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Yield and Economic Impact of Different Crop Establishment Methods and Weed Management Practices on Rice

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A B S T R A C T

A field experiment was conducted at College of Agriculture, PJTSAU, Hyderabad, during *kharif*-2016. The experiment was laid out in split plot design with three replications. The treatments consisted of three establishment methods of rice *viz.*, transplanted rice, direct seeded rice and aerobic rice, five levels of weed management practices *viz.*, Farmers method (Hand weeding 20 and 40 DAT/DAS), bispyribac sodium 10% SC 25 g ha^{-1} as PE fb fenoxaprop-p-ethyl 9.3% EC 62 g ha^{-1} + 2, 4-D 80% WP 0.5 kg ha^{-1}, penoxsulam+ pendimethalin 25% SE 25 g + 600 g ha^{-1}PE at 4-7 DAS/DAT, pretilachlor 50 % EC 0.75 kg ha^{-1} as PE fb hand weeding at 20 and 40 DAT/ DAS and unweeded control. The results from present investigation depicts that the direct seeded rice and transplanted rice recorded highest grain yield, straw yield and harvest index. Pretilachlor as PE *fb* hand weeding twice at 20 and 40 DAS/T, though it was at par with hand weeding twice at 20 and 40 DAS/T produced significantly more grain yield, straw yield and harvest index as compared to other treatments and the maximum gross and net return was recorded under crop raised through direct seeded rice in puddled condition in combination with application of pretilachlor as PE *fb* HW at 20and 40 DAS/T over rest of the treatments. The benefit: cost ratio was found highest underdirect rice in puddled condition followed by transplanted rice with the application of pendimethalin +penoxsulam as PE at 4-7 DAS/T over rest of the treatments.

Introduction

Rice (*Oryza sativa* L.) is the most important cereal crop and a staple food for one third of the world population. It is necessary to increase its production and productivity in order to meet the growing demand of rice by our increasing population. The total area of rice in India is 44.1 million hectares, with a production and productivity of 105.3 million tonnes and 2.38 t ha^{-1} respectively (Department of Agriculture and Cooperation, 2015-16). Telangana contributes 14.15 lakh hectares area annually with a production of 45.45 lakh tons, with an average productivity of 3211 kg ha^{-1} during 2015-2016.

(Department of Agriculture and Cooperation, 2015-16). In India, transplanting is the common method of establishing rice crop. However, this method is not much profitable due to several reasons such as labour shortage, power crisis and water shortage due to late release of water into the canals, higher cost of cultivation and delayed monsoon showers. This forced to identify alternate methods of rice cultivation without reduction in yield in addition to saving energy, water and time. Further, rice production under current inputs and technology fails to meet the projected demand thus, there is an urgent need to increase rice productivity per unit area in the world. Direct seeding is one of the alternative methods to transplanting, as it reduces labour requirement and performs as good as transplanting method at many places. Uncontrolled weed growth in transplanted rice causes 45-51% loss in yield (Veeraputhiran and Balasubramanian, 2013), whereas weed growth under direct seeded rice causes yield losses up to 80% (Jabran *et al.*, 2012). Several herbicides have been proved successful to control weeds in transplanted rice. Most of the herbicides in rice are used to control grassy weeds effectively, but sedges and broad leaved weeds are also the major weeds to reduce the yield. So change in rice cultivation methods and devise efficient weed management practice to cater the future needs of the rice production is the need of hour.

Materials and Methods

The experiment was carried out at College Farm, College of Agriculture, Rajendranagar, Hyderabad. The farm is geographically situated at $17^0$19' 16.4" North latitude and 78^0 24' 43" East longitudes and at an altitude of 542.3 m above mean sea level. The soil of the experimental field was sandy clay loam in texture with pH 7.85, low in available nitrogen (213.2 kg ha^{-1}), high phosphorus (36.8 kg ha^{-1}) and potassium (379.0 kg ha^{-1}). The experiment was laid out in split plot design with three replications. The treatments consisted of three establishment methods of rice *viz.*, transplanted rice, direct seeded rice and aerobic rice, five levels of weed management practices *viz.*, Farmers method (Hand weeding 20 and 40 DAT/DAS), bispyribac sodium 10% SC 25 g ha-1 as PE fb fenoxaprop-p-ethyl 9.3% EC 62 g ha-1 + 2, 4-D 80% WP 0.5 kg ha-1, pendimethalin + penoxsulam 25% SE 25 g + 600 g ha-1 PE at 4-7 DAS/DAT, pretilachlor 50 % EC 0.75 kg ha-1 as PE fb hand weeding at 20 and 40 DAT/ DAS and unweeded control. In aerobic rice, seeds were sown at 20 cm apart.

While, in direct seeded rice (under puddled condition) sprouted seeds were sown in line manually at 20 cm. The recommended nursery area (20 cents ha^{-1}) was puddled, leveled and the sprouted seeds (40 kg ha^{-1}) were broadcasted uniformly with a thin film of standing water. The nursery was managed well with irrigation. Uniform dose of 150, 60 and 60 kg N, P_2O_5 and K_2O ha^{-1}as urea, SSP and muriate of potash. Nitrogen was applied in three equal splits at transplanting, maximum tillering stage and panicle initiation stage. The recommended dose of phosphorous was applied as basal dose at the time of transplanting and potassium was applied in two splits at transplanting and panicle initiation stage.

To work out the economics of different crop establishment methods and weed control treatments information on the existing market price of different herbicides and inputs was used. Labour units required for hand weeding and herbicide application was considered in addition to regular components of the cost of cultivation. Cost of labour was calculated by taking into account the prevailing labour wages at the time of investigation. Harvest index (%), gross returns, net returns and benefit cost ratio (expressed in rupees) were worked out by using the following formulae.

$$HI\ (\%) = \frac{\text{Grain yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

Where, biological yield = Grain yield + Straw yield

Gross return = Grain yield x market rate of grain + straw yield x market rate of straw.

Net returns = Gross returns – total cost of cultivation

$$\text{Benefit Cost ratio} = \frac{\text{Gross returns}}{\text{Total cost of cultivation}}$$

Results and Discussion

Effect on yield (kg ha^{-1}) and harvest index

Different methods of establishment significantly influenced the grain and straw yield. Data depicted in the Table 1 show that the highest grain and straw yield was recorded in direct seeding and it was on par with transplanted rice. These two treatments were significantly superior to aerobic rice. This might be due to submerged conditions in direct wet seeded rice and transplanted rice that facilitated availability of more mineralized form of N, P and K uptake than that of aerobic rice which encouraged tiller production and contributed to higher dry matter production and grain yield. Similar type of findings was reported by Parameswari and Sreenivas (2014). Weed management practices also exerted significant influence on grain and straw yield. Pretilachlor as PE *fb* hand weeding twice at 20 and 40 DAS/T, though it was at par with hand weeding twice at 20 and 40 DAS/T produced significantly more grain yield, straw yield and harvest index as compared to other treatments. This might be due to weed free environment created from early stage to till harvest which led to less competition by weeds and minimum nutrient removal by weeds which might have increased the capacity of nutrient uptake and enhanced the source and sink sizes which in turn increased the yield attributes. The results are in agreement with the findings of Nandal *et al.,* (1999), Singh *et al.,* (2006) and Sunil *et al.,* (2010).

Interaction between crop establishment methods and weed management practices was significant with regard to grain yield and straw yield. Pretilachlor as PE *fb* hand weeding at 20 and 40 DAT/ DAS being on par with farmer's method (HW at 20 and 40 DAS/DAT) and pendimethalin + penoxsulam as PE resulted significantly higher grain yield and straw yield than other weed management practices under all the rice establishment methods. Higher grain and straw yield obtained due to interaction of establishment methods and weed management practices could be due to effective control of weeds and higher number of panicles and diversion of resources towards sink and source. Similar results were also reported by Ganesh (1999) and Khare *et al.,* (2014).

Economics

The data presented in the Table 2 depicts that among various rice establishment methods, the highest gross return was obtained under WSR (86898 ₹. ha^{-1}) which was on par with transplanted rice (84604₹ ha^{-1}) and significantly superior over aerobic rice (58833 ₹. ha^{-1}). Under different weed management practices, gross returns were higher under pretilachlor as PE fb hand weeding twice was on par with farmers method and both were significantly superior over bispyribac sodium as PE fb fenoxaprop-p-ethyl + 2, 4-D and pendimethalin + penoxsulam as PE. The maximum gross returns was received under the treatment combination of crop raised through sprouted seeds under puddled condition with crop kept in weed free situation followed by hand weeding twice.

Table.1 Effect of establishment methods and weed management practices on grain yield, straw yield (kg ha^{-1}) and Harvest Index (%) in rice

Treatments		Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index
Establishment methods	**Weed management practices**			
M_1-Transplanted rice	**S_1**	5868	6903	47.56
	S_2	5067	6279	44.23
	S_3	5741	6837	45.33
	S_4	5906	7070	49.33
	S_5	3100	4021	41.22
M_2-Direct seeded rice (In puddled condition)	**S_1**	5227	6321	46.42
	S_2	5150	5907	43.71
	S_3	5138	6249	45.06
	S_4	5872	6627	48.10
	S_5	3909	4799	42.42
M_3-Aerobic rice	**S_1**	3924	4812	43.82
	S_2	3807	4565	41.44
	S_3	3820	4593	42.42
	S_4	3940	4845	42.82
	S_5	1935	2524	38.44
MEAN				
Establishment methods (Main plots)				
M_1-Transplanted rice		5060	5980	46.85
M_2-Direct seeded rice (In puddled condition)		5136	6222	47.21
M_3-Aerobic rice		3486	4268	41.92
Weed management practices (Sub plots)				
S_1		5007	6012	46.14
S_2		4676	5584	45.51
S_3		4900	5893	45.94
S_4		5239	6180	46.75
S_5		2981	3781	42.29
		SE (m)± / **CD (P =0.05)**	**SE (m)±** / **CD (P =0.05)**	**SE (m)±** / **CD (P =0.05)**
Establishment methods		**153.9** / **604.2**	**152.2** / **597.6**	**NA** / **NA**
Weed management practices		**102.8** / **300.2**	**115.7** / **338.1**	**NA** / **NA**
SUB AT MAIN		338 / 592	283 / 586	**NA** / **NA**
MAIN AT SUB		214 / 474	280 / 662	**NA** / **NA**

NA*-not analysed

S_1- Farmers method (Hand weeding 20 and 40 DAT/DAS), S2-Bispyribac sodium 10% SC 25 g ha^{-1} as PE fb fenoxaprop-p-ethyl 9.3% EC 62 g ha-1+ 2, 4-D 80% WP 0.5 kg ha^{-1},S_3-Pendimethalin + Penoxsulam25 g + 600 g ha^{-1} PE at 4-7 DAS/DAT, S_4- Pretilachlor 50 % EC 0.75 kg ha^{-1} as PE fb Hand weeding at 20 and 40 DAT/ DAS, S_5- Unweeded control.

Table.2 Effect of establishment methods and weed management practices on economics

Treatments		Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Establishment methods	**Weed management practices**				
M_1-Transplanted Rice	S_1	42466	98973	60288	2.08
	S_2	38560	85934	51156	2.20
	S_3	37966	96946	62761	2.29
	S_4	41815	99787	61754	2.36
	S_5	34466	52854	22169	1.87
M_2-Direct seeded rice (In puddled condition)	S_1	38684	88421	45954	2.56
	S_2	34778	84657	46096	2.47
	S_3	34184	86968	49001	2.84
	S_4	38033	98610	56794	2.62
	S_5	30684	64369	29903	1.72
M_3-Aerobic rice	S_1	36236	65446	29209	1.81
	S_2	30330	64345	34015	2.12
	S_3	29736	64585	34848	2.17
	S_4	34585	66779	32193	1.93
	S_5	26236	33013	6776	1.26
MEAN					
Establishment methods (Main plots)					
M_1-Transplanted rice		39055	84604	45550	2.16
M_2-Direct seeded rice (In puddled condition)		35273	86898	51626	2.44
M_3-Aerobic rice		31425	58833	27408	1.86
Weed management practices (Sub plots)					
S_1		39129	84279	45151	2.15
S_2		34556	78312	43756	2.26
S_3		33962	82832	48870	2.43
S_4		38145	88392	50247	2.30
S_5		30462	50078	19616	1.62

	SE (m)±	CD (P =0.05)	SE (m)±	CD (P =0.05)	SE (m)±	CD (P =0.05)	SE (m)±	CD (P =0.05)
Establishment methods	**NA***	**NA**	2454	9895	2454	9637	**NA**	**NA**
Weed management practices	**NA**	**NA**	1673	4914	1673	4885	**NA**	**NA**
SUB AT MAIN	**NA**	**NA**	2899	8462	2899	8462	**NA**	**NA**
MAIN AT SUB	**NA**	**NA**	2657	10401	2588	10401	**NA**	**NA**

NA*-not analysed

S_1- Farmers method (Hand weeding 20 and 40 DAT/DAS), S2-Bispyribac sodium 10% SC 25 g ha^{-1} as PE fb fenoxaprop-p-ethyl 9.3% EC 62 g ha-1+ 2, 4-D 80% WP 0.5 kg ha^{-1},S_3-Pendimethalin + Penoxsulam25 g + 600 g ha^{-1} PE at 4-7 DAS/DAT, S_4- Pretilachlor 50 % EC 0.75 kg ha^{-1} as PE fb Hand weeding at 20 and 40 DAT/ DAS, S_5- Unweeded control.

The maximum net return was received under direct seeded rice (51626₹ . ha^{-1}) which was on par with transplanted rice (45550 ₹ ha^{-1}) and significantly superior over aerobic rice (27408 ₹ ha^{-1}). Under different weed management practices, net returns were higher under pretilachlor as PE fb hand weeding twice (50247 ₹ ha^{-1}) which was on par with pendimethalin + penoxsulam as PE (48870 ₹ ha^{-1}) and significantly superior over Farmers method (45151 ₹ ha^{-1}) and bispyribac sodium as PE fb fenoxaprop-p-ethyl + 2, 4-D (43756 ₹ ha^{-1}). The maximum net return was received under the treatment combination of crop raised through sprouted seeds under puddled condition and pretilachlor as PE fb hand weeding twice.

The benefit: cost ratio was found the highest under direct seeded rice (2.44) which was followed by transplanted rice (2.16) and least benefit cost ratio was recorded under aerobic rice (1.86). Under different weed management practices, benefit: cost ratio was found the highest under pendimethalin + penoxsulam as PE (2.43) which was closely followed by under pretilachlor as PE fb hand weeding twice (2.30) and bispyribac sodium as PE fb fenoxaprop-p-ethyl + 2, 4-D (2.26). Farmers method (Hand weeding twice) (2.15) recorded a lower B:C ratio (1.89) which could be due to higher cost involved in engaging human labour for weeding, whereas unweeded control recorded significantly lowest B:C ratio (1.11) over other treatments. This is due to lower grain yield due to heavy weed competition. These results are in conformity with Veeraputhiran and Balasubramanian (2013), Hossain *et al.,* (2014) and Uma *et al.*, (2014).

In the present investigation, an attempt was made to study the effect of different establishment methods, herbicide mixtures and sequential application of herbicides on weed control, growth and yield of rice and the following can be concluded that direct seeded rice under puddled condition or transplanting methods in combination with pre emergence application of pretilachlor 50% EC fb hand weeding or pendimethalin + penoxsulam 25% SE recorded highest grain yield, straw yield, harvest index and was economical which can be recommended for better weed control rice under solutions of labour scarce.

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