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Sustainable intensification of rice-fallows with pulses and oilseeds in Tungabhadra command area

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Abstract
Rice-rice is a major cropping system in Tungabhadra command (TBP) area. In recent years tail end rice farmers from command area's facing severe water shortage to rice crop and early withdrawal of monsoon rains or early closure of water channels leading to shortage of water to second season rice crop. A field experiment was conducted on medium black soil during *kharif* and *rabi season of* 2016-17 & 2017-18 at farmer field near Agricultural Research Station, Siruguppa. The results revealed that among rice varieties, kaverisona recorded higher grain yield during *kharif* season of 2016-17 & 2017-18 (5788 and 5773 kg ha^{-1}, respectively) as compared to BPT-5204 (5320 and 5241 kg ha^{-1}, respectively). Among pulses and oilseeds, significantly higher grain yield of fieldbean (1895 and 1912 kg ha^{-1}, respectively) were recorded in rice-fieldbean cropping system and lower crop yield was noticed with sesame (500 and 523 kg ha^{-1}, respectively) in rice-sesame cropping system during *rabi* season of 2016-17 and 2017-18. Higher net returns were noticed with rice-fieldbean system (₹163742 and 156153 ha^{-1}, respectively) as compared to rice-fallow (₹ 68216 and 63809 ha^{-1}, respectively).

Keywords: Sustainable, intensification, oilseeds, command area

Introduction
Rice fallows cultivation in India basically imply to those lowland *kharif* sown rice areas which remain uncropped during *rabi* (winter) due to various reasons such as lack of irrigation, cultivation of long-duration varieties of rice, early withdrawal of monsoon rains or early closure of water channels leading to shortage of water to winter crops, water logging and excess moisture in November / December, lack of appropriate varieties of winter crops for late planting, and socio-economic problems like stray cattle, blue bulls *etc*. Rice fallows are mainly spread in the states of Andhra Pradesh, Karnataka, Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, West Bengal and Uttar Pradesh (Subbarayudu *et al*., 2011) [4]. The coastal region of Andhra Pradesh, Karnataka and Tamilnadu form an important rice fallow ecology in peninsular area. In order to meet domestic demands of food, feed and fodder, there is huge scope to promote other alternative crops in such unconventional areas.
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) [2]. Hence, efforts are being made to promote diversification of rice- based cropping sequence in this zone of country with cereals, pulses and oilseed crops for sustaining the productivity and meet out demand for cereals, pulses and oilseeds.

Materials and Methods
Experimental site
The experiment was conducted in farmer field (Shri. Jagamohan Rao) near ARS, Siruguppa which is located at 76^0.54" E Longitude, 15^0.38" N Latitude and at an elevation of 380 meters from MSL located under Northern Dry Zone (Region II, Zone-3) of Karnataka with an average annual rainfall of 745.23 mm from July to October in about 42 rainy days. The experiment was laid out on black clay soil in split plot design. Main plot includes two rice varieties *viz.*,

BPT-5204 and Kaverisona, subplot includes seven cropping system C_1. Rice – Blackgram, C_2. Rice – Chickpea, C_3. Rice – Greengram, C_4. Rice – Fieldbean, C_5. Rice – Sesamum, C_6. Rice – Mustard and C_7. Rice – Fallow with three replications.

Climatic conditions

The monthly meteorological data for the period from June, 2016 to May, 2017 and June, 2017 to May, 2018 was collected from the meteorological observatory located at Agricultural Research Station, Siruguppa. The total annual rainfall of the year was 484.0 and 844.3 mm as against 545.5 mm mean annual rainfall for 2016-17 and 2017-18 respectively. Maximum rainfall of 220.6 mm received in June month of 2016 and 20.6 mm in 2017. The mean maximum temperature was highest in the month of May (44 ºC) & (43 ºC) followed by the month of April (43 ºC) and (40 ºC) for 2016 and 2017 respectively. The mean minimum temperature was lowest in the month of December (22ºC) and (23ºC) followed by the month of January (24ºC) & (22ºC) for 2016 and 2017 respectively.

Result and Discussion

The crop yield differed significantly among the two rice varieties. Kaverisona recorded significantly higher grain yield (5773 and 5768 kg ha^{-1}, respectively) as compared to BPT-5204 (5301 and 5238 kg ha^{-1}, respectively) during *kharif* season of 2016 and 2017. Among cropping systems, significantly higher grain yield of fieldbean (1895 and 1912 kg ha^{-1}, respectively) were recorded in rice-fieldbean cropping system and lower crop yield was noticed with sesame (500 and 523 kg ha^{-1}, respectively) in rice-sesame cropping system during *rabi* season of 2016 and 2017.This might be attributed to climatic conditions, potential yielding capacity of the crop and effect of previous crop and cropping practices. These results are in accordance with the findings of Yadav *et al*., (2013) [6]. Among different cropping system, significantly higher rice equivalent yield (kg ha^{-1}) were recorded with fieldbean (6600 and 6917 kg ha^{-1}, respectively) were recorded in rice-fieldbean cropping system. This is probably due to higher production potential of field bean coupled with the high price in the sequence that increased the rice-equivalent yield values. Lower crop yield was noticed with mustard (1312 and 1394 kg ha^{-1}, respectively) in rice-mustard cropping system during *rabi* season of 2016 and 2017. Kaverisona recorded significantly higher total REY (8961 and 9248 kg ha^{-1}, respectively) followed by BPT-5204 (8433 and 8432 kg ha^{-1}, respectively) in 2016 and 2017. Among different cropping system, significantly higher TREY were recorded with fieldbean (12129 and 12382 kg ha^{-1}, respectively) in rice-fieldbean system and lower total REY were noticed with fallow (5512 and 5464 kg ha^{-1}, respectively) in rice-fallow system.

Higher land use efficiency were noticed with BPT-5204 in 2016 and 2017 (62.50 and 62.31%, respectively) as compared to kaverisona (59.22 and 58.75%, respectively). Pooled data over two year had significantly higher with BPT-5204.This may be due to the higher crop duration of BPT-5204 as compared to kaverisona. Among different cropping system, higher land use efficiency were recorded with rice-sesame cropping system (65.48 and 65.62%, respectively). It can be attributed mainly to rice and field bean crops in respective sequences because these crops occupied the field for about 150 and 95 days respectively than other treatments led to achieve higher land use efficiency. Lower land use efficiency was observed in rice-fallow system (39.45 and 38.77%, respectively) in 2016 and 2017 indicated that it has the scope to include one more short duration pulse and oilseeds crop for soil fertility restoration. These results are in conformity with findings of Walia *et al.* (2011) [5] and Yadav *et al*., (2013) [6]. Higher production efficiency recorded with rice-field bean system (50.83 and 52.26 kg REY ha^{-1} day^{-1}, respectively) followed by rice-greengram (43.15 and 44.52 kg REY ha^{-1} day^{-1}, respectively), rice-chickpea (42.09 and 43.29 kg REY ha^{-1} day^{-1}, respectively) and lower production efficiency were noticed with rice-fallow system (38.43 and 38.78 kg REY ha^{-1} day^{-1}, respectively). Kaverisona recorded significantly higher system productivity (24.55 and 25.34 kg REY ha^{-1} day^{-1}, respectively) mainly due to the higher net returns in a year. Among different cropping system rice-field bean cropping system was noticed higher system productivity (33.23 and 33.92 kg REY ha^{-1} day^{-1}, respectively) followed by rice-chickpea (27.52 and 28.10 kg REY ha^{-1} day^{-1}, respectively) and it was on par with rice-greengram (27.06 and 27.60 kg REY ha^{-1} day^{-1}, respectively) as compared to rice-fallow (15.10 and 14.97 kg REY ha^{-1} day^{-1}, respectively) during 2016 and 2017. Kaverisona recorded higher net returns (₹ 107297 and 101809, ha^{-1}, respectively) as compared to BPT-5204 (₹106258 and 99644ha^{-1}, respectively) in 2016 and 2017. Among different cropping systems, higher net returns were noticed with rice-field bean system (₹163742 and 156153 ha^{-1}, respectively) as compared to rice-fallow (₹ 68216 and 63809 ha^{-1}, respectively) in 2016 and 2017. These results are in conformity with findings of Bastia *et al*., (2008). In the present study significantly lowest benefit cost ratio was recorded with prevailing rice-rice cropping system (2.62), this was mainly attributed to higher cost of production. The benefit cost ratio was higher in rice-field bean system (3.59 and 3.26) and lower value recorded with rice-sesame (2.47 and 2.26) during 2016 and 2017.Pooled data over two year significantly varied and significantly higher benefit cost ratio was noticed with rice-field bean system (3.43) was mainly attributed to higher gross returns and minimum cost of cultivation. Lower benefit cost ratio in rice-sesame (2.37) due to lower gross returns.

Significantly higher employment generation was noticed with BPT-5204 (198 and 200) as compared to kaverisona (189 and 192). Among cropping system, significantly maximum employment generation was observed with rice-field bean system (212 and 214) followed by rice-chickpea (210 and 213) as compared to rice-fallow system (133 and 135) during 2016 and 2017. These findings are in conformity with the results of Singh *et al*., (2012) [3] and Devkanth *et al*., (2013) [1]. Employment generation depends on duration of the cropping system and number of crops per year.BPT-5204 was recorded maximum employment generation efficiency (54 and 55%, respectively) as compared to kaverisona (52 and 53%, respectively) in 2016 and 2017. Rice-field bean system recorded significantly higher employment generation efficiency (58 and 59%, respectively) and it was on par with rice-chickpea (58 and 58%, respectively) and lower employment generation efficiency were observed with rice-fallow system (36 and 37%, respectively) during 2016 and 2017. Pooled data over two year significantly varied and maximum employment generation efficiency by filed bean (58%) and it was on par with rice-chickpea (58%) and lower employment generation efficiency were observed with rice-fallow system (37%). Due to growing two crops in year in the same piece of land more employment opportunity for male and female labours could be created and at the same time due to increased production of pulses and oilseeds, the food security and nutritional security could be ascertained for the farmers at same time cropping intensity and productivity could be increased. Similar results were also reported by Walia *et al.* (2011) [5].

Table 1: Crop yield, rice equivalent yield (REY) and Total rice equivalent yield (TREY) as influenced by different cropping System's and rice varieties (2016-17)

	Crop Yield (kg ha^{-1})						REY (kg ha^{-1})			Total REY (kg ha^{-1})		
	Kharif			Rabi			Rabi					
	V_1	V_2	Mean (C)	V_1	V_2	Mean (C)	V_1	V_2	Mean (C)	V_1	V_2	Mean (C)
C_1	5267	5808	5538	833	750	792	3262	2990	3126	8528	8799	8663
C_2	5335	5746	5540	1743	1913	1828	4297	4710	4503	9631	10456	10044
C_2	5387	5781	5584	1283	1120	1202	4554	4030	4292	9941	9810	9876
C_4	5287	5770	5529	1840	1950	1895	6404	6796	6600	11691	12566	12129
C_5	5353	5734	5543	537	463	500	2476	2195	2336	7829	7929	7879
C_6	5257	5773	5515	443	560	502	1179	1445	1312	6436	7217	6827
C_7	5222	5802	5512	0	0	0	0	0	0	5222	5802	5512
Mean (V)	5301	5773		954	965		3167	3167		8433	8961	
	MAIN	SUB	V X C	MAIN	SUB	V X C	MAIN	SUB	V X C	MAIN	SUB	V X C
S.Em.±	53	80	113	12	36	51	53	108	153	70	129	183
C.D (p=0.05)	325	NS	NS	NS	106	NS	NS	321	NS	424	384	NS

Main plot: Rice varieties: **Sub plot: Cropping systems**
V_1: BPT-5204 C_1. Rice – Blackgram C_4: Rice- Fieldbean C_5: Rice- Sesamum
V_2: Kaverisona C_2. Rice – Chickpea C_6: Rice- Mustard C_7: Rice- Fallow
C_3. Rice – Greengram

Table 2: Crop yield, rice equivalent yield (REY) and Total rice equivalent yield (TREY) as influenced by different cropping system and rice varieties (2017-18)

	Crop Yield (kg ha^{-1})						REY (kg ha^{-1})			Total REY (kg ha^{-1})		
	Kharif			Rabi			Rabi					
	V_1	**V_2**	**Mean (C)**	**V_1**	**V_2**	**Mean (C)**	**V_1**	**V_2**	**Mean (C)**	**V_1**	**V_2**	**Mean (C)**
C_1	5223	5782	5503	850	767	808	3319	3284	3302	8542	9066	8804
C_2	5264	5764	5514	1760	1943	1852	4331	5150	4741	9595	10914	10255
C_2	5290	5744	5517	1333	1137	1235	4716	4399	4558	10006	10143	10074
C_4	5133	5795	5464	1857	1967	1912	6452	7383	6917	11585	13178	12382
C_5	5277	5759	5518	570	477	523	2609	2425	2517	7886	8184	8035
C_6	5282	5798	5540	460	567	513	1214	1573	1394	6496	7370	6933
C_7	5195	5732	5464	0	0	0	0	0	0	5195	5732	5464
Mean (V)	5238	5768		976	980		3235	3459		8432	9248	
	MAIN	**SUB**	**V X C**	**MAIN**	**SUB**	**V X C**	**MAIN**	**SUB**	**V X C**	**MAIN**	**SUB**	**V X C**
S.Em.±	67	56	79	4	29	41	21	89	126	49	97	238
C.D (p=0.05)	409	NS	NS	NS	86	121	127	265	375	299	289	NS

Main plot: Rice varieties: **Sub plot: Cropping systems**
V_1: BPT-5204 C_1. Rice – Blackgram C_2. Rice – Chickpea C_3. Rice – Greengram
V_2: Kaverisona C_4: Rice- Fieldbean C_5: Rice- Sesamum C_6: Rice- Mustard
C_7: Rice- Fallow

Table 3: Land use efficiency, Production efficiency and System productivity as influenced by different cropping system and rice varieties

Treatment	Land use efficiency (%)			Production efficiency (kg REY ha^{-1} day^{-1})			System productivity (kg REY ha^{-1} day^{-1})		
Main plot: Rice Varieties	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
V_1: BPT-5204	62.50	62.31	62.41	36.86	37.00	36.93	23.10	23.10	23.10
V_2: Kaverisona	59.22	58.75	58.98	41.49	43.10	42.30	24.55	25.34	24.94
S.Em.±	-	-	-	0.35	0.28	0.28	0.19	0.16	0.16
C.D (p=0.05)	-	-	-	2.14	1.68	1.72	1.18	0.99	0.97
Sub plot: Cropping systems									
C_1:Rice – Blackgram	62.74	62.60	62.67	37.87	38.59	38.23	23.74	24.12	23.93
C_2:Rice – Chickpea	65.48	65.07	65.27	42.09	43.29	42.69	27.52	28.10	27.81
C_3:Rice – Greengram	62.74	62.05	62.40	43.15	44.52	43.84	27.06	27.60	27.33
C_4:Rice – Fieldbean	65.48	65.07	65.27	50.83	52.26	51.55	33.23	33.92	33.58
C_5:Rice – Sesamum	65.48	65.62	65.55	28.49	28.72	28.61	18.64	18.82	18.73
C_6:Rice – Mustard	64.66	64.52	64.59	33.36	34.20	33.78	21.52	22.00	21.76
C_7:Rice – Fallow	39.45	38.77	39.11	38.43	38.78	38.60	15.10	14.97	15.03
S.Em.±	-	-	-	0.59	0.44	0.48	0.37	0.28	0.30
C.D (p=0.05)	-	-	-	1.75	1.32	1.43	1.10	0.82	0.90
Interaction (V X C)									
S.Em.±	-	-	-	0.83	0.80	0.78	0.52	0.39	0.43
C.D (p=0.05)	-	-	-	NS	NS	NS	NS	NS	NS

Table 4: Cost of cultivation, gross returns, net returns and benefit cost ratio as influenced by different cropping system (Total)

Treatment	Cost of cultivation (Rs ha^{-1})			Gross returns(Rs ha^{-1})			Net returns(Rs ha^{-1})			B:C		
Main plot: Rice Varieties	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
V_1: BPT-5204	53843	59227	56535	159889	159924	159906	106258	99644	102951	2.95	2.68	2.81
V_2: Kaverisona	53843	59227	56535	161140	161894	161517	107297	101809	104553	2.97	2.71	2.84
S.Em.±	-	-	-	-	-	-	1102	991	991	0.02	0.02	0.02
C.D (p=0.05)	-	-	-	-	-	-	6706	6028	6033	NS	NS	NS
Sub plot: Cropping systems												
C_1:Rice – Blackgram	58200	64020	61110	159332	159835	159584	101132	94648	97890	2.74	2.50	2.62
C_2:Rice – Chickpea	58200	64020	61110	186289	186813	186551	128089	121743	124916	3.20	2.92	3.06
C_3:Rice – Greengram	57200	62920	60060	182943	183833	183388	125743	118746	122245	3.20	2.92	3.06
C_4:Rice – Fieldbean	63200	69520	66360	226942	226756	226849	163742	156153	159947	3.59	3.26	3.43
C_5:Rice – Sesamum	56700	59070	56385	132808	123453	133136	79852	73970	76911	2.47	2.26	2.37
C_6:Rice – Mustard	55200	56320	53760	131868	145032	132500	80668	76018	78343	2.58	2.36	2.47
C_7:Rice – Fallow	35200	38720	36960	103416	102529	102973	68216	63809	66013	2.94	2.65	2.79
S.Em.±	-	-	-	-	-	-	2613	2247	2352	0.04	0.03	0.03
C.D (p=0.05)	-	-	-	-	-	-	7764	6677	6987	0.13	0.09	0.10
Interaction (V X C)												
S.Em.±	-	-	-	-	-	-	3696	3178	2301	0.06	0.04	0.05
C.D (p=0.05)	-	-	-	-	-	-	NS	NS	NS	NS	NS	NS

Table 5: Employment generation and Employment generation efficiency as influenced by rice varieties and different cropping system

Treatment	Employment generation (man day's)			Employment generation efficiency (%)		
Main plot: Rice Varieties	**2016-17**	**2017-18**	**Pooled**	**2016-17**	**2017-18**	**Pooled**
V_1: BPT-5204	198	200	199	54	55	54
V_2: Kaverisona	189	192	191	52	53	52
S.Em.±	1.8	2.6	2.2	0.5	0.4	0.4
C.D (p=0.05)	3.6	4.6	4.4	1.5	1.2	1.2
Sub plot: Cropping systems						
C_1:Rice – Blackgram	198	201	199	54	55	55
C_2:Rice – Chickpea	210	213	211	58	58	58
C_3:Rice – Greengram	200	203	201	55	56	55
C_4:Rice – Fieldbean	212	214	213	58	59	58
C_5:Rice – Sesamum	201	203	202	55	56	55
C_6:Rice – Mustard	200	203	201	55	56	55
C_7:Rice – Fallow	133	135	134	36	37	37
S.Em.±	0.5	0.5	0.5	0.1	0.1	0.1
C.D (p=0.05)	1.6	1.5	1.4	0.4	0.4	0.4
Interaction (V X C)						
S.Em.±	0.75	0.72	0.67	0.20	0.20	0.18
C.D (p=0.05)	NS	NS	NS	NS	NS	NS

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