Indian Journal of Agronomy **46** (4) : 573–577 (December 2001)

Productivity, profitability and stability of rice (*Oryza sativa*)-based cropping systems in eastern Uttar Pradesh

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Received: December 2000

ABSTRACT

Six rice (*Oryza sativa* L.) - based cropping systems were tested from 1995–96 to 1999–2000 at Faizabad, Uttar Pradesh. Highly intensive crop sequences, viz. rice–potato (*Solanum tuberosum* L.) + Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson]–blackgram (*Phaseolus mungo* L.), rice– potato + wheat (*Triticum aestivum* L. emend. Fiori & Paol.)– sesbania (*Sesbania aculeata* Pers.) green-manure and rice–potato + garlic (*Allium sativum* L.)–cowpea [*Vigna unguiculata* (L.) Walp.] green fodder + maize (*Zea mays* L.), were found to be distinctly better in terms of rice-grain equivalent (15,336 to 17,782 kg/ha) and productivity (51.6 to 53.1 kg grain/day/ha) compared to rice–wheat– sesbania green-manure (GM) sequence which yielded rice-grain equivalent of 11,450 kg/ha and productivity of 44 kg grain/day/ha. However, in terms of stability, the rice–wheat–green-manure sequence was more stable, with a stability index 0.95 and profitable (benefit : cost ratio 1.68) than these intensive cropping systems. The benefit : cost ratio of the systems, which had potato as a component crop, became low because of higher cost of cultivation due to more labour (man-days) requirement. Rice–potato + garlic – green fodder was more nutrients exhaustive sequence which decreased organic carbon status and nutrient availability of soil. However, *in-situ* green-manuring of *Sesbania aculeata* during summer (*zaid*) enhanced soil fertility and improved organic matter and nutrient availability. Rice–wheat sequence with sesbania green-manuring was more suitable for better net returns and stable production with minimum labour (man-days) requirement under irrigated conditions.

Key words : Rice-based cropping systems, Productivity, Stability, Soil fertility

The importance of highly intensive crop sequence is well recognized to meet the growing demands of ever-increasing population. An intensive cropping system which is not only highly productive and profitable but also stable over time and maintains soil fertility, is of great importance in present conditions. Ghosh (1987)

concluded that the basic requirement for stabilizing the crop productivity lies in the betterment of soil fertility. To work out the stability of intensive crop sequences and their relative effects on soil fertility, 6 rice–based crop sequences were tested continuously for 5 years.

MATERIALS AND METHODS

The field experiment, involving 6 crop sequences, was carried out from 1995–96 to 1999–2000 at Main Experiment Station, Masodha, Faizabad. The soil of the experimental site was silty loam of alluvial origin. The soil was low in organic carbon (0.51%) and available N (142 kg/ha) and medium in available P (18 kg/ha) and K (136 kg/ha), with pH 7.3. Six rice-based crop sequences, viz. T_1, rice–wheat–green-manure; T_2, rice–maize–green-manure; T_3, rice–potato+ Indian mustard–blackgram; T_4, rice–potato + garlic – green fodder (maize + cowpea); T_5, rice–toria [*Brassica campestris* L. ssp. *oleifera* (Metzger) Sinsk. var. *toria*] –onion (*Allium capa* L.); and T_6; rice–potato + wheat – green-manure, were tested in randomized block design with 4 replications. All the crops were grown with recommended practices and rice was transplanted in each crop sequence. Crops in association, viz. potato + Indian mustard, were planted at 3 : 1 ratio, potato+ garlic and potato + wheat at 1 : 1 row ratio. For green-manuring, 45–50 days old *Sesbania aculeata* (*in situ*) was incorporated into the soil, 2–3 days before transplanting of rice. The crop-wise recommended doses of N, P_2O_5 and K_2O were respectively 120, 60 and 40 kg/ha for rice and wheat; 150, 60 and 40 kg/ha for winter (*rabi*) maize; 150, 60 and 60 kg/ha for potato + Indian mustard, potato + garlic and potato + wheat; 80, 40 and 40 kg/ha for *toria*; 60, 30 and 30 kg/ha for maize + cowpea (green fodder); 80, 40 and 80 kg/ha for onion; and 15, 40 and 0 kg/ha for blackgram and *dhaincha*. The N, P and K were applied through urea, diammonium phosphate and muriate of potash respectively. The crop duration was 130 days for rice and wheat each, 160 days for winter maize, 120 days for potato + Indian mustard, 150 days for potato + garlic and potato + wheat, 80 days for toria and onion, 60 days for green fodder and 50 days for green-manure crop. The total rainfall received was 1,004; 1,060; 1,400; 1,070 and 1,304 mm during 1995–96, 1996–97, 1997–98, 1998–99 and 1999–2000 respectively. However, in the winter season (November to April) there was 187, 69, 197, 58 and 124 mm rains during first, second, third, fourth and fifth year respectively. The economics and rice-equivalent yield were computed at prevailing market rates of different commodities during 1999–2000. The benefit : cost ratio was calculated as gross return divided by cost of cultivation. The soil samples (0–15) cm) were collected in June 2000 from each treatment and analysed for organic carbon, available N, P and K by standard methods.

Stability indices were computed for the individual crop and crop sequence (based on rice-grain-equivalent yield) as per the method of Singh *et al.* (1990).

RESULTS AND DISCUSSION

Productivity

The higher grain yield of rice was

obtained from the sequences which included summer green-manure (T_1, T_2, T_6) or pulse crop (T_3) than the sequence having green fodder crops (T_4) during summer season (Table 1.) It might be due to positive effect of green-manure or pulse crop on soil the fertility, while fodder crops are heavy feeders of the nutrients. The results confirm the findings of Nanda *et al.* (1999) and Verma and Warsi (1999). Intercropping of mustard / garlic / wheat did not show any influence on the yield of potato during the winter season.

Among the 6 crop sequences, the highest rice-grain equivalent (kg/ha) with productivity were obtained in the sequence rice–potato + Indian mustard–blackgram (Table 1), followed by the sequence rice–potato + garlic–green fodder (maize + cowpea) and rice–potato + wheat–green-manure. The lowest rice-equivalent yield was however recorded in the rice–maize–green-manure system having productivity of 35.0 kg/day/ha.

Stability

The rice crop during the rainy season showed high stability, depending upon the sequences followed (Table 1). In the winter the garlic crop was found highly unstable with lowest stability index, followed by *toria* and Indian mustard, while potato and wheat crops were found highly stable with stability indices (SI) 0.77–0.89 and 0.92 respectively. Higher stability of rice and potato was recorded when green-manure or pulse (blackgram) crop was taken during summer. When sequences as a whole was considered, rice–wheat–green-manure (T_1) was found to be more stable, followed by

Table 1. Productivity and stability of rice-based cropping systems (mean data of 5 years)

Treatment	Pooled yield (kg/ha)			Rice-grain equivalent (kg/ha)*	Productivity (kg/day//ha)	Stability indices			
	Rainy season	Winter	Summer			Rainy season	Winter	Summer	Sequences
T_1	5,988	4,575		11,450	44.0	0.87	0.92		0.95
T_2	5,909	4,609		10,142	35.0	0.87	0.75		0.87
T_3	6,003	19,062 + 631	737	17,782	53.1	0.85	0.89 + 0.59	0.49	0.85
T_4	5,601	19,465 + 1,003	46,375	17,550	51.6	0.81	0.77 + 0.25	0.84	0.74
T_5	5,793	917	9,640	11,602	40.0	0.82	0.51	0.77	0.77
T_6	5,939	19,916 + 1,063		15,336	52.9	0.84	0.84 + 0.78		0.87
T_7	231			729	2.54				
CD (P=0.05)									

Details of treatments are given in text
*Straw yield was not considered

rice–potato + wheat– green-manure and rice–maize–green manure. The sequences which did not include summer green-manure or pulse crop (T_4 and T_5) showed lower stability (0.74–0.77), mainly because of high fluctuations in the yields of some summer/inter crops, viz. garlic, *toria* and onion, in the systems. Inclusion of green-manure or pulse crop during summer may help in stabilizing the yields by improving soil fertility. Ghosh (1987) also concluded that maintenance of soil fertility is a basic requirement to ensure adequate stability in the yields.

Economics

The pooled analysis of results of successive 5 years (Table 2) revealed that minimum cost of cultivation was incurred in rice–wheat–green-manure sequence and provided maximum net returns with highest benefit : cost. This sequence was closely followed by rice–potato + garlic – green fodder and rice–potato + Indian mustard–

Table 2. Economics of rice-based cropping systems (mean data of 5 years)

Treatment	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	Benefit : cost ratio	Labour (man-days/ ha/year)
T_1	33,284	22,821	1.68	252
T_2	35,053	14,642	1.42	336
T_3	66,001	21,114	1.32	546
T_4	64,553	21,446	1.33	492
T_5	43,012	13,824	1.32	429
T_6	58,814	17,538	1.30	414

Details of treatments are given in text

Table 3. Changes in soil-fertility status over 5 years under different cropping systems

Treatment	Organic carbon (%)	Available (kg/ha)		
		N	P	K
T_1	0.55	156	24.0	150
T_2	0.53	149	22.5	148
T_3	0.52	158	24.6	156
T_4	0.48	140	17.4	139
T_5	0.49	144	19.8	145
T_6	0.54	153	25.2	154
Initial values (June 1995)	0.51	142	18.0	136

Details of treatments are given in text

blackgram. Economics showed that inclusion of potato in the system increased the cost of cultivation because of higher labour (man-days) requirement (Table 2) which decreased the benefit : cost ratio. Nanda *et al.* (1999) also reported that potato was labour-intensive and required more energy input.

Soil fertility

Changes in the organic carbon and availability of nutrients over 5 years (Table 3) showed that rice–potato + garlic–green fodder sequence (T_4) was the most exhaustive, as potato and maize are heavy feeders of nutrients. Inclusion of green-manure crop in the system increased the organic carbon and available N, P and K of the soil. The sequence involving legume crop (T_3) also showed slight improvement in soil fertility. Chaudhary *et al.* (1995) also observed that green-manuring of sesbania increased the availability of nutrients and organic carbon in soil. Thus green-manuring and legume crop could help in maintaining the soil fertility and stabilizing crop yields on a long-term basis.

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