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Production potential of rice-based cropping sequences on farmers' fields in low hills of Kangra district of Himachal Pradesh

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Abstract

Five rice-based cropping sequences *viz.* rice-wheat, rice - radish - potato, rice - garlic, rice-potato-onion and rice-berseem + oats were evaluated on cultivators' fields for their production potential and economic feasibility in the low hills of Kangra district of Himachal Pradesh. Results revealed that rice-potato-onion, rice - garlic and rice-radish-potato cropping sequences were more remunerative resulting in significantly higher rice equivalent yield (16342, 10997 and 12394 kg/ha/annum, respectively), net returns (INR 153257, 102767 and 106414/ha/annum), productivity and profitability. Rice-potato-onion, rice-radish-potato and rice-garlic cropping sequences resulted in 203.3, 130.1 and 104.1% higher rice equivalent yield over the traditional rice-wheat cropping sequence, respectively. Rice – berseem + oats was also superior to conventional rice - wheat cropping sequence in influencing rice equivalent yield, net returns, B:C and productivity and profitability. In terms of total calories, only rice - potato - onion and rice-radish-potato cropping sequences could excel over the rice-wheat sequence. Conventional rice – wheat cropping system was superior to all the new cropping systems in terms of energy intensity both in physical as well as economic terms. Land use efficiency ranged between 65.7 (rice-radish -potato) and 78.1% (rice-potato-onion) under different cropping systems.

Key words: Production efficiency, economics, yield, rice based cropping sequences

Rice-wheat is the most important cropping system in India (Prasad 2005). It occupies 10.5 m ha productive lands in Indo-Gangetic plains and contributes about 25% of the national food production (Ladha *et al.*, 2000). This system has sustained over years and brings together conflicting and complementary practices. Because of high productivity, stability and less risk, the wide adoption of this system will also play a major role in future planning to sustain self sufficiency of food grains in the years to come (Singh *et al* 2012). But now the productivity of both the crops have stagnated (Yadav 1998) and factor productivity is declining year after year. In Himachal Pradesh, this system covers more than 80 thousand hectares with average productivity of 3.07 t/ha (Anonymous, 2002) as against the national average of 5.70 t/ha (Anonymous, 2003). The farmers realize much of their food security from this cropping system but the low production level needs urgent attention. Besides food security, the low production levels jeopardize farmers' economic security to a considerable extent. To strengthen the economic security, it is imperative to intensify and diversify the existing rice-wheat system with some other crops of greater economic worth. In general, problems with transplanted rice are less than direct seeded rice and wheat. Therefore, it is essential to diversify the system with rice as the base crop with more productive and profitable crops in place of wheat on cultivators' fields on participatory mode.

Materials and Methods

Field investigation to evaluate the production potential of rice-based cropping sequences was undertaken at four centres viz; Fatehpur, Rehan, Jawali and Tripal-Kuthar in district Kangra within NARP Zone I of Himachal Pradesh during 2012-13. In all twelve locations (farmers), three at each centre were selected and considered as replications. Five rice-based cropping sequences *viz.* rice-wheat, rice – radish - potato, rice-garlic, rice-potato-onion and rice-berseem + oats were evaluated. The crops in each cropping sequence were raised in accordance with the recommended package of practices (Table 1).

Table 1. Crop varieties grown and crop wise fertilizer dose

Crop	Variety	Fertilizer dose (kg/ha)		
		N	P_2O_5	K_2O
Rice	Kasturi /HPR 1068	90	40	40
Wheat	HPW-184/HPW 236	120	60	30
Radish	Japanese white	100	50	40
Potato (spring)	Kufri Jyoti	120	80	60
Potato (autumn)	Pukhraj	120	80	60
French bean	Contender	50	80	60
Onion	N-53/AFDR	125	75	60
Berseem + oats	Local	25	60	-
Garlic	Selection-1	125	75	60

Table 2. Soil fertility status of the farmers' fields before sowing of the crops

Centre	pH	OC (%)	Available nutrients (kg/ha)		
			N	P	K
Min	4.9	0.46	243.4	4.5	44.8
Max	6.9	1.09	353.7	44.8	558.7
Average	6.3	0.85	289.6	31.4	320.4
SD	0.5	0.2	36.3	13.8	172.8
CV(%)	8.6	20.2	12.5	44.1	53.9

The soils of the zone were inceptisols having texture varying from loamy sand to silty clay loam, with pH 4.9-6.9 and organic carbon 0.46-1.09%, medium in available N, (289.6 kg/ha), low to high in available P (4.5 kg/ha to 44.8 kg/ha) with mean value of 31.4 kg/ha and low to high in available K with the mean value of 320.4 kg/ha (Table 2) The variation in the content of available K as determined in terms of coefficient of variation (CV%), was large followed by P, OC, N and pH in that order. Total rainfall received during the period was 2203.4 mm with minimum and maximum temperature of the experimental sites varying from 4.0-24.7 ^{0}C and 15.3-36.0 ^{0}C, respectively. Yields were harvested from net plot (Gross plot size, 13.8 m x 7 m). Economics of the crop sequences was computed based upon the prevalent market prices (minimum support price, market price and those fixed by the university). For comparison between crop sequences, the economic yields of crops were converted into rice equivalent on price basis. Area equivalent ratio (AER), relative profit, additional profit and profit equivalent ratio (PER) were determined according to our earlier studies (Rana *et al* 2010) as follows:

AER = Cost of cultivation of conventional cropping sequence/cost of cultivation of alternative cropping sequence

Relative profit (INR/ha) = AER x net returns (INR/ha)

Additional profit (INR/ha) = Relative profit of alternative cropping sequence – net returns of conventional cropping sequence

PER = Relative profit (INR/ha)/ net returns of conventional cropping sequence

Production efficiency (kg/ha/day) was obtained by dividing total production in terms of rice equivalent in a sequence by the total duration of year (365), while production efficiency (INR/ha/day) was obtained by dividing net monetary return by 365.

Energy intensity was worked out as follows:

Energy intensity (physical terms) = energy output/ equivalent yield

Energy intensity (economic terms) = energy output/Cost of cultivation

Homogeneity of error variances was tested by using Bartlett χ^2 – test; which were found to be homogeneous. Therefore, the data were pooled and analyzed in randomized block design.

Results and Discussion

Rice equivalent yield

Rice equivalent yield of the newly introduced cropping sequences *viz.* rice-potato-onion, rice -radish- potato

and rice-garlic was superior to prevalent rice - wheat sequence (Table 3). However, rice-potato-onion cropping sequence was relatively superior in terms of rice equivalent yield (16342 kg/ha/annum). This was followed by rice-radish-potato (12394 kg/ha/annum). The higher rice equivalent yield in these cropping systems was owing to replacement of wheat with high volume/high priced vegetable crops like potato, onion and garlic. Choudhary *et al.* (2001) also reported greater productivity by replacing wheat in rice-wheat system with vegetables like radish and potato under similar agro-climatic conditions. Similarly, a number of findings suggested that inclusion of oilseeds, vegetables, ornamental or fodder crops to diversify the existing rice-wheat system also helped in achieving higher rice equivalent yield (Kumar *et al*. 2008; Sharma *et al*. 2008; Tripathi and Singh, 2008).

The rice – berseem + oats cropping sequence was also superior to rice – wheat in terms of rice equivalent yield. Rice-potato-onion, rice-radish-potato and rice-garlic cropping sequences resulted in 203.3, 130.1 and 104.1%, higher rice equivalent yield over the rice-wheat cropping sequence, respectively.

Net return and B: C ratio

Rice - potato - onion (INR 153257/ha/annum) sequence fetched higher net returns than other cropping sequences (Table 3) due to higher yields. This was followed by rice-radish-potato (INR 106414/ha/annum), rice-garlic (INR 102767/ha/annum) and rice – berseem + oats (INR 100503/ha/annum) with corresponding increase in net returns of 58.3, 52.8 and 49.5%, respectively, over the rice - wheat cropping sequence. Chaudhary *et al* (2001) have also documented higher net income by diversification of the existing rice-wheat cropping system. Rice - berseem + oats gave higher B:C ratio than other cropping sequences. In spite of higher yields and net returns rice - potato – onion, rice - garlic and rice-radish-potato resulted in lower B: C ratio than rice-wheat cropping sequence due to higher cultivation costs incurred under these cropping sequences.

As indicated by the AER (0.367-0.0.516), a farmer cultivating 'rice-wheat' in one ha with cultivation cost of INR 45750, when switches to alternative rice – vegetable ('rice-potato-onion', 'rice-radish-potato' and 'rice - garlic) cropping sequence can cultivate 36.7-51.6% of the area with the same amount (Table 4). Consequently relative profit from these alternative cropping sequences will reduce to 0.367 – 0.516 times of that obtained from one ha. This was 66.7 – 83.8% (i.e. under 'rice-radish-potato' and 'rice – garlic and rice-potato-onion) of what was under rice -wheat. The further analysis indicated that to obtain the same return as under 'rice – wheat', the new cropping systems viz 'rice-potato-onion', 'rice-radish-potato', 'rice – garlic and rice – berseem + oats have to be sown in 43.9, 63.2, 65.4 and 66.9% of the entire area. By switching to cultivation of these alternative copping systems viz. 'rice - potato - onion', 'rice-radish-potato' and 'rice – garlic'), and to get equivalent return as under one ha rice-wheat, a farmer would require INR 8866, 22885 and 12267 more.

Table 3. Crop yield, rice equivalent yield and return under rice based cropping sequences

Sequence	Yield (kg/ha)			Rice equivalent (kg/ha)	Gross return (INR/ha)	Net return (INR//ha)
	Kharif	*Rabi* I	*Rabi* II			
Rice-wheat	2690	3088		5387	112985	67235
Rice-Radish-Potato	2763	13427	11565	12394	215027	106414
Rice-garlic	2736	4428		10997	191444	102767
Rice-Potato-Onion	2784	12442	9391	16342	277749	153257
Rice-Berseem + oats	2764	46974		8545	152620	100503
LSD (P=0.05)				1240	17058	17293

Rice (Basmati) INR15.0-18.0/kg; wheat INR 10.0-11.0/kg; Onion INR 5.00-10.00/kg; Potato INR 4.50-7.00/kg; French bean INR 8.00-20.00/kg; Berseem + Oats (Green fodder) INR 1.20-1.50/kg

Table 4. Economics, productivity (kg/ha/day) and profitability (INR/ha/day) of different crop sequences

Treatment	B:C ratio	COC System (INR/ ha)	AER	Relative profit (INR)	Additional profit	PER	Productivity	Profitability
Rice-wheat	1.47	45750	-				14.8	184.2
Rice-radish-potato	0.98	108613	0.421	44823	-22412	0.667	34.0	291.5
Rice-garlic	1.16	88678	0.516	53019	-14217	0.789	30.1	281.6
Rice-potato-onion	1.23	124492	0.367	56321	-10914	0.838	44.8	419.9
Rice-berseem+oats	1.93	52117	0.878	88225	20990	1.312	23.4	275.4
LSD (P=0.05)							3.4	27.4

However, he can spare 34.5-56.1% of his land resource for some other economic activity.

Production efficiency

All the cropping sequences resulted in higher production efficiency in terms of kg/ha/day (productivity) and INR/ha/day (profitability) over the rice-wheat cropping sequence (Table 4). Rice – potato – onion cropping sequence resulted in the greater productivity (44.8) and profitability (INR 419.9/ha/day) than other cropping sequences. This was followed by rice-radish-potato, rice – garlic and rice – berseem + oats cropping sequences. Productivity (kg REY/ha/day) under rice-potato-onion, rice-radish-potato and rice-garlic was, respectively, 3.0, 2.3 and 2.0 times higher than conventional rice-wheat cropping system. These were 2.1, 1.4 and 1.4 times, respectively, higher in profitability over the rice - wheat system.

The productivity and profitability scenario clearly depicted that there was sufficient availability of food and cash for an average marginal family having one ha of land.

Total calories of the main product

Rice - potato – onion and rice-radish-potato were excelled over the rice-wheat sequence in terms of the production of total calories of the main products (Table 5). Total calories under these cropping systems were 27.4 and 15.4%, respectively, higher than that observed under the rice-wheat system. This indicated that these systems had higher amount of high quality produce. Sharma *et al*. (2008) also documented higher energy output of cropping sequences in which potato crop was included. In spite of significant increase in rice equivalent yield, total calories under rice garlic and rice – berseem + oats sequences, were 53.8 and 87.7%, respectively, of rice - wheat sequence.

Table 5. Total calories of the main product and energy intensity under different cropping systems.

Cropping sequence	Total calories (10^6 K cal/ha)				Energy intensity	
	Kharif	*Rabi* I	*Rabi* II	Total	Physical terms (k cal/kg)	Economic (k cal/INR)
Rice-wheat	9.2	10.7		19.9	3695.9	435.2
Rice-radish-potato	9.5	2.3	11.2	23.0	1854.0	211.6
Rice-garlic	9.4	1.3		10.7	974.2	120.8
Rice-potato-onion	9.5	12.1	3.8	25.4	1552.7	203.8
Rice-berseem+oats	9.5	8.0		17.5	2044.0	335.1
LSD (P=0.05)				1.1		

It is pertinent to mention that in spite of higher total energy output of the main product, all the new cropping systems were inferior to the conventional rice – wheat cropping system in terms of energy intensity both in physical as well as economic terms (Table 5).

Thus, it is concluded that farmers of low hills of HP can adopt rice - potato – onion, rice – radish - potato and rice – garlic cropping sequences for higher net income as an alternative to rice-wheat cropping system. However, complete replacement is not advisable.

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