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IDENTIFICATION OF VIABLE RICE BASED CROPPING SYSTEMS FOR DOUBLE CROPPED DELTA AREAS OF ANDHRA PRADESH

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ABSTRACT
Field experiments were conducted for four consecutive *kharif- rabi* season of 2007-08, 2008-09, 2009-10 and 2010-11 at Andhra Pradesh Rice Research Institute, Maruteru, Andhra Pradesh. India ,on n Godavari Alluvia's (Vertic chromusters) with nine rice based cropping systems(Rice – Maize, Rice -Sunflower, Rice -Ground nut, Rice -Gingelly, Rice- Black gram,, Rice -Soy bean, Rice- Mustard, Rice- Ragi and Rice- Rice) with an objective to find out a viable profitable less water requirement and energy efficient rice based cropping system for double cropped delta areas. The results indicate that ,among different rice based cropping systems Rice-Maize is the most viable option as it recorded higher system productivity, production efficiency , Economic efficiency, Water use efficiency, energy productivity, Sustainable yield index and Net returns and benefit cost ratio. Whereas System energy use efficiency was higher in Rice – Mustard, higher land use efficiency was recorded with Groundnut followed by Ragi and Maize. Though the results of Rice-Groundnut/Mustard are encouraging they cannot substitute Rice during Rabi

KEY WORDS: Rice based cropping systems, yield, energetic, economics, water saving.

INTRODUCTION

Rice cultivation as a double cropping (rice- rice) during rainy season (SWM period) and dry season (Post monsoon period in December to April) has been the traditional cropping pattern in Krishna- Godavari delta popularly known as rice granary of peninsular India. As in the recent past years the rice –rice-cropping systems proved to be non profitable due to increased pest and disease load, increased cost of cultivation especially for planting and harvesting. Decreased inflows in major delta systems of the state, particularly Krishna Godavari delta in the recent years is one of the major concern for the farmers, researchers and policy makers. Predicted climate changes are likely to further accentuate the water crisis warrants the need for exploring of water saving cropping systems. As the water requirement for rice crop is very high and it consumes about 64% of the finite fresh water resources in Andhra Pradesh with very low water use efficiency of 2.45%. Keeping in view of the water shortage in coming years identification of efficient, profitable and less water requiring crops is very much essential. Identification of efficient cropping systems with reference to productivity, profitability and sustainability has become imperative for double cropped delta regions (Nanda *et al.*, 1999). Therefore a study was planned to identify a profitable ID crop in place of rabi rice for double cropped deltaic region.

MATERIALS & METHODS

Field experiments were conducted for four consecutive *kharif- rabi* season of 2007-08, 2008-09 , 2009-10 and 2010-11 on Godavari Alluvia's (Vertic chromusters) at Andhra Pradesh Rice Research Institute, Maruteru, A.P. India (26.38^0 N, 84.44^0 E and 5 m above mean sea level). The soil was clay loam having pH 7.1, CEC of 40.9 meq/100g of soil, organic carbon 0.85%, available nitrogen 284 kg ha^{-1}, available P_2O_5 39kg ha^{-1} and K_2O 271kg ha^{-1} the top 30 cm soil had a bulk density of 1.57 g/cc, field capacity of 28.9% and permanent wilting of point of 16.8% on an oven dry basis. The trial was conducted with nine rice based cropping systems with an objective to find out a profitable rice based cropping system for double cropped delta areas This experiment was laid out in randomized block design with three replications and nine treatments consists of eight ID crops raised during rabi after kharif rice T_1 Rice -Maize (DHM 117),T_2 Rice -Sunflower (NDSH 1),T_3 Rice -Ground nut (K6),T_4 Rice -Gingelly (YLM 17),T_5 Rice -Black gram (LBG 752) ,T_6 Rice- Soybean (JS 335),T_7 Rice -Mustard (Varun), T_8 Rice- Ragi (Godavari) along with rice- rice (MTU 1010). *Khari*f rice was sown during last week of June and harvested in last week of November .After harvest of rainy season rice, filed was ploughed thrice, thoroughly pulverized and then the rabi crops were sown during 4th week of January during all the four years of study and harvested as and when they were matured. Recommended standard cultivation practices were followed for the respective crops. Grain/seed from the net plot was thoroughly sun dried to 14 per cent moisture content, weighed and expressed in kg $ha^{-1.}$ Number of days taken for maturity was recorded and presented as days to maturity. Water was measured using Water meters and Parshall flume. Economic parameters like gross returns,

net returns and rupee returned rupee^{-1} invested were worked out treatment – wise taking prevailing market rates for different inputs and out puts. Exegetics were calculated as per the procedure given by Panesar and Bhatnagar (1994). Sustainability Index was calculated using formula given by Gangwar *et al*. (2004). Rice equivalent yield (REY), land use efficiency (LUE), production efficiency (PE) and Economic efficiency (EE) was calculated using the formulae given by Singh *et al.* (2005). Nitrogen was estimated by modified micro- kjeldahl method and crude protein was estimated by multiplying total N with factor 5.95. The available P was estimated by the method of Olsen *et al.* (1954), respectively. The available K was estimated by flame photometer (Jackson, 1973). Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference (p= 0.05) by pooling four years data.

RESULTS & DISCUSSION

Four years pooled data revealed that among different rice based crops cultivated during *rabi* after *kharif* rice, Maize recorded higher grain yield followed by Ragi and soybean. Whereas rice equivalent yield of *rabi* crops as well as rice equivalent yield of the system were higher with Maize followed by Groundnut and mustard however maize only recorded higher yield than rice and theses two systems were also at par. Similar results of on par rice equivalent yield of the rice-rice and Rice-Maize systems have been reported by Kumar *et al.* (2005). The lowest system rice equivalent yield was produced by Rice-Ragi , which was mainly due to low sale price of Ragi however, it was at par to Rice-Gingelly, Rice- Black gram and Rice- Soybean systems.

TABLE 1. Performance of different ID crops in terms of yield, efficiency, sustainability and available N, P_2O_5 and K_2O status

(Over four years)

cropping systems	Kharif Rice yield (kg/ha)		Rabi crop yield(kg/ha)			REY of System (kg/ha)	P.E (%)	LUE	EE (%)	Sustainable yield Index	Water used (mm)	WUE (kg/ha/ mm)
	Mean Grain	Mean Straw	Mean Grain	Mean Stower	REY							
T_1 Rice -Maize	5653	6719	7943	8015	7288	12941	50.75	69.86	59.90	0.93	2000	6.47
T_2 Rice-Sunflower	5653	6802	1709	2680	3827	9480	37.92	68.49	-35.05	0.87	1950	4.86
T_3 Rice- Blackgram	5653	6816	874	1086	2528	8181	37.19	60.27	-52.39	0.77	1800	4.54
T_4 Rice - Musturd	5653	6792	727	1499	4062	9715	40.48	65.75	-13.80	0.79	1850	5.25
T_5 Rice - Soybean	5653	6809	1918	2136	3117	8770	35.80	67.12	-36.12	0.80	1900	4.62
T_6 Rice -Groundnut	5653	6822	1699	1785	4354	10007	37.06	73.97	-51.09	0.88	2050	4.88
T_7 Rice -Gingelly	5653	6146	756	1392	2481	8134	35.36	63.01	-49.65	0.76	1850	4.40
T_8 Rice -Ragi	5653	6783	2375	3563	2146	7799	30.00	71.23	-52.51	0.87	1950	4.00
T_9 Rice-Rice	5653	6795	6650	7589	6650	12303	46.43	72.60	Eco.	0.90	2740	4.49
SE+ d	-	-	-	-	-	507	-	-	-	-	-	-
CD (0.05)	-	-	-	-	-	1519	-	-	-	-	-	-

REY- Rice Equivalent yield P.E -Production efficiency; LUE- Land use efficiency ; EE- Economic efficiency
SYI : Sustainable yield Index : Water Use Efficiency

TABLE 2. Performance of different ID crops in terms of Water use efficiency, energetic and economics

(Over four years)

cropping systems	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-})	Benefit cost ratio	Energy input (MJ)	Energy output (MJ)	Energy use efficiency (MJ MJ^{-1})	Energy Productivity (kg/MJ)	Post soil available status(kg/ha)		
									N	P_2O_5	K_2O
T_1 Rice -Maize	68543	132823	64279	1.94	26585	186737	7.02	274	263	36.4	248
T_2 Rice-Sunflower	71310	97419	26109	1.36	24760	181737	7.34	155	269	34.8	251
T_3 Rice-Blackgram	65105	84246	19141	1.28	22685	117524	5.18	111	291	41.3	277
T_4 Rice - Musturd	64507	99159	34651	1.55	22062	174370	7.90	184	285	38.1	270
T_5 Rice - Soybean	64569	90249	25680	1.39	23178	145544	6.28	134	288	40.7	272
T_6 Rice - Groundnut	82971	102633	19662	1.24	27460	185750	6.76	159	287	39.5	271
T_7 Rice - Gingelly	63031	83272	20241	1.33	23763	137557	5.79	104	280	37.7	263
T_8 Rice -Ragi	60761	79853	19092	1.32	21568	112898	5.23	99	272	37.4	260
T_9 Rice-Rice	86115	126316	40201	1.47	33866	178640	5.27	196	281	38.9	253
SE+ d	769	5305	5533	0.08	-	-	-	-	6.02	1.69	5.33
`CD (0.05)	2304	15905	16588	0.25	-	-	-	-	18	NS	16

Initial soil available N, P_2O_5 and K_2O status (kg/ha) 284,39 and 271 respectively

The highest production efficiency of different rice based systems was recorded with Maize followed by Mustard and Sunflower. Regarding land use efficiency it was higher with Groundnut followed by Ragi and Maize. Economic efficiency of different ID crops was higher and positive with Maize only over Rice and remaining all ID

crops were on negative side. Sustainable yield index was also higher with Maize followed by Groundnut. Among different ID crops water used was lowest by rice –black gram, rice-gingelly and rice- mustard, while it was higher with rice –Groundnut and Rice- maize. Regarding Water use efficiency, it was highest with rice-Maize followed by rice- mustard because of higher production with less water use. However, the water use efficiency was less with rice-ragi and rice- gingelly than rice-rice. Similar results on Water use efficiency were reported by Parihar *et al.*, (1999).Data on economics of rice based cropping systems reveals that, rice-rice system recorded the highest cost of cultivation, followed by rice –Groundnut and rice-sunflower, while Rice-Ragi system recorded less cost of cultivation. Gross returns were higher in Rice -Maize system followed by Rice-Rice and Rice-Groundnut. The higher gross returns were owing to higher yield of Maize and rice after rice in sequence. Net returns and benefit cost ratio were higher in Rice -Maize system followed by Rice-Rice and Rice-Mustard. The results are in agreement with those of Kumar *et al.,* (2005). Energy intake was higher in Rice-Rice followed by Rice-Groundnut and Rice –Maize system because of higher energy requirement through fertilizer to Rice and Maize, higher energy requirement through seed for Ground nut. Whereas energy output was higher in Rice –Maize, Rice-Groundnut and Rice - Sunflower systems, these recorded higher energy output than Rice-Rice system. System energy use efficiency was higher in Rice – Mustard followed by Rice – Sunflower and Rice –Maize, while it was lowest in Rice- Black gram and Rice-Ragi systems. Rice –Maize recorded the highest energy productivity followed by Rice-Rice and Rice – Musturd, where as the energy productivity was lowest in Rice-Ragi and rice-Gingelly. These results are in corroboration with those of Parihar *et al.* (1999) and Pal *et al.* (1985). The post soil available nitrogen status was significantly reduced with Rice –Maize system after four years than initial and it was at par with other systems due to its exhaustive nature and higher nitrogen requirement. There was no change in status of available P_2O_5 after three years of the study over initial. As the double cropped delta area of Andhra Pradesh predominantly having black alluvial soils phosphorus status was static with different rice based cropping systems. The available K_2O status was significantly declined with Rice –Maize, Rice – Sunflower and Rice-Rice systems shows the higher replenishment of Potassium in double cropped deltaic soils. The result shows that legume crops are able to maintaining the soil fertility status than non legumes. Planiappan and Sivaraman (1994) also reported the stability of soil health with inclusion of Legume crops in cereal based systems.

CONCLUSIONS

The results indicate that ,among different rice based cropping systems Rice-Maize is the most viable option as it recorded higher system productivity, production efficiency , Economic efficiency, Water use efficiency, energy productivity, Sustainable yield index and Net returns and benefit cost ratio. Whereas System energy use efficiency was higher in Rice – Mustard, higher land use efficiency was recorded with Groundnut followed by Ragi and Maize. Though the results of Rice-Groundnut/Mustard are encouraging they cannot substitute Rice during Rabi.

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