Indian Journal of Agronomy 44 (4) : 664–668 (December 1999)

Effect of combined use of green-manure crop and nitrogen on productivity of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) system under lowland rice

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Received : June 1998

ABSTRACT

A field experiment was conducted during 1992–93 to 1993–94 to study the effect of green-manuring crop in relation to nitrogen use on productivity of rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system. The treatments comprised 3 green-manuring crops, viz. *dhaincha* [*Sesbania cannabina* (retz.) Pers.] as green-manure, greengram (*Phaseolus radiatus* L.) as dual purpose and cowpea [*Vigna unguiculata* (L.) Walp.] as fodder crop, taken as pre-rainy season (*kharif*), apart from clean fallow in 4 main plots and 3 N rates (control, 50% and 100% of recommended dose in both crops) in subplots. Rice yield significantly responded to green-manuring, whereas succeeding wheat to the residual effect of green-manuring was only a marginal. *Dhaincha* and greengram showed superiority to rest of the treatments. Cowpea ranked second in position. More or less same trend was observed for economics. N level linearly responded up to 100% level in all respects. Green-manuring also improved the organic carbon of the soil irrespective of soil depth.

Key words : Green-manure Crop, Nitrogen, Productivity, Rice–wheat cropping system

In Bihar plains there is a ample scope of rice–wheat cropping system, especially in lowland rice ecosystem after the introduction of high-yielding rice varieties even in lowland situation. Besides, there is no alternative in winter season (*rabi*) due to late harvest of rice under the said environment. So, area under rice–wheat cropping system is increasing day-by-day under lowland ecosystem. Since both the crops are exhaustive in nature, it was considered imperative to find out the ways and means for sustaining the productivity of the said system.

MATERIALS AND METHODS

A field experiment was conducted at research farm of the Rajendra Agricultural University, Pusa (Bihar), from 1992–93 to 1993–94 on a silty loam soil. The soil had

pH 8.4, 172.0 kg available N, available P_2O_5 21.6 kg and 109.2 kg available K_2O/ha. The experiment was laid out in split-plot design with 3 replications. The experiment comprised 3 green-manuring crops, viz. *dhaincha* as green-manure, greengram as dual purpose and cowpea as fodder crop, taken as pre-*kharif* in main plots and 3 nitrogen levels (control, 50%, and 100% recommended dose of both the crops) in subplots. Initial soil samples from 0–15 and 15–30 cm soil depth were taken at the beginning of the experiment in 1992.

Green-manuring crops were grown during fallow period available between harvest of wheat and planting of succeeding rice (second week of April-end or June). Greengram was sown just after harvest of wheat in every year, while *dhaincha* and cowpea were sown in middle of May for maintaining suitable age for incorporation and green fodder respectively. All the green-manuring crops were raised at recommended practices under irrigated conditions. The addition of N due to *dhaincha* and greengram was 55.8–62.2 kg/ha and 21.2–24.7 kg/ha respectively (Table 1). The 30-day-old seedlings of succedding rice var. 'Radha' was transplanted (during last week of July) in a spacing of 20 cm × 15 cm, 1 day after incorporation of green-manuring crops in well-puddled conditions. The recommended dose of fertilizer for rice is 80, 40 and 20 kg N, P_2O_5 and K_2O/ha, out of which whole P and K was uniformly used in all the plots as basal and N was used in 3 equal splits, i.e. one-third basal, one-third at active tillering stage and remaining at panicle-initiation stage, according to treatments. Need-based cultural operations were practised.

To test the residual effects of green-manuring crops after rice, 'UP 262' wheat was sown on the same field layout during first week of December. The recommended dose of fertilizer for wheat is 100, 50 and 30 kg N, P_2O_5 and K_2O/ha. Out of which whole P and K was uniformly applied in all the plots as basal. N was used in 3 equal splits, i.e. one-third at seeding, one-third after first irrigation and remaining one-third at boot stage according to treatments. Need based cultural operations were given. Soil-samples of 2 depths (0–15 and 15–30 cm) were collected from each plots after harvest of last crop and all the parameters for physico-chemical properties of soils were analysed (Chapman and Pratt, 1961). The economics of the whole system was calculated on the basis of prevailing market prices of the materials.

Table 1. Effect of green-manure of legumes on green-matter production and nitrogen addition (mean data of 2 years)

Treatment	Green matter (q/ha)	N addition (kg/ha)
Dhaincha (control)	174.5	55.8
Dhaincha (50% N)	178.0	58.7
Dhaincha (100% N)	178.5	62.4
Greengram (control)	51.0	21.2
Greengram (50% N)	55.0	23.4
Greengram (100% N)	56.0	24.7

Figures in parentheses indicate N level of previous crop

RESULTS AND DISCUSSION

Productivity of rice

Yield and yield attributes of rice varied

significantly due to treatments (Table 2). Among the green-manuring crops, green-manuring with *dhaincha* used as pre-*kharif* significantly improved the productivity of rice over other sources. This might be owing to more panicles/m^2, filled grains/panicle and 1,000-grain weight compared with other 2 sources. The beneficial effects of green-manuring with *dhaincha* on rice yield was owing to more addition of nitrogen by green-manuring over haulm and root burried of greengram and cowpea respectively (Table 1). The green-manuring by *dhaincha* (45 days old) at the time of burial was succulent herbage having low C:N ratio. Favourable temperature (35–40°C) and adequate moisture in the field because of succeeding crop (water loving in nature), so more presence of water, caused rapid decomposition of green-manuring of *dhaincha* plant. Therefore, nitrogen was released into the soil for a longer period which was positively reflected in increasing yield and yield attributes of rice. In green-gram haulm and cowpea root-treated plots, there was marginal increase in yield. But it did not reach up to the level of significance compared to the control. This might be due to poor addition of N by greengram haulm and cowpea root. The finding confirms the results of Grewal *et al.* (1992).

The grain yield of rice increased significantly with increasing levels of N up to the 100% recommended dose of N. However, differences in yield between 50% and 100% was only marginal, i.e. 4.39 q/ha.

Table 2. Impact of green-manuring crop and nitrogen on yield and yield attributes o rice–wheat system (pooled data of 2 years)

Treatment	Rice				Wheat			
	Grain yield (q/ha)	Effective tillers/ m^2	Filled grains/ panicle	1,000-grain weight (g)	Grain yield (q/ha)	Effective tillers/ m^2	Filled grains/ panicle	1,000-grain weight (g)
Green-manuring crop								
Control	27.32	265	73	21.62	21.12	289	39.8	40.41
Dhaincha	33.90 (177.00)	301	89	22.17	22.35	295	40.2	40.50
Greengram	29.84 (2.2, 54.6)	278	84	22.15	22.10	291	40.1	40.47
Cowpea	29.50 (108.0)	277	84	22.15	22.11	291	40.1	40.48
CD (P = 0.05)	2.11	9	5	0.08	NS	NS	NS	NS
Nitrogen level								
Control	21.93	248	67	21.20	11.70	263	38.5	38.72
50%	3.32	290	86	22.36	23.61	298	40.2	40.85
100%	36.25	302	94	22.48	29.94	310	41.3	41.90
CD (P = 0.05)	2.72	11	8	0.10	2.42	11	0.7	0.52

Figures in parentheses indicate *dhaincha* green matter yield, greengram grain and haulm weight and cowpea fodder yield, respectively

Table 3. Effect of different treatments on total yield in terms of rice equivalent and economics of rice–wheat cropping system (pooled data of 2 years)

Treatment	Total yield in terms of rice equivalent q/ha)		Economics		
	Grain	Straw	Gross income (Rs/ha)	Net income (Rs/ha)	Benefit: cost ratio
Green-manuring crop					
Control	55.41	7015	17,321	7,921	1.84
Dhaincha	63.70	84.23	19,952	10,202	2.04
Greengram	62.74	82.40	19,634	9,884	2.01
Cowpea	60.61	71.00	18,920	9,170	1.4
CD (P = 0.05)	2.02	3.10	635	547	0.08
Nitrogen level					
Control	39.60	55.62	12,436	3,136	1.34
50%	65.24	82.20	20,382	10,832	2.13
100%	77.00	92.43	24.024	14,274	2.46
CD (P = 0.05)	3.62	4.43	1,102	844	0.011

This might be due to partial substitution of N by green-manuring crops. The results confirm the findings of Singh and Brar (1985) and Mahler and Auld (1989).

Residual effect of green-manuring on wheat

The residual effect of green-manuring crops on wheat behaves similarly but these differences were statistically alike, while N responded linearly up to recommended dose of N, might be due to only marginal residual effect of green-manuring crops.

Total yield in terms of rice equivalent of the whole system, *dhaincha* and greengram (grain+haulm)-treated plots were statistically similar and both showed superiority to rest of the sequences (Table 3). Cowpea (fodder + root effect)-treated sequence ranked second in position. The total yield increased significantly with increasing level of N.

Economics

Dhaincha-treated plot recorded the highest gross income, net income and benefit : cost ratio and all showed superiority to rest of the sequences except greengram. Cowpea-treated sequence ranked second in position. With regard to N level, all economical parameters studied increased significantly with increasing levels of N.

Green-manuring effect on soil fertility

All physico-chemical parameters studied except organic carbon recorded almost similar values at final stage as compared to initial values at both the depths of soil. The organic carbon of the soil improved in general with green-manuring, whereas control plot recorded lower value than initial, it declined to 0.4% (Table 4). Among the green-manuring crops,

Table 4. Change in physico-chemical properties of soil on soil-depth basis

Treatment	0–15 cm					15–30 cm				
	pH	N	P	K	OC (%)	pH	N	P	P	OC (%)
				Initial value						
	8.4	174.2	21.6	119.2	0.52	8.2	165.1	20.5	113.6	0.49
				Final value (after harvest of last crop)						
Green-manuring crop										
Control	8.4	172.0	21.4	118.4	0.48	8.3	163.4	20.0	113.0	0.43
Dhaincha	8.3	174.4	21.9	119.4	0.56	8.1	165.0	20.7	113.5	0.50
Greengram	8.3	174.3	21.5	119.2	0.54	8.2	165.2	20.6	113.4	0.49
Cowpea	8.4	174.2	21.5	119.3	0.53	8.2	165.0	20.5	113.2	0.47
Nitrogen level										
Control	8.5	171.5	21.0	118.3	0.55	8.3	162.9	20.1	112.5	0.48
50%	8.4	175.7	21.3	118.7	0.55	8.2	164.4	20.0	112.9	0.47
100%	8.5	174.0	21.4	119.0	0.52	8.3	165.0	20.2	113.1	0.46

N, Available nitrogen (kg/ha); P, available P_2O_5 (kg/ha); K available K_2O (kg/ha); OC= organic carbon

dhaincha recorded higher values owing to more addition of green matter. Since green-manuring was continuously done in each year, the increase in organic carbon content of the soil was obvious. Singh and Brar (1985) and Kolar *et al.* (1990) also reported increase in organic carbon content of soil with green-manuring. But nitrogen level showed retarding trend. This might be due to rapid decomposition of organic matter due to increasing rate of N.

It may, therefore, be concluded that green-manuring in general enhanced the productivity as well as nutrient-use efficiency of the rice-wheat system. Besides, it also improved the status of the soil fertility.

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