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Research Paper

Intensification of rice (*Oryza sativa*)-based cropping sequences with summer mungbean (*Vigna radiata*) in eastern Uttar Pradesh

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ABSTRACT

A field experiment was carried out during 2005-08 at Zonal Agriculture Research Sub-Station, Bari-Bagh, Ghazipur to evaluate the productivity, profitability and sustainability of rice (*Oryza sativa* L.)-based cropping sequences. In these 14 cropping sequences, rice was sequenced with feasible *rabi viz.*, wheat {*Triticum aestivum* (L.) emend. Fiori & Paol} lentil (*Lens culinaris* Medikus), pea (*Pisum sativum* L.), chickpea (*Cicer arietinum* L.), frenchbean (*Phaseolus vulgaris* L.), mustard {*Brassica juncea* (L.) Czern & Coss} and linseed (*Linum usitatissimum* L.) with and without inclusion of mungbean {*Vigna radiata* (L.) Wilczek} in summer and tested in randomized block design with three replications. Inclusion of mungbean during summer significantly increased the rice-equivalent yield. Rice-wheat-mungbean cropping sequence recorded the highest productivity (11.79 t/ha) in terms of rice equivalent yield with maximum gross returns (₹58,837/ha), net returns (₹28,532/ha), benefit: cost ratio (0.94), as well as production efficiency (₹96.06) and land use efficiency (81.37%). Rice-wheat-moongbean sequence was followed by rice-chickpea-mungbean and rice-mustard-mungbean pertaining to these parameters. Rice-wheat-fallow cropping sequence was more sustainable (0.67) and sustainability further improved to 0.87 when sequenced with moongbean in summer.

Key words: Profitability, Rice-based cropping sequences, Rice-equivalent, Sustainability, Summer mungbean

Rice-wheat is the most conventional and dominant cropping sequence in the gangetic plains region of the country, which occupies 65 to 70% of the total cultivated area in eastern Uttar Pradesh due to its higher and assured productivity. Rice-wheat crop sequence is very exhaustive as compared to rice-pulse and rice-oilseed sequences. Rice-wheat sequence removes 500-900 kg of $N+P_2O_5+K_2O$/ha/year along with significant amount of secondary and micronutrients (Shukla *et al*., 1998). Continuous cropping with rice-wheat has also adversely affected the physical properties of soil. Oilseeds and pulses are receiving more attention owing to higher prices due to increased demand. To fulfill the demand of cereal, pulses, and oilseeds of ever-increasing population, inclusion of oilseeds and pulses in rice based cropping sequence was found more beneficial than cereal alone (Kumar *et al.*, 2008). The short duration pulse crop could very well be introduced in rice-based cropping sequence during summer for maximizing the net return and restoring the soil fertility. Because, inclusion of legume crop during summer in the system increases the organic carbon and available N, P and K in the soil (Sharma *et al.*, 2004). An intensive cropping system which is not only highly productivity and profitable but also stable over time and maintains soil fertility, is of great importance in present scenario. Thus, fourteen rice based cropping systems were composed to develop economically viable, technically feasible and sustainable rice based sequence pertaining to eastern Uttar Pradesh.

MATERIALS AND METHODS

A field experiment was conducted for three years during 2005–08 at Zonal Agriculture Research Sub-Station, Bari-Bagh, Ghazipur (25^0 54' N, 83^0 58' E and 67.50 m above sea level) located in eastern part of Uttar Pradesh. The experimental soil was sandy clay with pH 7.6 and low organic carbon content (0.26%). Available phosphorus, potash and total nitrogen content of surface soil was 12.40, 139.80 and 244.42 kg/ha, indicating medium phosphorus

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and low in potassium and nitrogen in experimental soil. The experiment comprised of fourteen crop sequences viz., rice-wheat-fallow, rice-mustard-fallow, rice-linseed-fallow, rice-lentil-fallow, rice-pea-fallow, rice-chickpea-fallow, rice-frenchbean-fallow, rice-wheat-mungbean, rice-mustard-mungbean, rice-linseed-mungbean, rice-lentil-mungbean, rice-pea-mungbean, rice-chickpea-mungbean, rice-frenchbean-mungbean was conducted in randomized block design with three replications. The variety used for rice was 'NDR-80' during *kharif*, wheat 'HUW-234', mustard 'Varuna' linseed 'Garima', pea 'Rachana', lentil 'PL-460', chickpea 'Aurodhi', frenchbean 'PDR-14' during *rabi* and mungbean 'T-44'during summer, respectively. Half of the experimental field remained fallow during summer, where as mungbean 'T-44' was sown during summer in remaining half of experimental area after harvest of winter crops. After single picking of pods, crop residue of mungbean was incorporated in the remaining half of experimental area before transplanting of rice. Sowing of *kharif, rabi* and summer crops were done in second week of July, third week of November and second week of April. Sowing of different crops under different crop sequences was done as per recommended package of practices for crops under irrigated condition. The recommended dose of N: P: K (kg/ha) for rice and wheat 120:80:60, mustard 60:40:20, linseed 20:40:0, lentil, pea, chickpea and mungbean, 20:40:0 and frenchbean 120:60:30 was applied. The nitrogen, phosphorus and potash were applied through urea, single super phosphate and muriate of potash, respectively. Rice was supplied with 25 kg/ha $ZnSO_4$ each year.

The cropping sequences were evaluated in terms of rice yield-equivalent, economic returns and land use efficiency. Economic returns (₹/ha) and cost of cultivation (₹/ha) for individual crop in sequence were calculated on the basis of prevailing market rates of inputs and selling price of produce. Production efficiency in terms of ₹/ha/day was obtained by net monetary return of sequence divided by total duration of crops in that sequence. Sustainable yield index was worked out using the formula given by Singh *et al*. (1990):

$SYI = (Y_a - \sigma) \div Y_m$

Where, Y_a -is the estimated mean yield, 'σ' the estimated standard deviation and Y_m is the observed maximum yield obtained under cropping sequences.

RESULTS AND DISCUSSION

Crop Productivity

The grain yield of rice during rainy season registered significant variation under rice-based cropping sequences (Table 1). The maximum grain yield of rice was recorded in rice-chickpea-fallow (4.90 t/ha) followed by rice-pea-fallow (4.84 t/ha), rice-lentil-fallow (4.78 t/ha) and minimum under rice-wheat-fallow (4.30 t/ha). The exhaustive nature of wheat included in rice based cropping sequence might be the cause for decrease in rice yield (Shah *et al*., 1999). The grain yield of rice increased further with inclusion of moongbean during summer. The grain yield of rice increased to tune of 22.93, 21.68, 19.17 and 17.92 percent in rice-chickpea-mungbean (5.26 t/ha), rice-pea-mungbean (5.23 t/ha), rice-lentil-mungbean (5.12 t/ha) and rice-mustard-mung (5.07 t/ha) over the established cropping sequence i.e. rice-wheat-fallow (4.30 t/ha) cropping sequence. It was mainly owing to beneficial effect of moongbean during summer on the soil health. The results confirm the findings of Yadav *et al*. (2005).

System Productivity

The highest productivity of the cropping sequences based on rice equivalent yield (RYE) was recorded for rice-wheat-fallow (9.39 t/ha) followed by rice-chickpea-fallow (7.80 t/ha) and lowest under rice-linseed-fallow (6.75 t/ha). The higher rice equivalent yield in rice-wheat-fallow cropping sequence might be due to higher yield of wheat in the sequence. Further, the results revealed that there is sufficient scope to intensify the existing cropping sequence with inclusion of mungbean during summer. Inclusion of mungbean during summer increased cropping sequence productivity. Maximum productivity of the cropping sequence based on rice equivalent yield was registered in rice-wheat-mungbean (11.79 t/ha) and minimum under rice-linseed-mungbean (9.23 t/ha). This may be ascribed to low yield realized from linseed in the sequence.

Land Use Efficiency

Land use efficiency increased significantly with inclusion of mungbean during summer in all rice-based sequences compared to without moongbean during summer (Table 1). It clearly indicates that there is scope to include a pulse crop during summer after harvest of winter crops. Rice-wheat-mungbean sequence registered highest land-use-efficiency (81.37%), while the same was lowest (55.62%) in rice-mustard-fallow sequence. Rice-wheat-mungbean sequence occupied the field for longer duration (297 days) as compared to rice-mustard-fallow sequence (203 days). Further, rest of the rice with oilseed and rice with pulse crop sequences had more or less similar land use efficiency. The variation in land use efficiency was primarily due to variation in duration of winter crops in the sequences. The results are in conformity with those of Sharma *et al*., (2008).

Energy Production

The highest energy production of 28.26 x 10^6 K cal was

recorded with rice-wheat-fallow cropping sequence followed by rice-mustard-fallow (21.35 x 10^6 K cal) against lowest values of 18.19 x 10^6 K cal found with rice-frenchbean-fallow. Inclusion of mungbean during summer enhanced the energy output besides intensification of existing rice-wheat cropping sequence. These results are in conformity with the findings of Nanda *et al*. (2008)

Sustainability

The rice crop recorded highest sustainability (0.89) during rainy season when sequenced in rice-pea-fallow sequence, followed by rice-chickpea-fallow (0.88) and lowest (0.76) in rice-wheat-fallow sequence (Table 2). The sustainability of rice was further improved when sequenced with mungbean i.e. rice-chickpea-mungbean (0.95) during summer. It was probably because higher nutrient use in crop leading to accumulation with favourable effects on the rice yield in the sequence (Gangwar and Katyal, 2001). In winter season among the various crops raised in rice based sequences, wheat registered the highest sustainability (0.71), while lentil recorded the lowest sustainability (0.28). Kumar *et al.* (2001) also reported the rice-wheat sequence was most stable system in eastern Uttar Pradesh. Further the sequence sustainability was enhanced with inclusion of mungbean. Maximum cropping sequence sustainability was noted in rice-wheat-mungbean (0.87) and minimum under rice-linseed-fallow (0.50). Legumes are known to offer special advantage regarding stability of their system because of their legume effect and adoptability to diverse conditions

Table 1. Yield, land use efficiency energy production and system productivity of rice-based sequences (mean data of 3 years)

Cropping sequence	Mean crop yield (t/ha)			Rice grain equivalent yield (t/ha)	Duration of sequence (days)	Land use efficiency (%)	Energy production (× 10^6 k cal.)	System productivity (kg/ha/day)
	Rainy season	Winter season	Summer season					
Rice-wheat-fallow	4.30	3.87		9.39	221	60.55	28.26	42.49
Rice-mustard-fallow	4.60	1.01		7.78	203	55.62	21.35	38.34
Rice-linseed-fallow	4.46	0.70		6.75	207	56.71	19.11	32.59
Rice-lentil-fallow	4.78	0.65		7.10	209	57.26	18.76	33.92
Rice-pea-fallow	4.84	0.89		7.77	207	56.71	19.55	37.54
Rice-chickpea-fallow	4.90	0.71		7.80	210	57.53	19.48	37.12
Rice-frenchbean-fallow	4.62	0.63		7.63	204	55.89	18.19	37.39
Rice-wheat-mungbean	4.60	4.06	0.51	11.79	297	81.37	31.60	39.69
Rice-mustard-mungbean	5.07	1.12	0.52	10.50	281	76.98	25.51	37.27
Rice-linseed-mungbean	4.74	0.76	0.51	9.23	285	78.02	22.14	32.38
Rice-lentil-mungbean	5.12	0.71	0.52	9.57	287	78.63	22.06	33.36
Rice-pea-mungbean	5.23	0.97	0.55	10.41	285	78.08	22.98	36.52
Rice-chickpea-mungbean	5.26	0.82	0.56	10.65	288	78.90	22.99	36.99
Rice-frenchbean-mungbean	5.00	0.71	0.52	10.25	282	77.26	21.42	36.33
SEm±	0.82			0.71		0.60		0.45
CD (P=0.05)	2.38			2.07		1.74		1.32

Table 2. Sustainability, profitability and production efficiency of rice-based sequences (mean of 3 years)

Cropping sequence	Sustainability				Cost of cultivation (×10^3 ₹/ha)	Gross income (×10^3 ₹/ha)	Net returns (×10^3 ₹/ha)	Benefit: cost ratio	Production efficiency (₹/ha/day)
	Rainy season	Winter season	Summer season	Cropping sequence					
Rice-wheat-fallow	0.76	0.71		0.67	25.08	48.26	23.17	0.92	104.86
Rice-mustard-fallow	0.84	0.36		0.56	22.70	40.46	17.74	0.78	87.51
Rice-linseed-fallow	0.78	0.33		0.50	22.20	32.31	10.11	0.46	48.84
Rice-lentil-fallow	0.87	0.28		0.52	19.79	23.39	13.61	0.69	65.11
Rice-pea-fallow	0.89	0.35		0.55	20.94	37.79	16.83	0.80	81.30
Rice-chickpea-fallow	0.88	0.37		0.57	20.94	38.39	17.46	0.83	83.12
Rice-frenchbean-fallow	0.85	0.43		0.58	24.59	37.88	13.28	0.54	65.11
Rice-wheat-mungbean	0.81	0.77	0.81	0.87	30.31	58.84	28.53	0.94	96.06
Rice-mustard-mungbean	0.90	0.44	0.74	0.78	27.92	52.40	24.48	0.88	87.12
Rice-linseed-mungbean	0.87	0.37	0.79	0.71	27.42	42.36	14.94	0.54	52.43
Rice-lentil-mungbean	0.91	0.31	0.77	0.74	25.01	43.93	18.92	0.76	65.92
Rice-pea-mungbean	0.92	0.36	0.63	0.77	26.16	49.23	23.10	0.88	81.04
Rice-chickpea-mungbean	0.95	0.59	0.41	0.80	26.16	50.66	24.50	0.94	85.08
Rice-frenchbean- mungbean	0.88	0.48	0.78	0.81	29.82	49.26	19.49	0.65	68.96

(Sunil Kumar and Faruqui, 2009).

Profitability

The highest cost of cultivation (₹48,256) was incurred on rice-wheat-fallow (Table 2) followed by rice-frenchbean-fallow (₹24,593) and lowest on rice-lentil-fallow (₹19,788) cropping sequences. The inclusion of wheat and frenchbean in cropping sequence increased the total variable cost due to more fertilization, labour requirement and other intercultural operations. However, the gross return and net profitability were higher in rice-wheat-fallow (₹48,256 and 23,174), followed by rice-mustard-fallow (₹40,460 and 17,764) and lowest net profitability in rice-linseed-fallow (₹10,109) cropping sequence. The intensification of rice-wheat-fallow cropping sequence by rice-wheat-mungbean proved to be highly remunerative by generating higher net return income. The maximum net return and benefit: cost ratio was recorded in rice-wheat-mungbean (₹28,532 and 0.94) followed by rice-chickpea-mungbean (₹24,503 and 0.94) and minimum under rice-linseed-mungbean (₹14,942 and 0.54) cropping sequences. The lower net return and benefit: cost ratio under rice-linseed-mungbean may be due to lower yield and market price of produce.

Considering the production, profitability, sustainability and land use efficiency, rice-wheat-mungbean cropping sequence proved most promising and remunerative. Inclusion of mungbean during summer could further help in maintaining the soil fertility and stabilizing the yield on long-term basis in irrigated area pertaining to eastern Uttar Pradesh.

REFERENCES

Gangwar, B. and Katyal,V. 2001.Productivity, sustainability and profitability of rice (*Oryza sativa)* based crop sequences in West Bengal and Orissa. *Indian Journal of Agronomy* **46**(3): 387–94.

Kumar, A., Yadav, D.S., Singh, R.M. and Achal, R. 2001. Productivity, profitability and stability of rice (*Oryza sativa*)-based cropping system in eastern Uttar Pradesh. *Indian Journal of Agronomy* **46**(4): 573–77.

Kumar, A., Tripathi, H.P., Yadav, R.A. and Yadav, D.S. 2008. Diversification of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system for sustainable production in eastern Uttar Pradesh. *Indian Journal of Agronomy* **53**(1): 18–21.

Nanda, S.S., Mohanty, M., Pradhan, K.C., Mohanty, A.K. and Mishra, M.M. 2008. Production potential, profitability and energy efficient rice based cropping systems for coastal Orissa. *Journal of Farming Systems Research & Development* **14**(1): 1–5.

Shah, M.H., Khan, G.M., Amarjit S. Bali and Singh, K.N. 1999. Production potential of rice (*Oryza sativa*) based cropping sequences under temperate environment. *Indian Journal of Agronomy* **44**(1): 12–15.

Sharm, R.P., Pathak, S.K., Haque, M. and Raman, K.R. 2004. Diversification of rice (*Oryza sativa*)-based cropping system for sustainable production in south Bihar alluvial plains. *Indian Journal of Agronomy* **49**(4): 218–22.

Sharma, R.P., Pathak, S.K., Haque, M. and Manesar, Lal 2008. Productivity, profitability and nutrient balance as influenced by diversification of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **53**(2): 97–101.

Shukla, N.D. Shukla, K and Mishra, P.P. 1998. Production potential, production efficiency and economic variability of rice-wheat system under farmer's and researcher's practice of fertilization. *Fertilizer News* **43**(5): 59–67.

Singh, R.P., Parr, J.F. and Stewart, B.A.1990. Dry land agricultural strategies for sustainability. *Advances in Soil Science* **13:** 340–48.

Sunil Kumar and Faruqui 2009. Production potential and economic viability of food-forage based cropping system under irrigated conditions. *Indian Journal of Agronomy* **54**(1): 36–41.

Yadav, M.P., Kushwah, S.P. and Singh, G.K. 2005. Production potential and economic analysis of various cropping systems for central plains zone of Uttar Pradesh. *Indian Journal of Agronomy* **50**(2): 83–85.