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Diversification of rice (*Oryza sativa)* based cropping system for improving productivity and income in Telangana region of Andhra Pradesh

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ABSTRACT

Field experiments were conducted on a sandy clay loam soil during *kharif* and *rabi* 2006-07 and 2007-08 at Agriculture College Farm, Rajendranagar, Hyderabad to evaluate diversified rice (*Oryza sativa* L.) based cropping system with rice varieties and legume crops. The experiment was laid out in split plot design with three rice varieties of different durations, viz., 'Samba Mahsuri' (*BPT-5204*), 'Early Samba' (*M-7*) and 'Tellahamsa' as main plot treatments in *kharif* and sub-plot treatments of maize (*Zea mays* L.) with and without herbicides, greengram (*Vigna mungo* L.) and blackgram [*Vigna radiata* (L.) Wilczek] were super imposed on the rice varieties during *rabi* season in three replicates. 'Samba Mahsuri' long duration rice produced 0.9 and 1.9 t/ha higher yield and ₹ 7,891 and 16,074/ha higher net return over 'Early Samba' and 'Tellahamsa'. The performance of *rabi* crops was not influenced by the rice varieties of *kharif* season. In terms of rice equivalent yield and net returns, rice–zero tillage maize, irrespective of herbicides supplementation, was 103-197 percent superior over existing rice-pulse sequence. Soil fertility status and microbial population of the rice – maize system was lower than rice legume system.

***Key words* :** Cropping system, Economics, Maize, Microbial population, Pulses, Rice, Soil fertility

Rice–relay pulse crop sequence had been an important cropping system covering three lakh hectares in Andhra Pradesh and contributed to state and national food basket for nearly four decades. However, for the past five years, the greengram (*Vigna radiata* L.Wilczek) and blackgram (*Vigna mungo* L.) following rice crop have been infested by yellow vein mosaic and *cuscuta* weed. In the absence of immediate solution to the above problems, the rice-pulse sequence was replaced by rice-zero till maize (*Zea mays* L.) sequence. As tasseling stage in maize is thermo-sensitive (temperature more than 36°C causes pollen drying and barrenness), rice varieties of different durations were evaluated to identify a suitable rice variety which could be grown prior to maize crop, so that it escapes the unfavourable temperatures during tasseling stage. Problems of rice stubble rejuvenation and initial slow growth of maize crop and subsequent competition from the weeds are noticed in maize and not in pulse crops. Hence, herbicide treatments were included in maize crop only (Jugenheimer, 1958). Hence, the present investigation was undertaken to identify suitable variety of *kharif* rice fitting well in rice – maize/pulses cropping systems, compare the performance of rice – zero till maize / pulses crop sequences for productivity and soil fertility.

MATERIALS AND METHODS

The field experiments were conducted at the College Farm (17° 19' N latitude and 78° 23' E longitude, 542.6 m above mean sea level), College of Agriculture, Rajendranagar, Hyderabad, Andhra Pradesh. The average rainfall received during crop growing period in both years was 615.2 and 737.5 mm, respectively. Soil was sandy clay loam in texture with medium organic C content, low available N (235 kg/ha) and P (8.9 kg/ha) and medium available K (224.9 kg/ha) and slightly alkaline in reaction (pH 8.0). Three rice varieties *viz.*, 'Tellahamsa' of 120 days, 'Early Samba' of 135 days and 'Samba Mahsuri' of 150 days duration, were raised during *kharif* as main-plot treatments followed by sequential zero-till maize ('Kargil Super 900 M') with three treatment of herbicides (no herbicide, atrazine and paraquat) and two pulse crops *viz.*, greengram, 'ML-267' and blackgram, 'LBG-17' during *rabi* as sub-plot treatments, replicated thrice in a split-plot

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design. Rice received recommended dose of nutrients (120 N + 60 P_2O_5 + 40 K_2O kg/ha) of which nitrogen was applied in three equal splits i.e. basal (at the time of transplanting), active tillering and at panicle initiation stages while P and K applied as basal 'Maize' was fertilized with 120 N + 60 P_2O_5 + 40 K_2O/ha. Entire dose of P and K along with one-third quantity of N was applied at the time of sowing. Remaining quantity of N was top dressed in two equal splits at knee high and tasseling stages. Greengram and blackgram received 20 N + 50 P_2O_5 + 40 K_2O/ha each, all broadcasted on wet soil at the time of sowing. The source of N, P and K for all the crops was urea, single superphosphate and muriate of potash, respectively. During 2006, rice crop was planted on 16 July and harvested on 10 November 'Tellahamsa', 24 November 'Early Samba' and 7 December 'Samba Mahsuri', while during 2007, it was planted on 30 June and harvested on 25 October, 10 November and 22 November, respectively. Maize was sown on 11 November, 25 November and 8 December in 2006 and 26 October, 12 November and 23 November in 2007 and harvested on 15 March, 5 April and 21 April in 2007 and 26 February, 21 March and 4 April in 2008. Consequent to harvest of the three rice varieties at different dates, varieties of rice as main plot treatments become date of sowing treatments for *rabi* crops. For greengram and blackgram, soaked seeds were relay cropped one week prior to harvest of each rice variety and harvested on 9, 23 and 31 January in 2007 and 22 December 2007 and 7 and 16 January 2008 'Greengram' and 18 January, 2 February and 9 February in 2007 and 31 December 2007 and 17 and 26 January 2008 'Blackgram'. Initial and final available nitrogen, phosphorus and potassium in the soil were estimated by the standard methods. Total count of microbial population was estimated by using the standard dilution plate technique (Allen, 1957). Analysis of variance for split plot using the IRRISTAT programme was followed for statistical analysis.

RESULTS AND DISCUSSION

Productivity and economics

On an average, rice yield of 'Samba Mahsuri' increased by 10.4 and 24.7 percent over 'Early Samba' and 'Tellahamsa', respectively (Table 1). Long duration nature of the variety was favourable to assimilate and translocate maximum amount of photosynthates from source to sink resulting in higher percentage of filled spikelets compared to medium and short duration varieties. Such varieties have more vigour and inheritance of superior growth, yield attributing characteristics, and higher grain and straw yields. Hence rice grain yield and straw yield of 'Samba Mahsuri' was superior to 'Early Samba' which was in turn superior to 'Tellahamsa'. On the other hand, there was no significant effect of previous rice varieties on growth, development and yield of maize, even though dates of harvest of rice varieties and subsequent sowing times of maize were different as they fell within the recommended time of sowing of maize in this region. Hence, maize grain and stover yield following different varieties did not vary much leading to carry over effect of high *kharif* rice yields to higher rice equivalent yields with 'Samba Mahsuri' followed by 'Early Samba' and 'Tellahamsa' sequence. Consequently the net returns and B: C ratio followed the same trend. Mahapatra and Behera (2004) also reported similar results in rice–wheat cropping system.

Among the cropping systems, rice – maize cropping system, irrespective of the herbicide treatments, recorded 77.5 and 86.9 percent higher productivity over rice-blackgram and rice-greengram systems. Maize 'Kargil Super 900 M' being a single cross hybrid and C_4 in nature exploited well, the natural and applied resources over greengram or blackgram resulting in higher grain and stover yield. Greater yield and higher demand of the maize produce in summer fetched higher price. Consequently the rice equivalent yields from rice - maize sequence were higher. On an average the net income and benefit: cost ratio were ₹37,673 and 1.03 and ₹39,802 and 1.13 higher over rice – blackgram and rice – greengram sequence, respectively (Table 1). The results are in conformity with the findings of Sarkar *et al*. (2000), Gangwar *et al*. (2006) and Prasad and Urkurkar (2010) also reported superiority of rice – maize system over rice-pulse system. Within rice – maize cropping system, zero-tillage maize supplemented with paraquat spray on rice stubbles recorded the highest total productivity (11.13 t/ha) in terms of rice equivalent yield however, it remained on par with rice – maize cropping system supplemented with atrazine as pre – emergent spray (Table 1). Both of these treatments were significantly superior to rice – maize system without herbicidal treatment. The zero – till maize supplemented with paraquat application prevented rejuvenation of rice stubbles (Table 2) and early vigour of the crop could be maintained for improved vegetative, reproductive and yield structure of maize resulting in higher yield compared to no herbicide treatment. On the other hand, pre-emergence atrazine spray was more effective in controlling first flush of weeds (Table 1) and maintained better ambience and higher nutrient uptake resulting in improved growth, yield attributes and yield. Hence, their combined use in zero–tillage maize needs further investigation. Kumar *et al*. (2005) also reported similar results. Economic analysis of supplementation of herbicides in zero tillage maize revealed higher net returns with both paraquat and atrazine. Similar results were also reported by Anapurnamma *et al*. (2010). Between two herbicide treatments, paraquat results in higher B:C ratio. Even – though, the net returns and benefit cost of herbicide treatments were similar to no herbicide treatment, their use still appears mandatory to prevent further proliferation and population built up of weeds, particularly under zero–tillage. The results are in line with the findings of Mishra and Singh (2011)

Available N, P and K status of soil

Among rice varieties, 'Tellahamsa', being a short duration variety, got lesser time to assimilate the applied nutrients and thus left behind higher soil available N, P and K after its harvest (Table 2). On the other hand, 'Samba Mahsuri' a long duration variety had enough time to absorb and assimilate nutrients and hence left the soil with lower fertility status. These results corroborate with Kumar and Prasad (2004). Among cropping sequences, rice – maize irrespective of the herbicide treatments showed lower fertility status of the soil after harvest, compared to rice – pulse sequence. Obviously pulses, with characteristic promotion of free living micro organisms (*Rhizobium sps*), solubulization of insoluble Al-P and Fe-P fractions through exudation of organic substances through their nodules (Palaniappan and Sivaraman, 1994) and release of K by mineralization (Saha and Moharana,

Table 1. Productivity, economics, sprouted rice stubble and weed and dry matter of different cropping systems as influenced by various treatments (Mean of 2 years)

Treatment	*Kharif* rice yield (t/ha)	*Rabi* maize/pulse yield (t/ha)	Rice equivalent yield (t/ha)	Net returns (×10^3 ₹/ha)	B:C ratio	Sprouted rice stubbles (%)	Weed dry matter (g/m^2)
Kharif rice varieties							
'Tellahamsa'	3.51	4.09	7.69	34.5	2.1	21.1	16.9
'Early Samba'	4.49	4.11	8.69	43.0	2.4	17.5	21.5
'Samba Mahsuri'	5.38	4.11	9.59	50.9	2.7	15.0	26.7
SEm±	-	-	0.17	-	-	0.9	0.8
CD (P=0.05)	-	-	0.48	-	-	2.3	2.1
Rabi crops							
Maize without herbicide	4.43	6.36	10.56	56.2	2.8	32.5	36.0
Maize with atrazine	4.46	6.63	10.87	58.9	2.8	13.1	12.7
Maize with paraquat	4.46	6.91	11.13	60.1	2.9	8.1	16.4
Sole greengram	4.48	0.26	5.22	18.6	1.7	1.4	1.6
Sole blackgram	4.48	0.37	5.48	20.7	1.8	3.2	3.3
SEm±	-	-	0.36	-	-		
CD (P=0.05)	-	-	0.80	-	-		

Price of produce used were: paddy grain ₹7,100 and 8,000; paddy straw ₹550 and 600; pulse grian ₹20,000 and 20,000; pulse bhusha ₹600 and 600; maize grain ₹6,800 and 7,800; maize stover ₹ 350 and 400/tonne during 2006-07 and 2007-08 respectively.

Table 2. Available N, P and K (kg/ha) status of soil after harvest of *rabi* crops and microbial population in soil as influenced by treatments

Treatment	2006 – 07			2007 – 08			Microbial population before sowing of *rabi* crops (×10^6 cfu/g soil)	Microbial population at harvest of *rabi* crops (×10^6 cfu/g soil)
	N	P	K	N	P	K		
Kharif rice varieties								
'Tellahamsa'	281.1	29.5	295.9	288.4	31.4	297.5	15.44	21.90
'Early Samba'	247.2	24.9	248.2	253.7	26.1	249.3	15.54	22.01
'Samba Mahsuri'	228.2	17.5	206.2	228.5	18.1	206.3	15.62	22.16
SEm±	2.11	1.92	5.42	1.9	1.48	7.12	0.77	0.45
CD (P=0.05)	5.85	5.34	15.05	5.28	4.11	19.77	NS	NS
Rabi crops								
Maize without herbicide	252.5	23.2	233.1	256.1	24.4	234.5	15.46	19.58
Maize with atrazine	237.8	17.1	224.8	241.4	18.9	225.6	15.52	19.60
Maize with paraquat	226.3	14.5	216.6	231.4	15.9	217.5	15.50	19.67
Sole greengram	270.6	31.6	285.7	276.3	32.8	286.5	15.59	25.49
Sole blackgram	273.5	33.6	290.3	279.1	34.0	290.8	15.60	25.76
SEm±	4.53	3.93	10.97	4.05	3.04	14.40	1.55	0.91
CD (P=0.05)	9.90	9.27	27.16	8.90	7.06	35.69	NS	2.44

2007) are known to enrich the soil. Budgeting of the nutrients added as fertilizer and of those removed by crops showed lower status of the nutrients of N, P and K in rice–maize system compared to rice–pulse cropping sequence.

Microbial population

Microbial population was not significantly affected by previous rice crop varieties. However, on an average total microbial population decreased by 30.6 percents with new cropping system of rice–zero till maize compared to rice-greengram and rice-blackgram sequences (Table 2). Pulse crops are leguminous in nature, and known to encourage microbial activity through symbiotic biological nitrogen fixation, leaf shedding habit and exudation of organic substances from root nodules, act as substrate to microbes. Thus, rice–pulse crop sequence record higher microbial count than rice–maize. As nutrient status and microbial population of soil after the new rice–zero till maize sequence is comparatively lower, there is need to improve the soil health status by inclusion of short duration forage legume after rice–zero till maize or application of green leaf manure or organic manures like FYM etc, to restore original status and sustainability of the soil.

Rice–zero tillage maize was superior to the existing system of rice–relay pulse crop sequence in terms of productivity, and net returns. The results also portray the emerging problems of reduction in soil fertility status and microbial population with zero–till maize, and the need to restore the soil health for sustained production.

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