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Soil fertility as influenced by alternate sequential cropping systems to rice-rice (*Oryza sativa* L.) In Tunga Bhadra project area

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ABSTRACT

A field experiment was carried out in farmer's field near Agriculture Research Station, Siruguppa in Karnataka during *kharif* and *rabi* of 2014-15 to Study influence of alternate sequential copping systems to rice-rice (*Oryza sativa* L.) system on fertility status of soil in Tunga Bhadra Project (TBP) Area. The experimental site was medium deep black with soil pH (8.01), EC (0.54 dS m^{-1}), available nitrogen (240.80 kg ha^{-1}), P_2O_5 (22.90 kg ha^{-1}) and K_2O (347.49 kg ha^{-1}). The experiment comprised of seven sequential cropping systems viz., T_1: Rice-maize, T_2: Rice-sorghum, T_3: Rice-chickpea, T_4: Rice-sesame, T_5: Maize-chickpea, T_6: Cotton-sesame and T_7: Rice-rice. These treatments were laid out in completely randomized block design with three replications. The study revealed that significantly higher rice equivalent yield (REY) was recorded in cotton-sesame cropping system (13117 kg ha^{-1}) compared to rest of the cropping systems. Significantly higher system productivity was recorded with maize-chickpea (35.94 REY kg ha^{-1} day^{-1}) cropping system and it was significantly superior over existing rice-rice (26.89 REY kg $ha^{-1}day^{-1}$) cropping systems. Significantly higher available nitrogen (210.21 kg ha^{-1}) and P_2O_5 (34.22 kgha^{-1}) in soil was noticed with rice-chickpea cropping system whereas significantly higher available K_2O was obtained after the harvest of rice-rice cropping system (330.10 kg ha^{-1}). The cotton-sesame and maize-chickpea crop sequences are more productive and sustainable as they improve the productivity and fertility status of soil when compared to other cropping sequences and can be a better option for the farmers of the Tunga Bhadra Project area, Karnataka.

***Key words** : Alternate sequential cropping system, Rice equivalent yield, Soil fertility and System productivity.*

Introduction

Rice hulls can be used in manufacturing of insulation materials, cement, card board and as a litter in poultry keeping. Besides, rice straw is also used to feed cattle. Rice has been cultivated in four major ecosystems in India *viz*., irrigated, rainfed lowland, rainfed upland and flood prone system. More than half of rice growing area (55%) is under rainfed ecosystem. In India, rice is cultivated over an area of 43.95 million hectares with a production of 106.54 million tonnes. In Karnataka, it is grown in an area of 1.42 million hectares with an annual production of 3.5 million tonnes (Anon., 2015).

The system of rice cultivation is most water consuming and utilizes about 60 per cent of total avail-

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able irrigation water. Traditional low land rice grown with continuous flooding in Asia has relatively required high water input. Since, the rice is cultivated under continuously flooded ecosystem and it is associated with sequestration of N in resistant lignin compounds formed from the large amounts of retained crop residues. Constraints like high water requirement during summer season, and delay in rice planting due to long duration of summer grain legumes, however, restrict the integration of legumes in cereal–cereal systems on a large-scale. Diversification and intensification of rice-based or alternate cropping system for paddy-paddy to increase productivity per unit resource is very pertinent. Crop diversification shows lot of promises in alleviating these problems besides, fulfilling basic needs for cereals, pulses, oilseeds, vegetables and also regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, ensuring environmental safety and creating employment opportunity (Gill and Ahlawat, 2006). In this context, efforts are being made to promote diversification of rice based cropping sequence or development of an alternate cropping systems to paddy-paddy in our country as well as TBP area with cereals, legumes and oil seed crops for sustaining the productivity and meet out demand for vegetables, pulses and oilseeds. Therefore, keeping all these points in view, the present investigation was carried out.

Material and Methods

A field experiment was conducted at farmer's field near Agriculture Research Station, Siruguppa of Bellary district (Karnataka) to study the influence of cropping systems on productivity in TBP area, during *kharif-rabi* 2014-15. The soil of the experimental site was medium black with the soil pH of 8.01, EC 0.54 dS m^{-1}, available N 240.80 kg ha^{-1}, available P_2O_5 22.90 kg ha^{-1} and available K_2O 347.49 kg ha^{-1}. Experiment was laid out in randomised block design with seven sequential cropping systems as treatments in three replication. Treatment details are five rice based cropping systems *viz*., rice-maize, rice-sorghum, rice-chickpea, rice-sesame and rice-rice. Two non rice based cropping systems *viz*., maize-chickpea and cotton-sesame. All the crops under the above seven rice-based cropping sequences were chosen on the basis of their prevalence in the region. The rice–rice system is the major cropping sequence while the other crops, *viz*., sorghum, maize, sesame, cotton and chickpea are also taken by the farmers after harvesting of rice. Recommended dose of N, P and K (kg N, P_2O_5 K_2O ha^{-1}) were applied to the soil in the form of urea, di-ammonium phosphate and muriate of potash to all the crops at the time of sowing and subsequent N applications were done by following package of practice and details of the treatments are shown in Table 1. All agronomical packages of practices were followed to raise the crops in different cropping sequences.

Yield and yield parameters of rice and other crops in the cropping system were recorded. Economic yields of component crops were converted into rice-equivalent yield (REY), taking into account the prevailing market prices of different crops in the cropping sequences. The REY values were computed as per the following formula given by Verma and Modgal (1983).

$$\text{REY (kg ha}^{-1}\text{)} = \frac{\text{(YCC X MPCC) + yield of main crop (kg ha}^{-1}\text{)}}{\text{Price of main crop (₹ha}^{-1}\text{)}}$$

Whereas, YCC= Yield of component crop (kg ha^{-1}), MPCC=Market price of component crop (ha^{-1}). System productivity values in terms of kg REY $ha^{-1}day^{-1}$ were worked out for the total production by means of rice equivalent yield in a crop rotation divided by year duration. The organic carbon (Jackson, 1973), available nitrogen (Subbiah and Asija, 1956), available phosphorus (Olsen *et al.* 1954) and available potassium (Jackson, 1973) of soil estimated.

Results and Discussion

Rice equivalent yield and System Productivity

Among different cropping systems cotton-sesame produced significantly higher rice equivalent yield (13117 kg ha^{-1}) compared to rest of the cropping systems (Table. 2). The yield varied from 9.32 to 33.60 per cent over existing rice-rice (9816 REY kg ha^{-1}) cropping systems. Whereas, minimum rice equivalent yield was noticed with rice-sesame (8342 REY kg ha^{-1}) system. Significantly higher system productivity was recorded with maize-chickpea (35.94 REY kg $ha^{-1}day^{-1}$) cropping system and it was significantly superior over rice-sesame (22.85 REY kg $ha^{-1}day^{-1}$), rice-sesame (24.17 REY kg ha^{-1} day^{-1}) and existing rice-rice (26.89 REY kg $ha^{-1}day^{-1}$) cropping systems. These results are in conformity with finding of Sharma *et al*., (2008), who reported that inclusion of legume during summer/*rabi* in rice based cropping system resulted in an increased in productivity and profitability. The higher rice equivalent yield indicate that the residual advantage of a legume crop on the succeeding maize besides contribution in total system productivity. Similarly, rice-maize and rice-chickpea cropping systems which are ranked second and third respectively with system productivity. This might be due to higher production potential of maize along with the good market price of chickpea and rice that yielded better grain yield than rest other cropping systems. The chickpea in maize-chickpea and rice-chickpea cropping system also markedly contributed to the system productivity besides enhancing the productivity of succeeding crops and consequently resulted in higher crop equivalent yield and system productivity which was almost equal to the conventional rice-rice cropping system.

Soil fertility status

Post harvest soil available nitrogen, phosphorus, potassium and organic carbon (OC) contents varied with all the cropping systems. Highest soil available nitrogen and phosphorus was recorded with legume (chickpea) involving cropping systems such as rice-chickpea (210.21 and 34.22 kg ha^{-1}, respectively) and maize-chickpea (208.2 and 34.20 kg ha^{-1}, respectively). Significantly lower available nitrogen and phosphorus were observed with existing rice-rice system (201.5 and 24.21 kg ha^{-1}, respectively). Available potassium was significantly higher after the harvest of rice-rice (330.10 kg ha^{-1}) cropping system and significantly lowest potassium recorded from rice-sorghum (302.1 kg ha^{-1}) cropping system (Table 2). Organic carbon content in soil was higher in legume (chickpea) involving cropping systems such as rice-chickpea (6.54 g kg^{-1}) and maize-chickpea (6.54 g kg^{-1}) compared to other cropping systems. Lower organic carbon content in soil was recorded with rice-rice cropping system (6.51 g kg^{-1}). Similarly Porpavai, *et al*., (2011) also reported that legumes were potentially important to diversify cereal based mono cropping into cereal-legume sequences which had nutrient cycling advantages.

The increase in organic carbon is a function of amount of organic matter added, its decomposition, synthesis and subsequent mineralization. Soil organic carbon content after chickpea harvest was highest with crop biological nitrogen fixation of chickpea which was comparable with rice-chickpea and maize chickpea cropping systems. The increase in organic carbon with the above treatments could be attributed to the direct effect from incorporation of legume (chickpea) crop in the cropping system after the harvest of crops. These results are in line with findings of Mukundam *et al*., (2012).

Table 1. Details of crop, season, cultivar spacing, recommended dose of fertilizer, cropping duration and hectare factor used of the experiment

Sequence cropping system	Crop	Season	Cultivar	Spacing (cm)	Recommended dose of fertilizers (N, P_2O_5, K_2O kg ha^{-1})	Maturity duration (days)	Total cropping duration (Days)	Hectare factor
Rice-maize	Rice	*Kharif*	BPT-5204	20 x 10	150:75 :75	148	253	494.07
	Maize	*Rabi*	NK-6240	60 x 20	150:75:37.5	105		833.33
Rice-sorghum	Rice	*Kharif*	BPT-5204	20 x 10	150:75 :75	148	253	494.07
	Sorghum	*Rabi*	NSH-18	45 x 15	100:75:40	105		694.44
Rice-chickpea	Rice	*Kharif*	BPT-5204	20 x 10	150:75 :75	148	241	494.07
	Chickpea	*Rabi*	JG-11	30 x 10	25:50:00	93		541.12
Rice-sesame	Rice	*Kharif*	BPT-5204	20 x 10	150:75 :75	148	238	494.07
	Sesame	*Rabi*	DSS-9	30 x 15	25:50: 25	90		566.89
Maize-chickpea	Maize	*Kharif*	NK-6240	60 x 20	150 :75:37.5	112	212	833.33
	Chickpea	*Rabi*	JG-11	30 x 10	25: 50:00	90		541.12
Cotton-sesame	Cotton	*Kharif*	AJITH-155	90 x 60	150:75:75	170	260	771.60
	Sesame	*Rabi*	DSS-9	30 x 15	25:50: 25	90		566.89
Rice-rice	Rice	*Kharif*	BPT-5204	20 x 10	150:75 :75	148	286	494.07
	Rice	*Rabi*	Gangavathi sona	20 x 10	150:75 :75	138		494.07

Table 2. Crop yield, rice equivalent yield (REY), system productivity and available nutrient status as influenced by different cropping

Sequence cropping system	Crop yield ($kg\ ha^{-1}$)		REY ($kg\ ha^{-1}$)		REY ($kgha^{-1}$)	System productivity (kg REY ha^{-1} day^{-1})	Available nutrient status			
	Kharif	*Rabi*	*Kharif*	*Rabi*			N ($kg\ ha^{-1}$)	P_2O_5 ($kg\ ha^{-1}$)	K_2O ($kg\ ha^{-1}$)	OC ($g\ kg^{-1}$)
Rice-maize	5329	7372	-	6031	11361	31.13	182.51	26.86	302.12	6.52
Rice-sorghum	5291	3809	-	3532	8823	24.17	183.22	28.18	320.41	6.52
Rice-chickpea	5285	1975	-	5446	10731	29.40	210.21	34.22	322.81	6.54
Rice-sesame	5361	615	-	2981	8342	22.85	204.52	32.26	327.82	6.53
Maize-chickpea	7691	2075	6292	5723	12015	32.92	208.21	34.20	321.61	6.54
Cotton-sesame	4288	559	10405	2712	13117	35.94	204.52	32.35	328.33	6.53
Rice-rice	5395	5031	-	4421	9816	26.89	201.50	24.21	330.10	6.51
S.Em.±	114	81	-	-	216	0.60	0.60	0.60	0.90	0.04
CD (p=0.05) Systems	352	250	-	-	668	1.80	1.90	1.90	3.00	NS

Available N status was high with incorporation of chickpea crop in the cropping system, which might be due to considerable amount of N added through chickpea highest quantity of crop residue and N fixed by the rhizobial nodules resulting in higher soil N even after the removal of adequate quantity of N by the succeeding rice. Higher root and shoot biomass addition by growing legume during *rabi* improved the availability of N of their respective soils. The release of organic acids has increased the soil phosphorus content, which in turn increased the availability of P_2O_5. The extensive root system of legume improved the physical condition of the soil and the liberated CO_2 and organic acids which might have helped in dissolving native potassium in soil and thereby increasing the availability of potassium. Soil available nutrient status was low due to exhaustive nature of the crop and non contribution to soil nutrition with rice-rice cropping system.

Conclusion

Based on findings of this experiment it can be concluded that under conditions of Tunga Bhadra Project area, cotton-sesame and maize-chickpea cropping sequences were more productive and sustainable as they improve productivity and nutrient uptake respectively when compared to other cropping sequences and can be a better option for the farmers of the TBP area, Karnataka

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