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Energetics, yield, water use and economics of rice-based cropping system

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ABSTRACT

A field experiment was conducted during 1993-96 at Bilaspur to study the energy requirement, water use and economics of seven different rice-based cropping systems. Among the cropping sequences tried, the energy input and output were maximum in rice-rice. However, energy output of major products was maximum in rice-peanut system. Energy use efficiency was maximum with rice-chickpea followed by rice-wheat. Rice-chickpea system recorded the highest water use efficiency followed by rice-sunflower, but the total amount of water used was more in rice-rice system. Cultivation cost was maximum with rice-rice system (Rs 25398/ha) while the net return was more or less same in rice-rice, rice-wheat and rice-peanut cropping systems.

Key words: Energetics, Cropping system, Equivalent yield, Production efficiency

Rice (*Oryza sativa* L.) is a main crop grown extensively during the rainy season under both irrigated and rainfed conditions of Chhattisgarh region of Madhya Pradesh. In this region, double cropping system is gaining popularity with the increase in irrigation facilities. However, intensive agriculture involving high intensity cropping system requires larger amount of both energy and water. Irrigation water is a costly and scarce resource and availability of water to agriculture is expected to get reduced. Similarly, increase in the cost of commercial energy and decline in fuel reserves warn the researchers to work out the highly productive cropping system with better energy use efficiency. Since, not much information is available on the suitability of different winter crops grown after rice, an experiment was undertaken to select suitable rice-based cropping sequence to increase production potential and net returns for this region.

MATERIALS AND METHODS

The experiment was conducted at Regional Agricultural Research Station, Bilaspur. The experiment having seven cropping sequences with a single crop of IR 36 rice during the rainy season, and 7 crops viz., 'Swati' wheat (*Triticum aestivum* L.), 'JG 24' chickpea (*Cicer arietinum* L.), 'Varuna' Indian mustard (*Brassica juncea*

L.), (Czernj and Cosson), 'Modern' sunflower (*Helianthus annuus* L.), 'JS 11' peanut (*Arachis hypogaea* L.), 'TKJ 11' sesame (*Sesamum indicum*) and 'IR 36' rice (*Oryza sativa L.)* during winter season.

The experiment was conducted in randomized block design with three replications. The crops were raised adopting the standard package of practices. The experimental soil was clay-loam with 0.76% organic carbon, 218 kg/ha available N 20.05 kg/ha available phosphorus and 487 kg/ha available potassium and having pH 7.3. The climate of the region is humid sub-tropics. Energy input and output was calculated using the energy equivalents as suggested by Mital *et al.* (1985). Water use efficiency was worked out in terms of yield (kg/ha-cm) of

Table 1. Yield, water use and water expense efficiency of different crops in rice based cropping sequence (mean data of 3 years)

Cropping sequence	Water use (cm)	Yield (t/ha)			Total yield (t/ha)	WEE (kg/ha-cm)
		Rainy season	Winter season	Rice equivalent		
Rice-wheat	121.80	4.80	4.37	5.17	9.97	81.85
Rice-chickpea	102.55	4.96	2.02	5.05	10.01	97.61
Rice-mustard	107.30	4.81	1.21	3.02	7.83	72.97
Rice-sunflower	115.31	4.79	2.06	5.04	9.83	85.25
Rice-peanut	144.45	4.92	2.81	7.02	11.94	82.66
Rice-sesame	114.30	4.83	1.29	4.07	8.90	77.86
Rice-rice	232.00	4.89	5.73	5.73	10.62	45.78
CD (P = 0.05)	–	NS	0.91	–	0.62	–

Table 2. Economics, land use and production efficiency of different rice based cropping sequences (mean data of 3 years)

Cropping sequence	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Benefit : cost ratio	Land use efficiency (%)	Production efficiency (kg/day/ha*)
Rice-wheat	16,188	19,552	1.21	61.91 (226)	42.57
Rice-chickpea	15,634	14,236	0.91	63.83 (233)	40.13
Rice-mustard	15,001	14,109	0.94	60.03 (200)	36.64
Rice-sunflower	15,896	16,734	1.05	64.66 (236)	40.43
Rice-peanut	23,506	19,456	0.83	72.05 (263)	45.40
Rice-sesame	17,532	15,491	0.88	57.00 (208)	42.79
Rice-rice	25,398	19,942	0.78	68.49 (250)	42.48

*Calculated on rice equivalent basis

Figures in parentheses are total duration of crops in that sequence

water expense including effective rains during the crop season. Comparison among the cropping sequences was worked out by converting the yields of all crops into rice equivalent on price basis. The land use efficiency was worked out by taking total duration of crops in individual crop sequence divided by 365 days, and production efficiency values were obtained by total production in a sequence divided by total duration of crop in that sequence (Tomar and Tiwari, 1990)

RESULTS AND DISCUSSION

Yield equivalent

Rice-peanut was more productive followed by rice-rice and rice-wheat (Table 1). The lowest rice equivalent yield was obtained in rice-Indian mustard sequence. However, rice equivalent yields of rice-peanut, rice-rice and rice-chickpea systems were comparable to each other. The lowest rice equivalent yield in rice-Indian mustard system was mainly due to low yield of Indian mustard.

Water use efficiency (WUE)

Different cropping systems consumed varied quantities of irrigation water (Table 1). Total water use was maximum in rice-rice crop sequence followed by rice-peanut. The highest water expense under rice-rice system was mainly due to substantially high water requirement of summer rice. The lowest water use among the different cropping sequences was in rice-chickpea system (10.25 cm). The WUE was the highest in rice-chickpea system followed by rice-sunflower. The lowest WUE was obtained in rice-rice cropping sequence (45.78 grains/ha-cm).

Land use and production efficiency

Rice-peanut sequence achieved the

Table 3. Total energy (MJ x 10^3 / ha) input and output of different cropping systems (mean data of 3 years)

Cropping sequence	Human labour	Diesel	N	P_2O_5	K_2O	Seed	Irrigation	Plant protection	Total input	Energy output	Energy efficiency
Rice-wheat	3.06	3.89	10.91	1.01	0.48	2.06	2.31	0.65	24.37	259.42	10.64
Rice-chickpea	2.96	3.44	6.06	1.11	0.30	1.69	1.34	0.84	17.70	248.66	14.05
Rice-mustard	3.12	3.44	8.48	0.71	0.30	0.71	1.58	0.73	19.07	230.64	12.09
Rice-sunflower	3.35	3.44	9.70	1.11	0.42	0.96	2.07	0.63	21.68	271.32	12.51
Rice-peanut	3.83	3.89	6.06	1.31	0.36	3.09	3.28	0.56	22.38	277.57	12.40
Rice-sesame	3.56	3.44	9.70	0.81	0.30	0.68	1.82	1.26	21.57	224.46	10.41
Rice-rice	4.10	3.89	10.91	1.01	0.31	1.18	5.40	0.56	27.35	297.36	10.87

Table 4. Output-input energy ratio for various crop sequences

Cropping sequence	Input energy					Output energy		Output : input	
	Field operation	Seeds	Chemical/ fertilizer	Irrigation	Total	Major products	By-products	Major products	By-products
Rice-wheat	6.95	2.06	13.05	2.31	24.37	4.80	124.62	5.53	5.11
Rice-chickpea	6.40	1.69	8.27	1.34	17.70	102.61	146.05	5.80	8.54
Rice mustard	6.65	0.71	10.22	1.58	19.07	100.96	129.69	5.29	6.80
Rice-sunflower	6.79	0.96	11.86	2.07	21.68	121.91	149.41	5.62	6.89
Rice-peanut	7.25	3.09	8.76	3.28	22.38	142.57	135.00	6.37	6.03
Rice-sesame	7.71	0.68	11.36	1.82	21.57	103.25	121.20	4.79	5.62
Rice-rice	7.93	1.18	12.84	5.40	27.35	156.11	141.25	5.71	5.16

*Energy data presented as MJ x 10^3/ha

highest land use efficiency followed by rice-rice, rice-sunflower and rice-chickpea (Table 2). It is primarily due to the duration of winter crops. Rice during winter season took longer time to mature followed by sunflower. Production efficiency was the highest in rice-peanut sequence and the lowest in rice-Indian mustard cropping sequence. All other cropping systems had more or less similar production efficiency.

Energetics

The total energy input in different cropping sequences ranged from 17.70 to 27.35 x 10^3 MJ/ha (Table 3). In general, nitrogen accounted for single largest share of energy input followed by diesel and human labour. The energy input through seeds, plant protection chemicals, fertilizer potash and phosphorus was of lower magnitude. Rice-chickpea system gave the highest energy use productivity while the lowest was observed in rice-sesame. Though the total energy output was remarkably high in rice-rice cropping sequence the total energy input was also higher resulting in lower energy use efficiency (Table 3). Similar findings were observed by Pal *et al.* (1985) and Subbian *et al.* (1995).

Fertilizers and chemicals accounted for the highest percentage of total energy input ranging from 39.14 to 53.55% of the total energy input among the different cropping systems. The second largest was field operations followed by irrigation (Table 4). Among the different cropping systems rice-rice required the highest energy input (27.35 x 10^3 MJ/ha) while the lowest in rice-chickpea (17.70 x 10^3 MJ/ha). Rice-rice system produced the highest output energy followed by rice-peanut. However, output : input ratio was the maximum in rice-peanut (6.37) and the lowest in rice-sesame (4.79).

Economics

Maximum cost was incurred in rice-rice crop sequence followed by rice-peanut. The lowest cost was incurred in rice-Indian mustard sequence because of lower cost required in raising Indian mustard. Rice-rice,

rice-wheat and rice-peanut systems accrued more or less same net return but higher than other sequences (Table 2).

Rice-rice system recorded the highest energy output but it also consumed the highest amount of energy resulting in lower output : input ratio than rice-peanut sequence (Table 4). Considering the net return, output energy and production efficiency, rice-peanut and rice-wheat system are more promising than other systems in the region.

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