

Original Research Article

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Productivity and Economics of Rice (*Oryza sativa*)-Zero Till Maize (*Zea mays*) as Affected by Rice Establishment Methods and Weed Management Practices

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ABSTRACT

A field experiment was conducted during 2010-11 and 2011-12 at Hyderabad, to study the effect of rice (*Oryza sativa* L.) establishment methods and weed management practices on succeeding zero till maize. The experiment was laid out in split design during *kharif* and split- split during *rabi* season and the treatments were replicated thrice. Three rice establishment methods [sowing of sprouted rice under puddle condition, system of rice intensification and conventional transplanting] as main plots, four weed management practices [bensulfuron methyl 60 g + pretilachlor 600 ga.iha⁻¹ followed by mechanical weeding at 30 DAS/T, bispyribac sodium @ 25 g a.iha⁻¹, farmer's practice and weedy check] as sub plots and weed management practices in maize [weedy check, atrazine @ 1.0 kg a.iha⁻¹, atrazine @ 1.0 kg a.iha⁻¹ and hand weeding twice] as sub-sub plots on rice-maize sequence. Manual transplanting of rice resulted in higher dry matter accumulation, yield attributes and yield and recorded lower weed density and weed dry matter. Transplanted rice in rice-maize sequence recorded the highest rice equivalent yield, net returns and benefit cost ratio. Among weed management practices in rice, Farmer's practice recorded higher grain yield and yield attributes during both the years and it was followed by bensulfuron methyl 60 g + pretilachlor 600 ga.iha⁻¹ followed by mechanical weeding at 30 DAS/T. Hand weeding twice in maize resulted in higher yield of maize. Transplanting in rice, farmer's practice of weeding in rice and application of atrazine @ 1.0 kg a.iha⁻¹ followed by topamezone @ 30 g a.iha⁻¹ resulted in the highest total productivity and profitability of the rice-maize system.

Keywords

Establishment methods, Rice, Maize and yield.

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Introduction

Rice (*Oryza sativa* L.) – rice is the predominant cropping sequence in Andhra Pradesh. Rice is grown mostly under transplanting method in India, though transplanting is popular and successful method the fact is that it is labour intensive practice. The inadequacy of irrigation water and scarce labour coupled with higher wages during the peak period of farm operations,

invariably lead to delay in transplanting. To overcome this problem, farmers are gradually switching over to maize crop production in the *rabi* season. Replacement of rice with maize (*Zea mays* L.) in dry season is increasing to save water and for maximum system production. Weed management is an important key factor in obtaining higher crop yield. Unchecked weed growth causes a

reduction in grain yield by about 30-36% in transplanted rice and 61% in wet direct seeded rice. Though manual weeding is considered to be the best, the undependable labour availability and escalating wages in many cases has given impetus to the development and use of chemicals which can control broad spectrum of weeds. Residual effect of weed management practices of rice may influence weed flora in succeeding crops. When crops are grown under zero tillage conditions in rice fallows there is a chance of heavy infestation of weeds. To control weeds for extended period during crop growth pre and post emergence herbicides can be applied. The information on influence of various weed management practices in different rice establishment methods on succeeding zero till maize was merger. Keeping these facts in view, the present investigation was undertaken.

Materials and Methods

A field experiment was conducted during 2010-11 and 2011-12 at College Farm, College of Agriculture, Rajendranagar, Hyderabad, Andhra Pradesh, India. The soil was sandy loam with pH 7.8. The available nitrogen, phosphorus and potassium content in the soil was 234.5, 28.9 and 271.6 kg ha⁻¹ respectively. The experiment was laid out in split design during kharif season and split-split design during *rabi* season with three replications. The treatments consisted of three method of establishment methods, viz. sowing of sprouted seeds under puddle condition (20 x 10 cm), SRI (25 x 25 cm) and normal transplanting (20 x 10 cm) as main plots; four weed management practices in rice, viz. bensulfuron methyl 60 g + pretilachlor 600 g a.i ha⁻¹ followed by mechanical weeding at 30 DAS/T, bispyribac sodium @ 25 g a.i ha⁻¹, farmer's practice (hand weeding twice at 20 and 40 DAS in direct seeded rice and transplanted rice, conoweeding thrice from 20 DAT with 10 days interval in SRI) and weedy

check as sub-plots and weed management practices in maize (during *rabi*) weedy check, atrazine @ 1.0 kg a.i ha⁻¹, atrazine @ 1.0 kg a.i ha⁻¹ followed by topramezone @ 30 g a.i ha⁻¹ and hand weeding twice at 20 and 40 DAS as sub-sub plots.

Rice establishment methods

Direct sowing

Twenty four hour soaked and 48 hour incubated seeds were sown at 20 x 10 cm spacing in the main field designated to direct sowing treatment. After germination of seeds, excess seedlings were thinned out to maintain two seedlings per hill at 15 DAS. Direct sowing and nursery sowing for normal transplanting and system of rice intensification were done simultaneously on same day in both years. Sowing was done with a variety MTU 1010.

SRI transplanting

A seed rate of 5 kg ha⁻¹ was adopted. The sprouted seeds were sown on the mat nursery which was prepared by using the polythene or gunny bags on the shallow raised bed to prevent roots growing deep into the soil. Then 12 days old seedlings were pulled out and planted as single seedlings with a spacing of 25 x 25 cm.

Transplanting

Twenty five day old seedlings were transplanted at 20 x 10 cm spacing in leveled plots which were designated to be normal transplanting.

Weed management practices

Bensulfuron ethyl 60 g + pretilachlor mixture 600 g a.i ha⁻¹ was applied at 3 DAS/T by mixing with sand and followed by a mechanical weeding with push hoe at 30

DAS/T. Bisbyribac sodium @ 25 g a.iha⁻¹ was applied as early post emergence when, weeds were at 2-3 leaf stage. A thin film of water is maintained at the time of herbicide application. Farmer's practice comprises hand weeding twice at 20 and 40 DAS/T was carried out in normal transplanting and direct seeding of sprouted seeds, conoweeding thrice from 20 DAT with 10 days interval in SRI. The un-weeded control as weedy check was kept undisturbed for the entire cropping period.

Maize 'DHM -117' seeds were dibbled at 60 cm x 20 cm spacing in rabi season under zero tilled method after harvesting of rice crop. Fertilizer application, irrigation, pest and disease control and other crop management practices were adopted as per the recommendations for the region. Atrazine @ 1.0 kg a.iha⁻¹ was applied as pre emergence at 2 DAS and topamezone was applied as post emergence @ 30 g a.iha⁻¹ at 30 DAS. The cost of cultivation, net returns and benefit: cost ratio was calculated on the basis of prevailing market price of different inputs and outputs. Rice equivalent yield was calculated using price of crops.

Results and Discussion

Rice performance

Yield attributes and grain yield of rice were affected by various crop establishment methods. The highest grain yield was obtained with transplanting which was on par with SRI and significantly superior over direct sown rice under puddled condition. The effect on growth, viz. plant height, dry matter and yield attributes, viz., number of panicles and grains per panicle was also similar under transplanting. Submerged conditions in transplanted rice facilitate availability of more nutrients by reducing leaching and keep the salt content under control which encouraged tiller production while contributing to higher

dry matter production and grain yield. Similar findings were observed by Shashikumar (1990). Significantly lower values were observed under direct sown rice under puddle condition might be due to hindered spikelet differentiation resulting in few grains per panicle. Similar results were reported by Gill *et al.*, (2006) and Awan *et al.*, (2007). Among weed management practices in rice, farmer's practice of weeding gave significantly higher yield attributes and grain yield and which was on par with application of bensulfuron methyl 60 g + pretilachlor 600 g a.iha⁻¹ followed by mechanical weeding at 30 DAS/T.

The performance of rice 2011 was better than 2010 due to higher weed density and weed dry matter. Higher yield attributes have been achieved with both treatments is due to decreased weed competition during critical crop growth stages and thereby providing better crop growing environment and nutrition to the crop resulted in higher yield attributes.

The results are in conformity with the findings of Rajkhowa *et al.*, (2007), Bhat *et al.*, (2011) and Shan *et al.*, (2012). Crop establishment methods and weed management practices failed to bring significant difference with respect to 1000 grain weight during both the years. Interactions between the crop establishment methods and weed management practices in rice were not significant for yield and yield attributes of rice (Table 1).

Maize performance

Yield attributes and grain yield of maize were influenced significantly due to different methods of establishment in preceding rice, weed management practices in rice and in maize. Numbers of grains per cob, grain weight per cob and grain yield were found to be significantly higher when the maize was grown after transplanting method of rice and which was significantly superior over other two methods of establishment (Table 2).

Table.1 Effect of crop establishment methods and weed management practices on yield attributes and grain yield of rice

Treatments	Plant height (cm)		Panicles /m ²		Grains/panicle		Test weight (g)		Grain yield (kg/ha)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Main treatments										
SRI	82.70	84.36	260	263	92.10	95.68	20.14	20.16	4265	4438
Direct sown rice	78.37	79.83	255	261	82.58	88.33	19.29	20.03	3894	4075
Transplanting	84.16	85.50	269	266	94.41	98.08	20.31	20.38	4408	4593
SEm±	1.04	1.14	6	5	2.05	1.61	0.26	0.35	91	90
CD (5%)	4.09	4.47	NS	NS	8.03	6.33	NS	NS	356	354
Sub treatments										
Bensulfuron methyl+ Pretilachlor followed by mechanical weeding at 30 DAS/T	84.27	87.54	299	300	105.29	106.94	20.39	20.85	5326	5585
Bispyribac sodium	80.53	82.29	257	264	84.82	91.92	19.91	19.77	3975	4158
Farmer's practice	86.77	90.08	304	306	109.10	111.86	20.93	21.30	5601	5857
Weedy check	75.40	73.02	184	183	59.57	65.39	18.43	18.83	1854	1874
SEm±	1.34	1.11	5	6	1.39	1.70	0.30	0.34	95	107
CD (5%)	3.98	3.31	16	18	4.12	5.06	NS	NS	283	318
Interaction										
SEm±(MxS)	2.32	1.93	9	11	2.40	2.95	0.52	0.59	165	185
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEm± (SxM)	2.15	2.19	12	10	3.74	3.16	0.52	0.68	177	182
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table.2 Influence of crop establishment methods in rice and weed management practices in rice-maize sequence on yield attributes and yield of maize

Treatments	No. of grains cob ⁻¹		Grain weight cob ⁻¹ (g)		Test weight (g)		Grain yield (kg ha ⁻¹)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Main treatments (MT) -Rice								
M ₁ – SRI	335.08	347.63	135.01	139.17	29.54	29.57	5063	5438
M ₂ – Direct sown rice	321.04	338.38	129.86	132.41	29.40	29.34	4781	5124
M ₃ – Transplanting	361.77	387.13	147.44	151.06	29.85	30.41	5680	5843
S.Em±	6.04	6.61	2.97	2.63	0.10	0.37	154	102
CD (0.05)	23.71	25.95	11.68	10.34	NS	NS	606	400
Sub-treatments (ST) - Rice								
S ₁ – Bensulfuron methyl + Pretilachlor followed by mechanical weeding at 30 DAS/T	344.15	362.09	140.56	145.35	29.75	29.86	5329	5557
S ₂ – Bispyribac sodium	331.53	353.17	135.02	136.73	29.47	29.66	5059	5404
S ₃ – Farmer’s practice	356.17	365.50	143.01	149.54	29.82	30.23	5443	5665
S ₄ – Weedy check	325.42	350.47	131.16	131.91	29.33	29.34	4866	5248
S.Em±	5.56	3.86	2.57	3.64	0.11	0.15	119	80
CD (0.05)	16.51	11.49	7.64	10.82	NS	NS	353	239
Sub-sub treatments (W)-Maize								
W ₁ – Weedy check	188.75	195.31	97.36	96.06	27.85	28.04	2009	2074
W ₂ – Atrazine	350.25	372.17	139.73	141.84	29.80	29.83	5720	6154
W ₃ – Atrazine followed by Topramezone	398.92	419.83	150.83	156.97	30.28	30.44	6326	6652
W ₄ – Weed free(hand weeding twice at 20 and 40 DAS)	419.44	443.53	161.82	168.65	30.47	30.68	6644	6993
S.Em±	6.60	4.01	3.87	3.93	0.16	0.15	106	92
CD (0.05)	18.61	11.30	10.92	11.08	NS	NS	299	260
Interaction								
MT at ST : S.Em±	10.29	8.79	4.87	6.06	0.19	0.44	236	158
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
MT at W : S.Em±	11.59	8.93	6.53	6.45	0.26	0.45	222	172
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
ST at MT : S.Em±	9.63	6.70	4.45	6.31	0.18	0.26	206	139
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
ST at W : S.Em±	12.71	7.95	7.18	7.72	0.30	0.33	219	179
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
W at MT : S.Em±	11.43	7.95	6.71	6.80	0.28	0.30	184	160
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
W at ST : S.Em±	13.20	8.01	7.75	7.86	0.32	0.34	212	185
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
W at MT, ST : S.Em±	22.86	13.89	13.42	13.61	0.55	0.59	368	320
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
ST at MT, W : S.Em±	2.54	2.22	1.27	1.43	0.05	0.11	57	39
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
MT at ST, W : S.Em±	2.06	1.53	1.09	1.22	0.04	0.07	41	30
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table.3 Rice equivalent yields (REY) and economics of rice-maize system as influenced by rice crop establishment methods and weed management practices

Treatments	Grain yield of rice (kg/ha)	Grain yield of maize (kg/ha)	REY OF MAIZE (kg/ha)	Total REY (kg/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
Main treatments-Rice							
SRI	4438	5438	4934	9372	101223	58728	2.38
Direct sown rice	4075	5124	4650	8725	94225	51085	2.18
Transplanting	4593	5843	5302	9895	106866	62796	2.42
Sub-treatments- Rice							
Bensulfuron methyl + Pretilachlor followed by mechanical weeding at 30 DAS/T	5585	5557	5042	10627	114777	71834	2.67
Bispyribac sodium	4158	5404	4904	9062	97866	54933	2.28
Farmer's practice	5857	5665	5140	10997	118773	72840	2.59
Weedy check	1874	5248	4732	6607	71357	30537	1.74
Sub-sub treatments -Maize							
Weedy check	4369	2074	1852	6221	67187	25953	1.62
Atrazine	4369	6154	5584	9953	107492	65181	2.54
Atrazine followed by Topramezone	4369	6652	6036	10405	112375	69660	2.63
Weed free (hand weeding twice at 20 and 40 DAS)	4369	6993	6346	10715	115717	69360	2.50

The higher plant height may be due to higher available nutrients after transplanted rice crop. The highest grain yield was due to higher availability of nutrients, lower weed dry matter which resulted in higher dry matter accumulation and higher yield attributes. Chandrapala (2009) also reported similar results. Among weed management practices in rice, farmer's practice of weeding resulted in higher yield attributes and yield of maize and which was on par with bensulfuron methyl 60 g + pretilachlor 600 g a.iha⁻¹ followed by mechanical weeding at 30 DAS/T.

The treatments imposed on rice showed similar effect on weed dry matter and yield in both rice and succeeding maize. Similar findings were reported by Gangwar and Singh (2010) due to different establishment methods of rice on different succeeding crops. In maize, hand weeding twice at 20 and 40 DAS resulted in significantly lower weed density and dry matter and recorded higher yield attributes and yield of maize compared to other weed management practices.

This could be due to reduced weed competition and complete utilization of growth factors by crop. The results corroborate the findings of Shekhawat *et al.*, (2002) and Patel *et al.*, (2006). Interactions among different treatment were found to be non-significant.

Rice equivalent yield

Transplanting of rice gave the highest REY and proved better than other methods of establishment. The next best treatment was SRI. Dhiman *et al.*, (1998) also reported higher productivity of rice-wheat system with transplanting in rice. Farmer's practice of weeding in rice and hand weeding twice at 20 and 40 DAS resulted in higher rice equivalent yield compared other treatments.

Economics

In rice-maize system, transplanting of rice gave maximum gross returns, net returns and benefit: cost ratio and hence proved more remunerative than the other methods of establishment. The next best treatment was SRI. Sharma *et al.*, (2002) reported greater output: input ratio with transplanted rice than dry-seeded rice. Even though farmer's practice of weeding in rice resulted in higher gross and net returns, but higher B: C ratio was observed under bensulfuron methyl 60 g + pretilachlor 600 g a.iha⁻¹ followed by mechanical weeding at 30 DAS/T. Similarly, hand weeding twice at 20 and 40 DAS in maize registered higher gross and net returns in maize. However, higher B: C ratio was recorded with the application of atrazine @ 1.0 kg/ha followed by topramezone @ 30 g a.iha⁻¹ (Table 3).

It can be concluded that transplanting method of establishment and application of bensulfuron methyl 60 g + pretilachlor 600 g a.iha⁻¹ followed by mechanical weeding at 30 DAS/T in rice, application of atrazine @ 1.0 kg/ha followed by topramezone @ 30 g a.iha⁻¹ in maize is more beneficial to get higher productivity and profitability of the rice-maize system.

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