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Production potential, sustainability and economic viability of rice based crop sequences under mid hills of Himachal Pradesh

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Abstract

Six cropping sequences *viz.* 'rice-wheat', 'rice-pea-French bean', 'rice-radish-potato', 'rice- potato', 'rice-linseed-sunhemp' and 'rice-gobhi sarson' were evaluated for their production potential and economic feasibility under mid hill conditions of Himachal Pradesh. Six year's (2000-01 and 2005-06) results revealed that 'rice-radish-potato' sequence resulted in highest rice equivalent yield (26102 kg/ha), net return (Rs 90815/ha/year), B: C ratio, production efficiency (88.2 kg/ha/day and Rs 307/ha/day) and sustainable yield (0.640) and value index (0.481). 'Rice – pea - French bean' and 'rice – potato' sequences were also superior to the traditional 'rice-wheat' sequence in terms of paddy equivalent, net return, B: C ratio, production efficiency and sustainability. 'Rice-linseed-sunhemp' gave the highest land-use efficiency and was followed by 'rice-pea-French bean'. Economic analysis further indicated that 'rice-radish-potato' and 'rice – pea - French bean' were more economically viable than the conventional 'rice – wheat' sequence and allow marginal farmers to put half of their land resources to some other use.

Key words: Rice equivalent, production efficiency, sustainability, economic viability, rice based sequences.

Introduction

Rice-wheat is the most predominant traditional cropping system in the mid hills valley areas of Himachal Pradesh. The farmers realize much of their food security from this cropping system. However, the system is over-exploitative of the natural resources and consequently leads to degradation in soil health and fertility. This is ultimately leading to either stagnation (Nambiar and Abrol, 1992) or decrease in yield of both rice and wheat over a longer period of time (Woodhead *et al.* 1994). Therefore, to break the monotony of the system and sustain the productivity in a long term perspective, it is essential to identify more productive and profitable cropping systems than rice-wheat under irrigated ecosystem. Mid hills especially Kangra valley falls under high rainfall area and it may not be worthwhile to replace rice. The option left is to replace wheat with some remunerative oilseed or/and vegetable crops. Keeping the fact in consideration, an experiment was conducted to study the production potential and economic viability of the rice based cropping systems under irrigated conditions.

Material and Methods

The field experiment was conducted for six consecutive years (2000-01 and 2005-06) in a permanent layout at Cropping System Research Centre's Badhiarkhar Farm of CSK HP Krishi Vishvavidyalaya, Palampur (32.6° N latitude, 76.3° E longitude and 1250 m altitude). Six rice based cropping sequences (Table 1) were evaluated in a randomized block design with four replications. Rice was transplanted after normal puddling. Sunhemp was grown as a green manure crop and turned with a soil inverting plough at pre-flowering stage for decomposition in the field before the transplanting of rice. The soil of the experimental site was silty clay loam with pH 5.6, organic carbon 0.60%, available N 514.9 kg/ha, available P 47.6 kg/ha and available K 212.0 kg/ha. The average annual precipitation of the test site was 2500 mm with mean maximum and minimum temperature ranging from 19.3 to 38.2 & 3.0 to 23.1°C, respectively. The crops in each cropping sequence were raised in accordance with the recommended package of practices. Yields were harvested from net plot. For comparison between crop sequences, the yields of crops were converted into paddy equivalent on price basis (Verma and Modgal, 1983 and Tomer and Tiwari, 1990). Production efficiency (kg/ha/day) was obtained by dividing total production in terms of rice equivalent in a sequence by the total duration of crop, while production efficiency (Rs/ha/day) was obtained by dividing net monetary return by total duration of crops in a particular sequence. Economics of the crop sequences was computed based upon the prevalent market prices. Area equivalent ratio (AER), relative profit, additional profit and profit equivalent ratio (PER) were determined following the methods employed by Mohammed (2002) as follow,

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

Relative profit (Rs/ha) = AER x net return (Rs/ha)

Additional profit (Rs/ha) = Relative profit of alternative cropping sequence – net return of conventional cropping sequence

PER = Relative profit (Rs/ha)/ net return of conventional cropping sequence

Sustainable yield index (SYI) and sustainable value index (SVI) were determined using standard procedures as below,

$$SYI = \frac{\bar{Y} - SD}{Y_{max}}$$

Where, $\bar{Y}$ is the average yield of a cropping sequence over years, SD its standard deviation and Y_{max} is the observed maximum yield in the experiment. SVI was computed in the same way as SYI by taking net return into consideration in place of yield.

Results and Discussion

Rice equivalent yield

The data shown in Table 1 indicate superiority of 'rice-radish-potato' cropping sequence in terms of rice equivalent yield (26102 kg/ha). This was mainly ascribed to higher yield and price of radish as well as higher production of potato grown in the sequence. The 'rice-radish-potato' cropping sequence was followed by 'rice – pea- French bean' (20242 kg/ha) and 'rice-potato' (14042 kg/ha). The remaining cropping sequences had significantly lower rice equivalent than the prevalent 'rice-wheat' cropping sequence.

Table 1. Yield, energy, net return and B:C ratio under different crop sequences

Crop sequence	Yield main product (kg/ha)				Total energy (10^6 x k cal)	Net return (Rs/ha)	B:C ratio
	Rice	*Rabi* I	*Rabi* II	REY			
				2000-01			
Rice-wheat	2443	2250	-	5068	16.2	14008	0.52
Rice-pea –French bean	2934	2682	4792	15390	13.9	64495	1.13
Rice-radish-potato	3110	9352	19167	23758	30.9	87683	1.44
Rice- potato	2796	18125	-	17900	27.3	63343	1.29
Rice-linseed-sunhemp	2757	446	-	3799	11.9	318	0.01
Rice-gobhi sarson	2590	509		3948	11.7	5840	0.22
LSD (P=0.05)	-	-	-	1861	2.7	11327	0.23
				2001-02			
Rice-wheat	3905	4558	-	9374	29.3	36362	1.35
Rice-pea –French bean	3944	5833	2771	21153	19.8	74175	1.30
Rice-radish-potato	4033	14815	11375	24296	27.5	67851	1.11
Rice- potato	3650	10854	-	14504	23.2	30315	0.62
Rice-linseed-sunhemp	3542	478	-	4879	14.8	2315	0.07
Rice-gobhi sarson	3905	551	-	5448	16.5	10331	0.39
LSD (P=0.05)	-	-	-	2066	3.3	10624	0.21
				2002-03			
Rice-wheat	3964	2207	-	6612	21.4	18373	0.68
Rice-pea –French bean	3689	4896	1875	17231	17.8	42109	0.74
Rice-radish-potato	3763	25000	11563	33013	28.5	111991	1.84
Rice- potato	3601	5521	-	8018	17.8	-2009	-0.04
Rice-linseed-sunhemp	3238	576	-	4850	14.3	5324	0.17
Rice-gobhi sarson	3777	935	-	6396	18.1	13907	0.52
LSD (P=0.05)	-	-	-	1940	3.1	10220	0.23
				2003-04			
Rice-wheat	3934	3817	-	8515	26.8	27495	1.02
Rice-pea –French bean	3650	4688	7292	27608	18.9	101914	1.78
Rice-radish-potato	3665	19167	9740	24904	25.4	69373	1.14

Contd...

Rice- potato	3738	12813	-	16551	25.4	39833	0.81
Rice-linseed-sunhemp	3807	692	-	5744	16.8	5797	0.19
Rice-gobhi sarson	3876	556	-	5431	16.4	7135	0.27
LSD (P=0.05)	-	-	-	2064	2.4	11045	0.21
				2004-05			
Rice-wheat	3012	2813	-	6234	20.2	17402	0.60
Rice-pea –French bean	2865	2188	8979	23168	14.3	92980	1.57
Rice-radish-potato	2934	25278	5625	31027	19.9	133546	3.10
Rice- potato	2963	10156	-	12196	20.1	41893	1.36
Rice-linseed-sunhemp	2659	482	-	3886	11.8	-2965	-0.09
Rice-gobhi sarson	3297	676	-	5017	15.1	9139	0.33
LSD (P=0.05)	-	-	-	1265	1.3	6728	0.16
				2005-06			
Rice-wheat	2362	3346	-	6316	19.7	19062	0.65
Rice-pea –French bean	2168	4250	3854	16903	12.5	57239	0.97
Rice-radish-potato	2247	5926	13177	19613	21.6	74448	1.73
Rice- potato	2394	13958	-	15083	21.8	61667	2.01
Rice-linseed-sunhemp	2149	973	-	4626	12.6	1544	0.05
Rice-gobhi sarson	2266	691	-	4025	11.6	1119	0.04
LSD (P=0.05)	-	-	-	2473	1.7	14784	0.29
				Pooled			
Rice-wheat	3270	3165	-	7020	22.3	22117	0.80
Rice-pea –French bean	3208	4089	4927	20242	16.2	72152	1.25
Rice-radish-potato	3292	16590	11774	26102	25.6	90815	1.73
Rice- potato	3190	11905	-	14042	22.6	39174	1.01
Rice-linseed-sunhemp	3025	608	-	4631	13.7	2055	0.07
Rice-gobhi sarson	3285	653	-	5044	14.9	7912	0.30
LSD (P=0.05)				701	1.3	4144	0.10

REY, rice equivalent yield

Energy output

Total energy output of the main products was highest under 'rice- radish – potato' (25.6 mega k cal). This was higher by 14.8 per cent over the conventional 'rice-wheat' cropping sequence. 'Rice-potato' was statistically equal to 'rice – wheat' in terms of energy output. Total energy output due to the remaining cropping systems was significantly lower than under the 'rice-wheat' cropping system. However, 'rice- pea- French bean' was superior to 'rice-linseed-sunhemp' and 'rice- gobhi sarson' cropping systems. Energy output under 'rice- pea- French bean', 'rice- gobhi sarson' and 'rice-linseed-sunhemp' was 72.6, 66.8 and 61.4 per cent of the energy output under 'rice-wheat' cropping system.

Production efficiency and su*stainability*

Owing to better utilization of applied resources, 'rice-radish-potato' sequence recorded greater production efficiency in terms of kg/ha/day (88.2) and Rs/ha/day (307.0) (Table 2). This was followed by 'rice-pea-French bean' and rice-potato sequences both in terms of kg/ha/day as well as Rs/ha/day. Production efficiency (13.9 kg/ha/day) was lowest under 'rice-linseed-sunhemp' sequence. The land use efficiency ranged between 67.6 to 91.4 per cent. 'Rice-linseed-sunhemp', 'rice- pea-French bean' and 'rice-radish-potato' sequences occupied the land for longer duration and had higher land use efficiency than 'rice-wheat' sequence. 'Rice - potato' was most inferior in respect of land use, as the land remained idle for almost 4 months in a year (118 days).

'Rice-radish-potato' was the superior most cropping sequence both in terms of sustainable yield index (0.640) and sustainable value index (0.481). This was followed by 'rice-pea – French bean' and 'rice- potato' cropping sequences. Sustainability indices under 'rice-linseed-sunhemp' and 'rice-gobhi sarson' were significantly lower than under the prevalent 'rice-wheat sequence'

Table 2. Land use efficiency, production efficiency and sustainability of different crop sequences (Pooled data from 2000 to 2006)

Crop sequence	Duration				Land-use efficiency	Production efficiency		Sustainability Index	
	Rice	*Rabi* I	*Rabi* II	Total	(%)	kg/ha/day*	Rs/ha/day**	Yield	Value
Rice-wheat	105.2	172.7		277.8	76.1	25.3	79.6	0.164	0.104
Rice-pea –French bean	105.2	143.3	79.0	327.5	89.7	61.8	220.3	0.473	0.373
Rice-radish-potato	105.2	102.8	87.8	295.8	81.1	88.2	307.0	0.640	0.481
Rice- potato	105.2	141.5		246.7	67.6	56.9	158.8	0.319	0.114
Rice-linseed-sunhemp	105.2	190.0	38.4	333.6	91.4	13.9	6.2	0.118	-0.009
Rice-gobhi sarson	105.2	173.5		278.7	76.3	18.1	28.4	0.124	0.027

* Based upon paddy equivalent yield; ** Based upon net return

Employment

In the present day context unemployment is the major problem confronted in the country. 'Rice-radish-potato' engaged 146 additional man days/ha/annum over the 'rice –wheat' sequence (Table 3) besides promoting the fertilizer and other agro-industries. Fertilizer consumption worth Rs 7037/ha/annum was highest (kg/ha/annum) in 'rice- radish-potato'. However, 'rice–pea-French bean' engaged highest number of man days/ha/annum (356.7). 'Rice – potato' and 'rice-linseed-sunhemp' have also generated additional employment of 66.7 and 29.3 man days/ha/annum, respectively over the traditional 'rice-wheat' cropping sequence.

Table 3. Value of fertilizers and labour employed under different crop sequences (Pooled data from 2000 to 2006)

Crop sequence	Nutrients used in sequence (kg/ha/annum)				Value of fertilizers (Rs/ha/annum)	Labour employed* (Mandays/ha/annum)
	N	P	K	NPK		
Rice-wheat	210	43.6	58.1	311.7	4702	195.0
Rice-pea –French bean	150	69.8	83.0	302.8	5480	356.7
Rice-radish-potato	310	65.5	91.3	466.8	7037	341.0
Rice- potato	210	43.6	58.1	311.7	4702	261.7
Rice-linseed-sunhemp	140	52.4	49.8	242.2	4287	224.3
Rice-gobhi sarson	210	43.6	66.4	320.1	4776	194.7

* Based upon last three years

Nutrient uptake and available content

The higher recommended dose of nutrients (Table 3) tended to accumulate higher dry matter and thereby higher nutrient uptake by 'rice–radish–potato' cropping sequence (Table 4). However, 'rice–pea–French bean' was statistically equal to 'rice–radish– potato' in influencing N and P uptake. 'Rice–potato' cropping sequence also resulted in significantly higher N and K uptake over the 'rice–wheat' cropping sequence.

There was a slight build up of N in 'rice-pea-French bean' and 'rice-wheat' cropping sequences, while build up of K was observed in 'rice - pea - French bean' and 'rice – potato' (Table 5). There was no or negative N balance and K balance in rest of the cropping sequences. All the cropping sequences showed slight build up of available P.

Economic viability

The economic analysis of the data revealed superiority of 'rice-radish-potato' sequence in fetching highest net return (Rs 90815/ha) than remaining sequences (Table 2). The higher net return was associated owing to higher yields. This was followed by 'rice-pea- French bean' (Rs 72152/ha) and 'rice- potato' (Rs 39174/ha) sequences. These findings are in conformity with those of Thakur *et al.* (1994) and Chaudhary *et al* (2001) who also reported higher net returns due to multiple cropping systems. Rao and Willey (1980)

also opined that multiple cropping systems especially with legumes offer special advantage and reduce the probability of low income for small and marginal farmers. The net gain owing to 'rice-radish-potato', 'rice-pea- French bean' and 'rice – potato' was about 311, 226, and 77 per cent respectively, higher over the prevalent 'rice-wheat' sequence. 'Rice–linseed-sunhemp' and 'rice–gobhi sarson' crop sequences recorded significantly lower net return than 'rice-wheat' cropping sequence. 'Rice-radish-potato' gave highest B: C ratio of 1.73. The other crop sequences found remunerative in terms of B: C ratio over the existing 'rice–wheat' cropping sequence were 'rice–pea-French bean' and 'rice– potato'.

Table 4. Nutrient uptake by different crop sequences (Pooled data from 2000 to 2006)

Crop sequence	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Mean
				N			
Rice-wheat	124.6	247.0	195.5	196.7	121.8	171.0	176.1
Rice-pea –French bean	378.9	448.1	301.5	338.3	161.6	160.3	298.1
Rice-radish-potato	431.5	359.5	377.9	280.5	187.0	247.6	314.0
Rice- potato	330.0	271.5	180.3	249.1	101.5	185.2	219.6
Rice-linseed-sunhemp	99.9	145.2	159.2	133.1	91.8	161.1	131.7
Rice-gobhi sarson	98.8	153.4	180.2	137.5	114.6	119.7	134.0
LSD (P=0.05)	-	-	-	-	-	-	48.5
				P			
Rice-wheat	20.1	39.2	30.2	38.4	31.0	30.9	31.6
Rice-pea –French bean	85.6	56.2	50.8	64.0	34.7	25.6	52.8
Rice-radish-potato	65.7	51.1	52.5	49.1	37.8	33.0	48.3
Rice- potato	54.2	41.2	27.0	47.7	28.9	33.8	38.8
Rice-linseed-sunhemp	15.4	20.4	29.4	28.5	23.8	22.2	23.3
Rice-gobhi sarson	8.3	14.1	18.0	25.1	31.0	23.2	20.0
LSD (P=0.05)	-	-	-	-	-	-	9.7
				K			
Rice-wheat	23.5	73.8	45.4	86.8	88.3	109.4	71.2
Rice-pea –French bean	120.2	177.5	148.9	203.7	107.1	112.1	144.9
Rice-radish-potato	104.9	194.4	193.4	245.3	172.5	158.9	178.2
Rice- potato	61.9	124.7	60.6	136.1	96.2	128.6	101.4
Rice-linseed-sunhemp	49.5	56.4	84	68.4	65.5	96.1	70.0
Rice-gobhi sarson	37	48.9	65.6	65.9	87	101.1	67.6
LSD (P=0.05)	-	-	-	-	-		22.4

As indicated by the AER (0.48-0.50), a farmer cultivating 'rice-wheat' in one ha with cultivation cost of Rs 27757, when switches to alternative rice–vegetable–vegetable ('rice-radish-potato' and 'rice–pea-French bean') cropping sequence can cultivate half of the area with the same amount. Consequently relative profit from these alternative cropping sequences is also reduced to half of that obtained from one ha. However, additional profit was still higher by Rs 23291 and Rs 12516/ha/annum, respectively, under 'rice-radish-potato' and 'rice–pea-French bean'. Their cultivation in half the area under 'rice–wheat' gave 2.05 and 1.57 times, respectively higher profit than cultivation of 'rice–wheat' in entire area. Thus by switching to cultivation of these alternative copping systems, a farmer with resources just sufficient for cultivation of 'rice – wheat' can spare half of his land resource for some other economic activity. Rice based cropping sequences containing oilseeds were not viable. However, rice – potato was next to 'rice-radish-potato' and 'rice–pea-French bean' with regard to economic viability.

Table 5. Available nutrients status after the termination of the experiment and economics of different cropping sequences

Crop sequence	OC	pH	N	P	K	Cultivation cost (Rs/ha)	AER	Relative profit (Rs/ha)	Additional profit (Rs/ha)	PER
Rice-wheat	0.68	5.7	517.9	56.5	196.7	27757	-	-	-	-
Rice-pea-French bean	0.69	5.6	526.8	59.0	222.3	57860	0.48	34633	12516	1.57
Rice-radish-potato	0.70	5.6	508.9	61.0	196.7	55026	0.50	45408	23291	2.05
Rice- potato	0.68	5.7	511.9	59.5	222.3	43016	0.65	25463	3346	1.15
Rice-linseed-sunnhemp	0.65	5.7	505.9	53.8	199.5	31373	0.88	1808	-20309	0.08
Rice-gobhi sarson	0.67	5.7	514.9	47.9	193.8	26960	1.03	8149	-13968	0.37
Initial status	0.6	5.6	514.9	47.6	212	-	-	-	-	-

AER, area equivalent ratio; PER, profit equivalent ratio

Thus, it is concluded that for higher net income besides employment to the local people and family itself, farmers of mid hills can successfully adopt 'rice-radish-potato' followed by 'rice - pea - French bean' cropping sequence with adequate inputs in the irrigated mid hill conditions of Himachal Pradesh. Even a poor marginal farmer can improve his financial condition by cultivating these alternative sequences on half of his entire land with the same amount he is spending to cultivate 'rice-wheat' on entire area, thus sparing half of the area to some other economic activity.

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