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Effects of organic manures and chemical fertilizers on productivity and profitability in wheat – rice cropping sequence

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ABSTRACT

A field experiment was conducted to study the effect of organic manures and chemical fertilizers on wheat - rice crop sequence with five sources of organic manures and three chemical fertilizer levels (50, 100 and 150 per cent of recommended NPK 120 kg N + 60 kg P_2O_5 + 30 kg K_2O) in wheat along with one control. Rice was grown with 100 per cent of recommended NPK fertilizers 90 kg N + 40 kg P_2O_5 + 40 kg K_2O except absolute control to study the residual effect of organic manures and chemical fertilizers supplied to preceding wheat crop on yield attributes and yield of succeeding rice crop. Yield attributes, grain yield and harvest index of both wheat and rice as well as cropping system as a whole improved significantly in FYM supplied plots @ 10 t ha^{-1} followed by berseem 'in situ' green manuring + FYM, mushroom spent compost + FYM, mushroom spent compost and berseem 'in situ' green manuring, respectively during the study. Net returns in wheat and rice crops as well as system as a whole, were again found to be significantly highest with the application of FYM at 10 t ha^{-1}. A consistent and significant improvement in yield attributes, yield, harvest index, net returns and benefit : cost ratio of wheat and rice crops were observed with increase in chemical fertilizer levels from 50 to 150 per cent of recommended NPK. System productivity and profitability also followed the similar trend as that of grain yield in wheat and rice crops with the application of chemical fertilizers.

Key words: *Organic manures, chemical fertilizers, rice, wheat, green manuring, grain yield*

Rice-wheat cropping system is the most important cropping system in the hill region of north western Himalayas, but this system because of high nutrient requirement renders the soil unproductive if not supplemented with adequate nutrients. Thus, keeping in view of the poor economic conditions, growing a green manure crop or applying FYM and other locally available organic sources like mushroom compost can constitute the integrated nutrient supply system which can hold great promises in rice-wheat cropping system without affecting the age old practice of adding organics in wheat crop. Therefore, present investigation was undertaken to study the direct and residual effects of organic manures and chemical fertilizers on yield attributes, yield and profitability of wheat-rice cropping system in wet temperate Himalayas.

MATERIALS AND METHODS

The field experiment was conducted at the research farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh in a silty-clay loam soil (Alfisol, Typic Hapludalf) from dry season 1999-2000 to wet season 2001. The soil of the experimental site have organic carbon 0.80 %, total N 0.113 %, available nitrogen 284.3 kg ha^{-1}, available phosphorus 18.9 kg ha^{-1}, and high in available potassium 249.5 kg ha^{-1} and acidic in reaction (5.6). The treatments consisted of five sources of organic manures (OM_1– FYM at 10 t ha^{-1} on oven dry weight basis; OM_2– mushroom spent compost at 10 t ha^{-1} on oven dry weight basis; OM_3 – '*berseem*' *in situ* green manure; OM_4– mushroom spent compost at 5 t ha^{-1} on oven dry weight basis + FYM to supply remaining N equivalent to OM_1 on oven dry weight basis; and OM_5 –'*berseem*' *in situ* green manure + FYM to supply remaining N equivalent to OM_1 on oven dry weight basis), and three chemical fertilizer levels (50, 100 and 150 per cent of recommended NPK) in wheat crop along with one control without any organics. All organic manures were analyzed for their chemical composition with respect

to N, P and K contents, and then respective organic manure additions were made as per the organic manure treatments. The respective nutrient additions through various organic manure sources are presented in Table 1. In Wheat, recommended fertilizer dose was 120 kg N + 60 kg P_2O_5 + 30 kg K_2O per hectare. Rice was raised with 100 per cent recommended NPK fertilizers (90 kg N + 40 kg P_2O_5 + 40 kg K_2O per hectare) except control to study the residual effects of organic manures and chemical fertilizers applied to preceding crop. The wheat cultivar HPW-89 and rice cultivar RP-2421 were used for the experiment. The experiment was conducted under randomized block design replicated thrice. Statistical analysis and benefit : cost ratio were computed following standard procedures (Gomez and Gomez 1984).

Table 1 Nutrient additions (kg ha^{-1}) in soil through organic manures

Treatments	Dry season 1999-2000			Dry season 2000-01		
	N	P	K	N	P	K
OM_1	80	24	103	83	28	95
OM_2	33	14	32	33	14	32
OM_3	13.7	2.3	11	16.7	2.7	12.9
OM_4	80	26.1	97.8	83	29.4	92.1
OM_5	80	22.2	96.3	83	25.1	88.8

RESULTS AND DISCUSSION

Perusal of the Table 2 shows the number of wheat tillers m^{-2}, number of rice panicles m^{-2}, number of spikelets per spike panicle^{-1}, grains per spike in wheat, spikelet fertility in rice and 1000-grain weight both in wheat and rice were significantly higher in plots receiving FYM at 10 t ha^{-1} (OM_1) followed by *berseem* green manuring or mushroom compost in combination with FYM, and mushroom compost alone, respectively. The application of various organics in wheat significantly increased the wheat grain yield and also exhibited significant residual effect (Table 2) on grain yield of succeeding rice crop (Singh *et al.*, 2001a). FYM application @ 10 t ha^{-1} exhibited significantly higher grain yield of both the crops followed by *berseem* green manure + FYM, mushroom spent compost + FYM, mushroom spent compost and *berseem* green manure, respectively. However in case of rice, mushroom spent compost + FYM performed better than *berseem* green manure + FYM which can be ascribed to high nutrient additions in preceding wheat crop (Yadav *et al.,* 2003 and Mundra *et al.,* 2003). Harvest index of both the crops were significantly higher due to *berseem* green manuring while other organics exhibited lower control remained inferior with respect to yield attributes and yield over other treatments.

Increase in fertilizer levels from 50 to 150 per cent of recommended NPK resulted in consistent and significant improvement in number of wheat spikes and rice panicles m^{-2}, spikelets spike^{-1} or panicle, grains spike^{-1} in wheat, spikelet fertility percentage in rice, 1000-grain weight both in wheat and rice due to direct as well as residual effects of fertilizer levels applied to wheat crop, which ultimately resulted in consistent and significant improvement in grain yield of both the crops (Table 2) (Singh *et al.*, 2001b and Das *et al.*, 2003). Increase in fertilizer levels upto 100 per cent of recommended NPK significantly increased the harvest index of wheat but, further increase to 150 per cent of recommended NPK resulted in decline in harvest index (Table 2). Residual effect of 50 to 150 per cent of recommended NPK in wheat crop caused a significant reduction in harvest index of rice. Increasing fertilization might have increased the biological yield in terms of more biomass production (Choudhary *et al*., 2004), thus resulting in reduction in harvest index of rice and even wheat at 150 per cent of recommended NPK dose.

Net returns of wheat were maximum in plots supplied with FYM at 10 t ha^{-1} followed by mushroom spent compost and lowest in plots receiving mushroom spent compost + FYM. But it was mushroom spent compost which registered significantly highest benefit : cost ratio followed by *berseem* green manuring, FYM, mushroom spent compost + FYM and *berseem* green manure + FYM, respectively. This may be attributed to lower cost of mushroom spent compost while comparatively high cost of FYM decreased the benefit : cost ratio in treatments having FYM as organic addition, alone or in combination with other organics. The net returns and benefit : cost ratio in rice were significantly maximum in plots receiving FYM @ 10 t ha^{-1}, followed by mushroom spent compost + FYM, *berseem* green manure + FYM, mushroom spent compost and *berseem* green manuring, respectively (Table 3).

A significant increase in grain yield of both wheat and rice crops with increase in fertility levels

Table 2. Direct and residual effects of organic manures and chemical fertilizers on yield attributes, yield and harvest index of wheat and rice (Pooled data of two years)

Treatments	Wheat					Rice				
	Spikes m^{-2}	Grains $spike^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})	Harvest index (%)	Panicles m^{-2}	Grains $panicle^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})	Harvest index (%)
Organic manures										
OM_1	309.49	53.48	48.18	4.52	42.38	381.80	98.54	25.38	4.61	40.04
OM_2	289.32	52.18	47.93	4.01	42.31	366.89	93.05	25.09	4.48	40.16
OM_3	274.87	51.30	47.30	3.60	42.39	352.94	89.33	24.63	4.32	40.37
OM_4	298.96	53.29	48.14	4.13	42.35	375.43	96.46	25.18	4.55	40.06
OM_5	305.64	53.38	48.12	4.27	42.38	372.63	94.19	25.13	4.51	40.02
CD (P=0.05)	3.36	0.31	0.23	0.06	0.03	1.59	0.48	0.04	0.03	0.04
Chemical fertilizers										
F_{50}	233.09	50.31	46.08	3.52	42.27	333.22	83.76	24.21	4.26	40.66
F_{100}	307.47	52.96	48.21	4.24	42.44	370.26	94.38	25.14	4.50	39.95
F_{150}	346.41	54.91	49.52	4.56	42.38	406.33	104.80	25.90	4.72	39.78
CD (P=0.05)	2.60	0.24	0.18	0.04	0.03	1.23	0.37	0.03	0.02	0.03
Control vs Others										
Control	215.97	35.07	40.33	1.60	41.51	284.27	66.22	21.23	1.55	41.18
Others mean	295.66	52.73	47.93	4.11	42.37	369.94	94.32	25.09	4.49	40.13
CD (P=0.05)	4.25	0.39	0.29	0.07	0.04	2.01	0.61	0.05	0.03	0.05

Table 3. Effect of organic manures and chemical fertilizers on net returns and benefit : cost ratio in wheat and rice crops as well as on system productivity and profitability of wheat-rice crop sequence (Pooled data of two years)

Treatments	Pooled data of two years				Pooled data of two years			
	Wheat		Rice		System productivity		System profitability	
	Net returns (Rs ha^{-1})	B : C ratio	Net returns (Rs ha^{-1})	B : C ratio	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Net returns (Rs ha^{-1})	B : C ratio
Organic manures								
OM_1	23118	1.30	23779	2.36	9.13	13.06	46897	1.83
OM_2	22509	1.63	22846	2.27	8.49	12.15	45355	1.95
OM_3	19965	1.57	21605	2.14	7.92	11.31	41570	1.86
OM_4	19598	1.10	23380	2.32	8.68	12.44	42978	1.71
OM_5	19935	1.07	23078	2.29	8.78	12.57	43012	1.68
CD (P=0.05)	520	0.04	189	0.02	0.06	0.09	545	0.02
Chemical fertilizers								
F_{50}	16913	1.16	21120	2.10	7.78	11.03	38033	1.63
F_{100}	22207	1.41	23022	2.29	8.74	12.52	45229	1.85
F_{150}	23955	1.42	24670	2.45	9.28	13.36	48626	1.94
CD (P=0.05)	403	0.03	146	0.02	0.05	0.07	422	0.02
Control vs Others								
Control	6416	0.79	3151	0.39	3.15	4.44	9568	0.59
Others mean	21025	1.33	22938	2.28	8.60	12.30	43963	1.81
CD (P=0.05)	657	0.05	239	0.02	0.07	0.12	689	0.03

from 50 to 150 per cent of recommended NPK resulted in consistent and significant increase in net returns as well as benefit : cost ratio of both wheat and rice crops.

Pooled data of two years (Table 3) revealed that system productivity in terms of grain and straw yield in wheat - rice crop sequence followed the similar trend as that of grain yield of wheat and rice crops. It was significantly highest in FYM supplied plots @ 10 t ha^{-1} followed by *berseem* green manure + FYM, mushroom spent compost + FYM, mushroom spent compost and *berseem* green manuring, respectively. Increase in fertilizer levels from 50 to 150 per cent of recommended NPK in wheat also resulted in consistent and significant increase in grain and straw yield of rice - wheat cropping system as a whole (Yadav, 2001and Singh *et al.*, 2001b).

Though mushroom spent compost (OM_2) was second best after FYM (OM_1) in terms of net returns but due to low cost of mushroom spent compost benefit : cost ratio of wheat - rice sequence was significantly highest in mushroom spent compost supplied plots (OM_2) followed by *berseem* green manuring, FYM, Mushroom spent compost + FYM and *berseem* green manuring + FYM supplied plots respectively. Increase in chemical fertilizer levels from 50 to 150 per cent of recommended NPK in wheat also resulted in consistent and significant increase in system profitability in terms of net returns and benefit : cost ratio. Thus, integration of FYM at 10 t ha^{-1} with 150 per cent recommended NPK appears to be the best treatment combination over other organics to realize highest productivity of wheat - rice crop sequence under mid hill conditions of wet temperate Himalayas.

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