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Identification of Profitable Rice Based Cropping System for South Konkan Coastal Zone

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A B S T R A C T

Field experiments were conducted for three consecutive *kharif-rabi* seasons of 2012-13, 2013-14 and 2014-15 at Agricultural Research Station, Phondaghat, Dist. Sindhudurg (MS) India. The experiments were conducted with ten rice based cropping systems with an objective to find out most profitable rice based cropping system suitable for South *Konkan* Coastal Zone. The crops in sequences after *kharif* rice included one oilseed crop *i.e.* groundnut, two pulse crops *viz*. cowpea and wal, one cereal crop i.e. sweet corn; five vegetable crops *viz*. brinjal, chilli, cabbage, okra, watermelon besides rice followed by fallow during *rabi* season. Three years pooled data indicated that among different rice based crops cultivated during *rabi* after *kharif* rice, brinjal recorded higher fruit yield followed by watermelon, cabbage and sweet corn. Whereas, rice equivalent yield of *rabi* crops as well as rice equivalent yield of system were higher with brinjal followed by sweet corn, okra and chilli. The system productivity in terms of rice equivalent grain yield (REGY) was maximum in case of rice-brinjal (239.12 q/ha) sequence. During *rabi* it was found that yield of component crops varied fairly according to cropping system. Whereas, during *kharif* rice yield was found highest (51.32 q/ha) under rice-groundnut sequence. Maximum monetary efficiency (` 1000/ha/day) was obtained under rice-brinjal sequence followed by rice-sweet corn (` 875.1/ha/day). Rice-brinjal cropping sequences registered highest land use efficiency (76.71%) followed by rice-chilli (75.34%) and rice-okra (72.60%). Water use efficiency was lowest higher with rice-sweet corn (30.94 kg/mm) followed by rice-brinjal (22.11 kg/mm). The increase in available N, P and K status after three year was observed with the inclusion of leguminous crop in the rotation.

Introduction

Rice is staple food crop and is widely cultivated in various types of soils in South *Konkan* Coastal Region of Maharashtra. The agro climatic conditions prevailing in the region are ideal to realize higher productivity of the crop. However, during recent years, owing to labour scarcity coupled with other socio-economic constraints like fragmented land holding, higher labour cost, lack of co-operative farming efforts, reluctant of youth to take up the noble profession of rice, the cropped area under rice is dwindling, posing a

serious challenge to meet the food security of the region. This problem can partly be solved by changing from continuous rice-rice production to growing cropping systems like rice-sweet corn, rice-pulses, rice-oilseeds, rice-vegetables etc. in the region.

The traditional rice based cropping systems followed in the region are rice-cowpea, rice-horse gram under residual moisture situations and rice-groundnut, rice-vegetables under protective irrigation. There is an ample scope to improve both productivity and profitability in the system by identifying suitable crops through intensive management so as to enhance the returns of the rice grower and sustain the crop cultivation in the region. It has been reported that inclusion of sweet corn, pulses, oil seeds or vegetables in cropping system is more beneficial, as it increases the economics of the system and better utilization of residual moisture and fertilizers. Against this background, the present investigation is formulated to find out most profitable rice based cropping system for South *Konkan* Coastal Zone of Maharashtra.

Materials and Methods

Field experiment was conducted for three consecutive *kharif-rabi* seasons of 2012-13, 2013-14 and 2014-15 at Agricultural Research Station, Phondaghat, Dist. Sindhudurg (MS) India (16-22^0 35' N, 73-41^0 18' E and 145.10 m above mean sea level). The soil was clay loam having 5.8 pH, EC of 0.063 dSsqm^{-1}, 1.32 per cent organic carbon, 292 kg/ha available nitrogen available, 5.6 kg/ha P_2O_5 and 98.4 kg/ha K_2O. The total rainfalls received during three *kharif* seasons of experimental periods were 4287.5 mm (139 days), 3625.2 mm (112 days) and 2500.9 (105 days). The experiment was conducted with ten rice based cropping systems with an objective to find out most profitable rice based cropping system suitable for South *Konkan* Coastal Zone. The experiment was laid out in randomized block design with three replications and ten treatments consist of nine crops raised during *rabi* after *kharif* rice. Treatment details are as Rice-Watermelon (Black Boy) (T_1), Rice-Chilli (Konkan Kirti) (T_2), Rice-Groundnut (TKG Bold) (T_3), Rice-Cabbage (Golden acre) (T_4), Rice-Sweet corn (Sugar 75) (T_5),Rice-Okra (Niraml-Gopi NOH-1336) (T_6), Rice-Cowpea (Konkan Sadabahar) (T_7), Rice-Brinjal (Suvarna Pratibha) (T_8) and Rice-Wal (Local) (T_9) along with Rice-fallow (T_{10}). After harvest of rainy season rice, field was ploughed twice, thoroughly pulverized and then *rabi* crops were sown during last week of December to 1st week of January during all the three years of the study. Recommended standard cultivation package of practices were followed for the respective crops and harvested as per maturity. The seeds of chilli and cabbage were sown on raised beds in nursery for growing of sturdy seedlings during 1st fortnight of December and 25 days old seedlings were transplanted. Sowing of remaining *rabi* season crops *viz*., watermelon, groundnut, sweet corn, okra, cowpea and *wal* were done manually during second fortnight of January in the main field. Seeds of legume crops were treated with crop specific *Rhizobium* and phospho-bacteria before sowing. The details of crop varieties, spacing maintained and fertilizers applied for different crops were given in Table 1. Whole of P and K and basal dose of N was applied in rows 2-3 cm below seeds before sowing/planting of crops whereas remaining dose of N was applied in split doses as per scientific recommendations. In rice, whole of P and K and basal dose of N was given before puddling and incorporated in soil. Urea was used as source of nitrogen, single super phosphate for phosphorus and muriate of potash for potassium.

In *kharif* season sowing of rice cv. Ratnagiri 4 was done during 1st fortnight of June. In main

field, to reduce the water losses through deep percolation and seepage, impervious soil layer was created in sub-surface by puddling which included 4-5 cross cultivations in 5 cm standing water in field by power tiller followed by leveling and bunding. Seedlings of 21 days of age old were transplanted manually in field during first week of July depending on onset of monsoon and crop was harvested in the last week of October. The rice crop was harvested at physiological maturity. Grain yield was recorded from the net plot area. The produce was properly sun dried up to 12 per cent moisture content. Days to maturity was recorded on the basis of physiological maturity.

In rice, entire water requirement of crop was met through rainfall. *Rabi* crops were grown entirely on supplemented irrigation from the wells available at farm. In rainy season, rainfall received during the crop period was satisfactory. Recommended intercultural practices and plant protection measures were followed as and when required for successful cultivation of crops. In *rabi* season, crops *viz*., watermelon, okra, and brinjal were harvested for fruit yield purpose, chilli and *wal* as a green pods, sweet corn as a cobs, groundnut as a pods and cowpea for grains. In *rabi* season several pickings were performed in almost all the crops as per maturity of fruits/pods except in groundnut, which was harvested at the end of crop period at physiological maturity.

For economic evaluation of different rice-based cropping sequences, mean data of three crop cycles were used. Economic yields of the component crops were converted to rice-equivalent yield (REY), taking into account the prevailing market price. Whereas, biomass of remaining crops was removed from the plots after harvest of economic parts. The gross cost of cultivation of different crops grown was calculated on the basis of different operations performed and materials used for raising the crops. For treatment comparisons 'F test' was used, following the procedures of randomized block design (Cochran and Cox, 1957). Total field duration of a cropping system expressed in percentage of 365 days was taken as the land use efficiency (Tomar and Tiwari, 1990) of the system. Production efficiency was expressed as the ratio of system productivity in kg REY/ha to total duration of the system in days (Patil *et al.*, 1995). Water use efficiency (WUE) was computed by dividing system productivity with water requirement of the system and was expressed as kg REY/mm of water uses. Production efficiency and water use efficiency in economic term were calculated by taking net return instead of REY.

Results and Discussion

System productivity

Three years pooled data indicated that among different rice based crops cultivated during *rabi* after *kharif* rice, brinjal recorded higher fruit yield followed by watermelon, cabbage and sweet corn. Whereas, rice equivalent yield of *rabi* crops as well as rice equivalent yield of system were higher with brinjal followed by sweet corn, okra and chilli. The system productivity in terms of rice equivalent grain yield (REGY) was maximum in case of rice-brinjal (239.12 q/ha) sequence (Table 2). It can be attributed mainly to brinjal productivity (210.69 q/ha) besides fetching average prices in the market (` 14.00/kg). The next in the order was rice-sweet corn cropping sequence. Here, sweet corn crop contributed more (76.56%) to enhance the equivalent yield due to its higher marketable yield (Cobs 135.00 q/ha and Straw 194.42 q/ha). The crops like brinjal, sweet corn and groundnut were governed the REGY of the systems. Mishra *et al.*, (2007) also reported higher productivity and profitability through inclusion of vegetables and pulses in rice-based cropping

system. Results of higher yields by rice-maize cropping system have been also reported by Rao *et al.,* (2014) and Kumar *et al.,* (2005). Lowest REGY (43.83 q/ha) was recorded under rice-fallow (43.83 q/ha) followed by rice-wal (95.34 q/ha) system and rice-cowpea (107.21 q/ha), which was mainly due to low yield levels of *wal* and cowpea crops, which were at par with each other.

During *rabi* it was found that yield of component crops varied fairly according to cropping system. Whereas, during *kharif* rice yield was found highest (51.32 q/ha) under rice-groundnut sequence, which was at par with almost all crop sequences (Table 2). Results of incorporation of legume crops in rice-based cropping system increased the productivity of rice has been also reported by Hegde (1992) and Jat *et al.,* (2012). Minimum rice yield was recorded under rice-brinjal (43.78 q/ha). It might be due to nutrient exhaustive nature of brinjal crop which adversely affects the growth and development of succeeding rice in the rotation.

Economics

Data on economics of rice based cropping systems revealed that, rice-brinjal system recorded the highest cost of cultivation, followed by rice-sweet corn and rice-chilli, while rice-fallow recorded less cost of cultivation followed by rice-*wal* and rice-cowpea systems. Inclusion of vegetables like brinjal and sweet corn, chilli in these cropping systems besides, increasing the system productivity, fetched higher market price thereby, increasing the net returns. Kumar *et al.,* (2008) also reported that inclusion of vegetative crops in rice based cropping system improved the net returns. Gross returns were higher in rice-brinjal system followed by rice-sweet corn and rice-okra systems. The higher gross returns were owing to higher yields of brinjal and rice in the sequences. Rice-Sweet corn crop sequence secured significantly higher net returns of ` 135894.00/ha followed by Rice-Brinjal (` 130618.00/ha) crop sequence. However, rice- watermelon, rice-chilli and rice- groundnut remained at par in terms of net returns. The returns per rupee invested were highest for rice-sweet corn (1.74), rice-brinjal (1.56), rice-groundnut (1.42) and rice-watermelon (1.35). This was due to high gross returns of these systems. Growing of vegetable crops during *rabi* in areas with assured irrigation facilities is economically remunerative as supply of vegetables from rainfed areas is drastically reduced during *rabi* and vegetable prices soar up (Jat *et al.,* 2012).

Table.1 Details of the crops, varieties, spacing and fertilizers used in cropping system

Sr. No.	Season	Crop	Variety	Spacing (cm)	Fertilizers N: P: K (kg/ha)
1	*Kharif*	Rice (*Oryza sativa* L.)	Ratnagiri 4	20 x 15	100: 50: 50
2	*Rabi*	Watermelon (*Citrullus lanatus*)	Black Boy	200 x 50	150: 50: 50
3	*Rabi*	Chilli (*Capsicum annuum*)	Konkan Kirti	60 x 45	150: 50: 50
4	*Rabi*	Groundnut (*Arachis hypogaea* L.)	TKG Bold	30 x 15	25: 50: 00
5	*Rabi*	Cabbage (*Brassica oleracea var. capitata*)	Golden acre	45 x 45	120: 60: 60
6	*Rabi*	Sweet Corn (*Zea mays var. saccharata*)	Sugar 75	60 x 20	200: 60: 60
7	*Rabi*	Okra (*Abelmoschus esculentus*)	Nirmal-Gopi	45 x 15	100: 50: 50
8	*Rabi*	Cowpea (*Vigna sinensis.*)	Konkan Sadabahar	30 x 15	25: 50: 00
9	*Rabi*	Brinjal (*Solanum melongena*)	Swarna Pratibha	60 x 60	150: 50: 50
10	*Rabi*	Wal (*Dolichos lablab* L)	Local	30 x 15	25: 50: 00
11	*Rabi*	Fallow	--	--	--

Table.2 Mean yield and gross monetary returns from various crop sequences

Treatment	Mean grain/fruit yield (q/ha)		Straw yield (q/ha)		REGY (q/ha) of *Rabi*	Total REGY (q/ha) (K+R)	Total gross returns (`/ha) (K+R)	Total cost of cultivation (`/ha) (K+R)	Net returns (`/ha) (K+R)	B: C ratio
	Kharif (K)	*Rabi* (R)	*Kharif* (K)	*Rabi* (R)						
T_1 : Rice - Watermelon*	48.32	189.74	56.25	--	113.09	161.42	247971	184309	63663	**1.35**
T_2 : Rice - Chilli **	49.28	79.08	57.71	--	125.69	174.97	268578	211613	56965	**1.27**
T_3 : Rice - Groundnut	51.32	27.85	58.51	32.10	87.26	138.58	213564	150157	63408	**1.42**
T_4 : Rice - Cabbage	47.93	167.91	58.93	--	111.20	159.13	244957	202326	42631	**1.21**
T_5 : Rice - Sweet Corn***	48.93	135.00	56.05	194.42	159.85	208.78	319414	183520	135894	**1.74**
T_6 : Rice - Okra*	44.15	98.58	54.03	--	156.68	200.82	307509	232670	74839	**1.32**
T_7 : Rice - Cowpea	48.30	14.17	52.38	19.75	58.91	107.21	165543	129273	36270	**1.28**
T_8 : Rice - Brinjal*	43.78	210.69	53.49	--	195.34	239.12	365294	234676	130618	**1.56**
T_9 : Rice - Wal	45.37	10.43	53.68	12.24	49.97	95.34	148067	116855	31212	**1.27**
T_{10} : Rice - Fallow	43.83	--	55.66	--	--	43.83	70719	65449	5269	**1.08**
SE(m)±	**2.15**	**5.11**	**2.32**	--	**3.88**	**3.95**	--	--	**3002.93**	**0.02**
CD at 5%	**6.07**	**14.47**	**6.56**	--	**11.63**	**11.73**	--	--	**8922.15**	**0.07**

* Fruit yield, **Green pod yield and *** Cob yield

Selling rates (` q^{-1}) of main products and byproducts during final year of experiment

Crop	Watermelon (fruits)	Chilli (green)	Groundnut (dry pods)	Cabbage (heads)	Sweet corn (corns)	Okra (fruits)	Cowpea (grains)	Brinjal (fruits)	Wal (grains)	Rice (grains)
Main Product	900	2400	4500	1000	1500	2400	6000	1400	7000	1510
Straw	--	--	200	--	200	--	200	--	200	200

Table.3 Crop durations, irrigations applied, water use efficiency, productivity and gross monetary efficiency of different rice based cropping system

Crop sequence (Duration in days)		Duration of the system (days)	Land use efficiency (%)	No. of irrigations	Quantity of water applied to *Rabi* crops (mm)	FWUE of *Rabi* crops on the basis of yield (kg/mm)	FWUE of *Rabi* crops based on REY (kg/mm)	Production efficiency** of the system (kg/ha/day)	Monetary efficiency** of the system (Rs/ha/day)
Kharif	***Rabi****								
Rice (130)	Watermelon (100)	230	63.01	14.0	700.0	27.11	16.16	44.22	679.4
Rice (130)	Chilli (145)	275	75.34	17.0	850.0	9.30	14.79	47.94	735.8
Rice (130)	Groundnut (125)	255	69.86	13.7	683.3	4.08	12.77	37.97	585.1
Rice (130)	Cabbage (115)	245	67.12	13.3	666.7	25.19	16.68	43.60	671.1
Rice (130)	Sweet Corn (90)	220	60.27	10.3	516.7	26.13	30.94	57.20	875.1
Rice (130)	Okra (135)	265	72.60	16.0	800.0	12.32	19.58	55.02	842.5
Rice (130)	Cowpea (70)	200	54.79	8.0	400.0	3.54	14.73	29.37	453.5
Rice (130)	Brinjal (150)	280	76.71	17.7	883.3	23.85	22.11	65.51	1000.8
Rice (130)	Wal (100)	230	63.01	10.7	533.3	1.96	9.37	26.12	405.7
Rice (130)	Fallow	130	35.62	--	--	--	--	12.01	193.7

* Irrigations were given to *Rabi* crops only
** Based on 365 days of the year
FWUE = Field water use efficiency
GME = Gross monetary efficiency
REY = Rice equivalent yield

Resource use efficiency

Rice- brinjal cropping sequences registered highest land use efficiency (76.71%) followed by rice- chilli (75.34%) and rice- okra (72.60%). It attributed mainly due to brinjal, chilli and okra crops which occupied the field for about 150, 145 and 135 days, respectively. The land use efficiency (LUE) was lowest in rice- fallow (35.62%) followed by rice-cowpea (54.79%) crop sequences, indicating that it has scope to include one more short duration crop in rice- cowpea system. Rice-brinjal sequence registered the highest production efficiency (65.51 kg/ha/day) followed by rice-sweet corn (57.20 kg/ha/day). It was closely followed by rice-okra sequence, with 55.02 kg/ha/day of production efficiency. Lowest production efficiency was found with rice- fallow (12.01 kg/ha/day) followed by rice-*wal* (26.12 kg/ha/day) sequences. Among the different crops during *rabi* water use efficiency was lowest in rice- *wal* (9.37 kg/mm) followed by rice- groundnut (12.77 kg/mm), rice- cowpea (14.73 kg/mm) and rice- chilli (14.79 kg/mm). While, it was higher with rice- sweet corn (30.94 kg/mm) followed by rice- brinjal (22.11 kg/mm) and rice- okra (19.58 kg/mm) based on REY because of higher production with less water use (Table 3). Maximum monetary efficiency (` 1000/ha/day) was obtained under rice- brinjal sequence followed by rice- sweet corn (` 875.1/ha/day).

The increase in available N, P and K status after three year was observed with the inclusion of leguminous crop in the rotation. Among the cropping systems tested rice-groundnut, rice- cowpea and rice- *wal* significantly improved the soil available nitrogen, phosphorus and potassium status. The preceding crop species can have a beneficial or detrimental effect on the performance of the succeeding crop. The well-known beneficial effects of preceding legume crop on cereal are also found in multiple cropping systems, but the magnitude of the effects varies with management practices and the legume species used (Porpavai *et al.*, 2011). Maximum apparent nutrient productivity was recorded in Rice-Brinjal (53.14 kg/ha) followed by Rice-Groundnut (50.39 kg/ha) and Rice- Okra (50.21 kg/ha) cropping systems.

Based on findings of this experiments it can be concluded that under the conditions of South Konkan Coastal Zone of Maharashtra, rice- sweet corn was found most profitable cropping system followed by rice- brinjal on the basis of net returns and B: C ratio as it was more productive, sustainable, resource-use efficient and remunerative.

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