Indian Journal of Agronomy **51** (2) : 81–84 (June 2006)

Productivity and economics of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system under integrated nutrient-supply system in recently reclaimed sodic soil

VINAY SINGH

Department of Agricultural Chemistry and Soil Science, Raja Balwant Singh College, Bichpuri, Agra, Uttar Pradesh 283105

Received : March 2005

ABSTRACT

A field experiment was conducted during the rainy and winter seasons of 2001–04 to study the influence of integrated nutrient-supply system, comprising inorganic fertilizers and organic manures on the soil-fertility status, productivity and economics of rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system. Three organic manures @ 10 tonnes/ha, viz. farmyard manure (FYM), *Sesbania canabina* (Retz.) Pers. (*dhaincha*) and cut rice straw were added at 50 and 100% of the recommended doses of NPK fertilizers. The green-manure *dhaincha* [*Sesbania cannabina* (Retz.) Pers. syn, *S. aculeata*] applied with 100% of recommended dose of NPK fertilizers gave the maximum yield of rice as well as wheat crop. This treatment also gave the highest net return and benefit : cost ratio and produced significantly higher biomass in terms of rice-equivalent yield. The total uptake of N, P, K and Zn by both the crops increased significantly with the application of fertilizers or their combined use with organic manures. Among the organic manures the overall performance of green-manure was the best, followed by farmyard manure and cut rice straw. Application of farmyard manure and cut rice straw as well as green-manuring in rice and wheat significantly improved the available N, P, K and Zn status of the soil.

Key words : Rice-wheat, Integrated nutrient management, Reclaimed sodic soil

Rice and wheat sequential cropping plays a significant role in food security of India. Growing of two cereal crops in a year involves heavy removal of plant nutrients, which diminishes the soil fertility. It is therefore necessary to judiciously manage the inflow of organic sources of nutrients, and their integration with fertilizers, green-manures and recycling of crop residues, besides the adoption of package of practices by the Indian farmers. An experiment was therefore conducted to evaluate the productivity and economics of rice-wheat cropping system under integrated nutrient supply system and its influence on soil fertility status.

MATERIALS AND METHODS

The field experiment was conducted in the rainy (*kharif*) and winter (*rabi*) seasons of 2001–02 to 2003–04 at Jamon (Etah district) on recently reclaimed sodic soil with pH 9.2, organic carbon 2.0 g/kg; and the available N 130.4 kg/ha, P 10.4 kg/ha and K 192.0 kg/ha; and DTPA-Zn 0.56 mg/kg. There were 13 treatment combinations (Table 1) replicated four times in randomized block design. Rice (var. 'Pant 10') and wheat (var. 'HD 2329') were grown as the test crops. The recommended dose of fertilizers was 120 kg N/ha, 60 kg P_2O_5/ha and 60 kg K_2O/ha for both rice and wheat. The treatments comprised application of different combinations of inorganic and organic sources of nutrients to rice and wheat. The NPK contents of FYM, cut rice straw and *dhaincha* on oven-dry basis were 0.90, 0.25 and 0.30; 0.45, 0.11 and 2.0 and 2.0, 0.22 and 1.80% respectively. The grain and straw (rice and wheat) samples were analysed for their N content by Kjeldahl method. The grain and straw samples were digested in diacid (HNO_3, $HClO_4$, 4:1) mixture. Phosphorus was estimated in diacid digest by Vanadomolybdo phosphoric-yellow colour method. The extract was used for the determination of K by flame-photometer and zinc by atomic-absorption spectrophotometer. Sulphur in the digest was determined turbidimetrically. The soil samples collected after 3 years were analysed for available N by alkaline permanganate method, P by Olsen's method, K by flame-photometer after extraction with 1 N NH_4OAc (pH 7) and zinc by atomic-absorption spectrophotometer in DTPA-extract (Lindsay and Norvell, 1978). Data on grain and straw yields, total productivity/ha/year (grain and bio-

mass), gross monetary returns, net monetary returns and benefit : cost ratio obtained from the cropping sequence during the 3 years were pooled. Economics of fertilizer application in the cropping system was worked out.

RESULTS AND DISCUSSION

An increase in the levels of NPK applied both to rice and wheat increased their grain and straw yields significantly, giving the additional values at 150% recommended dose, i.e. 6.42 and 3.38 q/ha compared with 100% NPK (34.67 and 41.18 q/ha) in rice and wheat respectively. Application of higher amounts of nutrients increased the availability of nutrients in root zone, and thus greater uptake of nutrients by plants resulted in higher grain and straw production. Das *et al.* (2003) also reported similar results. By and large the application of *dhaincha* with 100 or 50% of the recommended dose of NPK proved significantly superior to other organic sources, followed by FYM and cut rice straw, which were inferior with 100% and 50% NPK. The application of *dhaincha* with 50% recommended dose of NPK gave rice yield equal to that of the 100% recommended NPK through chemical fertilizers. Though the highest rice yield was obtained at 150% NPK, it was on a par with that of 100% NPK dose + 10 tonnes/ha *dhaincha*. Amongst the different organics, *dhaincha* proved significantly superior to FYM and cut rice straw treatment, perhaps because of its fast decomposition, which led to better availability or release of the nutrients compared with other organic materials. Bhandari *et al.* (1992) also reported similar results.

Application of 10 tonnes/ha FYM or cut rice straw or *dhaincha* alone increased the yields of wheat grain and straw significantly compared with the control. The maximum yield of wheat was obtained at 150% NPK, which was on a par with that at 100% NPK + 10 tonnes/ha *dhaincha*. The results thus show that 50% NPK requirement can be supplemented through 10 tonnes/ha organics, indicating the essentiality of integrated use of different nutrient sources for maximizing the crop production. Bajpai *et al.* (2002) also reported similar results. The total grain and straw productivity in terms of rice-equivalent yield was higher at 100% NPK + 10 tonnes/ha *dhaincha*.

Table 1. Production potential and economics of rice–wheat crop sequence (mean data of 2001–04)

Treatment	Yield (q/ha)		Net profit (Rs/ha)	Benefit : cost ratio	Total rice-equivalent yield (q/ha)	
	Rice	Wheat				
T_0, Control	21.92 (43.80)	22.72 (32.94)	12,437	1.64	47.94	109.6
T_1, 10 t/ha FYM	25.17 (51.05)	26.85 (37.60)	16,655	1.81	55.92	126.2
T_2, 50% NPK	29.38 (60.67)	32.82 (45.27)	22,238	2.00	66.97	151.21
T_3, 50% NPK + 10 t/ha FYM	33.83 (69.63)	39.83 (57.56)	29,798	2.28	79.45	185.15
T_4, 100% NPK	34.67 (71.78)	41.18 (58.29)	29,529	2.18	81.83	188.36
T_5, 100% NPK + t/ha FYM	40.32 (82.00)	44.15 (63.92)	34,582	2.33	90.89	209.84
T_6, 10 t/ha cut rice straw	25.0 (58.35)	26.57 (37.19)	17,109	1.85	55.43	132.73
T_7, 50% NPK + 10 t/ha cut rice straw	33.05 (68.42)	38.49 (53.88)	28,477	2.25	77.13	176.18
T_8, 100% NPK + 10 t/ha cut rice straw	40.00 (81.91)	43.95 (63.52)	34,635	2.35	90.34	208.95
T_9, 10 t/ha *dhaincha*	27.17 (58.52)	28.32 (39.18)	18,613	1.88	59.60	136.88
T_{10}, NPK + 10 t/ha *dhaincha*	34.69 (72.64)	39.08 (56.37)	29,213	2.22	79.45	185.38
T_{11}, 100% NPK+10 t/ha dhaincha	40.84 (84.65)	44.35 (63.86)	34,521	2.30	91.64	212.37
T_{12}, 150% NPK	41.09 (85.66)	44.56 (64.16)	33,729	2.22	92.13	213.98
CD (P=0.05)	4.91 (5.97)	4.51 (4.09)				

Figures in parentheses indicate straw or stover yield

Recommended level of fertilizer NPK (100%) was 120 (N_{120}), 60 (P_{60}) and 60 (K_{60}) kg/ha of N, P and K respectively

This was however equal to that at 150% recommended dose of NPK. Thus there was a saving of 50% NPK by *dhaincha* on system basis. The net monetary return was highest at 100% NPK + 10 tonnes cut rice straw followed by 100% NPK + 10 tonnes/ha *dhaincha* and 100% NPK + 10 tonnes/ha FYM compared with that of 150% NPK to both rice and wheat (Rs 33,729/ha). The highest benefit : cost ratio was observed at 100% NPK + 10 tonnes/ha FYM and 100% NPK + 10 tonnes/ha *dhaincha*.

Nutrient uptake

The data (Table 2) indicate that the uptake of N, P, K, S and Zn increased significantly under all the treatments compared with the control in both rice and wheat. The increase in N uptake by different treatments varied from 17.8 to 112.0% in rice and 24.0 to 160.4% in wheat compared with the control. Application of 100% NPK + 10 tonnes/ha organics gave values of N uptake similar to those obtained at 150% NPK. Similar to the uptake of N, that of P and K in rice and wheat also increased significantly up to 150% NPK over the control. The uptake of P and K was significantly higher with *dhaincha* than with FYM and cut rice straw. Total uptake of S by rice increased from 9.0 kg/ha in the control to 24.8 kg/ha at 150% NPK. The increase in S uptake by wheat was 8.0 to 24.2 kg/ha at 100% NPK + 10 tonnes/ha *dhaincha*. The maximum total uptake of Zn by rice was recorded at this fertilizer level and of wheat at 100% NPK + 10

Table 2. Total uptake of N, P, K, S (kg/ha) and Zn (g/ha) by rice and wheat crops

Treatment	Rice					Wheat				
	N	P	K	S	Zn	N	P	K	S	Zn
T_0, Control	63.5	8.5	99.0	9.0	133.1	59.4	6.5	80.5	8.0	97.9
T_1, 10 t/ha FYM	74.8	11.2	116.9	11.1	179.6	73.7	8.2	94.6	10.5	134.1
T_2, 50% NPK	91.3	13.8	141.9	13.6	180.8	93.3	10.8	116.1	12.3	140.5
T_3, 50% NPK + 10 t/ha FYM	105.4	16.8	164.7	17.1	242.1	120.0	14.8	149.7	18.1	206.0
T_4, 100% NPK	111.3	18.3	172.5	17.6	209.0	127.9	17.1	155.8	18.4	168.4
T_5, 100% NPK + 10 t/ha FYM	130.4	22.4	200.0	22.0	284.9	143.7	21.7	175.7	22.5	231.0
T_6, 10 t/ha cut rice straw	77.9	11.4	131.7	11.7	192.6	74.0	8.0	94.4	10.3	114.7
T_7, 50% NPK + 10 t/ha cut rice straw	101.2	15.5	161.3	16.9	236.3	114.7	13.7	143.2	16.6	171.3
T_8, 100% NPK + 10 t/ha cut rice straw	127.5	21.0	199.6	22.7	282.1	141.2	20.0	174.9	22.3	212.4
T_9, 10 t/ha *dhaincha*	82.8	13.3	133.9	12.4	201.9	82.5	9.1	101.5	12.0	136.6
T_{10}, 50% NPK + 10 t/ha *dhaincha*	108.9	18.2	167.9	18.2	251.6	126.6	15.0	150.2	19.3	195.3
T_{11}, 100% NPK + 10 t/ha *dhaincha*	132.4	22.9	205.8	24.2	292.0	147.8	20.7	154.5	24.2	228.9
T_{12}, 150% NPK	134.7	24.4	210.3	24.8	247.6	154.7	22.9	181.5	23.3	178.0
CD (P=0.05)	3.7	1.8	3.4	1.3	5.6	8.2	3.7	8.2	3.2	13.7

Recommended fertilizer level (NPK) = $N_{120}P_{60}K_{60}$

Table 3. Available NPK (kg/ha) and Zn (mg/kg) in the soil

Treatment	After rice harvest				After wheat harvest			
	N	P	K	Zn	N	P	K	Zn
T_0, Control	83.3	9.4	184.0	0.56	73.0	7.7	176.6	0.52
T_1, 10 t/ha FYM	100.4	11.2	211.0	0.65	102.8	11.4	210.3	0.66
T_2, 50% NPK	102.8	11.7	216.0	0.54	105.0	12.0	216.0	0.52
T_3, 50% NPK + 10 t/ha FYM	138.6	12.8	236.0	0.64	141.7	12.9	238.3	0.65
T_4, 100% NPK	140.1	13.0	233.8	0.53	142.8	13.0	233.6	0.50
T_5, 100% NPK + 10 t/ha FYM	170.7	14.8	251.0	0.63	171.6	14.9	254.0	0.63
T_6, 10 t/ha cut rice straw	90.4	10.7	202.0	0.59	92.7	10.9	201.7	0.59
T_7, 50% NPK + 10 t/ha cut rice straw	128.9	12.1	223.0	0.58	130.1	12.2	224.0	0.56
T_8, 100% NPK + 10 t/ha cut rice straw	166.9	14.4	241.0	0.57	171.2	14.5	243.0	0.61
T_9, 10 t/ha *dhaincha*	104.4	11.5	213.0	0.62	107.4	10.9	214.6	0.62
T_{10}, 50% NPK + 10 t/ha *dhaincha*	146.8	12.9	232.0	0.62	147.3	12.8	231.3	0.62
T_{11}, 100% NPK + 10 t/ha *dhaincha*	175.0	15.1	250.0	0.63	176.7	15.5	255.0	0.63
T_{12}, 150% NPK	177.8	15.3	246.0	0.54	179.2	15.5	245.6	0.50
CD (P=0.05)	5.0	0.2	12.3	0.02	4.8	0.3	12.2	0.02

Recommended fertilizer level (100% NPK) = $N_{120}P_{60}K_{60}$

tonnes/ha FYM. Higher total uptake of all the five nutrients (N, P, K, S and Zn) at harvest due to combined application of organics and fertilizers might have resulted in higher yields. Similar observations were reported for NPK uptake by Das *et al.* (2003).

Available nutrients

The available N, P, K and Zn status of the soil decreased appreciably in the control plots on continuous cropping of rice and wheat grown in sequence (Table 3). The application of organic manures and chemical fertilizers individually and in combination increased the available N by 7.1–94.5 kg/ha after rice and 19.7–106.2 kg/ha after wheat over control. The soil-available P increased by 1.3–5.9 kg/ha after rice and 3.2-7.8 kg/ha after wheat. Similarly soil-available K recorded an increase of 18.0-66.0 kg/ha after rice and 25.1–78.4 kg/ha after wheat. Bellakki and Badanur (1997) also reported that sunnhemp alone or in combination with inorganic fertilizers significantly increased the available N and P status of the soil. The zinc status decreased with increase in the level of NPK fertilizers, but increased by 0.09 mg/kg after rice and 0.14 mg/kg after wheat on application of 10 tonnes/ha FYM. Among the different organics, FYM and *dhaincha* registered more increase in the available nutrients. The cut rice straw proved relatively less effective in increasing the status of these nutrients.

ACKNOWLEDGEMENT

We are thankful to National Agricultural Technology Project (ICAR), New Delhi for providing the financial support during the entire course of the study.

REFERENCES

Bajpai, R.K., Upadhyaya, S.K., Joshi, B.S. and Triapthi, R.S. 2002. Productively and economics of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system under integrated nutrient supply systems. *Indian Journal of Agronomy* **47**(1) : 20–25.

Bellakki, M.A. and Badanur, V.P. 1997. Long term effect of integrated nutrient management on properties of vertisol and dry land agriculture. *Journal of Indian Society of Soil Science* **45**(3) : 438–442.

Bhandari, A.L., Sood, Anil, Sharma, K.N. and Rana, D.S. 1992. Integrated nutrient management in a rice–wheat system. *Journal of Indian Society of Soil Science* **40** : 742–747.

Das, K., Medhi, D.N. 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 Journal of Agronomy* **48**(1) : 8–11.

Lindsay, W.L. and Norvell, W.A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Journal, Soil Science Society of America* **42** : 421–428.