

Crop productivity, returns and soil sustainability under rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system

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ABSTRACT

A field experiment was conducted during 1997–98 to 1999–2000 at Regional Research Station, Uchani, Karnal, Haryana, to study the effect of organic sources and recommended chemical fertilizers and higher doses of nutrients applied through recommended inorganic sources along with organic sources on rice (*Oryza sativa* L.) and succeeding wheat (*Triticum aestivum* L. emend. Fiori & Paol.). Higher productivity of rice–wheat cropping system with application of 150% recommended fertilizers + green-manuring in rainy season (*kharif*) and 150% recommended fertilizers + 10 tonnes/ha FYM to winter (*rabi*) crop gave the higher rice-equivalent productivity of 14,141 kg/ha and net returns of Rs 35,160/ha compared with 10,923 kg/ha total rice-equivalent productivity and net returns of Rs 25,041/ha recorded in 100% recommended fertilizers to both *kharif* and *rabi* crops. Negative values of nutrients balance were recorded in treatments where only 100%, 125% and 150% chemical fertilizers were applied. Nutrient's balance of (+) 314.0, 279.8 and 268.6 kg/ha was recorded with 100%, 125% and 150% recommended fertilizers + green-manuring in *kharif* and 10 tonnes/ha FYM in *rabi* crop respectively. [100% NPK levels : 120, 60 and 0, and 120, 60 and 60, N, P₂O₅ and K₂O, kg/ha, respectively, to rice and wheat crops in the sequence, year after year.]

Key words : Rice equivalent, Link relative index, Nutrients uptake, Nutrient balance

During the last 4 decades, with the release of high-yielding varieties, rice–wheat cropping system in India has attained immense significance in terms of increase in area, production and productivity. Both these crops are fertility exhaustive, and had resulted in decline of soil organic carbon and deteriorating soil health, in general. For sustainability of the system as well as the overall soil health, organic sources play an important role. Incorporation of farmyard manure and green-manuring in combination with inorganic fertilizers improves the productivity of rice and wheat, ameliorates and sustains soil health and also economizes fertilizers need (Tripathi and Chaubey, 1996). Combined use of farmyard manure and chemical fertilizer gave higher yield of both crops, owing to adequate availability of nutrients (Sumanthy *et al.*, 1999). Therefore, present study on predominant rice–wheat cropping system was undertaken to conserve soil nutrients, sustain crop and soil productivity in the North-Eastern Rice – Wheat Zone of Haryana.

MATERIALS AND METHODS

A field experiment was conducted during 1997–98 to 1999–2000 at Regional Research Station, Uchani, Karnal, (29° 43'N and 76° 58'E with annual rainfall of 750 mm

and altitude of 245 above mean sea level.) Haryana. The experiment was laid out in split-plot design with 3 replications keeping green-manuring and FYM levels in main plots and levels of NPK in subplots. There were 12 treatment combinations and detailed in Table 1.

The recommended dose of fertilizers was 120 kg N + 60 kg P₂O₅/ha in all the experimental years for rice crop and 120 kg N + 60 kg P₂O₅ + 60 kg K₂O/ha for the wheat crop. Pooled analysis of the yield as well as the nutrients uptake was carried out for the whole cropping system. The soil was alluvium with fine loamy texture. Initial organic carbon (%) was 0.48, while available N, P and K (kg/ha) was 137.7, 10.3 and 237.5 respectively. Per cent N, P and K content on oven-dry basis of green-manure crop *Sesbania aculeata in situ* and FYM was 2.88, 0.19, 2.4 and 1.62, 0.53 and 3.26 respectively. Economic gain (net returns) of each treatment was calculated for the pooled data of 3 years (along with rice equivalent) to judge the profitability of the treatments taking into account all the component of cost of cultivation involved in experimentation (Table 2). Link relative index over the control (T₁) and benefit : cost were also worked out and given in Table 2. Details of the uptake of N, P and K nutrients applied and nutrient balance at the end of 3 years investigation was

worked out and presented in Table 3.

RESULTS AND DISCUSSION

System productivity (Table 2) revealed that among the different treatments applied to enhance the yield and assess the crop productivity of system, significantly higher rice-equivalent productivity of rice wheat cropping system up to 14,141 kg/ha was recorded in the treatment where application of 150% recommended fertilizer + green-manuring to rice in rainy season (*kharif*) and 150% recommended fertilizers + 10 tonnes/ha FYM (T_{12}) to succeeding wheat crop in winter (*rabi*) was incorporated in the soil. Application of 125% recommended fertilizer + green-manuring to the *kharif* rice crop and 125% recommended fertilizers + 10 tonnes/ha FYM (T_8) to the *rabi* wheat crop gave the rice-equivalent productivity of 13,814 kg/ha. The

100% recommended fertilizer to *kharif* (paddy) as well as to the *rabi* (wheat) crop (T_1) gave rice-equivalent productivity of 10,923 kg/ha only. Thus inclusion of organic sources at either of the level, i.e. 100%, 125% or 150% in *kharif* or *rabi* or in both crops enhanced the crop productivity and brought significant higher levels of stabilized yield of the rice-wheat cropping system (Table 2).

The rice-equivalent yield for the rice-wheat cropping system showed significant yield differences with inorganic and organic sources applied in the experiment. The application of FYM in wheat crop gave significant higher yield and rice equivalent over non-manured crop. The higher levels of nutrients over and above the recommended levels also gave significant higher values of rice equivalent for the pooled data of rice-wheat cropping system (Table 2). These results are in line with those of Mundra *et al.*

Table 1. Treatment combinations of rice-wheat cropping system experiment

Treatment	Rice	Wheat
T_1	100% recommended fertilizers	100% recommended fertilizers
T_2	100% recommended fertilizers	100% recommended fertilizers + 10 tonnes/ha FYM
T_3	100% recommended fertilizers + GM	100% recommended fertilizers
T_4	100% recommended fertilizers + GM	100% recommended fertilizers + 10 tonnes/ha FYM
T_5	125% recommended fertilizers	125% recommended fertilizers
T_6	125% recommended fertilizers	125% recommended fertilizers + 10 tonnes/ha FYM
T_7	125% recommended fertilizers + GM	125% recommended fertilizers
T_8	125% recommended fertilizers + GM	125% recommended fertilizers + 10 tonnes/ha FYM
T_9	150% recommended fertilizers	150% recommended fertilizers
T_{10}	150% recommended fertilizers	150% recommended fertilizers + 10 tonnes/ha FYM
T_{11}	150% recommended fertilizers + GM	150% recommended fertilizers
T_{12}	150% recommended fertilizers + GM	150% recommended fertilizers + 10 tonnes/ha FYM

100% recommended level for rice : 120, 60, 0 of N, P_2O_5 , K_2O kg/ha; 100% recommended level for wheat : 120, 60, 60 of N, P_2O_5 , K_2O kg/ha

Table 2. Effect of different treatments on grain yield, rice equivalent, net return, link relative index and benefit : cost ratio in rice-wheat cropping system

Treatment	Grain yield (kg/ha)		Rice equivalent (kg/ha)	Net returns (Rs/ha)	Link relative index over T_1	Benefit : cost ratio
	Rice	Wheat				
T_1	4,873	4,088	10,923	25,041	1.00	1.81
T_2	4,939	4,597	11,742	28,241	1.13	1.89
T_3	5,688	4,247	11,974	28,094	1.12	1.85
T_4	5,790	4,812	12,912	31,891	1.27	1.93
T_5	5,616	4,499	12,274	30,309	1.21	1.94
T_6	5,640	4,866	12,842	32,284	1.29	1.97
T_7	6,242	4,679	13,167	33,581	1.34	1.97
T_8	6,370	5,030	13,814	34,961	1.40	1.98
T_9	5,496	4,599	12,302	29,025	1.16	1.86
T_{10}	5,586	4,987	12,948	31,482	1.26	1.90
T_{11}	6,200	4,883	13,427	32,439	1.30	1.90
T_{12}	6,457	5,192	14,141	35,160	1.40	1.95
CD (P=0.05)	190	272	235	150		

Details of treatments are given in Table 1

Table 3. Effect of different treatments of rice-wheat cropping system on nutrient uptake and balance

Treatment	Crop	Uptake (kg/ha)				Nutrient applied (kg/ha)	Nutrient balance (kg/ha)
		N	P	K	Total		
T ₁	Rice	106.2	12.1	102.2	220.7	352.4	-129.1
	Wheat	98.2	18.1	144.5	260.8		
	Total	204.6	30.2	246.7	481.5		
T ₂	Rice	116.3	12.2	104.0	232.5	597.2	+79.3
	Wheat	102.9	20.3	162.0	285.2		
	Total	219.2	32.5	266.0	517.7		
T ₃	Rice	130.6	14.5	117.5	262.6	571.2	+46.9
	Wheat	93.3	18.4	150.0	261.7		
	Total	223.9	32.9	267.5	524.3		
T ₄	Rice	126.6	14.5	114.8	255.9	815.8	+268.6
	Wheat	100.5	21.4	169.4	291.3		
	Total	227.1	35.9	284.2	547.2		
T ₅	Rice	135.2	13.7	166.8	315.7	440.6	-159.7
	Wheat	103.3	14.0	167.3	284.6		
	Total	238.5	27.7	334.1	600.3		
T ₆	Rice	129.1	13.8	126.9	269.8	685.2	+103.3
	Wheat	110.9	21.4	179.8	312.1		
	Total	240.0	35.2	306.7	581.9		
T ₇	Rice	153.4	18.1	150.2	321.7	659.4	+35.1
	Wheat	108.4	20.8	173.3	302.6		
	Total	261.9	38.9	323.5	624.3		
T ₈	Rice	144.1	18.0	142.6	304.7	904.0	+279.8
	Wheat	114.1	23.4	182.0	319.5		
	Total	258.2	41.4	324.6	624.2		
T ₉	Rice	126.7	13.2	119.3	259.2	528.6	-38.4
	Wheat	118.0	21.6	168.2	307.8		
	Total	244.7	34.8	287.5	567.0		
T ₁₀	Rice	121.9	13.9	123.5	259.3	773.2	+169.9
	Wheat	132.8	32.9	187.3	344.0		
	Total	254.7	37.8	310.8	603.3		
T ₁₁	Rice	141.8	16.5	143.2	301.5	747.4	+112.6
	Wheat	128.3	24.8	180.2	333.3		
	Total	270.1	41.3	323.4	634.8		
T ₁₂	Rice	147.3	17.5	160.8	325.6	992.0	+314.0
	Wheat	134.2	26.8	191.4	352.4		
	Total	281.5	44.3	352.2	678.0		

(2002), who reported that productivity of the cereal-cereal system increased with the increased levels of inorganic fertilizers applied in conjunction with organic sources.

Maximum net returns of Rs 35,160/ha was recorded in T₁₂, followed by T₈ (Rs 34,961/ha) showing that inclusion of organic sources even at 150% and 125% recommended fertilizer could give significantly higher net returns. While the lowest net returns of Rs 25,041/ha was recorded from T₁ where only 100% recommended fertilizers were applied. Benefit : cost ratio varied from 1.81 to 1.98, minimum in the control and maximum in 125% recommended fertilizer + green manure in *kharif* and 125% recom-

mended fertilizer + 10 tonnes/ha FYM in *rabi* (T₈). The maximum link relative index of 1.40 was recorded in 150% recommended fertilizer in *kharif* and 150% recommended fertilizer + 10 tonnes/ha FYM in *rabi* crop (T₁₂) in comparison to the control (T₁). Tripathi and Chaubey (1996) and Mundra *et al.* (2002) also reported similar findings on net gain from conjunctive use of organic and inorganic sources in pearl millet-wheat system.

Nutrient uptake

Maximum nutrient uptake of 678 kg/ha was recorded in T₁₂, followed by 624.2 kg/ha in T₈ and the lowest was in

T₁ with 481.5 kg/ha (Table 3). Application of nutrients also followed the above trend where maximum (992 kg/ha) and minimum (352.4 kg/ha) were applied in T₁₂ and T₁, respectively.

The negative values of nutrients balance viz. (-)129.1, (-)159.7 and (-) 38.4 kg/ha were recorded in treatments where 100%, 125% and 150% (T₁, T₅ and T₉) recommended fertilizers were applied through inorganic sources only and organic sources were not used (Table 3). Nutrient balance of (+) 314.0, (+) 279.8 and (+) 268.6 kg/ha was recorded with 100%, 125% and 150% recommended fertilizers + green-manuring in *kharif* and 10 tonnes/ha FYM in *rabi* crop respectively. Nutrient uptake and nutrient balance is the result of production and added nutrients to the soil. These results confirm the findings of Mundra *et al.* (2002) in pearl millet–wheat cropping system, where

use of organic sources with chemical fertilizers produced positive nutrients balance.

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