

Productivity and economics of rice (*Oryza sativa*) - based crop sequences under mid- to high-altitude temperate zone of Jammu and Kashmir

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ABSTRACT

A field experiment was conducted during 1987-92 on a silty clay-loam soil to identify appropriate rice (*Oryza sativa* L.) - based cropping systems with high productivity in mid- to high-altitude temperate zone of Kashmir Valley. Rice, as a base crop, was sequenced with other feasible crops, viz. rapeseed, wheat (*Triticum aestivum* L. emend. Fiori & Paol.), lentil (*Lens culinaris* Medikus), oat (*Avena sativa* L.) and berseem (*Trifolium alexandrinum* L.). A rice-fallow rotation was also included to represent area where soil is unfit due to waterlogging during winter season. Rice-rapeseed sequence recorded sustainable rice yield on a long-term basis. Rice-wheat sequence secured the highest rice yield equivalent (RYE), net returns and energy output/ha, which was followed by rice-rapeseed sequence. Oat had an adverse impact on rice yield sustainability as it decreased the same by 24%.

Key words: Rice-based cropping system, Productivity and economics, Rice-yield equivalent

The main crop grown under irrigated mid- to high-altitude temperate zones of Kashmir valley is rice. The zone represents a double cropping area where rice is grown during summer (*kharif*) and some winter crops during the season following rice. These crops are rapeseed, wheat, lentil, oat and berseem. Some of the farmers whose land remain waterlogged during winter season take only rice. The productivity, feasibility and economics of different crop sequences should be studied to identify need-based cropping systems with high returns of money and energy. Therefore, tak-

ing rice as the principal crop, a 5-year experiment was conducted with an objective of identifying ideal rotations which can suit the farmers of the region.

MATERIALS AND METHODS

A 5-year study was conducted on a fixed site at Shalimar Campus of Shere-e-Kashmir University of Agricultural Sciences and Technology. Soil was a silty clay loam, medium in organic matter, low in available N and P and medium in available K. Six cropping sequences with rice as base crop (as per Table

1) were laid out in randomized block design with 4 replications. The recommended dose of N, P₂O₅ and K₂O applied were 80, 40, 20 to rice ('K 39'); 30, 30 and 20 to rapeseed ('KOS 1'); 40, 60 and 20 to lentil (Precose), 80, 40 and 20 to oat ('Kent'); and 20, 80 and 20 to berseem ('Pusa Giant'). Rice was also supplied with 10 kg/ha of ZnSO₄ each year. Rice seedlings of 35 days were transplanted each year by the second week of June and crop was harvested in the first week of October. All winter-season crops were sown after rice by the second fortnight of October. During the years, rapeseed was harvested between 7 and 15 May, wheat 7 and 15 June, lentil 22 and 30 May, oat 22 and 30 April and berseem in 2 cuts by April-May end. The mean of weather parameters from 1987 to 1992 (6 years means) showed a maximum temperature of 4.30 to 30.43°C, minimum temperature of -2.0 to 19.0°C, relative humidity 54 to 90% and mean annual precipitation of 769 mm spread over 100 days. The comparison among cropping sequences were done by converting the respective grain or straw yields into rice yield equivalent (RYE) on price basis of 1991-92 (Table 2). Economics was calculated on prevalent prices from 1987 to 1992. Energy values for main produce (other than

straw or green fodder) obtained from different sequences was computed as per Gopalan *et al.* (1971).

RESULTS AND DISCUSSION

Crop yield

Maximum rice yield was recorded under rice-rapeseed sequence, which was on a par with rice-berseem sequence (Table 1). Yield obtained from these 2 crop sequences was however significantly superior to rice yield obtained from other crop sequences. But, Parihar *et al.* (1995) observed non-significant difference in rice yield under Bilaspur (Madhya Pradesh) conditions. Rice-oat recorded the minimum rice yield. These results indicated that there was a decline in average rice yield with oat or wheat in sequence, whereas the rice yield remained more or less stable when sequenced with rapeseed or leguminous crops like lentil or berseem. Wheat or oat being a cereal crop, and thereby heavy feeder of nutrients, might have impoverished the soil resulting in low rice productivity. On the other hand, rapeseed which is not a heavy feeder for nutrients, and leguminous crops (berseem or lentil) which are supposed to symbiotically contribute to soil N pool, must have helped in maintaining soil nutrients and in

Table 1. Grain or straw yields and rice equivalents of different rice-based cropping sequences in Kashmir (mean data of 5 years)

Crop sequence	Yield (q/ha)						
	Summer crop		Winter crop		Rice equivalent		
	Grain	Straw	Grain	Straw or GF	Summer crop	Winter crop	Total
Rice-rapeseed	62.0	68.3	9.9	23.7	50.56	21.60	72.16
Rice-wheat	52.0	59.7	37.7	53.6	42.74	34.00	76.74
Rice-lentil	58.0	65.9	8.9	14.8	47.62	25.20	72.82
Rice-oat	47.0	56.5		194.0	39.00	9.13	48.13
Rice-berseem	59.0	66.5		165.2	48.31	7.77	56.08
Rice-fallow	57.6	64.4			47.11		47.11
CD (P = 0.05)	4.0	4.5					3.53

GF, Green fodder; cost of produce (Rs/q) on 1991-92 price basis : Rice, 530; rapeseed, 1,158; wheat, 373, lentil, 1,500; oat (green fodder), 25; straw 75

Table 2. Economics and productivity of various crop sequences (mean data of 5 years)

Crop sequence	Economics of crop sequence (Rs)*				Productivity of crop sequence for food crops (based on 1991-92 prices)			
	Gross return	Total variable cost	Return to VC	Benefit: cost ratio	Energy equivalent (q/ha)			Calories K unit x 10 ⁶ /ha
					Rice equivalent of food crops only	Protein	Carbohydrate	
Rice-rapeseed	22,114	8,610	13,504	2.57	62.5	4.96	34.34	19.46
Rice-wheat	27,717	9,994	17,723	2.77	60.7	6.78	53.66	24.9
Rice-lentil	20,865	9,422	11,443	2.22	63.5	4.59	35.20	16.26
Rice-oat	17,188	9,458	7,730	1.82	31.0	2.08	24.24	10.70
Rice-berseem	20,570	9,289	11,281	2.22	38.9	2.645	30.42	13.42
Rice-fallow	14,114	5,770	8,344	2.44	38.0	2.584	29.7	13.11

*Based on means of yearly calculation from 1987 to 1992 at prevalent prices

turn the productivity or sustainability. Yield of *rabi* crops in the winter season remained moderate; however oat outyielded berseem, and hence could have removed a sizable amount of nutrients.

Rice-yield equivalent

Among the various rice-based cropping sequences including rice-fallow, rice-wheat proved significantly more productive by recording a RYE of 76.74 q/ha (Table 1), followed by rice-rapeseed. Gangwar *et al.* (1995) reported similar results. Lowest productivity in terms of RYE was recorded for rice-oat sequence which is again due to the exhaustive nature of the rotation and low market value of oat fodder.

Economics and productivity

Maximum cost was incurred in rice-wheat sequence followed by rice-oat and rice-lentil (Table 2). If we exclude rice-fallow sequence, minimum cost was incurred on rice-rapeseed which might have been due to lesser investments in the rapeseed cultivation. The results confirm the findings of Deka *et al.* (1984) and Padhi (1993). Maximum net returns were obtained from rice-wheat sequence

which was followed by rice-rapeseed and rice-lentil sequences. The maximum net returns in above 2 sequences might have been due to higher total production (wheat) and higher prices (rapeseed). These findings confirm results of Gangwar *et al.* (1995). The RYE for food crops (Table 2) was maximum for rice-lentil sequence, followed by rice-rapeseed. This was due to higher prevalent prices of the respective crops. Rice-wheat rotation yielded maximum energy output of 24.9×10^6 calories/ha by virtue of its being the highest protein or carbohydrate yielder/ha (Table 2). As the energy relationships were worked out on the basis of edible portions, the rice-oat rotation showed minimum values for the 3 measures of productivity. Higher nutrient equivalent/ha and in turn, higher energy equivalent obtained for rice-wheat sequence is due to more protein (per 100 g of edible portion) in wheat compared with rice (Gopalan *et al.*, 1971).

Thus rice followed by rapeseed and wheat sequences along with recommended doses of fertilizers to both was found beneficial from food production point of view, and rice-berseem could be conveniently recommended on the basis of food-fodder for adoption in Kashmir valley.

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