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Evaluation of rice-based cropping sequences on cultivators' fields in Una district of Himachal Pradesh

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Abstract

Five rice-based cropping sequences *viz.* rice-wheat, rice - onion, rice-potato-French bean, rice-potato-potato and rice-berseem + oats were evaluated on cultivators' fields for their production potential and economic feasibility in Una district of Himachal Pradesh. Three year's (2004-05 to 2006-07) results revealed that rice-potato-potato and rice - potato - French bean cropping sequences resulted in significantly higher rice equivalent yield (20371 and 20012 kg/ha/annum, respectively), net return (Rs 119793/ha/annum /year, 115428/ha/annum) and production efficiency. The extent of rice equivalent yield and net returns increase under rice-potato-potato and rice-potato-French bean sequences was 197.3 & 192.1 and 124.5 & 116.3%, respectively, over the conventional rice-wheat cropping sequence. Rice - onion was also superior to conventional rice - wheat cropping sequence in influencing rice equivalent yield, net returns, B: C ratio and production efficiency. Only rice - potato - potato cropping sequence could excel over the rice-wheat sequence in terms of total calories. Rice – potato – French bean was statistically at par with rice - wheat. Total calories in rice-onion sequence were 80.9% of the rice-wheat cropping sequence.

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

Introduction

Rice-wheat is one of the predominant cropping systems of Una district of Himachal Pradesh. The farmers realize much of their food security from this cropping system. The system is over-exploitative of the natural resources and consequently leads to degradation in soil health and fertility. This is ultimately leading to decrease in the yield of both rice and wheat over a longer period of time (Woodhead *et al.*, 1994). 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. 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.

Material and Methods

A field investigation was conducted on cultivators' field for three years (2004-05 to 2006-07) at Nakroh and Katohar centres of district Una within NARP Zone I of Himachal Pradesh. Three locations (farmers) at each centre were randomly selected and considered as replications. Five rice-based cropping sequences *viz.* rice-wheat, rice - onion, rice-potato-French bean, rice-potato-potato and rice-berseem + oats were evaluated. The soils of the zone were inceptisols having texture varying from loamy sand to silty clay loam, with pH 5.5-8.0 and organic C 0.17-0.90%. The crops in each cropping sequence were raised in accordance with the recommended package of practices (Table 1).

Table 1. Variety of crops grown and fertilizer dose

Crop	Variety		Fertilizer dose (kg/ha)		
	2004-05	2005-06 & 06-07	N	P_2O_5	K_2O
Rice	PR-108	Kasturi Basmati	90	40	40
Wheat	PBW-396	HPW-184	120	60	30
Onion	N-53	N-53	125	75	60
Potato (autumn)	Pukhraj	Pukhraj	120	80	60
Potato (spring)	Kufri Jyoti	Kufri Jyoti	120	80	60
French bean	Contender	Contender	50	100	50
Berseem + oats	Local	Local	25	60	-

Economics of the crop sequences was computed based upon the prevalent market prices (minimum support price, market price and those fixed by the university). Yields were harvested from net plot (Gross pot, 13.8 m x 7 m). The detail of sowing and harvesting is given in Table 2.

Table 2. Sowing and harvesting dates for different crops

Crop		Nakroh			Katohar		
		2004-05	2005-06	2006-07	2004-05	2005-06	2006-07
Rice	Sowing	17 May	25 May	16 May	21 May	3 June	27 May
	Harvesting	28-30 Oct	16-20 Oct	9-12 Oct	15-16 Oct	12-20 Oct	9-12 Oct
Wheat	Sowing	19 Nov.	14 Nov.	2 Nov	16 Nov.	12 Nov	7 Nov
	Harvesting	22-24 April	18-22 April	26-30 April	12-15 April	16-17 April	10-15 April
Onion	Sowing	23 Dec.	5 Dec	1 Jan	25 Dec	11 Dec	12 Dec
	Harvesting	12-14 May	5-8 May	2-5 May	8-14 May	18-26 May	17-22 May
Potato	Sowing	8 Oct	6 Nov	31 Oct	28 Oct	29 Oct	26 Oct
	Harvesting	9 Jan-13 Feb	16-29 Jan	16-28 Jan	12-22 Jan	29 Dec – 28 Jan	14-16 Jan
	Sowing	29 Jan	30 Jan	22 Jan	19 Feb	27 Jan	21 Jan
	Harvesting	28 May	29 April-4 May	29 April – 2 May	9-12 May	4-15 May	29 April - 5 May
French bean	Sowing	1 April	9 March	5 Feb	22 Feb	8 Feb	12 Feb
	Harvesting	25-26 May	7-10 June	26 April – 6 May	12-25 May	4-15 May	4-8 May
Berseem + oats	Sowing	14 Nov	20 Dec	25 Oct	24 Oct	31 Oct	31 Oct
	Harvesting	29 April-5 May	10-12 June	29 April – 25 May	20-25 April	18-21 April	24-28 April

For comparison between crop sequences, the economic yields of crops were converted into rice equivalent on price basis. The prices of different commodities are given in Table 3.

Table 3. Prices (Rs/kg) of different commodities

Commodity	2004-05	2005-06	2006-07
Rice grain	5.50	10.00	14.00
Wheat grain	6.30	6.30	7.50
Onion bulb	5.00	5.00	6.00
Potato tuber (autumn/spring)	4.50/4.50	4.50/4.50	5.00/4.00
French bean pods	9.00	9.00	10.00

Land utilization efficiency was worked out by summation of duration of each crop under individual crop sequence divided by 365. 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. 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

The data on initial soil status of the experimental sites are summarized in Table 4. Soil pH at different locations varied from 5.5 to 7.9 and 6.0 to 8.0 in Nakroh and Katohar, respectively, with mean value of 7.0 and 6.8. The soils of the test sites, in general were medium in respect of available N, K and organic carbon and high in P status. The variation in the content of available P was large in both the farming situations and that of K in Katohar and organic carbon in Nakroh.

Table 4. *Soil fertility status of the farmers' fields before sowing of the crops*

Parameter	Max	Min	Mean	Sd±	CV
Nakroh					
N (kg/ha)	443.7	188.2	317.5	92.7	29.2
P (kg/ha)	62.5	6.7	26.6	18.8	70.5
K (kg/ha)	267.4	112.0	178.9	55.2	30.8
OC (%)	0.90	0.17	0.52	0.22	41.2
pH	7.9	5.5	7.0	0.8	11.4
Katohar					
N (kg/ha)	419.1	213.3	303.3	59.8	19.7
P (kg/ha)	74.6	10.1	36.1	24.3	67.3
K (kg/ha)	470.4	118.9	231.8	129.9	56.0
OC (%)	0.86	0.42	0.55	0.13	24.0
pH	8.0	6.0	6.8	0.6	8.8

Crop yield

In the study years, the yields of rice, wheat, onion, potato, French bean, and berseem + oats ranged between 3560-3887, 3809-4616, 15957-21579, 11596-20783, 6985-9081 and 39895-44384 kg/ha, respectively (Table 5). Mean yield of rice, wheat, onion and potato was 261, 205, 11 and 49%, respectively, higher than the average yield of these crops in Himachal Pradesh (Anonymous 2005 and Baba 2007). Yearly variations in crop yields were small in the study years. The CV values were < 10% for rice and wheat, and about 15-20% for onion and potato.

The mean yield of French bean was about 20% lower than the state average yield of these crops. The yearly variation in yield indicated by CV was about 13 %. Over the years, the variation in yield of fodder berseem + oats was about 5%.

Table 5. Yield and returns under different rice based crop sequences in Una

Crop sequence	Yield* (kg/ha)			Rice equivalent (kg/ha)	Total calories (K x 10^6)
	Kharif	*Rabi* I	*Rabi* II		
				2004-05	
Rice-wheat	3775	3809	-	8137	26.2
Rice-onion	3791	15957	-	18297	21.1
Rice-potato-French bean	3801	11596	8161	26644	26.5
Rice-potato-potato	3823	11931	14074	25100	38.5
Rice-berseem + oats	3887	39895	-	12591	13.4
LSD (P=0.05)	NS	-	-	3695	4.4
				2005-06	
Rice-wheat	3569	4210	-	6221	26.9
Rice-onion	3560	18605	-	12862	21.6
Rice-potato-French bean	3564	15496	9081	18709	29.7
Rice-potato-potato	3605	16303	20712	20262	48.4
Rice-berseem + oats	3682	44384	-	9008	12.7
LSD (P=0.05)	-	-	-	1681	3.2
				2006-07	
Rice-wheat	3720	4616	-	6193	28.8
Rice-onion	3714	21579	-	12962	23.6
Rice-potato-French bean	3787	16538	6985	14683	31.0
Rice-potato-potato	3702	17112	20783	15751	49.6
Rice-berseem + oats	3770	42110	-	7680	13.0
LSD (P=0.05)	-	-	-	679	1.6
				Overall	
Rice-wheat	3688	4212		6851	27.3
Rice-onion	3688	18714		14707	22.1
Rice-potato-French bean	3717	14543	8076	20012	29.1
Rice-potato-potato	3710	15115	18523	20371	45.5
Rice-berseem + oats	3780	42130		9760	13.1
LSD (P=0.05)				2260	2.9

K. cal./100 g: rice & wheat 346; potato 97; French bean 26; Onion 50.

Rice equivalent yield

System's productivity plays a pivotal role in determining the most useful and profitable crop sequence. Rice equivalent yield of the newly introduced cropping sequences *viz.* rice-onion, rice-potato-French bean and rice-potato-potato was superior to prevalent rice - wheat sequence (Table 5). Rice-potato-potato and rice - potato - French bean cropping sequences were relatively superior in terms of rice equivalent yield (20371 and 20012 kg/ha). 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 French bean. 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; Kharub *et al.* 2003; Sharma *et al.* 2008; Tripathi and Singh, 2008). The next superior cropping sequence was rice – onion. Rice-potato-potato, rice-potato-French bean and rice-onion cropping sequences resulted in 197.3, 192.1 and 114.7%, respectively, higher rice equivalent yield over the rice-wheat cropping sequence.

Total calories of the main product

Rice - potato - potato cropping sequence had excelled over the rice-wheat sequence in terms of calories. Total calories under this cropping system were 66.7% higher than the rice-wheat system. This indicated that rice-potato-potato had high value of high quality produce. Sharma *et al.* (2008) also documented higher energy output of cropping sequences in which potato crop was included. Rice – potato – French bean was statistically at par with rice - wheat. In spite of tremendous increase in rice equivalent yield, total calories under rice - onion sequence were 80.9% of rice - wheat cropping sequence.

Net return and B:C ratio

Rice-potato-French bean (Rs 119793/ ha/ annum) and rice-potato-potato (Rs 115428/ ha/ annum) sequences fetched higher net returns than other cropping sequences (Table 6) due to higher

yields. This was followed by rice-onion (Rs 103484/ ha/ annum) and rice–berseem + oats (Rs 67724/ha/annum) sequences. Thakur *et al.* (1994) and Chaudhary *et al.* (2001) have also documented higher net income by diversification of the existing rice-wheat cropping system. Rice – potato – potato, rice – potato - French bean, rice - onion and rice – berseem + oats cropping sequences resulted in 124.5, 116.3, 94.0 and 26.9%, respectively, higher net returns over the rice - wheat cropping sequence. Rice – onion and rice - berseem + oats gave higher B:C ratio than other cropping sequences. In spite of higher yields and net returns rice - potato - potato and rice - potato - French bean resulted in lower B: C ratio than rice-wheat cropping sequence due to higher cultivation costs. However, rice - potato - French bean was statistically at par with rice-wheat sequence in terms of B: C ratio.

Table 6. Duration, production efficiency and economics of different crop sequences in Una

Crop sequence	Duration	LUE (%)	Production efficiency		Returns (Rs/ha)		B:C ratio
			kg/ha/day	Rs/ha/day	Gross	Net	
				2004-05			
Rice-wheat	307.5	84.2	26.5	111.6	60032	34224	1.33
Rice-onion	297.0	81.4	62.2	229.5	105606	67308	1.76
Rice-potato-French bean	307.8	84.3	86.5	297.7	153179	92467	1.50
Rice-potato-potato	335.0	91.8	76.0	229.4	143045	75626	1.10
Rice-berseem + oats	318.2	87.2	39.6	156.1	74440	49665	2.00
LSD (P=0.05)	20.7	5.7	13.7	69.0	-	20322	0.30
				2005-06			
Rice-wheat	295.3	80.9	21.1	174.8	77406	51598	2.00
Rice-onion	267.3	73.2	48.1	354.7	133033	94735	2.47
Rice-potato-French bean	316.0	86.6	59.4	417.2	192503	131192	2.14
Rice-potato-potato	318.5	87.3	63.8	438.7	207240	139221	2.05
Rice-berseem + oats	310.8	85.2	29.0	222.0	93764	68989	2.78
LSD (P=0.05)	9.6	2.6	6.3	59.0	-	16536	0.26
				2006-07			
Rice-wheat	304.3	83.4	20.4	244.1	103272	74242	2.56
Rice-onion	273.3	74.9	47.5	544.4	186654	148408	3.88
Rice-potato-French bean	304.7	83.5	48.3	448.6	215014	136318	1.73
Rice-potato-potato	321.8	88.2	48.9	409.9	230145	132036	1.35
Rice-berseem + oats	327.2	89.6	23.6	260.2	112753	84518	2.99
LSD (P=0.05)	16.2	4.4	3.5	45.0	-	10120	0.24
				Overall			
Rice-wheat	302.4	82.8	22.7	176.8	80237	53355	2.0
Rice-onion	279.2	76.5	52.6	376.2	141765	103484	2.7
Rice-potato-French bean	309.5	84.8	64.8	387.9	186899	119793	1.8
Rice-potato-potato	325.1	89.1	62.9	359.3	193477	115428	1.5
Rice-berseem + oats	318.7	87.3	30.7	212.8	93652	67724	2.6
LSD (P=0.05)	9.7	2.7	7.5	42.4	11195	11632	0.3

Production efficiency

Land use efficiency ranged between 76.5 and 89.1% under different cropping systems. Rice-potato - potato and rice – berseem + oats sequence occupied the land for longer duration and thus had higher land utilization indices than rice-wheat cropping sequence. Rice-onion occupied the land for a shorter duration than rice-wheat cropping sequence. The field remained idle for about three months under this cropping sequence. There was, therefore, possibility to include some other short duration crop to maximize returns. All the cropping sequences resulted in higher production efficiency in terms of kg/ha/day and Rs/ha/day over the rice-wheat cropping sequence. Rice – potato – French bean (64.8) and rice – potato – potato (62.9) cropping sequences recorded the greater production efficiency (kg/ha/day) than other cropping sequences. Productivity efficiency (kg REY/ha/day) under rice-potato-French bean and Rice-potato-potato was, respectively, 2.85 and 2.77 times higher than conventional rice-wheat cropping system. However, 'rice-onion' was at par with these cropping sequences in terms of production efficiency (Rs/ha/day). The production efficiency (Rs/ha/day) under rice-potato-French bean, rice-onion and rice-potato-potato was, respectively, Rs 211.1, 199.4 and 182.5 ha/day more than rice-wheat (Rs 176.8/ha/day) cropping system.

Thus, it is concluded that farmers of low hills of HP can adopt rice - potato - French bean, rice - potato - potato as well as rice - onion cropping sequences for higher net income.

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References

Anonymous 2005. *Statistical Outlines of Himachal Pradesh*, Directorate of Agriculture, Shimla, Himachal Pradesh.

Baba SH 2007. Economic analysis of vegetable production under irrigated conditions of Himachal Pradesh. Himachal J. Agric. Res. **33** (1): 60-65.

Chaudhary JB, Thakur RC, Bhargava M and Sood RD 2001. Production potential and economics of rice (*Oryza sativa* L.) based cropping systems on farmers' fields under mid hills conditions of Himachal Pradesh. Himachal J. Agric. Res. **27** (1&2): 31-35.

Kharub AS, Chauhan DS, Sharma RK, Chokhar RS and Tripathi SC 2003. Diversification of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) system for improving soil fertility and productivity. Indian J. Agron. **48**(3): 149-152.

Kumar A, Tripathi HP, Yadav RA and Yadav DS 2008. Diversification of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system for sustainable production in eastern Uttar Pradesh. Indian J. Agron. **53** (1): 18-21.

Sharma RP, Pathak SK, Haque M and Lal M 2008. Productivity, profitability and nutrient balance as influenced by diversification of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. Indian J. Agron. **53** (2): 97-101.

Thakur RC, Manuja S, Sharma RK, Sood RD and Bhargava M 1994. Production potential and soil fertility maintenance/depletion studies under intensive cropping. Farming system **10** (3&4): 26-35.

Tripathi SC and Singh RP 2008. Effect of crop diversification on productivity and profitability of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. Indian J. Agron. **53** (1): 27-31.

Woodhead T, Huke R and Huke EC 1994. Areas, location and ongoing collaborative research for the rice-wheat system in Asia. In: *Sustainability of rice-wheat production systems in Asia* (R.S. Paroda, Terenee Woodhead and R.B. Singh Eds) RAPA Publication: 1994/11 pp- 68-69. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

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