The Andhra Agric. J 58(2):133-139, 2011

Influence of Rice-Zero Tillage Maize System on Productivity and Soil Fertility Status

B Mukundam, S Srividya and V Raja
AICRP on Soil Test Crop Response, A R I, Rajendranagar, Hyderabad – 30 A P

ABSTRACT

Field experiments were conducted on sandy clay loam soils at Agricultural college farm of Acharya N.G. Ranga Agricultural University Rajendranagar, Hyderabad, during *kharif* and *rabi* seasons on the evaluation of package to *kharif* rice and zero till sequential maize on the productivity of newly evolved rice-till sequential zero-till maize in southern telangana zone of Andhra Pradesh. A long duration rice variety, higher recommended dose of nitrogen level of 125 % and granular form of urea recorded higher rice yield. The final nutrient status of the soil revealed that among rice varieties Tellahamsa left the soil with higher N, P and K status when compared to BPT-5204 and Early samba. The performance of *rabi* sequence crops under zero tillage were not influenced by duration of rice varieties of *kharif* season. Their performance on the basis of rice equivalent yield and net returns revealed that the new rice-zero tillage maize irrespective of weedicide treatment was superior over existing rice-pulse sequence. However, the sequential zero–till maize irrespective of the weedicide treatment showed lower fertility status as compared to traditional rice-pulse sequence warranting inclusion of third sequence short season legume or green leaf of manuring or organic manures to restore original status and sustainability of the soil health.

Key words : Atrazine, Blackgram, Forms of urea, Greengram, Paraquat and *Rabi* maize,

. To meet the food requirement of growing population, there is a need to produce more from unit area and in unit time. This would be possible by raising more crops by reducing turnover time (time gap between harvest of one crop and establishment of second crop). Zero tillage or reduced tillage is a means of achieving this breakthrough. As a result, rice relay pulse cropping sequence of rice-greengram / blackgram emerged. In the absence of improved cultivar and production technology, there will be crop shifts leading to change in cropping system. Rice fallow pulse sequence after forty years of its contribution to state food basket, is being replaced, as the pulse crops, greengram and blackgram were subjected to yellow vein mosaic and *cuscuta* problems leading to lower pulse yields and lower system productivity. In the absence of immediate solutions to the above problems, crop shift took place to utility oriented unexploited maize crop endowed with unparalleled cultivar and agro-technology improvement. But the problems encountered in the new cropping system are thermosensitive nature of maize at tasseling (Temperature more than 36^0C cause pollen drying and barrenness), competition to maize from rejuvenated rice stubble and first flush of weeds. The present study was, therefore, planned to overcome above problems and generate a package for the new cropping system and compare its productivity and post soil fertility status with the existing Rice-pulse relay sequence.

MATERIAL AND METHODS

Two separate field experiments were conducted at College Farm, College of Agriculture, Rajendranagar, Hyderabad, A.P, during *kharif* and *rabi* seasons of 2006-07 and 2007-08. The average rainfall received during crop growth 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 in available nitrogen (235 kg ha^{-1}) and medium in available phosphorus (20.2 kg ha^{-1}) and potassium (271 kg ha^{-1}) contents with slightly alkaline in reaction (pH 8.0). The first experiment was laid out in split-split plot design with three replications. The main treatments consisted of three rice varieties, (Tella hamsa, 120 days, Early Samba (M-7), 135 days and BPT-5204, 150 days). The sub treatments consisted of three levels of nitrogen *i.e.* 75, 100 and 125% of RDN and sub-sub treatments consisted of two forms of urea *i.e.* PU - Prilled Urea and GU – granular Urea. Recommended nitrogen in the region is 120 kg N ha^{-1}. The second experiment consisted of three rice varieties (Tellahamsa, 120 days, Early samba, 135 days and Samba Mahsuri, 150 days) raised during *kharif* as

Table 1. Yield attributes and grain yield and economics of rice as influenced by different treatments (mean of two years)

Treatments	Panicle length (cm)	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Net returns (Rs./ha)	B:C Ratio
Kharif rice varieties						
Tellahamsa	18.32	23.7	3.769	4.179	10, 841	1.54
Early Samba	19.59	21.1	4.813	5.552	19, 490	1.97
Samba Mahsuri	20.98	18.4	5.759	7.543	27, 793	2.38
SEm ±	0.18	0.48	0.156	0.278	-	-
CD (0.05)	0.71	1.89	0.612	1.091	-	-
N levels						
75% RDN	17.99	20.3	4.516	5.479	17, 535	1.89
100% RDN	19.58	21.1	4.800	5.762	19, 532	1.97
125% RDN	21.31	21.8	5.025	6.033	21, 056	2.03
SEm ±	0.13	0.11	0.046	0.036	-	-
CD (0.05)	0.41	0.35	0.141	0.112	-	-
Forms Urea						
Prilled Urea	19.08	20.8	4.666	5.662	18, 449	1.92
Granular Urea	20.18	21.3	4.894	5.854	20, 299	2.01
SEm ±	0.06	0.07	0.030	0.034	-	-
CD (0.05)	0.18	0.22	0.090	0.102	-	-

Note: Interaction non significant

main plot treatments and sequential zero-till maize (cv. Kargil Super 900 M) treated with herbicides (no herbicide (S_1), atrazine (S_2) and Paraquat (S_3)) and pulse crops viz., Greengram, cv. ML-267 (S_4) and Blackgram, cv. LBG-17 (S_5) sown during *rabi* as sub-plot treatments, replicated thrice in split plot design. As tasseling stage in maize is thermosensitive, different durations of rice varieties were tested to identify a suitable rice variety which can be grown prior to zero till *rabi* maize crop, so that it can escape from unfavourable temperature during tasseling stage of crop. Problem of rice stubble rejuvenation, wide spaced and initial slow growth nature of maize crop not noticed in pulses and encountered only in new cropping system, hence weedicides were tested only in maize crop and not in pulses. Pulses, greengram and blackgram were included in the sub treatments of the second experiment to compare the yield, economics and soil health of new cropping system with traditional system. The total number of irrigations were given to maize during crop growth period was 4, 8, 9 and 4, 7 and 7 for first, second and third sowing of maize in 2006-07 and 2007-08 respectively. In the second year due to unseasonal rains (197.0 mm in 11 rainy days) after sowing, number of irrigations were reduced. Greengram and blackgram raised on residual soil moisture required only two irrigations to complete their crop growth period. Recommended dose of 60 P_2O_5 and 40 K_2O kg ha^{-1} were applied uniformly to rice crop in both the experiments. Nitrogen as per the treatment in the first experiment and uniformly @ 120 kg N ha^{-1} was applied to second experiment. Nitrogen was applied to rice crop in *kharif* in three equal splits i.e. basal (at the time of transplanting), active tillering and at panicle initiation stages. Entire dose of P_2O_5 and K_2O was applied as basal and incorporated before transplanting. Similarly recommended dose of 120 N, 60 P_2O_5 and 40 K_2O kg ha^{-1} was also applied to maize crop. Entire dose of P_2O_5 and K_2O along with one third dose of nitrogen was applied as basal by 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 N, 50 P_2O_5 and 40 K_2O kg ha^{-1} was applied and entire dose of N, P_2O_5 and K_2O was broadcasted at the time of sowing in wet soil. The sources of N, P_2O_5 and K_2O for all the crops were Urea, SSP and Muriate of

Table 2. Productivity and economics of different cropping systems as influenced by various treatments (mean of 2 years)

Treatments	*Kharif* Rice yield (t ha^{-1})	*Rabi* Maize/ pulse yield (t ha^{-1})	Rice equivalent yield (t ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Kharif rice varieties					
Tellahamsa (V_1)	3.514	4.090	7.687	34, 837	2.1
Early Samba (V_2)	4.490	4.107	8.686	43, 020	2.4
Samba Mahsuri (V_3)	5.381	4.114	9.586	50, 911	2.7
SEm ±	-	-	0.171	-	-
CD (0.05)	-	-	0.475	-	-
Rabi crops					
Maize without herbicide(S1)	4.433	6.356	10.575	56, 263	2.8
Maize with atrazine(S2)	4.461	6.629	10.867	58, 905	2.8
Maize with paraquat(S3)	4.456	6.908	11.132	60, 086	2.9
Sole greengram(S4)	4.484	0.257	5.217	18, 616	1.7
Sole blackgram(S5)	4.475	0.368	5.476	20, 745	1.8
SEm ±	-	-	0.362	-	-
(P = 0.05)	-	-	0.801	-	-

Note: Interaction non significant

V_1, V_2 and V_3 becomes date of sowing treatments for *rabi* crops in column three

Data in column two against S_1, S_2, S_3, S_4 and S_5 treatments is Rice yield in *kharif*

	Rate of produce/tonne	
	2006-07	2007-08
Paddy grain	7, 100	8, 000
Paddy straw	550	600
Greengram and Blackgram grain	20, 000	20, 000
Greengram and Blackgram bhusha	600	600
Maize grain	6, 800	7, 800
Maize Stover	350	400

Potash respectively. The rice crop in both the experiments was planted on 16th July 2006 and 30th June 2007 and harvested on 10th Nov (Tellahamsa), 24th Nov (Early Samba) and 7th December (Samba Mahsuri) in the first year and 25th Oct, 10th Nov and 22nd Nov in the second year and in the second experiment sequential zero till maize crop was sown on 11th Nov, 25th Nov and 8th December in 2006 and 26th Oct, 12th Nov and 23rd Nov in 2007 (The sowing was done manually in rows 60 cm X 25 cm apart at 4-6 cm depth by making a hole with wooden stick and putting 2 seeds in each hole (dibbling)) and harvested on 15th March, 5th April and 21st April in 2007 and 26th February, 21st March and 4th April in 2008 consequent to harvest of the three rice varieties at different dates. Similarly in the second trial, soaked seeds of pulse crops were relay cropped one week 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). Initial and final available nitrogen, phosphorus and potassium in the soil were estimated by prescribed standard methods. Due to variation in economic products of

Table 3. Number of sprouted rice stubbles (%) and weed dry matter (g/m^2) in zero-till maize as affected by treatments (mean of 2 years)

Treatments	Sprouted rice stubbles	Weed dry matter
Kharif rice varieties		
Tellahamsa	21.1	16.9
Early Samba	17.5	21.5
Samba Mahsuri	15.0	26.7
SEm ±	0.8	0.8
CD (0.05)	2.3	2.1
Rabi crops		
Maize without herbicide	32.5	36.0
Maize with atrazine	13.1	12.7
Maize with paraquat	8.1	16.4
SEm ±	1.4	1.6
(P = 0.05)	3.2	3.3

Note: Interaction non significant

rice, maize, greengram and blackgram raised in different seasons, total productivity of the system was assessed in terms of rice equivalent yield.

RESULTS AND DISCUSSION

Performance of rice varieties

Long duration rice variety (BPT-5204) recorded 19.7, 35.9, 42.6, 24.0 and 52.8, 80.5, 156.4, 54.5 % more grain yield, straw yield, net returns and B:C ratio over Early samba and Tellahamsa varieties, 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 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 (Table 1). Hence rice grain yield and straw yield of BPT 5204 was superior to M-7 which was in turn superior to Tellahamsa. Reddy and Kumar (1999) also reported similar results. Even though rice varieties reached physiological maturity and harvesting at different times, the temperatures at the time of tasseling stage of the sequential maize crop after three rice varieties was below 36^{0}C permitting successful sequential zero till maize (Jugenheimer, 1958). Thus in case of early onset of monsoon and sufficient inflows into water bodies, rice variety of any duration can be planted in the existing rice zero till maize, as harvesting of all the varieties falls within recommended time of sowing of *rabi* maize (First week of October to 2nd fort night of December). Level of nitrogen or forms of urea did not effect the duration of rice varieties.

Effect of N levels

All the growth and yield parameters were found maximum with 125% RDN resulting in higher grain and straw yield of all the three varieties (Table 1). Continuous cropping and N losses in low land rice, warrant higher RDN level to any rice variety irrespective of the duration from the present study. Advantage of higher levels of N over lower levels of N was reported by Abdul Rasheed Wani *et al*. (1999).

Effect of forms of urea

Application of nitrogen through granular urea increased rice yield by 4.9 % over prilled urea (Table 1). Complete transformation of N in granular urea in to granular form and relatively large size and weight of granular urea made them to seep in to the reduced zone releasing positively charged NH^+ ions. This made nitrogen to remain stable for long period prevented its loss and made available to crop for long period. This also prevented excess availability of the nitrogen in the soil and to the crop at the time of N application and its deficiency before next split application favoring its uniform availability throughout growth processes. Complementary nature of N for P and K availability resulted in higher uptake of N, P and K leading to better vegetative, reproductive,

Table 4. Soil available N, P and K (kg/ha) status after harvest of *kharif* rice as influenced by different treatments in the years of 2006 and 2007

Treatments	2006			2007		
	N	P	K	N	P	K
Kharif rice varieties						
Tellahamsa	243.48	32.8	274.04	244.84	34.30	276.44
Early Samba	223.88	23.09	221.25	225.24	24.19	222.53
Samba Mahsuri	202.47	13.66	177.91	203.85	14.64	178.86
SEm ±	1.06	0.40	1.30	1.53	0.34	1.58
CD (0.05)	4.15	1.56	5.12	5.99	1.34	6.21
N levels						
75% RDN	218.02	24.80	231.98	218.72	26.25	233.43
100% RDN	223.35	23.23	224.62	224.45	24.34	225.71
125% RDN	228.46	21.59	216.59	230.746	22.53	218.68
SEm ±	1.14	0.34	0.83	0.95	0.36	1.03
CD (0.05)	3.50	1.06	2.57	2.93	1.10	3.19
Forms of Urea						
Prilled Urea	222.20	24.10	225.93	223.56	25.49	227.49
Granular Urea	224.35	22.31	222.87	225.72	23.26	224.39
SEm ±	0.68	0.23	0.741	0.6	0.26	0.92
CD (0.05)	2.02	0.67	2.11	1.96	0.78	2.73

Note: Interaction non significant

Initial Soil Status

N: 235.0 kg N/ha P_2O_5: 20.2 kg/ha K_2O: 271.0 kg/ha

yield structure and high grain and straw yield. Granular urea was superior to prilled urea, irrespective of rice varieties and RDN levels. Beneficial effect of granular urea over prilled urea was reported by Karuna Sagar and Rama Subba Reddy (1992)

Performance of cropping systems

Among the cropping systems, rice-zero till maize cropping system, irrespective of the herbicide treatments recorded 77.5 and 86.9 % more productivity over rice-blackgram and rice-greengram systems (Table 2). Maize with single cross hybrid and C_4 nature of the plant exploited well the natural and applied resources over greengram or blackgram resulting in higher grain and stover yield. High yield of the economic product and more demand of the produce in summer fetched good price and consequently the rice equivalent yield was high. On an average, the net income and benefit cost of rice-zero till maize were Rs. 37,604 and 1.0 and 39,748 and 1.1 higher over rice blackgram and rice greengram sequences in 2006-07 and 2007-08 respectively (Table 2). The results are in conformity with the findings of Gangwar *et al*. (2006) who also reported superiority of rice-maize system over rice-pulse system. Within rice-zero till maize cropping system, zero-tillage maize supplemented with paraquat spray on rice stubble recorded maximum total productivity in terms of rice equivalent yield and it remained on a par with rice-zero till maize cropping system supplemented with atrazine as pre-emergent spray (Table 2). The above treatments were found significantly superior to rice-zero till maize system without herbicidal treatment. The zero till maize supplementation with paraquat prevented rejuvenation of rice stubble (Table 3) and maintained early vigour of the crop for improved vegetative and

Table 5. Soil available N, P and K (kg/ha) status after harvest of *rabi* crops as influenced by different treatments under zero till conditions

Treatments	2006 – 07			2007 – 08		
	N	P	K	N	P	K
Kharif rice varieties						
Tellahamsa	281.05	29.52	295.93	288.44	31.36	297.51
Early Samba	247.15	24.93	248.18	253.65	26.10	249.29
Samba Mahsuri	228.23	17.54	206.16	228.49	18.10	206.33
SEm ±	2.11	1.92	5.42	1.9	1.48	7.12
CD (0.05)	5.85	5.34	15.05	5.28	4.11	19.77
Cropping Systems						
Maize with out herbicide (S_1)	252.52	23.18	233.11	256.11	24.35	234.54
Maize with Atrazine (S_2)	237.80	17.13	224.76	241.36	18.85	225.61
Maize with Paraquat (S_3)	226.30	14.51	216.64	231.39	15.87	217.46
Sole Green gram (S_4)	270.62	31.57	285.67	276.29	32.82	286.51
Sole Black gram (S_5)	273.47	33.60	290.25	279.14	34.04	290.76
SEm ±	4.53	3.93	10.97	4.05	3.04	14.40
CD (0.05)	9.90	9.27	27.16	8.90	7.06	35.69

Note: Interaction non significant

Initial Soil Status

N: 235.0 kg N/ha P_2O_5: 20.2 kg/ha K_2O: 271.0 kg/ha

reproductive growth and yield structure of maize resulting in high yield as compared to no herbicide treatment. On the other hand, pre-emergence atrazine spray was more effective in controlling first flush of weeds (Table 3) and maintained better ambience and higher nutrient uptake resulting in improved growth, yield attributes and yield of zero till maize. Hence, their combined use in zero tillage maize needs further research probe. On an average, rice equivalent yield in rice-maize sequence increased by 2.4 and 5.4 % due to paraquat over atrazine and no herbicide treatments. Avil 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, but benefit cost ratio was higher with paraquat. Eventhough, the net returns and benefit cost of herbicide treatment were marginal over no herbicide treatment, still their use in zero till maize appears mandatory to prevent further proliferation and population built up of weeds in already reduced intensively cultivated land holdings of India in general and Andhra Pradesh in particular and need being more to produce from limited holdings.

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 4). 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. The results are in conformity with the findings of Pandey *et al*. (1991). Among the N levels and sources tried, 125 % RDN and granular urea recorded higher available N status in soil. The

increase in available N might be due to increased and steady mineralization of N at 125 % RDN and in the form of granular urea respectively (Table 4). Whereas, the total available P and K recorded in the soil was higher with prilled form of urea and at lower level of N (75 % RDN). Lower N level and prilled form of urea might have favoured less utilization of available P and K leading to higher P and K status of soil and similar results were reported by Patel *et al*. (1997) and present findings are in line with above researchers.

Among cropping system treatments, all rice-maize cropping sequences irrespective of the weedicide treatment showed lower fertility status of the soil after their harvest when compared rice-pulse sequence (Table 5). Obviously pulses, with characteristic promotion of free living micro organisms (*Rhizobium*), solubulization of insoluble Al-P and Fe-P fractions through exhudation of organic substances through their nodules (Palaniappan and Sivaraman 1994) and release of K by mineralization (Sanjay Saha and Monalisa Moharana 2007) known to enrich the soil.

Conclusion

The results suggest planting of any rice variety irrespective of duration when monsoon onset and inflows into water bodies is at the recommended time. Additional dose of 125% RDN and granular form of urea sustains higher *kharif* rice yields. Paraquat application on rice stubbles prevent their rejuvenation while pre emergence application of atrazine control first flush of weeds. The newly evolved Rice-zero till maize cropping system is more profitable than the existing rice-pulse cropping system terms of productivity but leaves the soil with lower nutrient status.

LITERATURE CITED

Abdul Rasheed Wani, Badrul Haran and Amarjit S Bali 1999. Relative efficiency of some modified urea materials in transplanted rice under temperate conditions of Kashmir. Oryza 36 (4): 382 – 383.

Avil Kumar K, Reddy N V and Sadasiva Rao K 2005. Profitable and energy-efficient rice (*Oryza sativa*)-based cropping systems in northern Telangana of Andhra Pradesh. Indian Journal of Agronomy 50 (1): 6 – 9.

Gangwar B, Duhoon S K and Pandy D K 2006. Diversification of maize-based cropping systems. Indian Farming 56 (6): 20 – 24.

Jugenheimer W R 1958. Hybrid maize breeding and seed production. 1-369 p. Food and Agriculture Organization of the United Nations Rome.

Karuna Sagar G and Rama Subba Reddy G 1992. Effect of different forms of urea and levels and times of application of nitrogen on growth and yield of rice. Oryza 29(4): 376-378.

Palaniappan S P and Sivaraman K 1994. Cropping systems in the tropics principles and management. New age International Limited, Publishers pp. 1 -211.

Pandey S K, Rajkumar, Singh R and Singh B B 1991. Effect of different doses of nitrogen on dwarf and tall varieties of rice (*Oryza sativa*). Indian Journal of Agricultural Science 61 (2): 135 – 138.

Patel S R, Thakur D S and Pandya K S 1997. Response of rice (*Oryza sativa* L.) to nitrogen levels and pre conditioned urea in inceptisols. Fertilizer News 42 (8): 37-40.

Reddy M D and Kumar K A 1999. Effect of levels of time of nitrogen application on performance of late puddle seeded rice (*Oryza sativa*). Indian Journal of Agronomy 44 (2): 297 – 300.

Sanjay Saha and Monalisa Moharana 2007. Production potential and economics of different rice-based relay cropping systems under rainfed shallow lowlands of coastal Orissa. Oryza 44(2): 134-136.

(Received on 29.03.2011 and revised on 10.05.2011)