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Effect of organic and inorganic sources of nutrients on rice (*Oryza sativa*) – wheat (*Triticum aestivum*) cropping system

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ABSTRACT

A field experiment was conducted during 2002-03 to 2004-05 at Malan, Himachal Pradesh, to explore the possibility of an alternative to farmyard manure (FYM) as a component of integrated nutrient management in rice (*Oryza sativa* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system. Five organic sources, viz. FYM 5 t/ha *gobhi sarson* straw 5 t/ha, mushroom spent compost 2.5 t/ha, FYM 2.5 t/ha + *gobhi sarson* straw 2.5 t/ha, FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha, were applied in all possible combinations at three fertility levels, viz. 50, 100 and 150% of recommended fertilizer dose (RDF) to rice crop. Direct and residual effects of organic sources significantly affected the productivity of rice-wheat cropping system. Statistically equal rice and wheat yields were obtained with application of FYM 5 t/ha (5.03 t/ha rice, 2.48 t/ha wheat) and FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha (4.94 t/ha, 2.33 t/ha), whereas *gobhi sarson* straw 5 t/ha recorded lower yields (4.24 t/ha, 1.99 t/ha). Rice responded significantly up to 100% recommended dose (4.77 t/ha); residual effects of fertility levels on wheat did not differ significantly. Standard control (100% RDF to both crops) resulted in significantly higher grain yield of wheat compared with mean of others receiving only 50% RDF. Nutrient uptake uptake (159.1 kg N, 35.0 kg P and 147.9 kg K/ha) and net returns (Rs 41,535/ha) from the rice-wheat cropping system recorded higher values with FYM 5 t/ha, followed by FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha (155.0 kg N, 32.5 kg P and 139.0 kg K/ha; Rs 39,132/ha). The soil-available NPK status remained fairly constant under different treatments. Thus, FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha applied to rice helped in sustained productivity and profitability of the cropping system statistically equal to that with FYM 5 t/ha.

Key words: Integrated nutrient management, Mushroom spent compost, Nutrient uptake, Productivity, Profitability, Rice–wheat system

Rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L. emend. Fiori & Paol.) is the major cropping system in India, covering 10-12 million ha area and contributing 22% to the total foodgrain production. This system is equally important in Himachal Pradesh. There are indications of stagnation or even decline in the productivity of this cropping system due to decline in soil-organic matter, over-mining of nutrient reserves, loss of nutrients and non-availability of cost-effective fertilizers. Further, the application of inorganic fertilizers even in balanced form may not sustain soil fertility and productivity under continuous cropping. However, integrated use of inorganic and organics including crop residues may improve the soil productivity (Chettri and Bandhopadhaya, 2005; Mankotia, 2007). Farmyard manure is the proven source of nutrition to agricultural crops but its availability is quite inadequate (Misra and Prasad, 2000). Growing of leguminous green-manures is not possible in hills between harvest of wheat and transplanting of rice due to inadequate duration and greater dependence on rains. In this context, use of locally available low-value crop residues and other locally available organic materials can be a good option for supplementing the scarce farmyard manure and chemical fertilizers. *Gobhi sarson* (*Brassica napus* sp. *oleifera* var. *annua*) since its introduction in the state has replaced considerable rainfed wheat area. The straw of *gobhi sarson*, being a low profile fodder for cattle, is generally disposed off from the field either by removing or by burning, which otherwise is a potent source of organic carbon and plant nutrients. Also, as Himachal Pradesh is quite suitable for mushroom growing, considerable mushroom spent compost is available, which can be used suitably for crop production (Wuest *et al.*, 1995; Sangwan *et al.*, 2002). In view of this an experiment was planned to evaluate the chopped straw of *gobhi sarson* and mushroom spent compost alone or in combination with farmyard manure and different fertility levels in rice - wheat system.

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MATERIALS AND METHODS

A field experiment was conducted during 2002-03 to 2004-05 on Himalayan acid alfisols at Rice and Wheat Research Centre, Malan (76º2'N 32º1'S 950 m above mean sea-level, average annual rainfall 1,900 mm). The zone is categorized as mid-hill sub-humid zone. The soil was silty clay-loam, acidic (pH 5.7) in reaction, having available N 314 kg/ha, P 8.5 kg/ha, K 145.0 kg/ha and organic C 0.59%. Five organic sources, viz. FYM 5 t/ha on dry-weight basis, *gobhi sarson* straw 5 t/ha, mushroom spent compost 2.5 t/ha, FYM 2.5 t/ha + *gobhi sarson* straw 2.5 t/ha, FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha (*gobhi sarson* straw and mushroom spent compost applied on N-content basis to equate total N as in FYM 5 t/ha) were applied in all possible combinations at three fertility levels, viz. 50, 100 (90 kg N + 17.4 kg P + 33.3 kg K/ha) and 150% of recommended fertility level to rice crop. The succeeding wheat crop was raised with only 50% of the recommended dose of fertilizers to study the residual effect of organics and chemical fertilizers applied to rice. One standard control (100% of recommended dose of chemical fertilizers only, to both the crops in rotation) was also maintained, thereby forming a total of 16 treatment combinations, which were laid out in randomized block design with three replications. Chopped *gobhi sarson* straw and other organic sources were incorporated at the time of puddling. The N content in *gobhi sarson* straw (0.50-0.54%), mushroom spent compost (1.0-1.05%) and FYM (0.50-0.53%) was estimated before incorporation. The amount of crop residue (*gobhi sarson*) in terms of dry matter added was the same as that of farmyard manure because the N content in both was almost equal, whereas in mushroom spent compost it was reduced to half because the N content was almost double to that of in FYM (as per treatment). The moisture content in FYM, *gobhi sarson* straw and mushroom spent compost was 75, 5 and 67%, respectively. The organics applied singly or in combination supplied 25.8 kg N/ha in each of the five organics source treatments. FYM 5 t, *gobhi sarson* straw 5 t and mushroom spent compost 2.5 t contained 4.75, 3.60 and 13.0 kg P and 21.5, 42.0 and 25.5 kg K, respectively. The rice cv 'RP 2421' was transplanted in the first fortnight of July at 20 cm x 15 cm crop geometry. Half the fertilizer N through urea, and full P through single superphosphate and K through muriate of potash were applied at the time of last puddling, and the remaining N was top-dressed in two equal splits at the time of maximum tillering and panicle-initiation stages, respectively. The wheat cv 'HS 240' was sown in November as per recommended package of practices except fertilizer treatment. The RDF for wheat was 120 kg N + 26.2 kg P + 24.5 kg K/ha. Nutrient uptake by rice, wheat and rice – wheat cropping system was calculated based on the biomass accumulation with their respective concentrations of NPK. Available NPK nutrient status was monitored at completion of the experiment. Economic analysis (gross and net return) was made considering the prevailing market costs of inputs and prices of outputs.

RESULTS AND DISCUSSION

Direct effect on rice

Pooled data of 3 years revealed that the application of organic sources and fertility levels significantly affected the grain and straw yields of rice (Table 1) due to their positive influence on growth (plant height) and yield attributes (panicles/m^2, panicle length, grains/spike, and grain weight/panicle). This may be ascribed to the better macro- and micronutrient availability as well as physical condition of the soil. Parihar (2004) also reported similar effect of FYM on rice. The integrated nutrient management, on an average, increased the mean rice yield by 0.34 t/ha (7.8%) compared with the standard control, wherein only 100% recommended fertility level was applied to both the crops. This is attributed to the significantly better growth (plant height) and more number of panicles/m^2 besides higher values of panicle length and grains/panicle in the plots managed through integrated nutrient management approach.

In general, application of FYM 5 t/ha and higher fertility level proved superior and recorded higher values of these parameters, as the experimental soil was medium in available N, K and organic C and was low in P (8.5 kg/ha). Application of FYM 5 t/ha produced 5.03 t/ha rice grain-yield, which was on a par with that of FYM 2.5 t/ha + 1.25 t/ha (4.94 t/ha) and FYM 2.5 t/ha + *gobhi sarson* straw 2.5 t/ha (4.72 t/ha). *Gobhi sarson* 5 t/ha recorded low yield (4.24 t/ha). Application of FYM 5 t/ha produced significantly taller plants with more number of grains/panicle (94) and grain weight/panicle (2.35 g). *Gobhi sarson* straw 5 t/ha recorded significantly lesser values of plant height, grains/panicle (88) and straw yield. Better growth and productivity with FYM 5 t/ha may be attributed to the slow but sustained supply of the other nutrients besides N because FYM was well decomposed, whereas the supply from chopped *gobhi sarson* straw might have taken time to decompose and release the nutrients to the crop. Statistically similar grain and straw yields with FYM 5 t/ha and FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha revealed that mushroom spent compost can partially meet the requirement of FYM without any adverse effect on the rice grain yield. Our result of mushroom spent compost and FYM is fairly similar to that of Selvi and Selvaseelan (1999).

As the fertility level increased from 50 to 100% of the recommended fertility level, the plant height increased significantly. Further increase in fertility level did not increase the height significantly. Application of 100% RDF produced 295 effective panicles/m^2, with mean panicle weight of 2.28 g, and that of 50% RDF gave 288 and 2.27 g, respectively. The increase in fertility level from 50 to 100% increased the rice-grain yield (0.36 t/ha; 8.3%) and

Table 1. Direct effect of organic sources and fertility levels on rice in rice-wheat cropping system (pooled data of 3 years)

Treatment	Plant height (cm)	Effective panicles/ m^2	Panicle length (cm)	Grains/ panicle	1,000-grain weight (g)	Panicle weight (g)	Straw yield (t/ha)	Grain yield (t/ha)
Organic source								
FYM 5 t/ha	108.9	296	20.9	94	22.8	2.35	6.85	5.03
Gobhi sarson straw (GSS) 5 t/ha	100.6	308	19.9	88	22.7	2.19	6.13	4.24
Mushroom spent compost (MSC) 2.5 t/ha	103.7	285	20.3	90	23.0	2.27	6.41	4.44
FYM 5 t/ha + GSS 2.5 t/ha	104.6	298	20.5	91	22.9	2.31	6.35	4.72
FYM 5 t/ha + MSC 1.25 t/ha	104.3	294	20.7	93	22.8	2.31	6.86	4.94
SEm±	0.9	6	0.4	1	0.4	0.07	0.16	0.11
CD (P=0.05)	2.5	17	NS	3	NS	NS	0.44	0.31
Fertility level								
50% RDF	101.9	288	20.1	91	22.7	2.27	6.13	4.40
100% RDF	105.5	295	20.5	92	22.9	2.28	6.57	4.77
150% RDF	106.0	306	20.8	93	22.9	2.30	6.86	4.85
SEm±	0.7	5	0.3	1	0.3	0.05	0.12	0.08
CD (P=0.05)	1.9	13	NS	NS	NS	NS	0.34	0.24
Control vs others								
Standard control (RDF to both crops)	99.3	273	20.3	88	22.7	2.19	6.43	4.34
Others	104.4	296	20.5	91	22.8	2.28	6.52	4.68
SEd±	1.6	11	0.7	2	0.8	0.12	0.28	0.19
CD (P=0.05)	3.1	22	NS	NS	NS	NS	NS	0.38

Table 2. Residual effect of organic sources and fertility levels on wheat and economics of rice-wheat cropping system (pooled data of 3 years)

Treatment	Plant height (cm)	Spike length (cm)	Grains/ spike	1000 grain weight (g)	Spikes /m^2	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (x 10^3 Rs/ha)	Net returns (x 10^3 Rs/ha)
Organic source									
FYM 5 t/ha	86.4	8.99	42	38.1	220	2.48	5.98	36.86	41.54
Gobhi sarson straw (GSS) 5 t/ha	81.7	8.13	39	37.1	209	1.99	4.39	30.86	33.60
Mushroom spent compost (MSC) 2.5 t/ha	84.5	8.56	40	37.8	228	2.39	5.20	34.36	37.02
FYM 5 t + GSS 2.5 t/ha	84.1	8.22	39	37.3	228	2.18	5.09	33.86	37.34
FYM 5 t + MSC 1.25 t/ha	84.7	8.67	41	37.7	224	2.33	5.03	35.62	39.13
SEm±	0.6	0.25	0.4	0.5	5	0.07	0.14		
CD (P=0.05)	1.6	0.71	1.2	NS	15	0.20	0.40		
Fertility level									
50% RDF	84.1	8.43	40	37.2	205	2.22	5.08	33.20	35.75
100% RDF	84.0	8.54	40	37.7	229	2.28	5.16	34.32	38.59
150% RDF	84.7	8.57	41	37.9	231	2.33	5.16	35.44	38.84
SEm±	0.4	0.19	0.3	0.4	4	0.06	0.11		
CD (P=0.05)	NS	NS	NS	NS	12	NS	NS		
Control vs others									
Standard control (RDF to both crops)	84.3	8.66	41	38.1	244	2.54	5.96		
Others	84.3	8.51	40	37.6	222	2.28	5.14		
SEd±	1.0	0.45	0.8	0.9	10	0.13	0.24		
CD (P=0.05)	NS	NS	NS	NS	19	0.25	0.50		

Rice grain, Rs 7,500/t; rice straw, Rs 1,000/t; wheat grain, Rs 10,000/t; wheat straw, Rs 1,500/t; FYM Rs 350/t; *gobhi sarson* straw, Rs 200/t; mushroom spent compost, Rs 600/t

Table 3. Effect of organic sources and fertility levels on nutrient uptake (kg/ha) and nutrient balance (pooled data of 3 years)

	Rice			Wheat			Rice + wheat			Soil-available nutrients (kg/ha)			Computed N balance (kg/ha)	
	N	P	K	N	P	K	N	P	K	N	P	K	Addition	Balance
Organic source														
FYM 5 t/ha	95.3	20.8	90.7	63.8	14.2	57.2	159.1	35.0	147.9	324.3	8.94	147.9	175.8	+16.6
Gobhi sarson straw (GSS) 5 t/ha	83.0	17.2	80.3	49.9	11.1	42.5	132.9	28.3	122.8	315.4	9.16	143.7	175.8	+42.8
Mushroom spent compost (MSC) 2.5 t/ha	87.2	17.9	83.8	59.6	13.2	50.4	146.8	31.1	134.2	322.0	8.89	144.6	175.8	+29.0
FYM 5 t + GSS 2.5 t/ha	91.7	18.5	83.7	55.5	12.4	48.9	147.2	30.8	132.6	317.2	9.09	146.9	175.8	+28.6
FYM 5 t + MSC 1.25 t/ha	97.0	19.6	90.2	58.0	12.9	48.8	155.0	32.5	139.0	322.6	8.81	147.1	175.8	+20.8
SEm±	1.5	0.3	1.8	1.8	0.4	1.2	3.6	0.7	2.9	5.0	0.20	3.4		
CD (P=0.05)	4.3	0.9	5.1	5.0	1.0	3.9	10.0	1.8	8.3	NS	NS	NS		
Fertility level														
50% RDF	85.8	17.8	80.5	56.2	12.5	48.9	142.0	30.3	129.4	318.8	8.51	145.1	130.8	-11.2
100% RDF	91.6	18.9	86.6	57.6	12.8	49.8	149.2	31.7	136.4	319.0	8.92	147.2	175.8	+26.6
150% RDF	95.2	19.3	90.2	58.4	13.0	49.9	153.6	32.3	140.1	323.0	9.50	145.7	220.8	+67.2
SEm±	1.1	0.3	1.4	1.4	0.3	0.9	2.8	0.5	1.6	3.9	0.16	2.6		
CD (P=0.05)	3.3	0.7	3.9	NS	NS	NS	7.8	1.4	4.6	NS	0.45	NS		
Control vs others														
Standard control (RDF to both crops)	84.4	17.5	82.8	64.8	15.0	57.2	149.2	32.5	140.0	318.7	9.17	145.2	210.0	+60.8
Others	90.9	18.6	85.8	57.4	12.8	49.6	148.3	31.6	135.4	320.3	8.97	145.7	175.8	+27.4
SE±	2.7	0.6	3.2	3.2	0.7	2.7	6.4	1.2	3.7	8.9	0.37	6.1		
CD (P=0.05)	5.4	1.2	NS	6.3	1.3	5.3	NS	NS	NS	NS	NS	NS		

straw yield of the crop significantly. Application of 150% fertility level recorded higher values of grain (4.85 t/ha) and straw yields, which were on a par with those at 100% fertility level. The results are in conformity with those of Sharma and Sharma (1993) and Mankotia (2007).

Residual effect on wheat

Organics applied to the previous rice crop significantly affected the growth and productivity of wheat crop (Table 2). Application of FYM 5 t/ha (2.48 t/ha), being on a par with that of FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha and mushroom spent compost 2.5 t/ha, recorded significantly higher wheat productivity. Plant height, measured at the harvest of the crop, also revealed a similar trend. The values of spike length, grains/spike and spikes/m^2 were more in FYM 5 t/ha than in *sarson* straw 5 t/ha. Test weight did not vary much. Patidar and Mali (2002) and Mankotia (2007) also reported significant residual effect of organics applied to rice on the succeeding crop. Significant differences among fertility levels were not observed on wheat crop.

Comparison of standard control with mean of others revealed that wheat productivity was significantly more in the standard control (receiving 100% RDF to wheat also), as it recorded significantly higher values of effective spikes/m^2. It indicates that 50% RDF is not sufficient to wheat despite the application of organics and high fertility level to the preceding rice crop. Thus, the succeeding crop requires its full nutrition for higher productivity. These results are in conformity with those of Sharma and Kaur (2003).

Nutrient uptake

Organic sources and fertility levels significantly affected the NPK uptake by rice (Table 3). On an average, rice in integrated nutrient-managed plots removed higher N (7.7%), P (6.3%) and K (3.6%) compared with the standard control. Statistically equal NPK uptake occurred in FYM 5t/ha and FYM 2.5 + mushroom spent compost 1.25 t/ha treatments. Significant increase in NPK uptake was possible because the fertility level increased from 50 to 100%. Residual effect of organics on wheat significantly affected the nutrient uptake, whereas the residual effect of fertility levels was not significant. Wheat crop in FYM 5 t/ha plots accumulated the maximum nutrients, followed by FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha. As the nutrient uptake values were influenced greatly by the grain and straw yields of the crops, these followed a similar trend. Thus the highest NPK uptake by the rice-wheat cropping system (159.1%, kg N, 35.0 kg P and 147.9 kg K/ha) was recorded with FYM 5 t/ha, which was on a par with that of FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha. The increase in fertility level increased the nutrient uptake significantly by rice - wheat system. NPK uptake by the rice – wheat system at 100 (149.2 kg N, 31.7 kg P and 136.4 kg K/ha) and 150% RDF remained statistically equal.

Residual soil fertility

The available content of soil N, P and K determined after the completion of the experiment revealed that these did not vary significantly due to the application of organics and fertility levels, except that P content showed increase with increase in fertility level (Table 3). However, compared with the initial values, a little increase was observed. These observations are owing to highly dynamic nature of the nutrients and thorough moping up of the nutrients. N is subjected to various modes of losses and hence the balance N left in the soil is negligible. The computed difference between the added N and N uptake revealed positive balance (16.6–67.2 kg/ha), except at 50% RDF where it showed a negative value. In K, due to its characteristic equilibrium among different forms, the available pool was maintained at the same level irrespective of the treatment. However, more P at higher fertility level can be attributed to the negligible loss of P from the soil-plant system. The addition of higher levels of water-soluble P through single superphosphate might have increased the available P in the soil.

Economics

Variation in grain and straw yields of rice and wheat crops due to the treatment effects as well as the differential cost of cultivation increased the gross (Rs 78,400/ha) and net returns (Rs 41,535/ha) from rice - wheat with application of FYM 5 t/ha, closely followed by that with application of FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha (Table 2). Averaged over of the organic sources, application of 100% fertility level recorded net returns of Rs 38,586/ha, and 150% level recorded Rs 38,838/ha.

Thus it is concluded that application of FYM 2.5 t/ha + mushroom spent compost 1.25 t/ha is necessary to rice to realize sustained productivity and profitability of the cropping system, statistically equal with that by FYM 5 t/ha. Further application of recommended dose of fertilizers is necessary not only to rice but also to the succeeding wheat crop.

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