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Productivity and economics of rice-zero till maize as influenced by weed management practices in southern Telangana region of Andhra Pradesh

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ABSTRACT

A field experiment was conducted on sandy clay loam soil of Andhra Pradesh during *kharif* and *rabi* seasonsics of rice-zero till maize cropping system. The results showed that the rejuvenation of rice stubbles in the sequence crop of *rabi* maize were more in early harvested than late harvested rice varieties and reverse was the trend in weed growth. Among herbicide treatments, use of paraquat as pre-emergence application for controlling rejuvenation of rice stubbles in zero-till maize was superior to pre-emergence application of atrazine and no-herbicide treatment. On the other hand pre-emergence application of atrazine was more effective in controlling first flush of weeds than paraquat and no-herbicide treatment. Herbicide treatments, consequent to termination of rice stubble and weed competition, promoted plant growth, dry matter production, nutrient uptake, yield structure and yield of maize and consequently productivity and economics of the system as compared to no-herbicide treatment. Rice-zero till maize irrespective of the herbicide supplementation gave higher rice equivalent yield, net returns and benefit of cost when compared to existing rice-pulse sequence. However, soil fertility status and microbial status of the rice-maize cropping system was no match to the existing system of rice-pulse sequence and herbicide treatments did not exhibit any detrimental effect on microbial population. of 2006-07 and 2007-08 on the effect of weed management practices on the productivity and economy.

Key words : Rice stubbles Rejuvenation, PRE herbicides, soil microbial population Weed management , Economy of weed management.

Rice-relay pulse crop sequence is an important crop sequence covering three lakh hectares in Andhra Pradesh. For the past half decade, the green gram and blackgram were subjected to yellow vein mosaic and Cuscuta problem and in the absence of immediate solution to the problem, the rice-pulse sequence was replaced by rice-zero till maize sequence as the latter is endowed with unparallel cultivar and technology improvement. In the conventional rice-maize cropping system, due to efficient land preparation after rice, the problem of rejuvenation of rice stubble was not encountered and initial weed problem is solved by pre emergence application of atrazine. In rice relay pulse crop sequence, the broadcast of presoaked seeds in rice crop 10 days prior to harvest in standing crop, three times high seed rate, ephemeral crop growth nature prevented rejuvenation of rice stubbles and initial weed growth without any weed control measure. But these problems are encountered in present rice- zero till maize due to sowing of maize crop after rice harvest, wide spacing, erect and slow early growth nature of crop. Hence, the present study was undertaken to find out a package to overcome the above problems and evaluate this new cropping system in terms of production, net returns and soil fertility and sustainability aspects with the traditional rice-fallow pulse sequence.

MATERIAL AND METHODS

An experiment was conducted at College Farm, College of Agriculture, Rajendrangar, Hyderabad, Andhra Pradesh during *kharif* and *rabi* seasons of 2006-07 and 2007-08. The average rain fall received during crop growing period in both years was 615.2 and 737.5 mm, respectively. The soil was sandy clay loam in texture with medium organic carbon content, low available nitrogen (235 kg/ha) and medium available phosphorus (20.2 kg/ha) and potassium (271 kg/ha) contents with slightly alkaline pH (8.0). The experimental design was split plot with three replicates. The main plot treatments were three rice varieties (Tellahamsa, Early samba and Samba Mahsuri) raised in kharif. The sub plot treatments were

sequential zero till maize (Kargil super 900M) treated with herbicides, no herbicide (S_1), atrazine (S_2), 1.5 kg a.i./ha and paraquat (S_3),1.5 l/ha and pulse crops viz., greengram and blackgram. As tasseling stage in maize is thermo sensitive [temperature more than 36^0C cause pollen drying and barrenness (Jugenheimer 1958], different durations of rice varieties were tested to identify a suitable rice variety which can be grown prior to maize crop, so that it can escape from unfavourable temperature. Pulses like green and black gram were included in the sub treatments to compare the yield, economics and soil health of new cropping system with traditional system. Recommended dose of 120, 60 and 40 kg/ha, N, P and K were applied to rice crop. Nitrogen was applied in three equal splits i.e. basal (at the time of transplanting), active tillering and at panicle initiation stages. Entire dose of P and K were applied as basal and incorporated before transplanting. Similarly, recommended dose of 120, 60 and 40 kg/ha N, P, K was also applied to maize crop. Entire dose of P and K along with one third dose of nitrogen was applied as basal placement at a depth of 5 cm and 5-7 cm away from crop rows while remaining two equal splits of nitrogen were top dressed at knee high and tasseling stages. In case of greengram and blackgram recommended dose of 20, 50 and 40 kg/ha N, P and K was applied and entire dose of N, P and K was broadcasted at the time of sowing in wet soil. The sources of N, P and K for all the crops were urea, single super phosphate and muriate of potash, respectively. The rice crop was planted on 16th July 2006 and 30th June 2007 and harvested on 10th November (Tellahamsa), 24th November (Early Samba) and 7th December (Samba Mahsuri) in the first year and 25th October, 10th November and 22nd November in the second year and maize crop was sown on 11 th November, 25th November and 8th December in 2006 and 26th October, 12th November and 23rd November in 2007 and harvested on 15th March 5th and 2th April in 2007 and 26th February, 2st March and 4th April in 2008 consequent to harvest of the three rice varieties at different dates.

Soaked seeds of pulse crops were relay cropped 10 days prior to harvest of each rice variety and harvested on 9th, 23rd and 31st January in 2007 and 22nd December 2007 and 7th and 16th January 2008 (Greengram) and 18th January, 2nd February and 9th February in 2007 and 31st December 2007 and 17th and 26th January 2008 (Blackgram). The seed rate of rice, maize and pulse crops (greengram and blackgram) were 50, 20 and 40 kg/ha respectively. The herbicides were paraquat and atrazine was applied as pre-emergence. The weed data was collected at 30 DAS and rejuvenation of rice stubbles were counted on 15 DAS as quadratic method (0.5 m x o.5 m). The plot size for both crops was 6 m x 5 m (kharif rice followed by sequence crops). Initial and final available nitrogen, phosphorus and potassium in the soil were estimated by prescribed standard methods and total count of microbial population was estimated by following the standard dilution plate technique (Allen 1957). Analysis of variance for split plot using the IRRISTAT programme was followed for statistical analysis. Due to variation in economic products of rice, maize, greengram and blackgram raised in different seasons, total productivity of the system was assessed in terms of rice equivalent and straw equivalent yield.

RESULTS AND DISCUSSION

Rice stubble rejuvenation and weed growth

In the cropping system of rice- zero till maize, the removal of apical dominance due to rice harvest stimulated lower buds, and wide spacing and slow initial (3-4 weeks) growth nature of crop and maintenance of high soil moisture regimes in maize promoted both rice stubble rejuvenation and first flush of weeds. These problems were absent in the traditional rice-fallow pulse sequence due to high seed rate, emergence and development of pulse seedlings prior to removal of apical dominance by rice harvest. Consequent to lower moisture regimes (as the pulse crop raised on receding soil moisture) and ephemeral crop growth nature, the rejuvenation of rice stubbles and first flush of weeds did not have any impact on pulse crops. Sprouted rice stubbles and weed growth was significantly affected by previous rice varieties and herbicides treatments. The interaction was non-significant. Short duration rice variety promoted more rejuvenation rice stubbles than medium and long duration varieties (Table 1). On the other hand, higher weed growth (measured as weed dry matter) was recorded in long duration varieties when compared to medium and short duration varieties. Among herbicide treatments, paraquat spray on rice stubbles controlled rice stubble rejuvenation but was less effective in controlling first flush of weeds in zero-till sequential maize. Immediately after rice harvest, consequent to removal of apical dominance, the lower buds were stimulated and spray of paraquat on them appear to have instantly killed the emerging cells in the bud and inhibited their growth and rejuvenation. As

Table 1. Number of sprouted rice stubble (%) and weed dry matter (g/m^2) in zero-till maize as affected by treatments

Treatments	Sprouted rice stubble (%) (mean of 2 years)	Weed dry matter (g/m^2) (mean of 2 years)
***Kharif* rice varieties**		
Tel lahamsa	21.14	16.88
Early Samba	17.54	21.45
Samba Mahsuri	14.99	26.70
LSD (P=0.05)	2.33	2.12
***Rabi* cropping systems**		
Maize without herbicide (S_1)	32.47	35.97
Maize with atrazine (S_2)	13.12	12.66
Maize with paraquat (S_3)	8.08	16.40
LSD (P=0.05)	3.17	3.31

Note: - Interaction non-significant

paraquat was adsorbed by soil particles and was no consequence in control of first flush of weeds. Systemic nature of atrazine did not appear to have impact to suppress the rejuvenation of rice stubbles but could prevent first flush of weeds (Table 1). Hence the present finding is of practical utility to the farmers who are raising this cropping system in more than two lakh Hectares in Rice belt of Andhra Pradesh. However, the combined use of paraquat and atrazine on zero till maize in sequence to rice needs further research probe.

Productivity and economics

Zero till maize supplementation with paraquat and atrazine consequent to termination of the established and existing rice stubble rejuvenation and first flush of weeds (as shown by lower dry matter of weeds) and maintenance of early vigour and growth of the crop lead to higher nutrient uptake resulting in improved growth, yield attributes and yield of maize (Tables 2 and 3). Hence, the productivity of the system was superior with herbicide treatments over no-herbicide. Analysis of economics

Table 2. Plant height (cm) and dry matter production (kg/ha) of maize at 30 DAS as influenced by treatments

Treatments	2006- 07		2007- 08	
	Plant height (cm)	Dry matter production (kg/ha)	Plant height (cm)	Dry matter production (kg/ha)
***Kharif* Rice varieties**				
Tellahamsa	34.8	1245.0	36.4	1251.3
Early Samba	36.6	1248.5	37.3	1264.8
Samba Mahsuri	37.4	1252.9	38.0	1278.4
LSD (P=0.05)	NS	NS	NS	NS
***Rabi* cropping Systems**				
Maize without herbicide (S_1)	32.8	1145.4	33.1	1171.9
Maize with atrazine (S_2)	36.5	1260.9	37.2	1266.0
Maize with Paraquat (S_3)	39.6	1340.1	41.4	1356.7
LSD (P=0.05)	2.9	63.7	4.0	66.1

Note: - Interaction non-significant

Table 3. Yield and yield attributes of maize as influenced by treatments

Treatments	2006 – 07				2007 – 08			
	Cob length (cm)	Cob girth (cm)	Seed weight (g)	Maize yield (kg/ha)	Cob length (cm)	Cob girth (cm)	Seed weight (g)	Maize yield (kg/ha)
***Kharif* rice varieties**								
Tellahamsa	16.3	15.2	24.1	6596.4	16.8	15.3	24.3	6627.6
Early Samba	16.5	15.3	24.2	6620.1	16.9	15.5	24.6	6651.6
Samba Mahsuri	17.0	15.3	24.4	6625.4	17.1	15.6	24.6	6664.0
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
***Rabi* cropping Systems**								
Maize without herbicide (S_1)	15.8	14.3	23.0	6341.9	16.2	14.5	23.3	6369.1
Maize with atrazine (S_2)	16.6	15.2	24.0	6613.0	17.0	15.4	24.3	6644.9
Maize with Paraquat (S_3)	17.4	16.3	25.6	6887.1	17.5	16.6	25.9	6929.1
LSD (P=0.05)	0.4	0.7	NS	210.1	0.5	0.8	NS	224.6

Note : Interaction non-significant

Table 4. Total productivity of different cropping systems as influenced by treatments

Treatments	2006 07				2007 08			
	Rice yield (kg/ha)	Maize Grain yield/pulse yield (kg/ha)	Rice Equivalent yield (kg/ha)	Straw Equivalent yield (kg/ha)	Rice yield (kg/ha)	Maize Grain yield/pulse yield (kg/ha)	Rice Equivalent yield (kg/ha)	Straw Equivalent yield (kg/ha)
***Kharif* rice varieties**								
Tel lahamsa	3504	4079	7643	8033	3523	4101	7732	8229
Early Samba	4482	4096	8644	9349	4497	4117	8727	9560
Samba Mahsuri	5374	4100	9539	11195	5388	4128	9634	11439
LSD (P=0.05)	-	-	368	554	-	-	387	592
***Rabi* cropping Systems**								
Maize without herbicide (S_1)	4426	6342	10478	11334	4440	6369	10650	11675
Maize with Atrazine (S_2)	4451	6613	10785	11587	4470	6645	10949	12008
Maize with Paraquat (S_3)	4442	6887	11038	12200	4469	6929	11225	12569
Sole Green gram (S_4)	4476	250	5217	6134	4492	263	5216	6122
Sole Black gram (S_5)	4471	366	5503	6373	4478	370	5449	6341
LSD (P=0.05)	-	-	625	985	-	-	653	1003

Note: - Interaction non-significant

followed the same trend. Eventhough, the net return and benefit cost of herbicide treatments was not superior , still their use appear mandatory to prevent further proliferation and population built up of weeds in already reduced intensively cultivated land holdings of the country in general and Andhra Pradesh in particular and need to produce more from less land resource. Total productivity in terms of rice and straw equivalent yield was significantly effected by rice varieties and herbicide treatments during both the years of experimentation (Table 4). 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 grains as compared to medium and short duration varieties. Such varieties have more vigour and inheritance of superior growth and yield attributing characteristics and higher grain and straw yields. Hence rice grain yield and straw yield of BPT 5204 was superior over M-7 which was in turn superior over Tellahamsa. On the other hand, there was no significant effect of previous rice varieties on growth, development and yield of maize eventhough dates of harvest of rice varieties and subsequent sowing of maize crop were different as they fell within the recommended time of sowing 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 BPT- 5204 followed

Table 5. Available N, P and K (kg/ha) status of the soil after harvest of rabi crops as influenced by treatments

Treatments	2006 – 07			2007 – 08		
	N	P	K	N	P	K
***Kharif* rice varieties**						
Tellahamsa	281.1	29.5	295.9	288.4	31.4	297.5
Early Samba	247.2	24.9	248.2	253.7	26.1	249.3
Samba Mahsuri	228.2	17.5	206.2	228.5	18.1	206.3
LSD (P=0.05)	5.9	5.3	15.1	5.3	4.1	19.8
***Rabi* cropping systems**						
Maize without herbicide (S_1)	252.5	23.2	233.1	256.1	24.4	234.5
Maize with atrazine (S_2)	237.8	17.1	224.8	241.4	18.9	225.6
Maize with Paraquat (S_3)	226.3	14.5	216.6	231.4	15.9	217.5
Sole Greengram (S_4)	270.6	31.6	285.7	276.3	32.8	217.5
Sole Blackgram (S_5)	273.5	33.6	290.3	279.1	34.0	286.5
LSD (P=0.05)	9.9	9.3	27.2	8.9	7.1	35.7

Note: Interaction non-significant. Initial soil status N : 235.0 kg N/ha, P : 20.2 kg/ha and K : 271.0 kg/ha

by M-7 and Tellahamsa. Consequently the net returns and B : C ratio followed the same trend. Mahapatra and Behera (2004) also reported similar results. With present findings, rice – zero till maize become good substitute to the traditional rice maize system (Chandrapala *et al.* 2010 and Gangwar *et al.* 2011) and rice – relay pulse cropping (Naidu *et al.* 2012) .

Total available N, P and K status of the soil

Among rice varieties, Tellahamsa being short duration variety got lesser time to assimilate entire quantity of nutrients applied from extraneous sources which left higher soil available N, P and K after its harvest (Table 5). On the other hand, BPT- 5204, a long duration variety had enough time to uptake and assimilate nutrients and hence left the soil with lower fertility status.

Among cropping system treatments, all rice-maize cropping sequences irrespective of the weedicide treatments showed lower fertility status of the soil after their harvest when compared rice-pulse sequence. Obviously pulses, with characteristic promotion of free living micro organisms, solubulization of insoluble AI-P and Fe-P fractions through exudation of organic substances through their nodules and release of K by mineralization known to enrich the soil. Saha and Moharana (2007) also reported similar results.

Microbial population

Microbial population was not significantly affected by previous rice crop varieties. However, on an average total microbial population decreased by 30.6% with new cropping system of rice-zero till maize when compared to traditional rice- pulse cropping system. Zero till maize supplementation with herbicides, did not further lower the microbial population (Table 6). Evidently unlike pulse crops which are leguminous in nature, encourage microbial activity through symbiotic biological nitrogen fixation, leaf shedding habit and exudation of organic exudates from root nodules that acts as substrate to microbes and as all these were absent in maize crop which lead to lower microbial count. Hence, consequent to lower nutrient status and microbial population of soil after the new rice-zero till maize crop sequence, there is need to improve the soil health status by inclusion of short season forage legume after new sequence or application of green leaf manure or organic manures like FYM etc., to restore original status and sustainability of the soil.

Conclusions

Thus, if rice crop is planted in *kharif* on recommended time, a long duration rice variety like BPT- 5204 should be preferred over medium and short duration cultivars. Both paraquat application on rice stubbles and pre-emergence application of atrazine recommended to counter rejuvenation of rice stubbles and first flush of weeds and their combined use needs further probe. To restore original soil health status and sustainability it is mandatory to raise forage legume after this new cropping sequence or apply organic manures.

Table 6. Microbial population in soil at sowing and after harvest of *rabi* crops as influenced by treatments

Treatments	2006 – 07		2007 – 08	
	Microbial population at before sowing of *rabi* crops (x 10^6 cfu/g soil)	Microbial population at harvest of *rabi* crops (x 10^6 cfu/g soil)	Microbial population at before sowing of *rabi* crops (x 10^6 cfu/g soil)	Microbial population at harvest of *rabi* crops (x 10^6 cfu/g soil)
***Kharif* rice varieties**				
Tellahamsa	15.38	21.86	15.51	21.94
Early Samba	15.49	21.98	15.59	22.04
Samba Mahsuri	15.55	22.06	15.69	22.26
LSD (P=0.05)	NS	NS	NS	NS
***Rabi* cropping systems**				
Maize without herbicide (S_1)	15.41	19.56	15.52	19.60
Maize with atrazine (S_2)	15.48	19.59	15.55	19.62
Maize with Paraquat (S_3)	15.45	19.66	15.55	19.69
Sole Greengram (S_4)	15.52	25.40	15.65	25.57
Sole Blackgram (S_5)	15.51	25.61	15.69	25.90
LSD (P=0.05)	NS	2.21	NS	2.27

Note : Interaction non-significant

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