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Diversification of rice (*Oryza sativa*) – wheat (*Triticum aestivum*) cropping system for sustainable production in eastern Uttar Pradesh

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ABSTRACT

A field experiment was conducted at Faizabad during 2000-05 to find out the feasibility of diversification of traditional rice (*Oryza sativa* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system. Rice - potato (*Solanum tuberosum* L.) – greengram [(*Phaseolus radiatus* (L.) Wilczek)] sequence was found the most efficient for production (18.1 t/ha/year), employment generation (1.18 mandays/ha/day), monetary return (Rs 43,180/ha/year) and water-use efficiency (20.1 kg/ha/mm), followed by rice-onion (*Allium cepa* L.). Berseem [(*Trifolium alexandrinum* (L.) Tuslen.] may be taken as a break crop successfully for reducing weed problem (weed-control efficiency 88.7%) in continuous rice-wheat system without any monetary loss. Rice - berseem sequence was also found the most efficient in terms of nitrogen-use efficiency (80.2 kg grain/kg N). Inclusion of potato or onion (vegetable crops) was found quite stable with stability index of 0.86 and 0.83 respectively. The sequences including greengram or berseem (leguminous crops) improved the availability of NPK and organic C of the soil.

***Key words*:** Diversification, Rice-based cropping System, Soil fertility, Sustainability

Rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L. emend. Fiori & Paol.) is the most important crop sequence in India, occupying 60-70% of the total cultivated area in eastern Uttar Pradesh. Wide adoption of this system is mainly due to stable production and less labour requirement (Kumar *et al.,* 2001). But continuous adoption of this same sequence has led to the problem of specific weeds, reduced soil fertility in specific root zone with special reference to micronutrients and infestation of similar kind of pests, which ultimately resulted in declining the efficiency and productivity of the system (Katyal, 2003; Kumar and Yadav, 2005). Traditionally long-duration rice varieties, grown in lowland situations delay the sowing of wheat, which is another reason of yield decline in the system. It is difficult to replace rice by any other crop in rainy season due to soil and climatic conditions of the area. Hence the only option left is to replace wheat in winter season for diversification of rice-wheat system. Therefore, an experiment was conducted to find out the possible ways for the solution of weeds and delay in sowing wheat through diversification of the management practices and crop sequences for yield stability, potentiality and economic feasibility.

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MATERIALS AND METHODS

A field experiment was conducted at Crop Research Station, Masodha, Faizabad during 5 consecutive years from 2000-01 to 2004-05. The soil was silt loam in texture and taxonomically classified Typic Ustochrept. The soil was low in available N (142 kg/ ha), and medium in organic C (0.54%), available P (18.6 kg/ha) and available K (136 kg/ha) with pH 7.3. Eight treatments were adopted to find out the solution of weed problem and delay in sowing of wheat respectively. The treatments comprised four crop sequences with medium-duration rice variety 'NDR 359', viz. rice - wheat (normal sown); rice - berseem; rice - oat (multicut); and rice – potato - greengram; and four crop sequences with long-duration rice variety 'Jallahari', viz. rice - wheat (late sown); rice - wheat (zero till); rice - wheat (transplanted); and rice – onion. A randomized block design with four replications was followed. The varieties taken were: wheat 'HUW 234', potato 'C 140', onion 'Pusa Red', greengram 'NM 1', berseem 'JB 1' and oat 'UPO 94'. All the crops including rice (transplanted) were grown under irrigated conditions with recommended packages of practices. Wheat was transplanted using 15 day-old seedlings (raised in nursery) at a distance of 20 x 10 cm in moist soil and thereafter a light irrigation was applied to establish the seedlings. The recommended doses of NPK were applied through urea, diammonium phosphate and muriate of potash respectively. The soil samples (0-15 cm) were collected at the end of fifth cycle and were analysed for organic C, and available N, P and K by following standard procedures. The economics and rice-equivalent yield were computed at prevailing market rates during 2004-05 of different commodities. The land-use efficiency was worked out by dividing the total duration of crops in individual crop sequence by 365 (days). The production efficiency was worked out by dividing the total production of a sequence by total duration of the crops in that sequence (Tomar and Tiwari, 1990). Weed-control efficiency was calculated by taking rice - wheat as the check. Stability indices were computed for the sequences on the basis of rice-grain-equivalent yield (Singh *et al.*, 1990).

RESULTS AND DISCUSSION

Yield and economics

Maximum rice grain-equivalent yield of 18.1 t/ha/year was recorded with rice – potato - greengram sequence, which showed 54, 61, 107 and 84% increase over rice (medium duration) – wheat (normal sown), rice - berseem, rice - oat and rice (long duration) - wheat (late sown) sequences respectively (Table 1). The transplanting of wheat gave 0.76 t/ha higher grain yield than traditional late-sown wheat after long-duration rice. The increase in yield might be due to 15-20 days greater crop duration (seed to seed) in transplanted wheat, which resulted in longer reproductive phase than late-sown wheat.

The rice-wheat (conventional) system either in timely-sown or in late-sown condition was found most sustainable (SI = 0.96), followed by rice - oat (SI = 0.89) and rice - berseem (SI = 0.82). The system including vegetable crops, viz rice – potato - greengram and rice - onion were also noted quite stable (SI = 0.86 and 0.83). Kumar *et al.* (2001) also observed that rice - wheat was most stable system in eastern Uttar Pradesh conditions.

The highest net returns of Rs. 43,100/ha/year was provided by rice – potato - greengram sequence, followed by rice - onion (Rs. 36,400/ha/year), and both the sequences gave significantly higher net return than other crop sequences (Table 1). Kharub *et al.* (2003) also reported that inclusion of vegetable and legume crops in rice-based crop sequences improved the productivity and net returns. The other good sequences were rice - wheat (normal sown) and rice - berseem, which gave significantly higher net returns than rice - oat and rice - wheat (zero till) sequences. After long-duration rice, the advancement of wheat sowing through zero tillage practice showed higher monetary advantage (Rs 4,100/ha/year) over late-sown wheat after conventional tillage, but transplanting of wheat failed to provide any extra monetary gain over late-sown wheat due to its higher cost of cultivation (Rs. 36,400/ha/year), although it increased the grain yield (0.76 t/ha) by advancement of wheat sowing.

Weeds

The cultivation of oat and berseem as multicut-fodder crops in place of wheat reduced the total biomass of weeds to 13 g/m^2 from 108-115 g/m^2 recorded in wheat crop. The weed data showed that diversification of rice - wheat to rice - oat and rice - berseem effectively reduced the weed population of grassy weeds in *rabi*, recording 88.7% weed-control efficiency compared with the traditional rice - wheat system.

Table 1. Yield and economics of various rice-based crop sequences (mean data of 5 years)

Treatment	Yield (t/ha)			Rice yield equivalent (t/ha/year)	Cost of cultivation (x 10^3 Rs/ ha/year)	Net returns (x 10^3 Rs/ ha/year)	B : C ratio	Sustainability index
	Kharif	*Rabi*	*Zaid*					
Rice (MD) - wheat (NS)	5.30	4.61		11.7	30.6	33.4	1.10	0.96
Rice (MD) - berseem	5.35	53.91+0.15		11.2	28.7	33.1	1.15	0.82
Rice (MD) - oat (multi-cut)	5.32	34.21+0.83		8.7	24.0	23.9	0.99	0.89
Rice (MD) – potato - greengram	5.47	24.71	0.91	18.1	56.3	43.2	0.77	0.86
Rice (LD) - wheat (late sown)	4.99	3.24		9.8	30.2	23.8	0.79	0.96
Rice (LD) - wheat (transplanted)	4.84	4.00		10.9	36.4	23.4	0.64	0.94
Rice (LD) - wheat (zero till)	4.81	3.63		10.4	29.1	27.9	0.96	0.91
Rice (LD) - onion	4.89	13.65		13.4	37.4	36.4	0.97	0.83
SEm±				0.3		0.6		
CD (P=0.05)				1.0		1.9		

Sale price (Rs/kg): Rice grain 5.60, rice straw 0.25, wheat grain 6.40, wheat straw 1.00, berseem green fodder 0.50, berseem seed 80.00, oat grain 5.00, oat straw, 1.00, oat green fodder 0.50, potato-2.50, greengram 15.00, onion 3.50

Table 2. Efficiency of various rice-based crop sequences (mean data of 5 years)

Treatment	Production efficiency (kg/ha/day)	Land use efficiency (%)	N-use efficiency (kg grain/ kg N)	Water-use efficiency (kg/ha-mm)	Monetary return-use efficiency (Rs/ha/day)	Employment generation efficiency (mandays/ ha/day)	Dry weight of weeds (g/m²)	Weed-control efficiency (%)
Rice (MD) - wheat (NS)	45.1	71.2	48.9	19.5	131	0.54	115	
Rice (MD) - berseem	51.0	76.7	80.2	17.0	118	0.61	13	88.7
Rice (MD) - oat (multi cut)	33.5	71.2	39.6	14.5	92	0.47	13	88.7
Rice (MD) – potato - greengram	57.4	86.3	63.5	20.1	137	1.18	85	26.1
Rice (LD) - wheat (late sown)	38.9	71.8	40.9	14.9	91	0.54	75	34.8
Rice (LD) - wheat (transplanted)	38.1	78.1	45.3	16.5	82	0.85	87	24.3
Rice (LD) - wheat (zero till)	37.7	75.3	43.2	15.7	101	0.53	108	6.1
Rice (LD) - onion	55.9	65.7	49.7	20.3	152	0.85	70	39.1

Table 3. Changes in soil-fertility parameters after fifth cycle as influenced by different rice-based crop sequences

Treatment	Organic C (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Rice (MD) - wheat (NS)	0.56	154	21.5	148
Rice (MD) - berseem	0.62	168	24.2	146
Rice (MD) - oat	0.52	147	20.2	143
Rice (MD) – potato - greengram	0.59	160	23.4	159
Rice (LD) - wheat (late sown)	0.53	152	21.0	151
Rice (LD) - wheat (transplanted)	0.53	148	20.7	153
Rice (LD) - wheat (zero till)	0.55	150	20.3	148
Rice (LD) - onion	0.57	159	22.8	163
Initial soil-test values	0.54	142	18.6	136

LD = Long duration, SD = short duration, NS = normal sown, LS = late sown

Input use efficiency

Rice – potato - greengram and rice-onion sequences gave 57.4 and 55.9 kg/ha/day higher production efficiency compared with 45.1 kg/ha/day in rice - wheat sequence. The land-use efficiency (86.3%) and employment-generation efficiency (1.18 mandays/ha/day) was found highest in rice – potato - greengram sequence due to intensification of this system. Sharma *et al.* (2004) also reported that intensification through inclusion of vegetable and leguminous crops increased the production and land use efficiency. The increase in employment generation in rice - potato - greengram and rice - onion system improved the profitability, but in rice - wheat (transplanted) system it did not give monetary advantage over the existing rice - wheat system. The highest monetary return use efficiency (152 Rs/ha/day) and water-use efficiency (20.3 kg/ha/mm) were obtained in rice - onion system (Table 2). Rice - berseem sequence was found most efficient in terms of N-use efficiency (80.21 kg grain/kg N) and third in production efficiency and land use efficiency. Late sowing of wheat after long-duration rice showed lower values of nitrogen and water-use efficiencies, which were very close to the respective minimum values obtained in rice-oat system.

Soil fertility

Changes in the organic C and availability of major nutrients during the years (Table 3) showed that rice - oat (multicut) was more exhaustive cropping system, probably due to higher dry-matter production by multicut oat (fodder) crop. Inclusion of legume crop (greengram, berseem) in the system increased the organic C and availability of N, P and K in the soil. Sharma *et al.* (2004) also observed that sequences including fodder and legume crops improved the soil fertility.

These results clearly indicated that rice – potato - greengram sequence was the most efficient with respect to production, monetary returns and water-use efficiency, followed by rice - onion. Berseem may be taken as a break crop successfully for reducing the weed problem effectively.

REFERENCES

Katyal, J.C. 2003. Soil fertility management - A key to prevent desertification. *Journal of the Indian Society of Soil Science* **51**: 378–387.

Kharub, A.S., Chauhan, D.S., Sharma, R.K., Chokhar, R.S. and Tripathi, S.C. 2003. Diversification of rice (*Oryza sativa*) - wheat (*Triticum aestiivum*) system for improving soil fertility and productivity. *Indian Journal of Agronomy* **48**(3): 149–152.

Kumar, A. and Yadav, D.S. 2005. Influence of continuous cropping and fertilization on nutrient availability and productivity of an alluvial soil. *Journal of the Indian Society of Soil Science* **53**: 194–198.

Kumar, A., Yadav, D.S., Singh, R.M. and Achal, R. 2001. Productivity, profitability and stability of rice (*Oryza sativa*) – based cropping systems in eastern Uttar Pradesh. *Indian Journal of Agronomy* **46**(4): 573–577.

Sharma, R.P., Pathak, S.K., Haque, M. and Raman, K.R. 2004. Diversification of traditional rice (*Oryza sativa*) - based cropping system for sustainable production in south Bihar alluvial plains. *Indian Journal of Agronomy* **49**(4): 218–222.

Singh, R.P., Parr, J.F. and Stewart, B.A. 1990. Dry land agriculture-strategies for sustainability. *Advances in Soil Science* **13**: 340.

Tomar, S.S. and Tewari, A.S. 1990. Production potential and economics of different crop sequences. *Indian Journal of Agronomy* **35**(1&2): 30–35.