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System Productivity, Production Efficiency and Economic Feasibility of Rice *(Oryza sativa)* and Maize *(Zea mays)* Based Crop Sequences under Temperate Conditions of Western Himalayas

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Abstract A field experiment was conducted from *rabi* 2007 to *kharif* 2010 at Krishi Vigyan Kendra, Farm, Sartangal which is located at 1826 m above mean sea level to evaluate the productivity and economic viability of eight different crop sequences (wheat-rice, wheat-maize + rajmash, mustard-rice, mustard-maize + rajmash, oats-rice, oats-maize + rajmash, pea-rice and pea-maize +rajmash). Three years field study revealed that the highest grain yield in terms of maize equivalent yield (8.53 t/ha) was recorded in oats-maize + rajmash sequence followed by wheat-maize + rajmash (8.16 t/ha) and wheat-rice (8.14 t/ha). Study further revealed that oats-maize + rajmash sequence gave the highest net returns (Rs 65032/ha), crop profitability (187.41 Rs/ha/day), system profitability (178.16 Rs/ha/day), benefit cost ratio (1.91) with maximum land use efficiency of 95.07% and apparent nutrient productivity (32.83 kg/ha). Whereas, employment generation efficiency was maximum with pea-rice cropping sequence (110.41%) due to more mandays (403 mandaus) engaged. Thus there is the ample scope to introduce oats-maize + rajmash wheat-maize + rajmash like cropping sequences for higher productivity and profitability which will ultimately improve socio-cconomic conditions of farmers.

Keywords System productivity, Rice, Maize, Crop sequences, Western Himalayas.

Introduction

Rice and maize + rajmash are major rainy season crops and wheat, mustard, oats and pea are winter season crops in temperate agro-climatic regiona of Jammu. Most of the farmers of this temperate region comes under the marginal and small farmers category [1] are economically poor and practice subsistence farming. Moreover,due to harsh and unfavorable climatic conditions the productivity of crops is much below the national average productivity and sometimes due to excessive snow and chilling farmers can take only one crop in a year. Therefore, efficient cropping systems with respect to productivity along with its economic viability are to be evaluated before making its recommendation to the farmers. Thus, an experiment was conducted to evaluate the productivity and economic viability of some cropping sequences to

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imorove the socio-economic conditions of the farmers in this temperate region.

Materials and Methods

A field experiment was conducted for 3 consecutive years at fixed location from *rabi* 2007 to *kharif* 2010 at Krishi Vigyan Kendra, Farm, Sartangal. The research farm falls within $32^0 53´$ N to $34^0 21´$ N latitude and $75^0 1´$ E to $76^0 47´$ E longitude and is located at 1826 in above mean sea level. The climate is temperate with mean rainfall of 891.0 mm. The soil of the experimental site was clay loam in texture, medium in available N (180 kg/ha), low in available P (14 kg/ha) and high in available K (230 kg/ha) with neutral pH (6.2). The eight crop sequence viz. T_1-wheat-rice, T_2-wheat-maize + rajmash (1:1), T_3-mustard-rice, T_4-mustard-maize + rajmash (1:1), T_5-oats-rice, T_6-oats-maize + rajmash (1:1), T_7-pea-rice and T_8-pea-maize + rajmash (1:1) were evaluated in randomized block design with three replication. Wheat *(Triticum aestivum)* cv Shalimar wheat-1, rice *(Oryza sativa)* cv K-84, oat *(Avena sativa)* cv Subzar, pea *(Pisum sativum)* cv Bonne villa and mustard *(Brassica campestris)* cv KS-101, were sown on 10th November, 10th June, 10th November , 15th November and 01st November respectively with a corresponding spacing of 22.5 cm (R × R), 20 cm × 10 cm, 30 cm (R × R), 30 cm × 15 cm, and 30 cm × 10 cm, while maize *(Zea mays)* cv KH 517 and rajmash *(Phaseolus vulgaris)* cv Local were sown as intercrop on 05th May in alternate rows 30 cm apart by keeping plant to plant spacing of 25 cm for maize and 15 cm for rajmash. During *kharif* only rice crop was irrigated while to remaining *kharif* and all the *rabi* crops no irrigation was applied. The recommended dose of NPK (kg/ha) for wheat (100:50:25), rice (80:40:20), oat (80:40:20), pea (50:60:50), mustard (60:30:15) and maize + rajmash (60:40:20) was applied and were harvested on 08th June, 18th October, 08th June, 29th May, 11th May and 20th September respectively. The oats taken in the cropping sequence was utilized both as green fodder and for seed preoduction (oats under Bhaderwah conditions is a two cut crop out of which 1st cut of *rabi* sown oat is utilized as fodder and then the crop is allowed to grow for seed production).

The maize equivalent yield (MEY) was calculated by converting the economic yields of crops grown during *rabi* and *kharif* season into maize yield on the basis of market price of the crops. Production efficiency (kg/ha/day) was obtained by dividing the total productivity of a system in terms of MEY by total duration of that system [2]. Land utilization efficiency, crop profitability and system profitability were computed by using the following formula :

$$\text{Land utilization efficiency (\%)} = \frac{\text{Duration of crop sequence (days)}}{365} \times 100$$

$$\text{Crop profitability (Rs/ha/day)} = \frac{\text{Net monetary returns from sequence (Rs/ha}}{\text{Total duration of the crop in that rotation (days)}}$$

$$\text{System profitability (Rs/ha/day)} = \frac{\text{Net monetary returns from sequence (Rs/ha)}}{\text{365 days}}$$

Employment generation efficiency was determined by dividing the total mandays employment for the system by 365 days and expressed in percentage [3]. Apparent nutrient productivity was calculated by dividing the equivalent yield of the system with the total quantity of the nutrients applied.

Results and Discussion

Crop productivity

The yield of all the crops in different crop sequences showed an increase in yield during subsequent years (Table 1). Thus, highest yield of all the crops were recorded during *rabi* 2009-10 and *kharif* 2009-10.There was a marked effect of the preceding crops on the grain yield of rice. In all the three seasons, highest rice yield was recorded in pea-rice sequence. This might be due to the beneficial effect of legume pea crop on the succeeding rice [4]. During all the years of study wheat yield was highest in wheat-rice sequence (3.27-3.80 t/ha), mustard in mustard-rice sequence (0.93-1.01 t/ha), oat green fodder and seed yield in oat-maize + rajmash sequence and pea in pea-maize + rajmash sequence (1.65-1.94 t/ha).

System productivity

The productivity of crop sequences under study was

Table 1. Productivity, maize equivalent yield (MEY), crop duration, production efficiency of different cropping sequences (average of 03 years). *GF=green fodder, Price (Av of 3 years): Whear @ Rs 1300/q, Paddy @ Rs 1083/q, Maize @ Rs 1160/q, Rajmash @ Rs 8000, Mustard Rs 2730, Oats @ Rs 100/g (green fodder) and Rs 1300/q (seed) and Peas @ Rs 1700/q.

Treatments	Yield t/ha *rabi* (2007-08)	*kharif* (2007-08)	*rabi* (2008-09)	*kharif* (2008-09)	*rabi* (2009-10)
Wheat -rice	3.27	4.17	3.64	4.47	3.80
Wheat-Maize+majmash	3.12	2.7 + 0.19	3.40	3.1 + 0.20	3.59
Mustard - rice	0.93	4.0	0.90	4.40	1.01
Mustard-Maize+rajmash	0.90	3.4 + 0.21	0.96	3.7 + 0.24	1.02
Oats-rice	150 (GF)* + 2.02	4.0	17.3 (GF)* + 2.23	4.40	17.7 (GF)*+2.34
Oats-Maize+rajmash	156.6 (GF)*+2.02	2.82 + 0.19	18.2 (GF)* + 2.32	3.12 + 0.22	18.6 (GF)*+2.38
Pea-rice	1.52	4.28	1.88	4.63	1.87
Pea-Maize + rajmash	1.65	3.51+0.20	1.89	3.80 + 0.23	1.94

Table 1. Continued.

Treatments	Yield t/ha *kharif* (2009-10)	MEY (t/ha)	Duration of crop sequence (days)	Production efficiency (kg/ha/day)	Land use efficiency (%)
Wheat - rice	4.75	8.14	340	23.94	93.15
Wheat-Maize + rajmash	3.2 + 0.22	8.16	347	23.51	95.06
Mustard-rice	4.62	6.26	322	19.45	88.22
Mustard Maize+rajmash	3.91 + 0.25	7.52	330	22.80	90.04
Oats-rice	4.62	7.92	340	23.31	93.15
Oats-Maize + rajmash	3.27 + 0.23	8.53	347	24.60	95.07
Pea- rice	4.89	6.84	325	21.05	89.04
Pea-Maize + rajmash	4.02 + 0.24	7.97	332	24.00	90.96

evaluated in terms of maize equivalent yield (Table 1). The highest system productivity was obtained in oats-maize + rajmash sequence (8.53 t/ha) in all the years owing to higher yield of oat and high market price of rajmash, followed by wheat - maize + rajmash (8.16 t/ha) and wheat-rice sequence (8.14 t/ha). While, lowest maize equivalent yield (6.26 t/ha) was recoded with mustard-rice sequence due to the lowest seed yield of mustard among all the crops [5, 6].

Land use and production efficiency

Land use efficiency ranged between 88.22 to 95.07% under different cropping systems (Table 1). Out-maize + rajmash sequence occupied the land for longer duration (347 days) and thus registered highest land use efficiency of 95.07%. While, mustard-rice sequence having shortest duration (322 days) has lowest land use efficiency of 88.22% [7]. The production efficiency was maximum in oat-maize + rajmash (24.60 kg/ha/day) sequence followed by pea- maize + rajmash (24.0 kg/ha/day) and wheat-rice (23.94 kg/ha/day) sequence. This is mainly attributed to the higher MEY in these cropping sequences . While mustard-rice sequence resulted in lowest production efficiency of 19.45 kg/ha/day due to low yield of mustard crop [8, 9].

Monetary returns and economic viability

Among all the crop sequences evaluated, oats-maize + rajmash fetched the highest net returns (Rs 65032/ha) followed by wheat-maize + rajmash (Rs 59610/ha), pea- maize + rajmash (Rs 54558/ha) and oat-rice (52302 Rs/ha/day) whereas lowest not-return (Rs 31937/ha) was recorded with mustard-rice. Mean benefit cost

Table 2. Economics, economic viability and qpparent nutrient productivity of different cropping sequences (average of 03 years).

Treatments	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C	Economic viability: Crop profitability (Rs/ha/day)	System profitability (Rs/ha/day)	Mandays employment of the system (days)	Employment generation efficiency (%)	Apparent nutrient productivity (kg/ha)
Wheat - rice	41,000	53.712	1.31	157.97	147.15	393	107.67	25.84
Wheat- maize+rajmash	35,000	59, 610	1.70	171.78	163.31	321	87.95	27.66
Mustard- rice	41,000	31,937	0.78	99.18	87.49	393	107.67	25.57
Mustard- maize+rajmash	35,000	52,180	1.49	158.12	142.95	321	87.95	33.44
Oats-rice	40,000	52,302	1.30	153.82	143.29	383	104.93	28.31
Oats-maize+rajmash	34,000	65,032	1.91	187.41	178.16	311	85.21	32.83
Pea - rice	44,000	35,908	0.81	110.48	98.37	403	110.41	22.80
Pea- maize + rajmash	38,000	54,558	1.43	164.33	149.47	331	90.68	28.46

ratio was also observed maximum (1.91) in oats-maize + rajmash followed by wheat-maize + rajmash (1.70), mustard-maize + rajmash (1.49) and pea-maize + rajmash. The highest net returns and benefit: cost ratio recorded in oat-maize + rajmash sequence is mainly due to its lower cost of cultivation and higher net net returns. Crop profitability (187.41 Rs/ha/day) and system profitability (178.16 Rs/ha/day) was also highest in oats-maize + rajmash The maize + rajmash based cropping system provided maximum net returns than the rice based systems, because of high local market price of rajmash (Table 2). Thus, crop diversification will not only enhance the productivity and the profitability of the farmers but also generates the employment to the farming community for the longer periods which reduces the problem of migration during the lean periods. Employment generation efficiency is an important index to measure the viability of the system. Pea- rice recorded the highest employment generation efficiency of 110.41% due to more man days (403 man days) engaged in picking of peas. Whereas lowest man days (311) employed in oats-maize + rajmash reduced its employment generation efficiency to 85.21% [3, 10].

Apparent nutrient productivity

Among the different systems by mustard -maize + rajmash had highest apparent nutrient productivity (33.44 kg/ha) closely followed oats-maize + rajmash (32.83 kg/ha) and pea-maize + rajmash (28.46 kg/ha), whereas lowest apparent nutrient productivity was observed in pea-rice (22.80 kg/ha) (Table 2). Highest apparent nutrient productivity obtained in inter-cropped maize + rajmash was due to efficient use of nutrients as the nutrients were applied only to the main crop and production was more.

Thus there is the ample scope to introduce oats-maize + rajmash, wheat-maize + rajmash like cropping sequences for higher productivity, profitability and sustainability which will ultimately improve socio-economic conditions of farmers.

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