:2) 8.2, organic carbon 0.40%, available N 228 kg/ha, P_2O_5 19.6 kg/ha and K_2O 176 kg/ha before starting the experiment. There were 13 treatments, viz. T_1, no NPK; T_2, 100% of recommended dose of fertilizers (RDF) through inorganic fertilizers; T_3, 25% of recommended dose of N (RDN) through farmyard manure and 75% RDF through inorganic fertilizers; T_4, 50% of recommended dose of N (RDN) through farmyard manure and 50% RDF through inorganic fertilizers; T_5, 75% of recommended dose of N (RDN) through farmyard manure and 25% RDF through inorganic fertilizer; T_6, 25% of recommded dose of N (RDN) by pressmud and 75% RDF through inorganic fertilizer; T_7, 50% of recommded dose of N (RDN) through pressmud and 50% RDF through inorganic fertilizer; T_8, 75% of recom-

mended dose of N (RDN) through pressmud and the rest 25% RDF through inorganic fertilizer; T_9, 25% of recommended dose of N (RDN) through paddy straw and 75% RDF through inorganic fertilizer; T_{10}, 50% of recommended dose of N (RDN) through paddy straw and 50% RDF through inorganic fertilizer; T_{11}, 75% of recommended dose of N (RDN) through paddy straw and 25% RDF through inorganic fertilizer; T_{12}, 100% of recommended dose of fertilizers (RDF) through inorganic fertilizers + $ZnSO_4$ @ 25 kg/ha; and T_{13}, farmer's practice @ 40% N + 30 P_2O_5 kg/ha + FYM @ 2 tonnes/ha. These were tested in randomized block design with three replications, keeping the lay-out undisturbed throughout the field experimentation. The rice and wheat crops were fertilized @ 120 kg N, 60 kg P_2O_5 and 50 kg K_2O/ha. The organic sources like farmyard manure (FYM), pressmud and paddy straw were incorporated in the respective treatment 20 days before sowing both the crops. The whole quantify of P and K and half that of N were applied basal to both the crops, and the remaining amount of N was top-dressed in two equal splits at tillering (35 days after transplanting) and panicle-initiation stage (85 days after sowing) in rice, and after first irrigation and second irrigation in wheat crop. Seedlings of rice 'Mahsuri' at 25 days were transpanted 20 × 10 cm apart in the second week of July, and wheat 'HUW 234' was sown in rows 20 cm apart, using 125 kg seed/ha on 15 December in all years. All improved packages of practices were followed to raise both the crops. The soil analysis before and after three cropping seasons was done by using standard methods. An amount of 995 mm, 1012 mm and 980 mm rainfall in *kharif* and 102, 94 and 97 mm in *rabi* was received in 1999–2000, 2000–01 and 2001–02 respectively.

RESULTS AND DISCUSSION

Growth and yield attributes

All the growth and yield parameters improved significantly due to integrated nutrient-management practice (T_3 to T_{11}) treatments over the rest of the treatments. The application of organic manures in these treatments and their subsequent decomposition in soil released the plant nutrients slowly throughout the crop growth and thus improved all the yield attributes of both the crops. Das *et al.*, (2003) reported similar results. The highest values of these parameters were recorded with integrated use of pressmud along with inorganic fertilizer, followed by FYM and paddy straw. This was owing to higher availability of nutrients to crop owing to narrow C : N ratio of pressmud compared with that of farmyard manure and paddy straw.

Table 1. Yields, rice-equivalent yield and economics as influenced by integrated nutrient-management practices

Treatment	Grain yield (q/ha)		Straw yield (q/ha)		Rice-equivalent yield (q/ha)	Economics			
	Rice	Wheat	Rice	Wheat		Cost (Rs/ha)	Net income (Rs/ha)	Cost : benefit ratio	Productivity (kg/ha)
T_1	17.90	18.25	21.48	25.55	46.38	20,090	3,102	1.15	15.99
T_2	34.62	38.10	48.46	54.34	94.73	24,386	22,980	1.94	33.17
T_3	34.50	39.21	48.64	55.87	96.18	24,812	23,280	1.94	32.42
T_4	33.72	38.32	47.54	54.75	94.02	25,240	21,772	1.86	30.00
T_5	31.15	35.40	44.23	51.43	87.02	25,664	17,847	1.70	35.30
T_6	36.62	41.62	52.11	60.76	102.36	24,362	26,821	2.10	33.06
T_7	34.29	38.97	47.97	56.85	95.72	24,338	23,526	1.97	30.58
T_8	31.77	36.11	44.45	52.57	88.68	24,314	20,178	1.84	31.31
T_9	32.51	36.95	45.84	53.94	90.82	24,562	20,848	1.85	30.53
T_{10}	31.68	36.01	44.98	52.68	88.52	24,740	19,542	1.79	27.87
T_{11}	28.91	32.86	40.76	48.30	80.81	24,914	15,491	1.62	33.54
T_{12}	35.30	38.85	51.59	57.10	97.27	25,086	23,482	1.93	21.01
T_{13}	21.79	24.77	31.59	36.28	61.01	22,850	7,658	1.34	
CD (P=0.05)	2.41	2.73	3.61	4.01	5.11				

Cost (Rs/q); FYM 25, pressmud 35, paddy straw 17, rice grain 500; rice straw 30, wheat grain 630, wheat straw 80

T_1, no NPK; T_2, 100% recommended dose of nutrients (RDF); T_3, 25% RDN through FYM + 75% RDF through inorganic fertilizers; T_4, 50% RDN through FYM + 50% RDF through inorganic fertilizers; T_5, 75% RDN through FYM + 25% RDF through inorganic fertilizers; T_6, 25% RDN through pressmud + 75% RDF through inorganic fertilizers; T_7, 50% RDN through pressmud + 50% RDF through inorganic fertilizers; T_8, 75% RDN through pressmud + 25% RDF through inorganic fertilizers; T_9, 25% RDF through paddy straw + 75%RDF through inorganic fertilizers; T_{10}, 50% RDN through paddy straw + 50% RDF through inorganic fertilizers; T_{11}, 75% RDN through paddy straw + 25% RDF through inorganic fertilizers; T_{12}, 100% RDF through inorganic fertilizers + $ZnSO_4$ @ 25 kg/ha; T_{13}, Farmer's practice
RDN, recommended dose of N; RDF, recommended dose of fertilizers

Yield

Integrated use of inorganic fertilizer either 25 or 50% of RDN through FYM, pressmud and paddy straw and the rest RDF through inorganic fertilizers gave significantly higher grain and straw yields of both rice and wheat over 75% of RDN through organic sources and 25% RDF through inorganic fertilizers (Table 1).

Application of 25% RDN through pressmud + 75% RDF through inorganic fertilizers (T_6) gave significantly highest grain and straw yields of both rice and wheat than the rest of the treatments, except treatments T_2, T_3 and T_7 in rice and T_3 and T_6 treatments in wheat. The higher response of pressmud combinations compared with that of FYM and paddy straw might be due to higher availability of nutrients to both the crops owing to narrow C : N ratio in the former. Ram and Saha (1992) also reported similar results. However, excessive immobilization and fixation of available soil N caused temporary deficit, and severe N starvation of rice and wheat plants resulted in poor efficiency of paddy-straw combinations. Both the crops fertilized @ 100% of recommended NPK through inorganic fertilizer + $ZnSO_4$ (T_2) gave higher yield than that of 100% of recommended NPK alone through inorganic fertilizers (T_2). Singh *et al.,* (2001) also reported similar positive response of Zn with NPK. The rice-equivalent yield was also highest with T_6 (Table 1). The increase in total productivity of the system was 7.6 at 25% recommended dose of N through pressmud and 75% RDF through inorganic fertilizer (T_6) over full recommended dose of fertilizer through inorganic fertilizer (T_2).

NPK uptake by rice-wheat system

The pressmud-incorporated treatments resulted in highest removal of N, P and K by rice + wheat crops, followed by farmyard manure and paddy straw-treated plot. The highest uptake of N, P and K by rice + wheat crops was recorded in the plot receiving 25% RDN through pressmud + 75% RDF through organic fertilizers (T_6). The total removal of NPK through rice-wheat cropping system was also highest (422.1 kg/ha) with treatment (T_6), followed by 50% RDN by pressmud and 50% RDF through inorganic fertilizers (T_7) (412.3 kg NPK/ha). Addition of zinc along with 100% RDF (T_2) improved significantly the depletion of NPK by rice–wheat system compared with 100% RDF through inorganic fertilizers (T_2).

Economics

The cost of cultivation was marginally higher when the nutrient was applied in combination, but due to higher grain and straw yields the net income and benefit : cost ratio were also higher in the integrated use of organic and inorganic fertilizers (Table 1). The highest net income and benefit : cost ratio (2.10) accured with application of 25% RDN through pressmud and the rest 75% NPK through inorganic fertilizers (T_8). This was because of higher yield of rice and wheat with these treatments than with no farmyard manure and paddy straw treatments.

Soil fertility

The values of organic carbon content of the soil in-

Tablel 2. Nutrient uptake (kg/ha) and soil fertility as influenced by integrated nutrient-management practices

Treatment	Nutrient uptake (kg/ha)						Total NPK uptake (kg/ha)		Organic C	Soil fertility after 3 years			Bulk density
	Nitrogen		Phosphorus		Potassium					Available nutrient (kg/ha)			
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	(%)	N	P_2O_5	K_2O	(mg/m³)
T_1	23.6	39.6	9.5	7.0	26.5	51.1	72.7	84.3	0.28	218	16.1	136	1.56
T_2	58.6	100.9	25.5	17.7	75.4	117.2	185.0	210.3	0.36	225	16.5	140	1.54
T_3	54.8	98.6	24.0	17.2	75.1	116.3	177.4	208.6	0.37	252	22.2	142	1.50
T_4	59.8	99.3	24.6	17.4	76.2	115.6	183.7	209.2	0.38	256	22.5	144	1.49
T_5	53.2	94.9	22.1	16.8	69.0	110.1	170.2	195.9	0.39	261	23.0	145	1.48
T_6	62.5	107.2	25.8	19.1	81.7	126.1	195.5	226.9	0.36	256	22.7	138	1.49
T_7	65.0	103.9	26.1	18.4	78.2	120.7	195.0	217.3	0.37	260	23.1	142	1.47
T_8	57.3	99.1	23.4	17.5	71.0	114.1	179.8	202.6	0.38	265	24.2	147	1.45
T_9	54.4	95.1	24.9	15.4	70.8	112.9	174.4	199.1	0.37	247	21.7	144	1.46
T_{10}	57.3	94.3	23.1	15.7	71.7	112.0	174.7	199.4	0.38	250	22.0	149	1.45
T_{11}	49.8	88.6	20.8	14.8	63.6	103.9	159.2	182.3	0.40	255	22.9	151	1.44
T_{12}	61.3	105.6	26.6	18.8	81.7	124.5	193.5	225.0	0.35	227	20.2	141	1.53
T_{13}	34.5	58.5	14.1	10.3	40.9	102.3	107.1	153.5	0.30	220	16.5	140	1.55
CD (P=0.05)	2.6	1.8	0.8	0.7	1.1	2.4	1.7	2.7					
Initial value									0.32	235	19.6	176	1.56

Details of treatments are given with Table 1

creased from initial status of 0.32% to 0.40% with T_3 to T_{11}, 0.39 with T_5 and 0.38 with T_8 treatments (Table 2). Singh *et al.* (2000) reported similar improvements in organic carbon content in soil with the combined use of organic and inorganic fertilizer. However, application of 100% RDF through inorganic fertilizers slightly improved the organic carbon content due to rapid mineralization and absence of formation of organic mineral complexes (Yoshida and Padre, 1975).

The available N of soil improved from the initial values of 235 kg/ha to 265 kg/ha with T_8, 261 kg N/ha with farmyard manure (T_4) and 255 kg N/ha with paddy straw treatments (T_{11}). Available K status of the soil decreased in all the treatments due to higher removal by crop and inadequate addition of K through fertilizer. Mishra and Sharma (1997) and Singh *et al.* (2000) also reported similar results. The values of bulk density, pH and EC decreased under integrated use of treatments (T_3 to T_{11}) compared with the rest of the treatments. This could be ascribed to higher organic carbon content in these treatments, which had better soil aggregate and higher macropore space (Bellaki *et al.,* 1998).

It was concluded that 25 to 50% of the recommended dose of nitrogen may be substituted by pressmud to obtain higher yields and benefit : cost ratio from rice-wheat cropping system in lowlands of eastern Uttar Pradesh.

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