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SYSTEM PRODUCTIVITY, PROFITABILITY, SUSTAINABILITY AND SOIL HEALTH AS INFLUENCED BY RICE BASED CROPPING SYSTEMS UNDER MID CENTRAL TABLE LAND ZONE OF ODISHA

SAMANT T.K.*
Krishi Vigyan Kendra (OUAT), Angul-759132, Odisha, India
*Corresponding E-mail: - tksamant_2003@yahoo.co.in

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Abstract- A field experiment was conducted during both *kharif* & *rabi* seasons in 2009-10 & 2010-11 at Instructional farm, *Krishi Vigyan Kendra*, Angul district under mid central table-land zone of Odisha to study the effect of different rice-based cropping system on system productivity, profitability, sustainability and soil health. The treatments consisted of seven cropping sequences and replicated thrice in randomized block design on sandy loam soil with low to medium fertility level and slightly acidic in reaction, Rice-Brinjal cropping sequence was evaluated to be most remunerative and sustainable with maximum rice equivalent yield of 277.35 q ha^{-1}, production efficiency of 118.02 kg ha^{-1} day^{-1}, land use efficiency of 64.38%, sustainable yield index of 1.00 , employment generation of 525 man days ha^{-1}, profitability of Rs.510.57 ha^{-1} day^{-1}, relative economic efficiency of 1404.03 % and net return of Rs.186357 ha^{-1} $year^{-1}$. Rice-Greengram cropping sequence reported the maximum increase in available N, P_2O_5 and K_2O and organic carbon content followed by Rice-Blackgram. Rice-Brinjal/Tomato/Onion and Rice-Groundnut cropping sequences has reduced soil fertility. The Nitrogen use efficiency was maximum (118.02 kg grain kg^{-1} of N applied) in Rice-Brinjal sequence. The traditional sequence of Rice - Fallow system has minimum production efficiency of 41.36 kg ha^{-1} day^{-1} with profitability of Rs.37.37 ha^{-1} day^{-1}, land use efficiency of 32.88 % and sustainable yield index of 0.18. Under the prevalent edaphic, climatic, sequential and socio economical situations the Rice-vegetables cropping sequences have relatively more productive and remunerative but Rice-legumes cropping system were potentially important in nutrient cycling advantages

Key words- Economics, Land use efficiency, Nitrogen use efficiency, Production efficiency, Rice equivalent yield.

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Introduction

Rice (*Oryza sativa* L.) is a component of widely varying cropping systems. Rice-based cropping systems form an integral part of agriculture in Odisha. In India, more than 80% of farming community belongs to marginal and small farmers having only 32.5% of the total operational area. The income from single season field crop is hardly sufficient to sustain the small farmer's family [11].

The Odisha state comes under agro-climatic region of Eastern Plateau and Hills Zone with annual rainfall of 1451.2 mm. Rice is the main crop of the state with a total coverage of 4365 thousand hectares in both *kharif* & *rabi* season which is about 71% of the total cultivable area of the state [1]. *Kharif* paddy is predominant in the state contributing about 94% of the total rice area. *Rabi* paddy is grown only in irrigated pockets, specifically in areas where there is facility of flow irrigation. Rabi paddy in lift-irrigated area is quite rare due to the high cost of lifted water and less remuneration from rice. There are areas where paddy is grown in *kharif* season with facility to provide life saving irrigation. Here the water source is a dug well and the second crop is a non-rice crop, particularly a pulse or oilseed or vegetable crop is taken up in *rabi* season. It seems to be pertinent to suggest a suitable cropping sequence for the farmers in order to get more income & profit. Therefore, a suitable rice based cropping system has to be identified to enhance the productivity, profitability and cropping intensity of the state. Inclusion of pulses, oilseeds and vegetables in the cropping system is more beneficial than rice-rice cropping system [6].

An intensification of cropping sequence is essential in the existing farming situation. Non-rice crop like oilseeds, pulses and vegetables are receiving more attention owing to higher price due to increased demand. Inclusion of these crops in a sequence changes the economics of the cropping sequences [15].

Thus, a suitable rice based cropping sequence is to be identified to meet the problem of soil health & labour scarcity and to enhance the total productivity, profitability and cropping intensity of the state.

Material and Method

A field experiment was conducted during both *kharif* & *rabi* seasons in 2009-10 & 2010-11 at Instructional farm, *Krishi Vigyan Kendra*, Angul district under mid central table-land zone of Odisha to study the effect of different rice-based cropping system on system productivity, profitability, sustainability and soil health. The geographical location of the area has 20^0 31´ to 21^0 41´N latitude and 84^0 16´ to 85^0 23´ E longitude and it has an average elevation of 195 m above sea level. Climate of the region is fairly hot and humid monsoon and mild winter with average annual rainfall of 1401.9 mm. The mean maximum and mean minimum temperature vary from 42.0°C in April to 28.0°C in December and from 26.0^0 C in June to 12.0^0 C in December respectively. The soil of the experimental site was acidic in reaction (pH-5.94), sandy loam in texture with medium organic carbon content (0.42 %), low in nitrogen (225 kg ha^{-1}), medium in phosphorus (13.9 kg ha^{-1}) and potassium (186.4 kg ha^{-1}) contents.

The treatments comprised of seven cropping sequences viz., Rice-Fallow, Rice-Greengram, Rice-Blackgram, Rice-Groundnut, Rice-Brinjal, Rice-Tomato and Rice-Onion and were replicated three times in a Randomized Block Design. Rice "MTU 1010", Greengram "TARM 1", Blackgram "PU 30", Groundnut "TMV 2", Brinjal "Tarini", Tomato "Chiranjivi" and Onion "Agri found light red" were selected and were raised with recommended package of practices. The soil fertility status was analyzed by standard methods [5]. Final crop yield were recorded and gross return (Rs ha^{-1}) were calculated on the basis of prevailing market price of the produce. For comparison between crop sequences the yield of all crops were converted into rice-equivalents on price basis. The benefit: cost ratio (BC ratio)

for different sequences was calculated by dividing gross return by cost of cultivation. Profitability of the system was calculated by dividing the net return ha^{-1} in a sequence by 365 days. The production efficiency value was calculated by dividing the total grain production ha^{-1} in a sequence with total duration of crops in a sequence [15]. The relative economic efficiency (REE) of the system was calculated and expressed in percentage.

$$REE = \frac{(B - A)}{A} \times 100$$

Where, A = Net return of existing system
B = Net return of diversified cropping system

Land use efficiency (LUE) was calculated by taking total duration of crops in a sequence and dividing by 365 and sustainable yield index was calculated as per the formula suggested by [13]. The datas were statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations were tested by error mean square of Fisher Snedecor's *'F'* test at probability level 0.05[3].

Results and Discussion

Effect of Rice based cropping system on cropping systems yield

The yield of rice during *kharif* season was maximum (54.20 q ha^{-1}) in Rice-Greengram system [2]. During *rabi* yield of vegetables like Brinjal, Tomato were at par and followed by Onion (210.24 q ha^{-1}). Greengram, Blackgram and groundnut can be included as *rabi* crops due to their productive yield [Table-2].

Effect of Rice based cropping system on land use efficiency and employment generation

The maximum land use efficiency of 64.38% was observed in rice-brinjal cropping sequences [Table-1] with greater combined yield followed by rice-groundnut (63.01%) and rice-onion (63.01%) sequence which had given relatively lower yield due to its longer duration with less return [7]. The rice-brinjal cropping sequences provided the most employment generation (525 man-days ha^{-1}) followed by rice-onion sequence (420 man days ha^{-1}).

Table-1 *Cropping sequences , fertilizer dose, crop duration, land use efficiency and man days under different rice based cropping systems*

Treatments	Crop sequence		Fertiliser dose kg ha^{-1} (N:P:K)		Duration of cropping system (No. of days)	Land use efficiency (%)	Man days ha-1
	Kharif	Rabi	Kharif	Rabi			
T_1	Rice (MTU 1010)	Fallow	75:30:30	-	120	32.88	100
T_2	Rice (MTU 1010)	Greengram (TARM 1)	75:30:30	25:40:20	185	50.68	170
T_3	Rice (MTU 1010)	Blackgram (PU 30)	75:30:30	25:40:20	195	53.42	170
T_4	Rice (MTU 1010)	Groundnut (TMV 2)	75:30:30	25:40:40	230	63.01	240
T_5	Rice (MTU 1010)	Brinjal (Tarini)	75:30:30	160:75:125	235	64.38	525
T_6	Rice (MTU 1010)	Tomato (Chiranjivi)	75:30:30	150:75:100	225	61.64	350
T_7	Rice (MTU 1010)	Onion (AFLR)	75:30:30	150:60:100	230	63.01	420

Values represent mean values of two years.

Effect of Rice based cropping system on system productivity, production efficiency and sustainable yield index

The total production of sequence in term of rice equivalent yield was significantly higher in rice-brinjal of 277.35 q ha^{-1} [Table-2] followed by rice-tomato (218.44 q ha^{-1}) & rice-onion (176.57 q ha^{-1}) which was owing to higher quantum in terms of yield and price of vegetable crops [8].The rice-groundnut system has rice equivalent yield of 108.62 q ha^{-1} which was significantly higher than rice-greengram or rice-blackgram sequence. The lowest total productivity (49.63 q ha^{-1}) was recorded in existing rice-fallow cropping sequence.

The maximum production efficiency (118.02 kg ha^{-1} day^{-1}) was obtained in rice-brinjal followed by rice-tomato system with production efficiency (97.08 kg ha^{-1} day^{-1}). The lowest production efficiency (39.13 kg ha^{-1} day^{-1}) was found in rice-blackgram system [Table-2] owing to lower grain yield in rice in spite of higher market price in blackgram. The maximum sustainable yield index (1.00) was obtained in rice-brinjal cropping sequences and minimum (0.18) was in rice-fallow sequence [Table-2].

Effect of Rice based cropping system on soil Status

Rice with vegetables and oilseed like groundnut sequences has reduced soil fertility might be due to higher uptake and lower addition of nutrient in soil. Inclusion of pulse crop in rice based cropping systems increased the available nitrogen, phosphorus potash and organic carbon of soil due to addition of nutrient by biologically N-fixation [10]. Rice-greengram cropping sequence reported the maximum increase in available N, P_2O_5, K_2O and organic carbon [4].

Maximum organic carbon build up was obtained in Rice-greengram sequence(0.438 %) and rice-blackgram sequences (0.435%) which is attributed to root residues accumulation and leaves shedding the legumes[14]. The Nitrogen use efficiency was the highest (118.02 kg grain kg^{-1} of N applied) under rice-brinjal sequence [Table-3]. The fertility status after one cycle rice-based cropping system increases due to inclusion of pulses like greengram or blackgram crop which is in conformity with the findings of Prasad *et al.* [9].

Table-2 *Effect of different rice based cropping systems on crop yield, systemic productivity, production efficiency and sustainable yield index*

Treatments	Yield (q ha^{-1})		System productivity REY (q ha^{-1})			Production Efficiency (kg day^{-1})	Sustainable yield index
	Khar	Ra	Khari	Rab	Total		
Rice-Fallow	49.6	-	49.63	-	49.63	41.36	0.18
Rice-Greengram	54.2	8.8	54.20	27.9	82.16	44.41	0.30
Rice-Blackgram	48.5	9.5	48.56	27.7	76.31	39.13	0.27
Rice-Groundnut	50.2	21.8	50.22	58.4	108.62	47.23	0.39
Rice-Brinjal	48.2	352.	48.24	229.1	277.35	118.0	1.00
Rice-Tomato	48.1	340.	48.18	170.2	218.44	97.08	0.79
Rice-Onion	50.4	210.	50.43	126.1	176.57	76.77	0.64
SEm ±					2.248	1.048	0.009
CD (5%)					6.926	3.229	0.029

Values represent mean values of two years.
Prices Rs.q^{-1}: rice 1,000, greengram 3,170, blackgram 2,900, groundnut 2,700, brinjal 650, tomato 500, onion 600

Table-3 *Effect of different rice based cropping systems on soil health*

Treatments	Organic carbon content of soil (%)		Nitrogen use efficiency(kg grain yield kg^{-1} of N applied)	Available nutrient (kg ha^{-1})					
				N		P_2O_5		K_2O	
	2009-10	2010-11		2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Rice-Fallow	0.412	0.415	66.17	204.2	200.5	13.5	13.7	182.8	184.5
Rice-Greengram	0.436	0.438	82.16	227.1	231.2	14.6	14.9	192.5	192.8
Rice-Blackgram	0.432	0.435	76.31	226.2	230.8	14.3	14.4	191.2	191.6
Rice-Groundnut	0.408	0.412	108.62	197.8	203.8	11.2	11.6	180.5	180.8
Rice-Brinjal	0.392	0.395	118.02	197.2	195.9	13.2	13.5	182.6	183.5
Rice-Tomato	0.400	0.405	97.08	200.2	194.6	13.5	13.7	185.2	185.9
Rice-Onion	0.419	0.422	78.48	197.4	194.5	12.6	12.8	185.4	185.8
Initial status	0.42			225.2		13.9		186.4	
SEm ±	0.004	0.004	1.507	1.072	1.304	0.197	0.218	0.362	0.510
CD(5%)	0.012	0.012	4.644	3.304	4.016	0.608	0.672	1.114	1.573

Effect of Rice based cropping system on Economics

Economic analysis [Table-4] showed that highest net return(Rs. 186357 ha^{-1}) and B:C ratio (3.05) were recorded with rice-brinjal followed by rice-tomato sequence with net return (Rs. 132097 ha^{-1}) and B:C ratio of 2.53. The results conform with the findings of Srikant *et al. [*12]. The lowest economic yield from rice-fallow system showed the poor net return (Rs. 13640 ha^{-1}) and B:C ratio (1.38). The B:C ratio of rice-onion sequence is (1.99) was found to be higher than rest of the sequences rice-blackgram, rice-greengram, rice- groundnut which were equivalent.

Effect of Rice based cropping system on profitability and relative economic efficiency

The maximum profitability (Rs. 510.57 ha^{-1} day^{-1}) and relative economic efficiency (1404.03%) was obtained rice-brinjal sequence followed by rice-tomato sequence with profitability (Rs. 361.91 ha^{-1} day^{-1}) and relative economic efficiency (962.66 %) which is due to higher value of total produce of brinjal [Table-4] . The rice-fallow sequence has lowest profitability (37.37 kg ha^{-1} day^{-1}) where as lowest relative economic efficiency (91.52 %) was found in rice-blackgram system [Table-4] due to lower grain yield in rice in spite of higher market value of blackgram.

Table-4 *Effect of different rice based cropping systems on economics*

Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Profitability (Rs. ha^{-1} day^{-1})	Relative economic efficiency (%)	B:C ratio
Rice-Fallow	35990	49630	13640	37.37	-	1.38
Rice-Greengram	52567	82160	29593	81.08	137.00	1.56
Rice-Blackgram	51770	76310	24540	67.23	91.52	1.47
Rice-Groundnut	73507	108620	35113	96.20	179.83	1.48
Rice-Brinjal	90993	277350	186357	510.57	1404.03	3.05
Rice-Tomato	86343	218440	132097	361.91	962.66	2.53
Rice-Onion	88744	176570	87826	240.62	608.81	1.99
S.Em ±	95.798	2247.537	2234.701	6.122	116.567	0.03
CD (5%)	295.162	6924.906	6885.349	18.864	359.153	0.926

Values represent mean values of two years.

Hence, it was concluded that the existing rice based cropping system can effectively be diversified with inclusion of vegetables like brinjal, tomato and onion during *rabi* season which were viable systems in productivity and economical point of view . Legumes were potentially important to diversify rice-based mono cropping into rice-greengram/blackgram which had nutrient cycling advantages.

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