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Diversification of rice-wheat cropping system in sub-humid Indo-Gangetic plains of Jammu

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ABSTRACT

A field experiment on diversification of rice-wheat system was carried out from 1999 to 2003 under assured irrigation to identify alternative cropping system with higher productivity and profitability. Sixteen rice based cropping sequences with four dominating varieties of rice viz. short duration (IET-1410), medium duration (PC-19), long duration (Jaya) and Basmati (Basmati-370) were tested. The study revealed that the existing rice-wheat cropping system should be diversified to short duration rice (IET-1410)-cauliflower-french bean which recorded highest rice equivalent yield (REY) of 27.20 t ha^{-1} year^{-1}, net return of Rs. 105085 ha year^{-1} and production efficiency of 74.52 kg ha^{-1}day^{-1}. The REY of short duration rice (IET-1410)-potato-wheat, medium duration rice (PC-19)-potato-rajmash and basmati rice (Basmati-370)-potato-okra were next in order. Short duration rice (IET-1410)-toria-wheat had lowest system equivalent yield (11.87 t ha^{-1}year^{-1}). Maximum energy of 77.70 x 10^{6} K calories ha^{-1}year^{-1} was produced in medium duration rice (PC-19)-pea-maize (cob's), followed by short duration rice (IET-1410)-potato-wheat and medium duration rice (PC-19)-potato-rajmash. Land utilization efficiency was maximum with rice (Basmati-370)-potato-okra (95%). After five years study, available N and soil organic carbon were found to decline in rice wheat as well as rice-toria wheat cropping sequence, while inclusion of green manuring/legumes/pulses in the system, particularly in summer season markedly improved organic carbon, bulk density as well as available N, P and K content in soil.

Key words: *Diversification, rice-wheat, profitability, sustainability*

In Indo-Gangetic plains of India, rice (*Oryza sativa* L) - wheat (*Triticum aestivum* L) is an important cropping sequence. Both crops are heavy nutrient feeders and continuous cropping with rice-wheat reported decline in yield with time (Brar *et al*., 1998 and Thakur, *et al.*, 2009). For this, diversification of rice-wheat cropping system is necessary to achieve more yield, returns and to maintain soil fertility. Thus, not only the number of crops but the types of crops included in the cropping sequences are also important (AICRP, 2004). Inclusion of potato, french bean and rajmash in short and medium duration rice based cropping sequences in Jammu region under assured irrigated conditions have become attractive because of high yield. Inclusion of vegetable/legume in a system increases profitability and soil fertility status (Thakur *et al*., 2006). The present study was undertaken to work out diversified and profitable cropping sequences in clay loam soil.

MATERIALS AND METHODS

A field experiment was conducted from 1999 to 2003 at Sher-e-Kashmir University of Agricultural Sciences and Technology Farm, R. S. Pura, Jammu, Jammu and Kashmir which is located at 32^{o} 40$^{/}$N latitude and 74^{o} 50$^{/}$E longitude and an altitude of 356m above mean sea level. The climate at the experimental site was hot and humid rainy season, hot dry summer, warm autumn and cool winter. The maximum temperature during summer rises to about 44^{o} C and minimum temperature during winter falls to 5^{o} C. Average annual rainfall of the study area was 900-1100 mm, 70% of which was received during the month of July to September, the rice growing period. The soil of the experimental site was well drained clay loam with 40% sand, 28% silt and 32% clay in the surface (0-15cm) soil horizon. The surface soil had neutral soil reaction (pH6.8), 0.62% organic carbon, 0.10dSm^{-1} EC, 168.0, 16.0 and 82.0 kg ha^{-1}

available N, P and K, respectively. Sixteen rice based cropping systems with four dominant varieties of rice viz. short duration (*IET-1410*), medium duration (*PC-19*), long duration (*Jaya*) and basmati (*Basmati-370*) were tested (Table 1) in randomized complete block design with 4 replications in fixed plots of 6m x 3m area. Data were pooled and analyzed statistically. Total energy production was calculated by using the conversion factors as suggested by Mittal and Dhawan (1988). Composite surface (0-15cm) soil samples were collected from each plot after completion of study and were analyzed (Jackson, 1964). Average existed selling price of different commodities were, rice (IET-1410) and (PC-19) (Rs. 500 q^{-1}), Jaya (Rs. 450 q^{-1}), Basmati (Rs. 1200 q^{-1}), wheat (Rs. 650 q^{-1}), Toria (Rs. 2000 q^{-1}), potato (Rs. 400 q^{-1}), Rajmash (Rs. 3500 q^{-1}), chickpea (Rs. 1500 q^{-1}), green gram (Rs. 2000 q^{-1}), radish (Rs. 250 q^{-1}), Peas (Rs. 550 q^{-1}), okra (Rs. 500 q^{-1}), onion (Rs. 400 q^{-1}), maize (Rs. 50/100cob), berseem seed (Rs. 7000 q^{-1}), cauliflower (Rs. 400 q^{-1}), French bean green (Rs. 500 q^{-1}), berseem fooder (Rs. 50 q^{-1}), rice and wheat straw (Rs. 50 and 100 q^{-1}), respectively.

RESULTS AND DISCUSSION

Total productivity in term of rice equivalent yield (REY) of different rice based cropping system (Table 2) indicated that rice (IET-1410)-Cauliflower-French bean recorded highest and significant REY (27.20 t ha^{-1} $year^{-1}$), which was closely followed by rice-potato-wheat (REY 26.56 t ha^{-1} $year^{-1}$). However, rice-potato-rajmash sequence (REY 26.14 t ha^{-1} $year^{-1}$) was at par with rice-cauliflower-frenchbean, which might be due to replacing wheat in rice-wheat system with high value vegetables crops, while rice-toria-wheat and existing rice-wheat system recorded the lowest REY of 11.87 t $ha^{-1}year^{-1}$and 13.02 t ha^{-1} $year^{-1}$, respectively. Similar results were also reported by Thakur et al (2006) and Nanda et al (2008). However, highest net return of Rs. 105085 ha^{-1} was also recorded in rice-cauliflower-french bean sequence immediately followed by rice-potato-wheat (Rs. 98031 ha^{-1}) and rice-potato-rajmash (Rs. 94252 ha^{-1}), which owing to increase in productivity, potentiality and preferability by the farmer community of Jammu region to replace existing rice-wheat system. While highest B:C ratio of 3.03 was

Table 1. Details of different rice based cropping sequences tested at SKUAST farm, Jammu (1999-2003)

Wet season	Winter season)	Dry season
Short duration rice		
Rice (*IET-1410*)	Potato (*Kufri Badshah*)	Wheat (*PBW-373*)
Rice (*IET-1410*)	Toria (Local)	Wheat (*PBW-373*)
Rice (*IET-1410*)	Berseem (*Mescavi) for fodder)*	Seed production
Rice (*IET-1410*)	Cauliflower (*SB-16*)	French beans (*Pusa parvati*)
Medium duration rice		
Rice (*PC-19*)	Wheat (*PBW-343*)	Fodder
Rice (*PC-19*)	Mustard (*GSL-1*)	Green gram (*SML-688*)
Rice (*PC-19)*	Potato (*Kufri Badshah)*	Rajmash (*VL-63*)
Rice (*PC-19*)	Peas (*Arkel*)	Maize (*Green cobs*)
Long duration rice		
Rice (*Jaya*)	Wheat (*PBW-343*)	Fallow (Existing system)
Rice (*Jaya*)	Wheat (*PBW-343)*	Green manuring
Rice (*Jaya*)	Chickpea (*C-235*)	Fodder (Maize+Cowpea)
Rice (*Jaya*)	Radish (*Pusa Himani*)	Okra (*Pusa Sawani*)
Scented rice		
Rice (Basmati-370)	Wheat (*PBW-343*)	Fallow
Rice (Basmati-370)	Wheat (*PBW-343*)	Green manuring*
Rice (Basmati-370)	Potato (*Kufri Badshah*)	Okra (*Pusa Sawani*)
Rice (Basmati-370)	Onion (*N-53*)	Fodder (Maize+ Cowpea)

* Through *Sesbania aculeata* (Dhaincha)

Table 2. Average yield and economics of different rice-based cropping sequences tested at SKUAST farm, Jammu (1999-2003)

Cropping sequences	Yield (q ha^{-1})			REY (t ha^{-1}) (Days)	System duration (kg REY ha^{-1} day^{-1})	Production efficiency efficiency (%)	Land utilization (x 10^6 K cal (Rs ha^{-1})	Total energy production (Rs.ha^{-1})	Net return	B:C ratio
	wet	dry	Summer							
Short duration rice										
Rice-Potato-Wheat	33.31	212.50	23.60	26.57	335	72.80	92	40.995	98031	2.74
Rice-Toria-Wheat	34.37	7.82	29.80	11.87	305	35.52	84	26.433	37130	2.16
Rice-Berseem-Seed	33.66	490.60	3.12	13.16	295	36.05	81	11.636	51189	3.03
Rice-Cauliflower-french beans	32.68	202.50	74.85	27.20	280	74.52	77	26.618	105085	2.99
Medium duration rice										
Rice-Wheat-Fodder	43.93	40.60	362.40	15.12	315	41.42	86	29.247	53152	2.53
Rice-Mustard-Greengram	46.87	14.82	5.14	13.12	340	35.95	93	25.951	45076	2.45
Rice-Potato-Rajmash	43.09	172.92	10.60	26.14	300	71.62	82	35.349	94252	2.64
Rice-Peas-Maize(Cobs)	45.16	82.60	43520(No.)	18.78	340	51.45	93	77.706	67914	2.65
Long duration rice										
Rice-Wheat (Existing System).	52.87	39.60	-	13.02	290	35.67	79	31.994	47191	2.38
Rice-Wheat-G.M	50.45	42.40	-	13.23	335	36.25	92	32.126	44809	2.40
Rice-Chickpea-Fodder	50.56	14.80	346.50	15.17	317	41.56	87	22.821	53625	2.56
Rice-Radish-Okra	51.87	132.50	56.20	19.51	308	53.45	84	22.166	63898	2.29
Rice Basmati.										
Rice-Wheat-Fallow	27.12	36.80	-	12.44	298	34.08	82	22.116	46703	2.61
Rice-Wheat-G.M	28.43	38.90	-	13.10	343	35.89	94	22.296	46957	2.63
Rice-Potato-Okra	27.68	142.60	48.60	25.22	348	69.10	95	25.110	86536	2.44
Rice-Onion-Fodder	27.87	128.50	336.80	21.36	293	58.52	80	16.068	83568	2.97
CD (P=0.05)	-	-	-	1.32	-	-	-	-	-	-

recorded in rice(IET-1410)-berseem(fodder)-seed production, which was closely followed by rice-cauliflower-french bean (2.99) which is attributed to more input cost involved in cauliflower and French bean production. Thus, rice-cauliflower-french bean cropping sequence was ranking second in terms of benefit cost ratio. Likewise, rice (Basmati-370)-onion-fodder, medium duration rice(PC-19)-pea-maize (cob's) long duration rice (Jaya)- radish-okra, rice(IET-1410)-berseem (fodder)-seed production were also identified as potential alternatives to diversify the existing rice-wheat system on the basis of improved soil health and profitability.

Rice(Basmati)-potato-okra, rice-potato wheat and rice-cauliflower-french bean sequences were found to be most preferable in terms of providing employment for maximum number of man days in a year with better economic return (Table 2). Highest production efficiency of 74.52 kg ha^{-1}day^{-1} was noticed in rice (IET-1410)-cauliflower-french bean which was closely followed by rice-potato-wheat 72.80 kg ha^{-1} day^{-1} and rice-potato-rajmash (71.62 kg ha^{-1}day^{-1}), whereas the lowest production efficiency was recorded in rice-toria-wheat (35.52 kg ha^{-1}day^{-1}) and existing rice-wheat cropping system (35.67 kg ha^{-1}day^{-1}). Because of realizing low profit per unit area. Sharma *et al* (2004) reported the similar findings. Similarly the highest land utilization efficiency of 95% was recorded in rice (Basmati-370)-potato-okra closely followed by rice (*Basmati-370*)-wheat-green maturing (94%), rice (PC-19)-pea-maize (93%), rice (*IET-1410*)-potato-wheat (84%) and lowest of 70 and 79% with rice (*IET-1410*)-cauliflower-french bean and in existing rice-wheat system. However, in term of energy production medium duration rice (*PC-19*)-pea-maize was the highest producer of energy (77.70 x 10^6 K calories ha^{-1} year^{-1}) followed by short duration rice (*IET-1410*)-potato-

Table 3. Role of different cropping sequences on soil fertility over a period of 5 years tested at SKUAST farm, Jammu (1999-2003)

Treatments	Organic carbon (%)	Bulk density (g cm^{-3})	Available nutrients (kg ha^{-1})		
			N	P	K
Short duration rice					
Rice-Potato-Wheat	0.63	1.34	177.90	17.20	88.57
Rice-Toria-Wheat	0.52	1.35	166.00	15.20	78.35
Rice-Berseem	0.71	1.32	180.20	17.90	89.00
Rice-Cauliflower-french beans	0.69	1.32	175.10	16.80	87.00
Medium duration rice					
Rice-Wheat-Fodder	0.68	1.34	177.15	17.10	86.50
Rice-Mustard-Green gram	0.66	1.33	170.00	16.40	85.31
Rice-Potato-Rajmash	0.67	1.31	178.10	17.15	90.50
Rice-Peas-Maize (Cobs)	0.68	1.31	175.00	17.00	87.30
Long duration rice					
Rice-Wheat (Existing System)	0.60	1.36	163.00	15.10	80.00
Rice-Wheat-G.M*	0.71	1.30	187.00	18.00	87.30
Rice-Chickpea-Fodder	0.67	1.31	177.35	17.20	86.20
Rice-Radish-Okra	0.65	1.30	170.00	17.10	84.84
Rice Basmati					
Rice-Wheat-Fallow	0.59	1.37	162.00	15.80	81.50
Rice-Wheat-G.M*	0.70	1.30	189.35	18.20	95.30
Rice-Potato-Okra	0.65	1.32	176.30	17.75	89.30
Rice-Onion-Fodder	0.66	1.31	179.30	18.00	84.50
Initial	0.62	-	168.00	16.00	82.00

wheat (40.99 x 10^6 K calories $ha^{-1}year^{-1}$) and medium duration rice *(PC-19)*-potato-rajmash (35.35 x 10^6 K calories $ha^{-1}year^{-1}$), respectively. Similar findings were also reported by Sharma and Gill (2007).

Among the sustainable and profitable rice based sequences, it was observed (Table 3) that after completion of 5 crop cycle, there was a build up of soil organic carbon and available N, P and K content in 0-15cm soil profile in crop sequences except existing rice-wheat system over initial value of 0.62%, 168, 16 and 82 kg ha^{-1}, respectively. The initial soil organic carbon was 0.62% which was reduced to 0.59% i.e 5% over initial value in continuous adoption of rice-wheat system over a period of five years. However, the increase of soil organic carbon content was 15, 13, 11 and 9% in rice-wheat-GM, rice-berseem (fodder)-seed production, rice-pea-maize and rice-wheat-fodder, respectively. Available N, P and K content and bulk density of soil was also improved in those cropping sequences where legumes for green manuring / vegetables/fodder/tuber crops were added in a system rather than existing rice-wheat system (Thakur *et al*., 2006). However a depletion of N, P & K content to the tune of around 6, 1 and 2 kg ha^{-1}, respectively was recorded in existing rice-wheat system (Table 3). The data showed that among profitable sequences, rice-wheat-GM, rice-wheat-fodder, rice-cauliflower-french bean, rice-pea-maize, rice-potato-rajmash were also identified sustainable sequences. Addition of legume based crops not only increased the productivity but also improved the soil health. Similar results were also reported by Samui *et al.*, (1995).

The study thus concluded that diversified system have recorded good returns and also found to be employment generating system. Inclusion of green manuring/legume crops /pulses in cropping sequence for particularly in summer season improved soil health in terms of physical and chemical properties. Hence existing rice based cropping system (rice-wheat) can effectively be diversified with the inclusion of vegetables and other preferably cash crops like French bean, Potato, Cauliflower, Rajmash, Peas and Garlic to full fill the daily needs of farmers and to get higher returns.

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