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Crop productivity and soil fertility restoration in rice-based cropping system as influenced by fertility levels

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ABSTRACT

Field experiment was conducted during 2002-03 and 2003-04 to study the production potential and soil fertility restoration in rice based cropping system under hill zone of Karnataka. The treatment comprised eight main plot treatments of cropping systems and five sub plot treatments of nutrient management. In cropping system rice-soyabean, followed by rice-bell pepper and rice-marigold recorded the highest productivity (REY) and returns. Application of 100% RDF (to respective crop) recorded significantly higher rice grain equivalent yield, energetics and net returns and that was at par with integrated use of 50% RDF and 5.0 t of *Chromoleana Odorata* compost than other treatments tried. Integration of major nutrient through chemical fertilizer in conjunction with organic manure (compost of *Chromoleana Odorata*) enhanced the soil fertility.

Key words: Productivity, Soil Fertility, Restoration, Cropping systems, RGEY

INTRODUCTION

Rice based cropping system has assumed paramount importance to meet the dietary habit of 42 per cent population of India (Nanda *et al*; 1999). In hill Zone of Karnataka, rice is being cultivated in an area of 1.73 lakh hectares with an average productivity of 2.5 t/ha, which is 20% lower than the state average. The existing mono-rice cropping system in low lands of the zone is becoming less remunerative, as only one crop of rice is being cultivated in a year. In order to harvest economic yields, rice alone will not be remunerative, thus a cropping system under this situation demands proper nutrient management by utilizing the available resources more effectively and efficiently. It is also necessary to find out suitability of short duration crops, which are suitable for the soils of the zone having acidic in nature for higher returns by efficient utilization of residual soil mixture with minimum expenditure. Keeping these in view a study was conducted to examine the production potential and soil fertility restoration in rice-based cropping system as influenced by fertility levels under hill zone of Karnataka.

MATERIALS AND METHODS

The field experiments were conducted during rainy (June-December) and post-rainy season (January-May) seasons of 2002-03 and 2003-04 in the farmer field of Amour village, near to Zonal Agricultural Research Station, Mudigere, University of Agricultural Sciences, Bangalore. The soil of the experimental site was red sandy loam with soil pH of 5.50, medium in available nitrogen, phosphorous and potash.

The annual rainfall was 1875 mm and 1760 mm and mean maximum and minimum temperature 26.53 and 17.43 C respectively during cropping years. Treatment comprised eight main plot treatments of cropping systems viz; C_1: Rice-fallow, C_2: Rice-rice, C_3: Rice-Soy bean, C_4: Rice-cowpea, C_5: Rice-radish, C_6: Rice-bell pepper, C_7: Rice-fodder maize and C_8: Rice-marigold and five sub plot treatments of nutrient management were F_1: Control, F_2:50% RDF, F_3:75% RDF, F_4: 100% RDF and F_5:50% RDF+5.0t of well decomposed *Chromoleana Odorata* compost. The experiment was laid out in split-plot design with three applications. For reasonable comparison between crop sequences, the yield of all crops were converted into rice grain equivalent yield using prevailing market prices (Yadav and Newaj, 1990). The land Use Efficiency (LUE) was calculated by dividing the total duration of different crops in a sequence by 365 days expressed in percentage. The Production Use Efficiency (PUE) value in terms of kg/ha / day was obtained by total production in a sequence divided by total duration of crops in that sequence (Tomar and Tiwari, 1990). The energetic of the different crops and different cropping systems were computed using the values as provided by Gopalan *et al*.(1978), and economics was calculated based on prevailing market prices. The recommended varieties were used. Also recommended fertilizers were applied as per the treatment and management practices followed for raising different crops in the cropping system. The organic source *Chromoleana odorata* compost applied at the rate of 5.0 t/ha (equivalent to 35.5-38 kg N, 11.5-12.5 kg P_2O_5 and 29-30 kg K_2O/ha) and soil samples were collected before sowing of rice and after harvesting of rice and analysed for organic carbon, available N (Subbaiah and Asija, 1956), P and K (Jackson, 1973) content.

RESULTS AND DISCUSSION

Crop productivity:

The total productivity of rice-based cropping system differed significantly due to cropping sequences and fertility levels. Rice-fodder maize (25948 kg/ha) and rice-marigold (13451 kg/ha) recorded highest system productivity than rest of the sequences (Table 1). It may probably on account of higher yields of succeeding crops and confirms the

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findings of Raju and Reddy (2000). Among the fertility levels, application of 100 per cent recommended dose of fertilizer recorded the highest system productivity (13011 kg/ha) in all the cropping sequences and was at par with integrated use of 50 per cent recommended dose of fertilizer + 5.0 tones compost of *Chromoleana odorata.* There was no significant adverse effect on system productivity was noticed when a part of nitrogen was supplied through compost of *Chromoleana odorata.* The interaction effect between the cropping sequences and fertility levels were found to be significant.

***Production use efficiency**:*

Efficiency measured in terms of yield per day is dependent on total grain yield of a system and period in days consumed to produce the yield.

Rice-fodder maize sequence gave the highest PUE (111.0 kg/ha/day), followed by rice-radish sequence (48.73 kg/ha/day) over other sequences and was rice-cowpea sequence (24.13 kg/ha/day) recorded the lowest PUE (Choudhary *et al*; 2000). Even though rice-marigold and rice-bell pepper sequence recorded the higher yield potential, the PUE was low because of its longer duration compared to rice-fodder maize sequence. The PUE of rice-cowpea and rice-soybean system was low because of its lower economic yield compared to other crops under the investigation inspite of its less duration.

Table1: Production potential of cropping systems as influenced by fertility levels under rice based cropping system.

Treatment	System productivity (Kg/ha)	Rice grain equivalent yield (Kg/ha)	Production use efficiency (PUE)	Land use efficiency
C_1: Rice-fallow	4886	48.87	29.21	45.40
C_2: Rice-rice	9640	96.27	34.12	74.60
C_3: Rice-soybean	6351	75.60	24.13	72.11
C_4; Rice-cowpea	5897	80.81	22.62	71.65
C_5 Rice-radish	10401	70.90	48.73	57.30
C_6: Rice-bell pepper	12513	181.00	45.14	75.20
C_7: Rice-fodder maize	25984	57.15	111.0	63.95
C_8: Rice-marigold	13450	165.60	49.30	74.40
CD (P=0.05)	779.03	10.43	-	-
F_1: Control	9169	71.10	38.80	65.70
F_2: 50% recommended dose of fertilizer	10320	88.30	42.75	66.90
F_3: 75% recommended dose of fertilizer	11299	98.34	46.20	67.60
F_4: 100% recommended dose of fertilizer	13011	116.51	52.32	68.40
F_5: 50% recommended dose of fertilizer and 5.0 tones of *Chromoleana odorata* compost.	11919	105.06	47.72	67.50
CD (P=0.05)	215.97	2.52	-	-
CS X F	952.10	12.21	-	-

Rice grain equivalent yield :

Rice grain equivalent yield revealed the significant response of different cropping systems in both years and also in pooled analysis. Rice-bell pepper cropping system was 165.60 t/ha recorded significantly the highest rice grain equivalent yield (181.0 q/ha), followed by rice-marigold which yielded 165.60 q/ha. The third best sequence was rice-rice with rice grain equivalent yield of 96.27 q/ha. as compared to other sequences (Table 1). The higher equivalent yield might be due to higher yield potential and price of produce and efficient utilization of time and space (Choudhary *et al.*, 2000). Rice equivalent yield increased significantly with each successive increase in the level of nutrient from F5 to F1. The integrated use of 50 per cent recommended dose of fertilizer and 5.0 tones compost of *Chromoleana odorata* treatment recorded at par yield with the recommended dose of fertilizer over control plots. The interaction effect between cropping sequences and fertility levels also found to be significant.

Land use efficiency:

Land use efficiency provides information about the occupation of land (duration) by cropping sequence. Rice-bell pepper cropping sequence recorded highest land use efficiency 75.20%. it was followed by rice-rice sequence (74.6%), rice-fodder maize (74.4%), rice-soybean (72.11%) and rice-cowpea sequence (71.65%) (Table 1). Because this sequence occupied the field for longest duration compared to other sequence or due to occupation of land for longest duration by these crop sequences (Choudhary *et al*; 2000). However, in other sequences the land use efficiency ranged from 45.4 to 68.40% indicated that land remained vacant for considerable time during agricultural year offering scope to raise crops during summer.

Energy equivalents :

Energy equivalents are considerable better indicator of the performance of a cropping system for comparison purpose, as it is not affected by market prices. Highest amount of digestible carbohydrate could be produced in the rice-fodder maize (8961 kg/ha), followed by rice-rice cropping system (7771 kg/ha) (Table 2). In terms of digestible proteins, rice-fodder maize (1372.8 kg/ha) was identified to be the highest producer (1372.8 kg/ha). It was followed by rice-soybean sequence in the order of merit.

The highest digestible fat productivity was recorded in rice-soybean sequence (246.40 kg/ha), followed by rice-fodder maize sequence (231.8 kg/ha)

Soil fertility status :

The pH of the soil varied significantly due to influence of the cropping sequences and soil fertility levels. The soil pH declined after two crop cycles in all the cropping sequences as compared to initial value (5.35). Rice-soybean sequence registered the highest pH value (4.87) and was significantly superior over other sequences. The soil pH in control plot increased as compared to the plots receiving fertilizers except the treatment receiving 50 RDF+ 5.O t compost of *Chromoleana odorata* that had higher values (4.88). Lower electrical conductivity (EC) values were noticed in continuously fertilized plots than control plots in all the cropping sequences. Rice-cowpea sequence registered higher EC values than other sequences.

The organic carbon status of the soil declined at the end of each cropping sequences (0.97%) compared with initial values (1.57%). The inclusion of leguminous crops in sequence increased the organic carbon status of the soil compared to non-leguminous crops. The higher organic carbon was noticed in rice-soybean sequence (1.20 %) and found significantly higher than other sequences. The integrated use of 50 %RDF +5.0t compost of *Chromoleana odorata* plot showed significantly higher organic carbon values (1.11 %) where the mineralisation was slow due to wider C: N ratio (Swarup and Singh, 1989). Rice-soybean sequence recorded the highest available soil nitrogen over the other cropping sequences. This might be due to the inclusion of leguminous crops in the sequence that fixes the huge amount of atmospheric nitrogen continuously year after year leading to available nitrogen (Barlow et al., 1981). Significantly higher available nitrogen content of the soil was noticed with 50% RDF + 5.0 t compost of Chromoleana odorata compost plots in all the cropping sequences compared to fertilized plots. There was substantial build up in available phosphorus was noticed in the combined use of 50 % RDF + 5.0 t compost of *Chromoleana odorata* plot treatments than control plot.

The available potassium content of the soil declined after two years of cropping in all the sequences than initial values (148.0 kg/ha) (Table 3). Rice-soybean system recorded relatively higher available potassium content than other sequences. It clearly shows that rice-fodder maize crop being deep-rooted crops removes more potassium content indicating its luxurious consumption. Potassium content of the soil increased remarkably in the combined use of 50 % RDF+5.0t compost of Chromoleana odorata than fertilized plots. Being rich in potassium, *Chromoleana odorata* compost enriched the potassium status of the soil despite heavy removal by the crop. It may be concluded that application of organic manure in combination with inorganic fertilizer improved the soil fertility.

Table2: Energy equivalents and economics of rice-based cropping system as influenced by fertility levels (2 years data)

Treatment	Net returns (Rs./ha)	Energy equivalents (kg/ha.)		
		Digestible proteins	Digestible carbohydrate	Digestible fat
C_1: Rice-fallow	18088	332.0	3800	24.7
C_2: Rice-rice	39343	676.8	7771	49.8
C_3: Rice-soybean	26937	845.0	4338	246.4
C_4; Rice-cowpea	30380	591.0	4435	35.5
C_5 Rice-radish	2253	359.0	3656	28.3
C_6: Rice-bell pepper	62283	407.2	3656	47.4
C_7: Rice-fodder maize	15885	1372.8	8961	231.8
C_8: Rice-marigold	66573	797.4*	1256*	78.3*

* Rice nutritive values

Economics :

Choice of a cropping system in area is mainly guided by the profitability under the prevailing market prices of different crop commodities in recent years the pooled data on economics of different cropping sequences indicated that the rice- marigold sequence gave the highest mean net returns of Rs.66573/ha than the other sequences, followed by rice-bell pepper (Rs.62283/ha) (Table 2). It may be attributed to the higher yield realized from the succeeding crops. Among the fertility levels, net returns of the system was maximum from recommended dose of fertilizer in each crop. The second best remunerative fertilizer treatment was combined use of 50 per cent recommended dose of fertilizer and 5.0 t compost of *Chromoleana odorata.*

Table 3: Residual soil fertility status after two crop cycle of Rice-based cropping system as influenced by different fertility levels.

Treatments	pH	OC (%)	Available N (kg/ha)	Available nutrients (kg/ha)		
				N	P2O5	K2O
C_1: Rice-fallow	4.81	0.063	0.90	339.50	25.40	186.04
C_2: Rice-rice	4.72	0.052	0.82	307.00	22.72	175.60
C_3: Rice-soybean	4.87	0.076	1.20	374.00	29.14	200.82
C_4; Rice-cowpea	4.86	0.116	1.15	364.00	27.51	195.26
C_5 Rice-radish	4.78	0.080	0.99	343.40	26.00	188.00
C_6: Rice-bell pepper	4.75	0.054	0.96	322.71	24.85	185.40
C_7: Rice-fodder maize	4.68	0.041	0.83	305.10	22.60	175.08
C_8: Rice-marigold	4.73	0.059	0.92	326.00	23.70	183.00
CD (P=0.05)	0.11	0.04	0.06	17.14	0.89	8.30
F_1: Control	4.82	0.060	0.83	306.00	22.00	178.80
F_2: 50% recommended dose of fertilizer	4.74	0.060	0.89	321.70	23.60	180.00
F_3: 75% recommended dose of fertilizer	4.72	0.050	0.97	336.52	25.30	184.44
F_4: 100% recommended dose of fertilizer	4.69	0.050	1.05	350.40	26.90	191.90
F_5: 50% recommended dose of fertilizer and 5.0 tones of *Chromoleana odorata* compost.	4.88	0.050	1.11	361.30	28.44	198.80
CD (P=0.05)	0.03	0.03	0.03	6.29	0.33	2.39
CS X F	-	0.08	0.09	23.52	1.20	-

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