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Productivity and economics of rice (*Oryza sativa* L.)–wheat (*Triticum aestivum*) cropping system under integrated nutrient supply systems

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ABSTRACT

A field experiment was conducted during the rainy and winter seasons of 1995–96 and 1996-97 to study the influence of integrated nutrient-supply system, comprising inorganic fertilizer and organic manures, on the soil-fertility status, productivity and economics of rice (*Oryza sativa* L.)–wheat *(Triticum aestivum* L. emend. Fiori & Paol.) cropping system. Green-manuring with prickly sesban or *dhaincha* [*Sesbania cannabina* (Retz) Pers.; syn. *S. aculeata*] to supplement 50% of the recommended nitrogen dose and rest through inorganic fertilizer and 100% recommended dose of fertilizer to wheat crop gave the maximum yield of rice as well as wheat crops. The same treatment also gave the highest net returns and benefit : cost ratio, and produced significantly higher bio-mass in terms of rice-equivalent yield. Among the organic manures, the overall performance of green-manure was best followed by farmyard manure and rice straw. The results showed a possibility of saving 50% fertilizer N in rice and 25% in wheat. Application of farmyard manure and rice straw as well as green-manuring in rice significantly improved the available N and P status of soil.

Key words : Integrated nutrient management, benefit : cost ratio, Net return, Available N, P status

Rice and wheat are the staple food of our population and an efficient and sustainable production system under cereal-based cropping system in India. At a time when the use of high-energy agricultural inputs in the form of excessive fertilizers and pesticides are causing environmental hazards, it is imperative to develop a sustainable production system with maximum productivity and minimum environment pollution.

The role of plant nutrient would be extremely important from sustainability point of view. It is therefore necessary to judiciously manage the inflow of organic source of nutrients and their integration with fertilizers. The integrated use of chemical fertilizers, green-manuring and recycling of crop residues thus assumes greater significance (Meelu, 1996). At the same time it is important to ensure that whether economics of Indian farmers allow them to follow such a system of production.

Keeping this in view the experiment was conducted to evaluate the productivity and economics of rice–wheat cropping system under integrated nutrient supply system and its influence on soil-fertility status.

MATERIALS AND METHODS

A field experiment was conducted in the rainy *(kharif)* and winter *(rabi)* seasons of 1995-95 and 1996-97 at Raipur (21^{0}N and 81.36^{0}E, 289.56 msl), with pH 7.4 and 7.3, organic carbon 0.60 and 0.62%, total N 231 and 236 kg/ha, available P 11.5 and 12.1 kg/ha and available K 274 and 279 kg/ha during 1995-96 and 1996-97 respectively.

There were 12 treatment combinations, replicated 3 times in randomized block design. The net plot size was 62.4 m^2. The experimental plots were permanent for both the years. Rice variety 'Kranti' and wheat variety 'Mangla' were grown. The recommended dose of fertilizer was 80 kg N, 60 kg P and 40 kg K for rice and 100, 50 and 30 kg N, P and K/ha for wheat. In the rainy season, integrated nutrient-supply system was accomplished by supplementing 25-50 % of the recommended N doses through organic matter, viz. farmyard manure, rice straw and green-manure. In the winter season, only inorganic fertilizers were used as per the treatments. For treatments T_6 and T_7, FYM was analysed for N content and the required amount was supplied to obtain 50% and 25% of the N dose. Similarly, for treatment T_8 and T_9 cut paddy straw from the preceding crop season was used, and for treatments T_{10} and T_{11} *Sesbania cannabina* green-manure was grown during summer and the required amount was supplied at the time of puddling preceding rice transplanting (Table 1).

Grain and biomass yields, total productivity/ha/year (grain and biomass), gross monetary returns, net monetary returns and benefit : cost ratio obtained from the cropping sequence during 1995-96 and 1996-97 were pooled. Economics of fertilizer application in the cropping system was worked out.

RESULTS AND DISCUSSION

Grain yield and land productivity

The grain yield of rice was the highest when 50% N was substituted by green-manure, but was at par with 100% recommended dose of fertilizer. Reducing the general recommended dose of fertilizer by 50% resulted in significant yield reduction. Among different organic sources of nitrogen, green-manure was found superior, followed by FYM and rice residue.

The grain yield of wheat was higher with 100% dose of chemical fertilizer and green-manuring in preceding rice than 100% recommended dose of fertilizer applied to both the crops. This shows the positive residual effect of green-manuring.

The total grain productivity in terms of rice-equivalent yield was significantly superior when 50% recommended dose of nitrogen was supplemented in rice through green-manure to the application of 100% dose of chemical fertilizer to both the crops. This was however, at par with 25% substitution and 75% recommended dose of fertilizer applied to wheat crop. Thus there

Table 1. Details of treatments integrated nutrient supply system

Treatment	Cropping system with specific treatments		Fertilizer dose applied N : P : K (kg/ha)	
	Rainy season	Winter season	Rainy season	Winter season
T_1	No fertilizer, no organic manure (control)	No fertilizer, no organic manufe (control)		
T_2	50% recommended NPK dose through fertilizers	50% recommended NPK dose through fertilizers	40:30:20 (50%)	50:25:15 (50%)
T_3	50% recommended NPK dose through fertilizers	100% recommended NPK dose through fertilizers	40:30:20 (50%)	100:50:30 (100%)
T_4	75% recommended NPK dose through fertilizers	75% recommended NPK dose through fertilizers	60:45:30 (75%)	75:37.5:22.5 (75%)
T_5	100% recommended NPK dose through fertilizers	100% recommended NPK dose through fertilizers	80:60:40 (100%)	100:50:30 (100%)
T_6	50% recommended NPK dose through fertilizers + 50% N through FYM	100% recommended NPK dose through fertilizers	40:30:20 (50%) + 50% N (FYM)	100:50:30 (100%)
T_7	75% recommended NPK dose through fertilizers 25% N through FYM	75% recommended NPK dose through fertilizers	60:45:30 (75%) + 25% N (FYM)	75:37.5:22.5 (100%)
T_8	50% recommended NPK dose through fertilizers + 50% N through rice straw	100% recommended NPK dose through fertilizers	40:30:20 (50%) + 50% N (FYM) (rice straw)	100:50:30 (100%)
T_9	75% recommended NPK dose through fertilizers 25% N through rice straw	75% recommended NPK dose through fertilizers	60:45:30 (75%) + 25% N (FYM) (rice straw)	75:37.5:22.5 (75%)
T_{10}	50% recommended NPK dose through fertilizers + 50% N through green-manure	100% recommended NPK dose through fertilizers	40:30:20 (50%) + 50% N (GM)	100:50:30 (100%)
T_{11}	75% recommended NPK dose through fertilizers + 25% N through green-manure	75% recommended NPK dose through fertilizers	60:45:30: (75%) + 25% N (GM)	75:37.5:22.5 (75%)
T_{12}	Conventional farmer's practice	Conventional farmer's practice	50:30:20	60:40:20

P, P_2O_5; K, K_2O

was a saving of 50% N by green-manuring on system basis.

Crop productivity economics

The gross monetary return was significantly higher when 50% N in rice was substituted by green-manure and following wheat was fertilized with 100% recommended dose compared with application of 100% dose of recommended fertilizer to both rice and wheat crops.

The highest benefit : cost ratio was observed where rice was fertilized by 50% or 75% recommended dose of N and 50%

Table 2. Production potential and economics of rice–wheat crop sequence under integrated supply system (mean data of 1995–96 and 1996–97)

Treatment	Grain yield (q/ha)		Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit : cost ratio	Total rice - equivalent yield (q/ha)		
	Rainy season (rice)	Winter season (wheat)				Grain	Straw	Biomass
T_1	25.81 (63.80)	13.00 (18.46)	21,855	8,176	0.59	46.03	91.14	137.17
T_2	46.60 (190.40)	23.12 (32.11)	38,328	22,246	1.38	82.56	156.97	239.53
T_3	48.88 (115.60)	29.50 (40.65)	43,615	26,889	1.60	94.76	175.82	270.50
T_4	54.61 (130.35)	27.45 (38.15)	45,147	27,948	1.62	97.31	186.86	284.17
T_5	58.91 (138.30)	31.30 (43.41)	49,800	31,753	1.75	107.59	202.61	301.20
T_6	55.82 (132.52)	31.70 (43.80)	48,515	29,468	1.54	95.13	197.40	292.53
T_7	57.36 (133.46)	31.35 (43.89)	49,057	30,995	1.71	106.12	198.48	304.60
T_8	54.12 (128.00)	31.10 (43.20)	47,275	28,506	1.51	102.49	192.00	294.49
T_9	55.14 (130.05)	31.10 (43.38)	47,785	29,795	1.65	103.51	194.31	297.82
T_{10}	61.83 (145.85)	33.60 (46.56)	52,755	34,368	1.87	114.09	214.82	328.91
T_{11}	60.67 (145.60)	32.00 (44.14)	51,135	33,356	1.87	110.44	210.99	321.43
T_{12}	46.58 (119.48)	26.80 (36.36)	42,210	26,196	1.63	91.26	173.34	264.60
CD (P=0.05)	3.31	1.71	1,648	4,727	0.07	3.98	20.14	18.17

Details of treatments are under Table 1; figures in parentheses indicate straw yield

or 25% through green-manure and the following wheat by either 75% or 100% NPK. This result confirms the possibility of saving 50-25% fertilizer N with the incorporation of green-manure.

Nutrient status

An application of 100% NPK through chemical fertilizers or their combined use with organic sources showed a significant increase in available N and P status of soil over the control plot (Table 3). The most effective contribution of inorganic and organic nutrient sources to available N status of soil was observed where 50% N was applied through green-manure in the rainy season and 100% NPK in winter season (T_{10}). Bellakki and Badanur (1997)

Table 3. Available nutrient status after rice and wheat

Treatment	After rice-harvest						After wheat harvest					
	N		P		K		N		P		K	
	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97
T_1	206	205	6.8	6.6	196	203	208	211	6.2	6.10	208	205
T_2	228	232	9.2	9.9	204	212	220	225	10.3	11.63	210	208
T_3	234	232	10.3	11.6	212	224	238	240	12.6	13.14	217	216
T_4	240	240	11.9	13.1	218	229	245	240	13.9	13.25	221	219
T_5	249	252	16.2	20.0	238	246	256	254	19.3	22.32	230	234
T_6	252	249	17.6	18.6	229	243	259	264	18.5	21.71	225	227
T_7	246	247	15.8	17.5	226	232	252	256	17.8	20.24	222	226
T_8	247	246	15.2	18.3	221	239	257	261	14.2	20.05	221	225
T_9	241	241	14.3	16.5	226	240	251	257	15.9	18.05	232	230
T_{10}	261	265	14.5	17.5	231	242	261	269	17.8	20.26	225	228
T_{11}	251	254	13.7	17.2	218	225	255	258	16.0	20.10	230	231
T_{12}	231	225	13.2	15.5	210	223	239	243	14.8	16.10	217	214
CD (P=0.05)	25	24	2.7	2.8	NS	NS	23.3	27.0	1.1	2.76	NS	NS

Details of treatments are given in Table 1 also reported that sunhemp (*Crotolaria juncea* L.) alone or in combination inorganic fertilizer significantly increased the available N and P status of the soil. The build up of available N and P in the soil in 100% NPK or 50% NPK + 50% N through organic source can be attributed to the residual effect of fertilizers and mineralization of organic sources respectively. The available K status of the soil did not show any substantial change in all the treatments, however the maximum K content was observed with 100% dose of NPK (T_5).

REFERENCES

Bellakki, M. A. and Badanur, V. P. 1997. Long term effect of integrated nutrient management on properties of vertisol and dry land agriculture. *Journal of Indian Society of Soil Science* **45** (3) : 438–442.

Bhandari, A. L., Sood, Anil, Sharma, K. N. and Rana, D. S. 1992. Integrated nutrient management in a rice-wheat system. *Journal of Indian Society of Soil Science* **40** : 742.

Meelu, O. P. 1996. Integrated nutrient management for ecologically sustainable agriculture. *23rd Tamhane Memorial Lecture. National Seminar on Development in Soil Science,* held during 28 October-1 November 1996, held at the Gujarat Agricultural University, Anand.

Patil, C. B. 1997. Effect of varying fertility levels on productivity of cropping systems under irrigation in semi-arid regions of India. *Indian Journal of Agronomy* **42** (2) : 210–213