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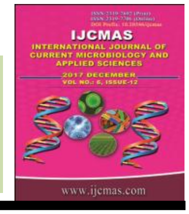

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An Alternative Cropping Systems for Tunga Bhadra Command Area of Karnataka, India

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A B S T R A C T

An AICRP experiment was conducted under irrigated condition during 2016-17 at Agricultural Research Station, Siruguppa, University of Agricultural Sciences (UAS), Raichur, Karnataka, India, to study feasibility of alternative cropping system for existing predominant rice – rice system in TBP command area on deep black soil. The experiment consisted of ten cropping systems and laid out in completely randomized block design with three replications. The results revealed that, growing of rice followed by ridge gourd (*Kharif-summer*) recorded significantly higher Rice equivalent yield (11540 kg/ha), Gross return (Rs.226114/ha), Net return (Rs.157504/ha), B:C ratio (3.30), System profitability (431.5 Rs/ha/day) and System productivity (31.62 kg/ha/day) and followed by rice – coriander cropping system (T_6) with respect to gross return (Rs.183209/ha), Net return (Rs.121199/ha), B:C ratio (2.95) and System profitability (332.1 Rs/ha/day) compared to predominant rice –rice cropping system (T_1, T_9 and T_{10}). The higher N uptake of 134 kg/ha/year and P uptake of 49 kg/ha/year and K uptake of 221 kg/ha/year was noticed in rice followed by rice cropping system (T_{10}). Results indicated that, growing of rice followed by vegetables (*Kharif-summer*) was best to higher income for the farmers and it improves the soil fertility and productivity compared to only growing of rice followed by rice.

Keywords

Cropping system, Rice equivalent yield, System profitability, System productivity and nutrient uptake.

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Introduction

Rice followed by rice is the most dominant cropping system in the deep and shallow black soil of Tungabhadra Command Area of Karnataka, India. Continuous cultivation of rice for longer periods with low system productivity, and often with poor crop management practices, results in loss of soil fertility due to emergence of multiple nutrient deficiency (Dwivedi *et al.*, 2001) and deterioration of soil physical properties, and decline in factor productivity and crop yields in high productivity areas (Yadav, 2002). Diversification and intensification of rice-based system 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 and vegetables and, 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). Crop diversification has been recognized as an effective strategy for achieving the objectives of food security, nutrition security, income growth, poverty alleviation, employment generation, and judicious use of land and water resources, sustainable agricultural development and environmental improvement (Hedge *et al.*, 2003). The crop diversification may enhance profitability, reduce pests, spread out labour more uniformly, reduce risks from aberrant weather by different planting and harvesting times and source of high value products from new crops (Reddy and Suresh, 2009).

Rice being the staple food of people, hence, rice cannot be replaced with other crops during *kharif* season. The only option left is to identify suitable crops for *rabi*/summer seasons for non-availability of water due to less storage capacity in the reservoirs coupled with low water availability for the tail end farmers in the command area it is more so with TBP. Growing of crops such as vegetables, pulses and oilseeds during summer is an alternative approach for realizing higher productivity and profitability. Moreover, growing non paddy crops during summer has a special reference for efficient utilization of irrigation water, labour and other inputs for higher productivity, profitability and food security. There is need to evaluate the possibilities of replacing summer rice with other suitable upland crops and include summer season crops for higher productivity. Similarly, there are opportunities to include grain legumes and vegetables during summer season.

The demand for vegetable crops has increased enormously leading to sharp increase in their prices and it has been the dominant factor for high inflationary pressure in Indian economy during recent years. Inclusion of crops like oilseeds, pulses, vegetables and fodder crops will improve the economic condition of small and marginal farmers owing to higher price and/or higher volume of their main and by-products (Sharma *et al.*, 2007). Hence, efforts are being made to promote diversification of rice - based cropping sequence in this area of country with vegetable crops for sustaining the productivity and to meet out demand for vegetables. Therefore, the present investigation was carried out to find out most productive, resource-use-efficient and remunerative cropping system for this region.

Materials and Methods

An AICRP experiment was conducted under irrigated condition during 2016-17 to find out alternative cropping system for existing rice – rice system in TBP command area at Agricultural Research Station, Siruguppa. The experiment consists of 10 treatments with rice grown in the *kharif* followed by different crops in the *rabi* and treatments were replicated thrice. The randomized complete block design was adopted. The soil was deep black having slightly alkaline in pH (8.18) and low in soluble salt concentration (0.38 dS/m), medium in soil organic carbon content (0.65 %) and available phosphorus (11.3 kg/ha), low in available nitrogen (177 kg/ha) and rich in available Potassium (348 kg/ha) status. The treatments details, fertilizer dosage and varieties used in the experiment were given in Table 1 and 2**.** The fertilizers were applied in the form of urea, Diammonium phosphate (DAP) and muriate potash as per the recommended package of practice for each crop tested during both the season 2016-17. The data on the yield parameters were recorded at harvest. The cost of inputs that were prevailing at the time of their use was considered for working out the economics of various treatments. Net return per hectare was calculated by deducting the cost of cultivation from gross returns per hectare, gross returns was calculated by using the total income obtained from grain and straw yields and the benefit cost ratio was worked out as follows. Benefit cost ratio = Gross returns/Cost of cultivation. The rice equivalent yield was calculated by using the following formula (Verma and Mudgal, 1983),

REY (kg/ha) = YRC (kg/ha) × MPCC (Rs./kg) + Yield of main crop (kg/ha) / Price of rice (Rs./kg)

Whereas, YRC= Yield of rabi crop (kg ha^{-1}), MPRC=Market price of *rabi* crop (Rs. kg^{-1}). The System Productivity (SP) for the cropping system was calculated as dividing the REY by number of days in a year and expressed in kg/ha/day and System profitability was calculated by dividing the Net Returns by number of days in a year i.e. 365 days. The plant samples were collected and subjected to chemical analysis. The grain and stover samples were analyzed for N by digesting sample with concentrated H_2SO_4 and the acid digested was distilled for NH_3 by using 40% NaOH and was estimated by titration against standard acid and phosphorus and potassium in the plant sample extracted by diacid were determined by vanodomolybidic yellow colour and flame photometry method, respectively (Jaiswal, 2004). MSTAT was used for statistical analysis of data and means were separated using critical difference (CD) at p=0.05 (Gomez and Gomez, 1984).

Results and Discussion

Grain and straw yield

The data on grain and straw yield were presented in Table 3. The grain and straw/stover yield of different crops during kharif/summer were significantly influenced by different cropping systems. Among the three rice varieties tested, SIRI- 1253 recorded higher yield (7159 kg/ha) followed by GNV 10-89 (6961 kg/ha). Similar results were also reported by Bastia *et al.,* (2008)**.** However, BPT 5204 recorded least grain yield (5109 kg/ha). In case of rice straw yield definite trend with respect higher grain yield was not observed, but the higher rice straw yield was noticed in T_5 (7854 kg/ha) followed by T_6 (7308 kg/ha) and lowest being was observed in T_{10} (5919 kg/ha).

Rice equivalent yield

The rice equivalent yield was worked out to arrive the best cropping system among the different cropping systems tested and are presented in Table 3. The significantly higher rice equivalent yield (11540 kg/ha) was noticed in rice followed by ridge gourd cropping system compared to other cropping systems. The higher rice equivalent in rice followed by ridge gourd was attributed to higher ridge gourd yield and higher price might be the reason to record the higher REY. The next best cropping system after rice – ridge gourd system was existing/traditional cropping system of rice followed by rice in Thunga Bhadra Project (TBP) area. Among the rice varieties tested, the higher REY (9752 kg/ha) was observed in T_9 (Rice –rice variety GNV 10-89) and it was significantly superior to T_1 which includes traditional and fine quality variety of BPT 5204. The higher yield in GNV 10-89 than BPT 5204 might be due to higher yield. After these cropping systems, next best alternative rice cropping system is rice followed by coriander cropping system which recorded REY (7914 kg/ha) and it was on par with T_8 (7812 kg/ha) and significantly superior to T_4 (7435 kg/ha), T_7 (7270 kg/ha), T_5 (6694 kg/ha) and T_3 (6053 kg/ha). The low REY in these systems might have low yield potential. However, in the water scarcity situation in tail end user may be practiced these cropping systems. These results are conformity with the findings of Hegde *et al.,* (2003).

System productivity and profitability

The data on system productivity and profitability was presented in Table 4. Results revealed that, the system profitability and system productivity were significantly influenced by different cropping systems. The significantly higher system profitability (431.5 Rs/ha/day) was observed in T_2 followed by T_6 (332.1 Rs/ha/day). Whereas, least system profitability was recorded in T_3 (171.3 Rs/ha/day). Further, the significantly higher system productivity (31.62 kg/ha/year) followed by T_{10} (26.72 kg/ha/year) and T_9 (25.47 kg/ha/year) and lowest being was observed in T_3 (16.59 kg/ha/year).

These results corroborates the findings of Singh *et al.,* (2007) who reported rice-pea-okra followed by rice-pea-onion as the most productive cropping sequence for eastern Uttar Pradesh, India. Mishra *et al.,* (2007) also reported higher productivity and profitability through inclusion of vegetables and pulses in rice-based cropping system. Walia *et al.,* (2014) who reported that productivity in terms of REY and system productivity was highest for rice-green pea-summer moongbean as compared to rice-wheat and all other crop sequences.

Economics of different systems

Significantly higher gross returns (Rs. 226114/ha), net returns (Rs. 157504 /ha) and B: C ratio (3.30) was observed in T_2 (rice followed by ridge gourd) compared to other cropping systems. The higher gross returns, net returns and B: C ratio was owing to higher yields in the T_2. It was followed by T_6. Although rice followed by coriander (T6) was not superior to rice followed by rice in terms of REY (Table 3), however, it recorded significantly higher GR, NR and B: C ratio of Rs. 183209/ha, Rs. 121199/ha and 2.95, respectively over all the three treatments of rice followed by rice system with different rice varieties (T_1, T_9 and T_{10}) and other treatment also. This was might be due to higher price for coriander in *rabi* season. The significantly lower GR and, NR was observed in T_3, however lower B: C ratio was observed in T_9 (rice followed by rice). Kumar Alok *et al.,* (2008) also reported that inclusion of vegetable crops in rice- based crop sequences improved the net returns.

Table.1 Treatment details

Treatments	Kharif	Rabi	Summer	Pre-monsoon
1	Rice (BPT-5204)	-	Rice	Existing system
2	Rice (SIRI-1253)	-	Ridge gourd (ZT and DS)	-
3	Rice (SIRI-1253) + Sesbania (Incorporation after 55 days)	-	Mustard	Green gram (Residue incorporation)
4	Rice (SIRI-1253)	-	Beans	Sesbania incorporation
5	Rice (SIRI-1253)	-	Siyazeera	Sesbania incorporation
6	Rice (SIRI-1253)	-	Coriander	-
7	Rice (GNV 10-89)	Spinach	Black gram (Residue incorporation)	-
8	Rice (GNV 10-89)	Methi	Green gram(Residue incorporation)	-
9	Rice (GNV 10-89)	-	Rice (RASI)	Sesbania incorporation
10	Rice (GNV 10-89)	Sesbania incorporation	Rice (RASI)	-

Table.2 Varieties and fertilizer used during experimentation

Treatments	Crops	Varieties	Fertilizer doses (N,P,K kg/ha)
1.	Paddy	BPT-5204, Siri-1253 and GNV 10-89	150:75:75
2.	Ridge gourd	Jaipur long	50:50:00
3.	Mustard	Varuna	100:60:40
4.	Beans	Local	60:20:20
5.	Siyazeera	Local	50:20:20
6.	Coriander	Local	75:30:30
7.	Blackgram	T9	12.5:25:00
8.	Green gram	Chinamung	12.5:25:00
9.	Spinach	Local	25:00:00
10.	Methi	Local	100:00:00

Table.3 Grain and Straw yield (kg/ha) and Rice equivalent yield (kg/ha) of rice followed by diversified cropping system during *kharif* and rabi

Treatments	*Kharif*			*Rabi*			REY (kg/ha)
	Crop	Grain	Straw	Crop	Grain	Straw	
T_1	Rice (BPT-5204)	5109	6514	Rice	3818	4919	8927
T_2	Rice (SIRI-1253)	5886	6795	Ridge gourd	5606*	2830	11540
T_3	Rice (SIRI-1253)	5473	7159	Mustard	495	759	6053
T_4	Rice (SIRI-1253)	5952	6399	Beans	1483*	1824	7435
T_5	Rice (SIRI-1253)	6299	7854	Siyazeera	395	570	6694
T_6	Rice (SIRI-1253)	7159	7308	Coriander	755*	965	7914
T_7	Rice (GNV 10-89)	6200	6795	Black gram	1070	1350	7270
T_8	Rice (GNV 10-89)	6961	7126	Green gram	852	1092	7812
T_9	Rice (GNV 10-89)	5374	6018	Rice	3923	4801	9297
T_{10}	Rice (GNV 10-89)	5704	5919	Rice	4048	4997	9752
SEm±		185	194		86	104	178
CD (0.05)		550	574		256	309	529

*– Fresh weight

Table.4 The economics, system profitability and system productivity of rice followed by diversified cropping system

Treatments	Gross return (`Rs/ha.)	Net return (Rs/ha)	B:C	System Profitability (`Rs/ha/day)	System Productivity (kg/ha/day)
T_1	178956	100361	2.28	275.0	24.48
T_2	226114	157504	3.30	431.5	31.62
T_3	121470	62520	2.06	171.3	16.59
T_4	159411	95211	2.48	260.9	20.37
T_5	146128	83163	2.32	227.8	18.34
T_6	183209	121199	2.95	332.1	21.68
T_7	147102	87802	2.48	240.6	19.92
T_8	145672	86372	2.46	236.6	21.40
T_9	153266	78361	2.04	214.7	25.47
T_{10}	160466	85561	2.14	234.4	26.72
SEm±	3322	3322	0.05	9.1	0.49
CD (0.05)	9871	9866	0.152	27.03	1.45

Table.5 Nutrient uptake (kg/ha) by rice – diversified cropping system

Treatments	N uptake by crop			P uptake by crop			K uptake by crop		
	Kharif	*Rabi*	Total	*Kharif*	*Rabi*	Total	*Kharif*	*Rabi*	Total
T_1	94	64.0	158	26	19.1	45	126	88.6	215
T_2	102	23.9	126	32	4.4	36	136	52.1	188
T_3	104	23.7	128	32	2.6	35	131	12.3	143
T_4	107	43.9	151	35	7.1	42	133	32.4	165
T_5	113	15.7	129	34	2.0	36	152	9.1	161
T_6	124	12.1	136	39	3.5	43	149	18.5	168
T_7	111	50.0	161	34	7.0	41	142	25.1	167
T_8	120	39.2	159	36	5.5	42	150	22.6	173
T_9	95	65.7	161	29	15.3	44	125	89.4	214
T_{10}	98	66.0	164	31	17.5	49	125	95.7	221
SEm±	3.6	2.7	4.8	1.98	0.7	2.1	5.85	1.7	6.0
CD (0.05)	10.58	7.9	14.3	5.89	2.3	6.3	17.40	5.2	17.9

Nutrient uptake

Uptake of Nitrogen, phosphorus and potassium in both seasons were studied and are presented in Table 5. The data reveals that, the N, P and K uptake by grain and straw in both *kharif, rabi/summer* seasons were significantly influenced by various cropping systems. The total N, P and K uptake by rice crop was varied from 94 (T_1) to 124 (T_6) kg/ha 26 (T_1) to 39 (T_6) kg/ha and 125 (T_9 and T_{10}) to 152 (T_5) kg/ha, respectively during *kharif*.

However, during *rabi/summer*, the N uptake varied from 12.1 (T_6) to 66 (T_{10}) kg/ha, P uptake ranged from 2.0 (T_5) to 19.1 (T_1) kg/ha and K between 9.1 (T_5) and 95.7 (T_{10}) kg/ha. Similar findings were noticed by Gill and Ahlawat (2006).

The N, P and K removal from soil by various cropping systems was also significantly influenced by various cropping system. The higher N uptake of 134 kg/ha/year and P uptake of 49 kg/ha/year and K uptake of 221 kg/ha/year was noticed in rice followed by rice cropping system (T_{10}). It was closely followed by T_9 and T_1 they too were rice – rice cropping system. These results suggested that the rice – rice cropping systems removes lot of nutrients from the soil. However, the lower nutrient removal was not followed a define trend with respect of N, P and K nutrients. The lower N (126 kg/ha/year) removal was recorded in T2 (Rice followed by ridge gourd) and lower P (36 kg/ha/year) and K (143 kg/ha/year) uptake was in T_3 (rice followed by mustard). However, the removal of nutrients from different cropping system from the soil mainly depends on their nutrient concentration of a crop and biological yield of a system.

The results indicated that, farmers can grow rice during kharif followed by ridge gourd or coriander during rabi/summer to get higher income. Further, these systems may improve the soil fertility and productivity in TungaBhadra Command Area of Karnataka.

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