J. Farm Sci., 33(3): (338-341) 2020

RESEARCH PAPER

Effect of *kharif* rice establishment methods on various rice fallow crops with different irrigation systems

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(Received: August, 2019 ; Accepted: September, 2020)

Abstract: Crop performance in rice fallows was greatly affected by *kharif* rice establishment and agro techniques during *rabi*. Objective of the study to identify alternate potential crops to rice in order to intensify rice fallows in irrigation command area. A field experiment was conducted in *Vertisol* at the Agriculture Research Station, Dhadesugur, Karnataka during *kharif* and *rabi* 2018-19. Experiment was laid out in split-split with thirteen replications in *kharif* and three replications in *rabi*. Treatments comprised of transplanted rice (TPR) and direct seeded rice (DSR) establishment methods in *kharif*, while drip and surface irrigation methods for pulses in *rabi* as sub factor and different pulses are as sub-sub plots. Results indicated that there was no significant yield difference between TPR and DSR in *kharif*. Drip irrigation had significant effect on yield and WUE over surface irrigation for crops grown in rice fallows. Whereas, DSR-cowpea recorded significantly greater rice equivalent yield (REY) (5140 kg ha^{-1}) system productivity (44.6 REY kg ha^{-1} day^{-1}). Whereas, DSR-dolichos bean has gave higher net profit (₹ 85603 ha^{-1}) and BC ratio (1.94). Results inferred that DSR in *kharif* subsequently cowpea, dolichos/lablab or rice bean are highly productive and profitable over traditional rice-rice in the region.

Key words: Direct seeded rice, Drip irrigation, Paddy fallows, Pulses, Rice equvalent yield

Introduction

Rice (*Oryza sativa* L.) occupies a pivotal place in Indian food security accounts for 43 per cent of total food grain production and 55 per cent of cereal production of the country (Singh *et al*., 2004). Continuous rice-rice is a predominant in the major irrigation commands of the country and Tungabhadra command is not an exceptional. Sustainable rice production over years was dwindled by shortage of water, labour and deteriorated soil health. Further, in many of the growing seasons, *rabi* paddy crop failure is a common-phenomena. Continuous paddy has led to several environmental hazards and development of problematic soils. Diversification and intensification of rice-based or alternate cropping system for paddy-paddyto increase productivity per unit resource is very pertinent. Crop diversification in irrigation command shows lot of promises in alleviating these problems besides, fulfilling basic domestic needs,yearround crop production (Gill and Ahlawat, 2006). Research information available in the region was restricted to performance evaluation of different crops in paddy fallows not under micro irrigation and previous rice establishment methods. Judicious use of residual soil moisture and reuse of harvested rain water through micro irrigation gaining momentum to enhance crop potential in paddy fallows. In this context, this field experiment was undertaken with an objective to findout potentiality and profitability of crops in rice fallows when previous season paddy was grown under transplanted and DSR Direct Seeded Rice method.

Material and methods

Field experiment was conducted at ARS, Dhadesugur ($76^0.54``$E, $15^0.38``$N, elevation 380 m) during *kharif* and *rabi* 2018-19. Experimental site is located in Northern Dry Zone of Karnataka had annual rainfall of 745.2 mm received in 42 rainy days. Experiment was laid out in split-split design with thirteen replications in *kharif* and three replications in *rabi*. Main plots in *kharif* consist of TPR and DSR methods each at 2000 m^2. After harvest of *kharif* crops each block was equally divided into drip and surface irrigation methods for pulses as sub plots. Each irrigation block in *rabi* was further divided into eight plots of 32.4 m^2 to accommodate greengram (cv.BGS-9), cowpea (cv. C-152), mustard (cv. PM-25), sorghum (cv. GS-23), dolichos bean (cv. HA-3), ricebean (cv. KBR-1) and chickpea (cv. JG-11) replicated thrice in each block. Paddy variety 'Gangavati sona' was used in both *kharif* and *rabi*. Direct seeded rice was sown in dry soil during July, 2019 at 20 cm row spacing. For transplanting, healthy paddy seedlings were transplanted in August with row spacing, fertilizers and plant protection measures as per the recommendation for the region. Fertilizers are applied in the form of urea, diammonium phosphate and muriate of potash at the time of sowing and subsequent N was applied as per the package of practice. At physiological maturity DSR was harvested in December, 2019 and TPR matured 15 days later than former. Randomly 13 spots of two sq. meter from DSR and TPR were harvested to estimate yield attributes, grain and straw yield then converted into hectare basis.

For *rabi* crops land was prepared by ploughing twice and harrowing to make fine seedbed. Pulses were sown at 4 to 5 cm deep in the seed lines of cowpea, sorghum, ricebean, dolichos bean, chickpea whereas mustard at 2 to 3 cm deep by following the specified row and plant spacing. All agronomic package of practices was followed to raise the crops in different cropping systems. Drip irrigation to *rabi* pulses was laid out at 0.6 m lateral spacing and drippers at 0.3 m distance accommodated

120 drippers with discharge rate of 1.6 lph. Each plot has provision of separate water control valve to facilitate water application as per crop requirement. Surface irrigation means controlled flooding with uniform water depth for all crops. Economic yields of component crops were converted into rice-equivalent yield (REY), considered the prevailed market prices of different crops in the cropping sequences. The above values were computed as per the following formula.

$$\text{REY (kg ha}^{-1}) = \frac{\text{Ycc x MPcc + Grain yield of paddy (kg ha}^{-1})}{\text{Market Price of paddy (₹ ha}^{-1})}$$

Whereas, YCC= Yield of component crop (kg ha^{-1}) and MPCC=Market price of component crop (₹ ha^{-1}). Total REY was sum of rice yield in *kharif* and REY of pulses in *rabi*. Cost of cultivation and net profit were calculated in terms of ₹ ha^{-1}, benefit cost ratio was calculated by dividing gross returns by cost of cultivation. The data of each crop season was statistically analyzed separately. Fisher's method of analysis of variance was applied for analysis and interpretation of the data. The level of significance used in 'F' test was at p = 0.05. Critical difference values were calculated whenever 'F' was significant.

Results and discussion

Yield attributes of *kharif* paddy

Significantly higher dry matter production per hill, panicle weight and grains per panicle were recorded in transplanted rice as compared to DSR (Table 1). It has resulted 5.53 % higher grain and 12.0 % straw yield in transplanted rice over DSR. However, higher cost of cultivation in TPR had compensated greater yield indicated by higher net returns and BC ratio in DSR (Table 2). Transplanted rice had incured additional ₹ 6490 per acre over DSR. A difference in yield attributes, yield and economics was earlier reported by Prashanth *et al.* (2019) and Gururaj (2013).

Rabi crops yield

Grain and straw yield of different crops was significantly influenced by *kharif* rice establishment methods and irrigation methods (Table 3). Crops grown in transplanted rice fallows has favoured *rabi* crops growth yield as compared to DSR fallow. Irrespective of the crops drip irrigation has produced higher yield over surface irrigation. *Rabi* sorghum and ricebean performance were higher in DSR fallow over rest of the crops. Paddy yield in *rabi* was also 10.35 % higher in TPR fallow compared to DSR fallow. *Rabi* crops grain yield was converted into rice equivalent yield and it indicated that significantly influenced by irrigation methods and establishment methods (Table 3). Crops grown in TPR fallow has recorded higher REY (3909 kg ha^{-1}) compared to DSR fallow (3827 kg ha^{-1}). Further drip irrigation has produced greater yield of *rabi* crops in terms of REY (4284 kg ha^{-1}) over surface irrigation (3451 kg ha^{-1}). Among different sequence, cowpea has produced significantly higher REY (5140 kg ha^{-1}) followed by dolichos bean (4829 kg ha^{-1}) compared to rest of the cropping systems. Lower REY was recorded in mustard (1915 kg ha^{-1}). However, it was improved under drip irrigation. It may be attributed to sowing time January was found not optimum for mustard. Yield potential of different crops in rice fallows was earlier reported by Kar *et al*. (2006) and Rinki Kumari *et al*. (2017).

Total REY (TREY) is a sum of both seasons yield was significantly influenced by *kharif* establishments, irrigation methods and crop species. There was no significant difference (3.51%) in TREY between crops in transplanted paddy fallow and DSR fallow. Whereas drip irrigated crops have produced significantly 11.06 % greater TREY as compared to surface irrigation. Among cropping systems TREY was higher from rice-cowpea cropping system (10009 kg ha^{-1}) due to its superior grain yield of both rice and cowpea also attributed to less crop duration of the system. Further it was significantly superior over rice-dolichos bean (9698 kg ha^{-1}), rice-ricebean (9531 kg ha^{-1}). Parthasarathi *et al.* (2013) also reported that 72.1 per cent efficient usage of water coupled with 1.6 times higher total productivity of water under drip irrigation in rice.While Kar *et al*. (2006) and Rinki Kumari *et al*. (2017) who reported that inclusion of legume during summer/*rabi* in rice based cropping system resulted in an increased 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. In the present study, rice-rice bean and rice-dolichos bean cropping

Table 1. Grain yield and attributes of *kharif* rice under different rice crop establishment methods at Dhadesugur

Treatment	Dry matter production (g hill^{-1}) At harvest	Panicle length (cm)	Panicle weight (g)	Grains panicle^{-1}	Test weight (g)	Days to maturity	Productive tillers hill^{-1}
Transplanted rice	88.10	22.6	16.0	156.2	24.72	145.6	10.5
Direct seeded rice	67.8	23.2	14.3	129.4	21.45	136.3	11.7
S.Em.±	1.02	0.45	0.15	2.26	0.17	2.03	1.1
C.D. at 5%	3.17	NS	0.46	07.05	0.52	6.08	NS

Table 2. Yield and economics of rice production in *kharif* 2018 under different crop establishment methods

Cropping sequence	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net Returns (₹/ha)	BC ratio
Transplanted rice	5000	6446	0.437	46286	99946	53660	2.16
Direct Seeded Rice	4738	5877	0.447	39826	94478	54652	2.37
S.Em.±	85	147	0.003				
C.D. at 5%	263	323	0.009				

Table 3. Grain and straw yield of different crops grown in rice fallows as influenced by *kharif* rice establishment methods and irrigation methods

Treatment	S_1		S_2		Mean (C)
	I_1	I_2	I_1	I_2	
	Grain yield (kg ha^{-1})				
C_1: Greengram	823	732	818	591	741
C_2: Cowpea	1236	854	1148	606	961
C_3: Mustard	1111	340	1029	669	787
C_4: Sorghum	1965	1728	2232	1893	1955
C_5: Dolichos bean	1163	1029	1240	1084	1129
C_6: Ricebean	1062	1062	1214	1022	1090
C_7: Chickpea	1214	1109	1193	1049	1141
Paddy	4818 (S_1)		4366 (S_2)		
	S.Em.+	C.D. at 5%		C.D. at 5%	
S	25.1	NS	S x I	NS	
I	13.2	51.4	S x C	149.7	
C	37.2	105.9	I x C	149.7	
			S x I x C	NS	
	Stover/stalk yield (kg ha^{-1})				Mean (C)
C_1: Greengram	3521	3129	3499	2531	3170
C_2: Cowpea	6613	4567	6140	3240	5140
C_3: Mustard	2377	1726	2201	1430	1934
C_4: Sorghum	4414	3882	5014	4252	4391
C_5: Dolichos bean	4974	4401	5303	4639	4829
C_6: Ricebean	4542	4542	5194	4370	4662
C_7: Chickpea	3116	2847	3063	2693	2930
Paddy	5152 (S_1)		4771 (S_2)		
				C.D. at5%	
S	83.88	NS	S x I	NS	
I	39.2	153.1	S x C	491.6	
C	122.7	347.6	I x C	491.6	
			S x I x C	NS	

S_1: *Kharif* Transplanted rice S_2: *Kharif* Direct seeded rice
I_1: Drip irrigation I_2: Surface irrigation

Table 4. *Rabi* pulse crops rice equivalent yield of crops grown in rice fallows as influenced by *kharif* rice establishment and irrigation methods

Treatment	S_1		S_2		Mean
	I_1	I_2	I_1	I_2	(C)
Rice equivalent yield of pulses (kg ha^{-1})					
C_1: Greengram	3521	3129	3499	2531	3170
C_2: Cowpea	6613	4567	6140	3240	5140
C_3: Mustard	2377	1796	2201	1430	1951
C_4: Sorghum	4414	3882	5014	4252	4391
C_5:Dolichos bean	4974	4401	5303	4639	4829
C_6:Ricebean	4542	4542	5194	4370	4662
C_7: Chickpea	3116	2847	3063	2693	2930
C_8: Rice	4818 (S_1)			4366 (S_2)	
Mean (S)	3909 (S_1)			3827 (S_2)	
Mean (I)	4284 (I_1)			3451 (I_2)	
	C.D. at5%		C.D. at5%		
S	NS	S x I	247.5		
I	175	S x C	525.1		
C	371.3	I x C	525.1		
		S x I x C	NS		
Total Rice Equivalent Yield *(kg ha^{-1})					Mean (C)
C_1: Rice- Greengram	8521	8129	8237	7269	8039
C_2: Rice- Cowpea	11613	9567	10878	7978	10009
C_3: Rice-Mustard	7377	5726	6939	6168	6553
C_4: Rice- Sorghum	9414	8882	9752	8990	9260
C_5: Rice- lablab	9974	9401	10041	9377	9698
C_6: Rice-Ricebean	9542	9542	9932	9108	9531
C_7: Rice- Chickpea	8116	7847	7801	7431	7799
C_8: Rice-Rice	9818		9104		9461
Mean (S)	8832 (S_1)		8565 (S_2)		
Mena (I)	9153 (I_1)			8244 (I_2)	
	C.D. at5%		C.D.at5%		
S	584.4	S x I	247.5		
I	175	S x C	525.1		
C	371.3	I x C	525.1		
		S x IxC	NS		

S_1: *Kharif* Transplanted rice; S_2:*Kharif* Direct seeded rice;
I_1: Drip irrigation; I_2: Surface irrigation
* Sum of *kharif* paddy yield and *rabi* REY
Greengram- ₹ 80/kg; cowpea- ₹ 100/kg; Mustard- ₹ 40/kg; Sorghum- ₹ 42/kg; Dolichos lablab- ₹ 80/kg; Ricebean ₹ 80/kg; Chickpea ₹ 48/kg; Paddy ₹ 18.7/kg

systems are found better yield advantage over rest of the treatments. This might be due to higher production potential of ricebean along with the good market price of dolichos bean and rice that yielded better grain yield than rest other cropping systems. 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. Similar findings on production potential of different cropping systems in rice fallows are also reported by Jat *et al*. (2012) and Devkant *et al*. (2013).

Among different indicators of feasibility of system economic advantage has greater impact on the practical utility and acceptance of the technology by the farmers. Economic return was influenced by *kharif* establishment and irrigation methods (Table 4). Expenditure towards drip irrigation system was calculated with the assumption that the life of the physical infrastructure would be 10 years with 10 % annual depreciation. Production of rice-cowpea under drip irrigation gave higher net profit (₹ 122452 ha^{-1}) and BC ratio (2.34) compared to rice-rice and other crop combinations. However, surface irrigation for rice-rice system has given higher net returns (₹ 109002 ha^{-1}) and BC ratio (2:30).The reduced BC ratio might be due to additional investment on drip irrigation system during the first year. Further highest net profit was noticed with rice-rice bean cropping system and this was mainly attributed to higher gross returns and minimum cost of cultivation. These results are in conformity with the findings of Shridhara *et al*. (2017) and Mallareddy (2018). Who reported with respect to benefit cost ratio, it was highest in case of rice-ricebean cropping system mainly due to higher price of rice and ricebean and less cost of production.

Conclustion

Based on findings of this experiment it was concluded that transplanted rice out yielded over direct seeded rice in *kharif*. In DSR fallow either cowpea, dolichos bean or ricebean can be

Table 5. Economics of transplanted and DSR based cropping sequence involving pulses in rice fallows under surface and drip irrigation for *rabi* crops

Cropping system	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit Cost ratio	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit Cost ratio
	Transplanted rice (*Kharif*)			Direct seeded rice (*Kharif*)		
	Surface irrigation					
Rice-Greengram	91867	61001	1.66	85407	61993	1.73
Rice-Cowpea	87698	85242	1.97	81238	86234	2.06
Rice-Mustard	87326	32785	1.38	80866	33777	1.42
Rice-Sorghum	88106	87889	2.00	81646	88881	2.09
Rice-Lablab	98870	85603	1.87	92410	86595	1.94
Rice-Rice bean	87695	95584	2.09	81235	96576	2.19
Rice-Chickpea	93678	58070	1.62	87218	59062	1.68
Rice-Rice	90407	108010	2.19	83947	109002	2.30
S.Em.±		2663	0.03		2663	0.03
C.D. at 5%		8155	0.09		8155	0.10
	Drip irrigation					
Rice-Greengram	101894	63690	1.63	95434	64682	1.68
Rice-Cowpea	97725	119637	2.22	91265	122452	2.34
Rice-Mustard	97353	45391	1.47	90893	46383	1.51
Rice-Sorghum	98130	89964	1.92	91673	90953	1.99
Rice-Lablab	108897	87140	1.80	102437	88132	1.86
Rice-Rice bean	97722	93253	1.95	91262	94245	2.03
Rice-Chickpea	103705	54019	1.52	97245	55011	1.57
Rice-Rice	98133	85577	1.87	83947	109002	2.30
S.Em.±		6909	0.07		4309	0.05
C.D. at 5%		21158	0.220		13198	0.16

grown as an alternative to paddy. Micro irrigation can save irrigation water in rice fallows compared conventional surface irrigation. Further, these crops sequence with paddy will give higher system productivity, profitability and remunerative as they fetched more net returns per unit area for time invested. These crops can be grown in place of rice-rice for large scale adoption in Tunga Bhadra Project irrigation command for successful crops in rice fallows.

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