Int.J.Curr.Microbiol.App.Sci (2018) *7*(4): 1473-1480

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 7 Number 04 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.704.166

Effect of Establishment Methods and Weed Management Practices on Economics of Direct Seeded Rice (*Oryza sativa* L.)

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Keywords

Rice, Establishment methods, Weed management practices, Growth, Economics, Yield

Article Info

Accepted:
12 March 2018
Available Online:
10 April 2018

A B S T R A C T

The field experiment was conducted at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during *Kharif* season of 2015 and 2016. The experiment was laid out in split-plot design with three replications taking four establishment methods *viz.*, Dry Seeding, Seeding through Drum Seeder (Wet) and Broadcasting (Wet) under puddled condition in main plot, and eight weed management practices *viz.* Bispyribac-Na @ 25g/ha at 25DAS (3-4 Leaf stage of rice crop), Pendimethaline @100g/ha at 0-2DAS fbBispyribac-Na@25g/ha at 25DAS (3-4 Leaf stage of rice crop), Oxadiargyl @100g/ha 0-2DASfb Bispyribac-Na@25g/ha at 25DAS (3-4 Leaf stage of rice crop), Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop), Pyrazosulfuran @ 20 g/ha at 0-2DAS fb ethoxysulfuran @18.75 g/ha at 25DAS (3-4 Leaf stage of rice crop), Manual Weeding (20,40,60 DAS),Weed free and weedy check were kept in sub-plot. The observations were recorded on weeds and on crop at successive stages of crop growth during both the years. The major weed flora recorded in the experiment were *E. crusgalli E. colona* and *P. maximum* of grassy, *Commelina benghalensis* L. and *Eclipta alba* of broad leaved group and Cyperus spp. of Sedges group. However, grassy weeds were dominant over other weeds species. Lower values of weed density and dry weight, N uptake and higher values of growth attributes, N uptake by crop, yield and yield attributes were recorded significantly due to manual weeding thrice, and Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop)being at par at all characters during both the years. However, weedy check treatment recorded significantly lower values of the entire growth characters yield and yields attributes at all the stages over rest of the weed control treatments. Both of the DSR (wet) drum seeding and broadcasting being at par recorded significantly lower values of weed density, weed dry weight and higher values of growth and yield attributes, grain and straw yield over dry seeding methods during both the years. On the basis of two years experimentation, it may be concluded that higher values of grain yield and net return may be obtained due drum seeding methods of establishment of rice along with integrated method of using weed management by Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop), while, broadcasting (wet) showed the same response However, direct seeding of rice through drum along with Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) proved superior (BCR values of Rs 2.12 per ha) over other methods of rice establishment under puddled condition.

Introduction

Rice (*Oryza sativa* L.) is a member of Poaceae family and is relished as staple food by majority (more than 60%) of world's population. Rice plays a pivotal role in Indian agriculture, as it is the principal food crop for more than 70 per cent of the world population. Among the cereal crops, it serves as the principal source of nourishment for over half of the global population (Davla *et al.,* 2013). Uttar Pradesh is the largest rice growing state only after West Bengal in the country, in which it is grown over an area of 5.54 million hectares with production and productivity of 11.70 million tonnes and 2.06 tonnes ha^{-1}, respectively. Though average productivity of rice in the state is nearly equal to national average, it ranks seventh after Punjab, Tamilnadu, Haryana, Andhra Pradesh, Karnataka and West Bengal. Crop established in rice largely affects the initial stand and uniformity. Although transplanting method of establishment has been reported to be best amongst all the factors for higher productivity of rice, this method is not much profitable due to consumes a large quantity of water (Bouman and Tuong, 2001).

Dry-seeded rice (DSR) has been developed as an alternative method of rice establishment that reduces labor requirements and other inputs while increasing or maintaining economic productivity and alleviating soil degradation problems (Ladha *et al.,* 2009; Farooq *et al.,* 2011). However, some studies reported a reduction in yield when shifting from puddled transplanted rice (PTR) to DSR using alternate wetting and drying (AWD) water management (Bhushan *et al.,* 2007; Choudhury *et al.,* 2007). The yield reductions were related to the management practices applied and the climatic conditions in the planting site (Belder *et al.,* 2004; Gathala *et al.,* 2006; Kato *et al.,* 2009; Singh *et al.,* 2011).Weed control is particularly challenging in DSR systems because of the diversity and severity of weed infestation, the absence of standing water layer to suppress weeds at the time of rice emergence, and no seedling size advantage of rice over the weed seedlings as both emerge simultaneously. A variety of herbicides have been screened and found effective for pre-plant/burn-down, pre-emergence, and post emergence weed control in direct drill-seeded rice systems (Singh *et al.,* 2006; Anwar *et al.,* 2012a). Application of different pre-emergence herbicides including thiobencarb, pendimethalin, butachlor, oxadiazon and nitrofen has been found to control weed satisfactorily in direct seeded rice (Moorthy and Manna, 1993; Pellerin and Webster, 2004). Among the post emergence herbicides, ethoxysulfuron, cyhalofop-butyl, pritilachlor, chlorimuron, metsulfuron, bispyribac sodium and penoxsulam effectively controlled weeds in direct seeded rice (Mann *et al.,* 2007; Singh *et al.,* 2008; Mahajan *et al.,* 2009; Juraimi *et al.,* 2010).

Materials and Methods

The field experiment was conducted at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology Kumarganj, Faizabad (U.P.) during *kharif* season of 2015 and 2016. The farm is located 42 km away from Faizabad city on Faizabad-Raebareily road at 26.47˚ N latitude and 82.12˚ E longitude and about 113 metres above the mean sea level. The total rainfall during the crop period was 484.30 mm and 779.20 mm during 2015 and 2016, respectively. Minimum temperature of 11.10C was recorded in the month of November during 2015 and 2016; whereas the maximum temperature was recorded in the month of July as 39.0^0C during 2015 and 50.9^0C in the month of September, 2016. The relative humidity was highest in July being 74.7% during 2015 and 95.7% in September 2016.The mean average precipitation of

Kumarganj, Faizabad is 837.4 mm, most of which received during the period of June to September. The experiment was laid out in split-plot design with three replications taking four establishment methods *viz.*,M_1= Dry Seeding, M_2=Seeding through Drum Seeder (Wet) and M_3=Broadcasting (Wet) under puddled condition in main plot, and eight weed management practices *viz.*W_1= Bispyribac-Na @ 25g/ha at 25DAS (3-4 Leaf stage of rice crop), W_2=Pendimethaline @100g/ha at 0-2DAS fbBispyribac-Na@25g/ha at 25DAS (3-4 Leaf stage of rice crop), W_3=Oxadiargyl @100g/ha 0-2DASfb Bispyribac-Na@25g/ha at 25DAS (3-4 Leaf stage of rice crop),W_4=Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop), W_5=Pyrazosulfuran @ 20 g/ha at 0-2DAS fb ethoxysulfuran @18.75 g/ha at 25DAS (3-4 Leaf stage of rice crop), W_6=Manual Weeding (20,40,60 DAS), W_7=Weed free and W_8=Weedy check were kept in sub-plot.

For direct seeding treatments (dry seeding,drum seeding and broad casting), a seed rate of 80 and 45 kg/ha was used for broad-casting and drum seeding treatments, respectively. Seed was sown on 25th July 2015 and 26th July 2016. In dry seeding, rice seeds were sown at 45 kg ha^{-1} with a 4-wheel tractor-drawn seed drill at a row spacing of 20 cm and depths of 1-2 cm.

For DSR establishment methods except dry seeding, the seeds were soaked in water for 24 h. The crop was fertilised with an uniform dose of 60 kg P_2O_5/ha through single super phosphate, 40 kg K_2O/ha through muriate of potash and half dose of the nitrogen (120kg/ha) through urea were applied as a basal dose while the remaining nitrogen was applied in two equal split doses at tillering and panicle initiation stages of crop growth. Weed management was done as per treatments. From the individual plot the crop of net plot area was recorded on weed parameters and crop parameters. After air d harvesting and seed were cleaned. The final seed weight was recorded in kg per plot and converted in to t/ha.

Results and Discussion

The data pertaining to different moisture regimes and varieties, plant growth and yield given in Table 1 and 2 reveal that the weeds parameter, growth and yield of rice were affected by crop establishment methods and weed management practices.

Effect on crop growth

The data given in Table 1 revealed that plant height was influenced significantly due to establishment methods at all the stages of crop growth. The plant height recorded at 60 and 90 days after seeding and at harvest stage, both the DSR (wet) methods recorded significantly more plant height over dry seeding methods. It is also clear from the data given in the table that both of the DSR (wet) methods (Drum and broad casting) being at par recorded significantly more plant height over dry seeding treatments. However, broadcasting treatments recorded numerically higher values of plant height over drum seeding method, respectively, but statically similar to DSR wet method at all the stages.

As far as the various weed management practices were concerned, plant height was influenced significantly at all the stage of crop growth due to various weed management practices. The plant height at successive stage that manual weeding thrice (20, 40 and 60 days) and Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) being at par recorded significantly more plant height over bispyribac-Na alone and weedy check treatments, Likewise, all pre and post

herbicide combination also recorded being at par to each other. However, weedy check treatment recorded significantly lower plant height over rest of the weed control treatments during both the years.

Dry matter accumulation is directly related to the growth pattern of the crop, which influences the grain yield directly. The crop dry matter accumulation (gm^{-2}) was increased significantly due to various rice establishment methods at different growth stages during both the years. Both the DSR (wet) methods at all the growth stages being at par recorded significantly more dry matter accumulation over dry seeding methods. In case of direct seeding of rice treatments, drum seeding treatment recorded significantly more dry matter accumulation as compared to broad-casting of rice (DSR) treatments at all the stages of crop growth during both the years of experimentation.

As far as the various weed management practices were concerned, dry matter accumulation was influenced at all the crop growth stage due to various weed management practices. Manual weeding thrice (20, 40 and 60 days) and Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) being at par recorded significantly more dry matter accumulation over bispyribac-Na 25g ha^{-1} as post emergence application alone and weedy check treatments, except 30 DAS stage. However, weedy check treatment recorded significantly less dry matter accumulation over rest of the weed control treatments, likewise two herbicide combination also being at par to each other at all the stages of crop growth during both the years.

Effect on yield

Among the various establishment methods, broad-casting and drum seeding method being at par recorded significantly higher values of effective shoot (m^{-2}) over dry seeding. The yield attributes viz., number of effective shoots (m^{-2}) was influenced significantly with different weed management practices during both the years (Table 1) Manual weeding thrice (20, 40 and 60 days) and Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) being at par recorded significantly higher values of these yield attributes over bispyribac-Na 25g ha^{-1} as PoE alone and weedy check treatments. However, weedy check treatment recorded significantly lower values of yield attributes over rest of the weed control treatments. This might because of the treatments which were able to control effect only gave poor crop-weed competition and results to which higher values of yield attributes and yield. The results are in agreement with the findings of Khattak *et al.,* (2006) and Aslam *et al.,* (2008).

Grain and straw yield were also influenced significantly by various crop establishment methods during both the years. Drum seeding being at par with broadcasting (wet) produced significantly higher grain and straw yields over all other establishment methods during both the years.

Yield is the functions of complex inter relationship of growth in vegetative phase and yield attributes. Higher yield under drum seeding was due to better crop growth and devolvement resulting into higher values of yield attributes which increase the grain yield. Higher straw yield under drum seeding was probably due to more dry matter production per unit area caused by better nutrient absorption from soil, increased rate of metabolic processes, rate of light absorption, photosynthetic activity and more number of leaves. Harvest index was not appreciably influenced by crop establishment methods. This might be due to almost similar increase in grain and straw yield under each method.

Table.1 Effect of establishment methods and weed management practices on growth, yield attributes and yield of direct seeded rice

Treatments	Plant height (cm)						Dry matter accumulation (g/m2)						Effective tillers (m^{-2})		Test weight (g)		Grain yield (qha^{-1})		Straw yield	
	60 DAS		90 DAS		At harvest		60 DAS		90 DAS		At harvest									
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Methods of rice establishment																				
Dry seeding	47.28	49.88	64.04	66.53	62.49	64.55	307.79	303.50	618.99	651.52	709.52	763.74	204.49	209.17	20.28	21.33	26.02	29.62	37.13	41.44
Drum seeding	52.26	53.62	72.23	75.60	70.75	72.54	358.07	365.89	755.37	799.96	878.75	945.90	268.75	274.89	22.22	23.38	35.68	40.62	47.75	53.31
Broadcasting (wet)	55.20	58.25	75.14	78.18	74.56	77.63	341.19	348.64	714.00	767.83	838.21	899.45	255.47	262.88	21.11	22.20	32.36	36.84	45.05	50.28
SEm±	1.05	1.11	1.73	1.79	1.15	1.18	5.64	5.59	11.03	13.07	11.59	12.45	3.73	3.83	0.62	0.65	0.84	0.96	1.18	1.22
LSD (P=0.05)	4.14	4.37	5.32	5.06	4.52	4.62	22.15	21.95	43.30	51.33	45.51	48.87	14.64	15.03	NS	NS	3.30	3.76	4.36	4.52
Weed management practices																				
Bis.	46.43	48.16	62.68	64.32	60.56	62.47	315.47	323.56	649.44	703.67	749.60	826.30	236.77	239.07	21.11	21.59	26.67	30.36	38.30	42.76
Pendi. fbBis.	51.45	54.07	70.31	70.48	68.47	70.46	334.00	332.97	694.80	732.02	804.74	859.63	242.95	250.22	21.83	22.58	32.68	37.19	44.74	49.94
Oxadi.fbBis.	49.68	52.73	68.68	69.62	66.59	67.73	328.88	328.27	681.84	719.99	790.72	845.49	240.89	243.93	21.18	21.79	28.65	32.62	40.10	44.76
Preti.fbAlm.	52.33	55.22	71.93	74.49	71.32	73.05	348.99	351.01	727.20	773.25	843.05	908.11	250.38	259.36	21.92	22.78	36.23	41.24	48.99	54.69
Pyra.fbethox.	50.62	53.27	69.26	70.22	67.37	68.30	333.22	330.23	692.37	725.15	801.93	851.55	241.97	246.62	21.74	22.58	30.30	34.49	42.73	46.58
Manual weed.	56.60	59.61	75.93	76.61	75.30	76.05	359.64	361.60	749.89	799.62	869.22	939.12	259.35	267.45	22.23	22.78	38.46	43.78	51.12	57.07
Weed free	58.26	61.45	78.74	79.56	77.42	79.18	372.65	374.55	779.86	833.37	903.80	978.81	267.72	278.05	22.90	24.94	41.67	47.44	54.30	60.61
weedy	36.62	39.19	53.55	55.77	49.86	52.36	292.60	312.58	593.58	631.12	707.54	748.53	203.20	207.13	20.71	21.40	16.19	18.43	27.19	30.35
SEm±	1.46	1.54	2.56	2.47	1.59	1.55	7.45	7.52	15.08	16.21	17.82	19.10	5.39	5.54	0.77	0.81	1.47	1.68	1.61	1.63
LSD (P=0.05)	4.16	4.39	5.79	6.02	4.84	4.73	21.27	21.45	43.04	46.28	50.85	54.50	15.40	15.80	NS	NS	4.21	4.79	5.59	5.67

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

Treatments	Cost of cultivation (Rs.ha^{-1})	Gross return (Rs.ha^{-1})	Net return (Rs.ha^{-1})	Benefit : Cost (ReRs^{-1})
$M_1 W_1$	20780.00	37978.91	17198.91	0.83
$M_1 W_2$	21303.33	43554.72	22251.39	1.04
$M_1 W_3$	22390.00	40987.81	18597.81	0.83
$M_1 W_4$	20777.55	48836.63	28059.08	1.35
$M_1 W_5$	20904.60	43995.67	23091.07	1.10
$M_1 W_6$	27870.00	52002.12	24132.12	0.87
$M_1 W_7$	33870.00	53783.57	19913.57	0.59
$M_1 W_8$	18870.00	26129.50	7259.50	0.38
$M_2 W_1$	20288.00	54359.59	34071.59	1.68
$M_2 W_2$	20811.33	58832.53	38021.20	1.83
$M_2 W_3$	21898.00	54919.31	33021.31	1.51
$M_2 W_4$	20285.55	63329.05	43043.50	2.12
$M_2 W_5$	20412.60	57227.77	36815.17	1.80
$M_2 W_6$	27378.00	66754.85	39376.85	1.44
$M_2 W_7$	33378.00	69437.12	36059.12	1.08
$M_2 W_8$	18378.00	35245.86	16867.86	0.92
$M_3 W_1$	21080.00	47221.96	26141.96	1.24
$M_3 W_2$	21603.33	52746.29	31142.96	1.44
$M_3 W_3$	22690.00	48780.93	26090.93	1.15
$M_3 W_4$	21077.55	57506.64	36429.09	1.73
$M_3 W_5$	21204.60	52098.89	30894.29	1.46
$M_3 W_6$	28170.00	60464.37	32294.37	1.15
$M_3 W_7$	34170.00	71630.54	37460.54	1.10
$M_3 W_8$	19170.00	32249.42	13079.42	0.68

As far as the various weed management practices were concerned, Manual weeding thrice (20, 40 and 60 days) and Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) recorded significantly higher values of grain and straw yield as compared to bispyribac-Na 25g ha^{-1} at 30 days stage alone and weedy check. However, bispyribac-Na 25g ha^{-1} alone recorded significantly higher values of grain and straw yield over weedy check. Weedy check produced significantly lower grain and straw yield as compared to all the weed management practices during both the years of experimentation. Such type of results with respect to grain and straw yield were recorded on the lines of growth and yield attributes recorded with the respective treatment. Lower harvest index under weedy check condition may be explained on the basis that the menace of weeds go on increasing with increase in age. Hence, the vegetative growth was affected comparatively less than the reproductive growth of rice plants lowering the harvest index. These results were in coordination with the earlier findings of Tamilselvan and Budhar (2002), Jayadeva *et al.*, (2009) and Pramanick *et al.*, (2014).

Effect on economics

The maximum cost of cultivation (Rs. 34170.00ha^{-1}) was obtained in broadcasting with weed free treatment combination followed by with Manual weeding thrice. It might due to more cost involved in weed free labour charges incurred on weeding. The Minimum cost of cultivation was recorded in direct-seeding method of establishment along with weedy check treatment. The maximum gross return was obtained broadcasting with weed free treatment combination followed by with Manual weeding thrice under during both the years.

It might be due to higher yield of rice. The maximum net return (Rs. 43043.50ha^{-1}) was recorded in drum seeding with Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) and While the minimum net return of was recorded in dry seeding with no weed control treatment due to low yield of rice, during both the years.

The highest benefit-cost ratio (Rs. 2.12 ha^{-1}) was obtained under drum seeding with Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop). These results are in close conformity with those of Aslam *et al.,* (2008) and Shivaramu and Krishnamurthy (2011).

On the basis of two years experimentation, it may be concluded that higher values of grain yield and net return may be obtained due drum seeding methods of establishment of rice along with integrated method of using weed management by Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop), while, broadcasting (wet) showed the same response However, direct seeding of rice through drum along with Pretilachlore @ 750g/ha at 0-2DASfbAlmix @ 4 g/ha at 25DAS (3-4 Leaf stage of rice crop) proved superior (BCR values of Rs 2.12 per ha) over other methods of rice establishment under puddled condition.

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How to cite this article:

Sanjay Kumar, Nareshmani Pandey, Ajit Kumar, Ashok Kumar Singh, Tarun Gopal and Dinesh Kumar. 2018. Effect of Establishment Methods and Weed Management Practices on Economics of Direct Seeded Rice (*Oryza sativa* L.). *Int.J.Curr.Microbiol.App.Sci.* 7(04): 1473-1480.
doi: https://doi.org/10.20546/ijcmas.2018.704.166