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EFFECT OF CROP ESTABLISHMENT AND WEED CONTROL PRACTICES ON THE PERFORMANCE OF RICE (*Oryza sativa* L.)

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ABSTRACT

The present study was undertaken to evaluate the performance of transplanted rice and direct seeded rice (DSR) as crop establishment methods under different weed control practices. Transplanting method proved superior over DSR. Among the weed management practices, butachlor (1.5 kg *a.i.* ha^{-1}) + almix (4 g *a.i.* ha^{-1}) proved superior over other weed management practices with respect to grain yield and yield attributes. Maximum grain yield weed control efficiency was recorded in transplanted rice with the application of butachlor @ 1.5 kg *a.i.* ha^{-1} + almix @ 4 g *a.i.* ha^{-1}.

Keywords: Crop establishment methods, herbicides, rice, yield

INTRODUCTION

World-wide rice occupies an area of about 153.77 m ha which is 30% of the total area under food grains. Rice presently accounts for more than 20% of daily caloric intake of about 2.4 billion people. In India rice is grown on an area of 44.5 m ha with annual production of 91 million tones accounting for 46% of the area under cereals and 42% of total food grains (Anonymous, 2007). Transplantation of rice is traditional method for rice establishment; however due to labour scarcity at peak seasons of transplantation and availability of water for shorter periods the cultivation of direct seeded rice (DSR) is gaining momentum in India. The estimate losses in DSR are high (50-60%) due to the weeds as compared to transplanted rice. Even at times it may lead to complete crop failure because the land remains almost exposed till initial seedling establishment and weed management techniques are critical (Govindarasu *et al.*, 1998). Appropriate crop establishment methods and weed control measures may practiced to overcome this problem. The present study was undertaken with the objective to evaluate the crop establishment methods and weed management practices on rice under Kashmir conditions.

MATERIALS AND METHODS

The experiment was carried out at Rice Research and Regional Station, SKUAST-Kashmir, Khudwani (J&K) during *kharif* 2008. The experiment comprized of 2 cultural methods and 7 weed control methods and was laid out in a randomized block design with three each treatment replicated thrice. Rice cv. 'Shalimar Rice-1 (SR-1)' was sown @ 80 kg ha^{-1} for transplanting and @ 100 kg ha^{-1} for direct seeding method. Pre-germinated seed were sown on 5th May in field for direct seeding and in nursery for seedling transplantation after 30 days. Weed control in the experimental field was followed as per the treatments. Seven weed management practices were employed including weed free and weedy

check. The herbicides butachlor (1.5 kg *a.i.* ha^{-1}) and pendimethaline (1.0 kg *a.i.* ha^{-1}) were applied as pre- emergent at 5 to 7 DAS/DAT, almix (0.004 kg *a.i.* ha^{-1}) and 2,4-D (1.0 kg *a.i.* ha^{-1}) as post-emergent at 12 and 30 DAS/DAT, respectively. Various growth parameters were recorded at 60 DAS/DAT and at harvest. Leaf area constant was calculated as under:

$$C = \frac{Lm}{Ls}$$

Where, C = Leaf area constant
Lm = Leaf area measured with leaf area meter (Systronics 211)
Ls = Leaf area obtained by scale

For weed count, identification and dry weight, the weeds falling in a quadrant of 0.25 m^2 were uprooted from each plot periodically (at 60 DAS/DAT and at harvest), identified, counted and expressed as weed m^{-2}. Weeds from each plot at 60 DAS/DAT and at harvest were counted, washed and after sun drying these were oven-dried at 60-65^oC for 48 h to a constant weight. Weed control efficiency (WEC) for different weed control treatments was worked out using the following formula:

$$WCE\ (\%) = \frac{WDC - WDT}{WDC} \times 100$$

Where, WDC = weed dry weight in control plot, and WDT = weed dry weight in treated plot

Economics of different treatments was worked out on the basis of grain and straw yield ha^{-1}. The cost of input and output was estimated as per prevailing market rates. The benefit cost ratio was determined as:

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

The data was statistically analyzed as per Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Growth characters

The crop establishment methods i.e. transplanted and direct seeded rice (DSR) did not show any significant effect on plant height at any of the crop growth stages (Table 1). However, plant height showed an increasing trend upto harvest. At harvest, transplanting method recorded 4.05% higher plant height than DSR. Higher plant height in transplanted rice could be attributed to better nutrient uptake. Singh *et al.* (1997) observed significantly taller rice plants in transplanted method rather than in other establishment methods. The influence of weed management practices on plant height was at par with butachlor + almix, butachlor + 2,4-D and butachlor alone. At harvest, weed free plots recorded an increase of 25.0, 7.0, 6.9, 10.8, 3.8 and 2.4% in plant height over weedy check, two hand weedings, butachlor, pendimethaline, butachlor + 2,4-D and butachlor + almix, respectively. Butachlor + almix showed an increase of 7.6 and 21.6% in plant height than pendimethalin and weedy check, respectively. This could be ascribed to the better weed control by this herbicidal combination due to better nutrient uptake by the crop. Singh *et al.* (2004) also found the use of almix @ 4 g *a.i.* ha^{-1}, as tank mixture with butachlor at 938 or 1250 g ha^{-1}, effective against weeds in rice resulting in the improvement of growth characters. Dry matter accumulation was significantly increased under transplanting method at all the crop growth stages over DSR method of crop establishment. At harvest transplanting method showed 10% enhancement in dry matter over DSR. It was observed that dry matter accumulation continued to increase up-to harvest. Improvement in plant height and other growth attributes viz., leaf area index might have resulted in higher dry matter production under transplanting method of crop establishment.

Besides, favourable effect of puddling might have decreased weed competition and increased nutrient availability. Chander and Pandey (2001) also reported similar findings. As regards the effect of weed management practices, weed-free treatment although was at par with butachlor + almix and butachlor + 2,4-D, significantly enhanced dry matter content in rice at all stages over other weed control methods. The reduction in weed growth with herbicide allowed the crop to grow to its potential, thereby increased dry matter production. Similar results were reported by Bhat *et al.* (2011). Leaf area index increased upto 60 DAS, and thereafter declined gradually till harvest. The two methods of crop establishment did not differ significantly in their effect on leaf area index at various crop growth stages. However, transplanting method recorded higher LAI over direct seeding. This might be due to increase in the number of green leaves and more shoots per-unit area resulting from better nutrition due to reduced growth of weeds. The results are in conformity with the findings of Jaiswal and Singh (2001). The weed free plots showed significant improvement in leaf area index at all the stages of crop growth over other treatments. However, weed free treatment was at par with butachlor + almix. The crop treated with butachlor + almix acquired increased LAI than weedy check and two hand weedings. This could be attributed to the fact that during reproductive phase of crop shading to lower leaves caused their senescence and death. The reduction in weed growth with the herbicidal application might have allowed the crop to get adequate nutrient supply resulting in higher leaf area index. These results are in conformity with Singh *et al.* (2001).

Table 1: Growth parameters as affected by crop establishment methods and weed management practices in rice

Treatments	Plant height (cm)		Leaf area index		Dry matter (q ha^{-1})	
	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest
Crop establishment methods						
Direct seeded	60.00	100.82	3.86	0.99	33.72	130.09
Transplanted	63.24	104.91	3.92	1.00	36.80	142.63
$CD_{0.05}$	Ns	ns	ns	Ns	3.62	3.89
Weed control practices						
Weedy check	49.18	88.55	3.04	0.88	22.51	108.70
Two hand weedings	60.57	102.93	3.19	0.94	32.46	133.47
Butachlor	62.26	104.16	4.29	0.99	35.86	142.20
Pendimethalin	59.63	100.08	3.08	0.93	32.62	129.07
Butachlor + 2,4-D	64.90	106.25	4.31	1.03	38.23	145.37
Butachlor + Almix	66.30	107.70	4.49	1.07	41.79	147.22
Weed free	68.50	110.39	4.82	1.12	43.37	148.51
$CD_{0.05}$	7.29	8.01	0.37	0.11	2.84	7.29

DAS = days after sowing; ns = non-significant

Yield contributing characters

The yield contributing characters viz., number of panicles m^{-2}, grains panicle^{-1}, panicle weight and 1000 grain weight showed significant increase in transplanting method of crop establishment (Table 2). Amongst the herbicidal treatments, butachlor + almix, although at par with butachlor + 2,4-D, proved significantly superior over other chemical treatments and weedy check. Transplanting method of crop establishment remarkably improved the number of grains panicle^{-1} over DSR method. The superiority acquired in this respect by transplanted rice over transplanting method was 7.8%. The weed management practices significantly improved the number of grains panicle^{-1} as compared to weedy check. This may be attributed to the puddling operation in transplanted method, since puddling has great significance in rice establishment method, because it facilitates increase in the availability of nutrients, ensures better plant establishment and controls weeds Prasad *et al.* (2001) also reported similar results.

Application of butchlor + almix significantly increased the entire yield attributing characters viz., panicles m^{-2}, panicle weight, grains $panicle^{-1}$ and 1000-grain weight over other weed control measures. This could be ascribed to the fact that weed free and butachlor + almix treated plots absorbed the applied nutrients as well as other growth factors due to less competition between crop and weeds and hence all the yield attributing characters acquired higher values. Our results are in conformity with Bhat *et al.* (2011).

Table 2: Effected of crop establishment methods and weed management practices on yield contributing parameters, grain and straw yield, protein and amylase content of rice

Treatments	Panicles m^{-2} (No.)	Panicle weight (g)	Grains $panicle^{-1}$ (No.)	1000-grain wt. (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Protein content (%)	Amylose content (%)
Crop establishment methods								
Direct seeded	373.00	2.34	97.33	24.65	60.65	79.98	6.93	21.98
Transplanted	404.95	2.53	105.00	24.85	64.93	86.40	6.99	22.63
$CD_{0.05}$	8.32	0.12	4.86	ns	3.10	5.54	ns	ns
Weed control practices								
Weedy check	309.50	1.95	71.50	22.64	50.56	69.95	5.02	15.72
Two hand weedings	372.16	2.32	102.16	25.38	63.33	85.36	6.76	21.75
Butachlor	402.33	2.36	104.33	24.10	63.81	85.84	6.80	22.89
Pendimethalin	347.66	2.14	90.33	24.39	54.34	75.35	6.74	21.65
Butachlor + 2,4-D	419.00	2.48	108.16	25.41	64.87	87.45	6.86	23.89
Butachlor + Almix	431.66	2.86	115.00	25.53	70.50	89.00	6.98	25.00
Weed free	440.50	2.95	116.66	25.82	72.63	89.40	7.08	25.24
$CD_{0.05}$	15.57	0.23	9.09	1.72	5.81	10.36	0.72	3.18

ns = non-significant

Grain and straw yield

The rice grain and straw yield exhibited a significant increase under transplanted method of crop establishment as compared to DSR method (Table 2). The higher grain yield under transplanted method might be due to less weed competition and optimum utilization of nutrients. While, overcrowding in direct seeded rice seems to have increased the inter- and intra-plant competition for resources. These results are in conformity with Singh *et al.* (1997, 2005). The increase in straw yield could be attributed to the significant increase in plant height and dry matter production under transplanting method of crop establishment. Amongst the different weed control measures, apart from weed free treatment, the application of butachlor + almix significantly increased rice grain and straw yield over other weed control measures. Higher grain yield with butachlor + almix use (70.5 q ha^{-1}) could be due to the significant improvement in all yield attributes. These results are in conformity with Subramanian *et al.* (2005) and Bhat *et al.* (2011).

Weed density

The rice field generally was observed to be infested with grassy weeds, broad leaf weeds and sedges. The predominant grassy weeds observed were *Echinochloa crusgalli, E. colona* and *Cynodon dactylon.* The broad leaf weeds included *Ammania baccifera, Marsilea qudrofolia, Monochoria vaginalis* and *Potamogeton distinctus* and prominent sedges were *Cyperus iria, Cyperus difformis* and *Fimbristylis miliacae.* The periodic weed density data showed that both dry weight and weed density were significantly low in transplanted rice than in DSR (Table 3). The weed density increased till 60 DAS and then declined. The low dry matter of weeds in transplanted field may be due to frequent ploughing aimed to achieve puddled conditions, higher moisture content and better crop canopy. Singh *et al.*

(2005) also reported low weed dry matter in transplanted rice as compared to DSR. The higher dry weight of weeds in DSR may be due to the failure to maintain flooded conditions in field owing to deep percolation of water, repeated flash of weeds and keen competition between crop and weeds for growth. Bajwa and Pasricha (1995) observed frequent aerobic soil environment for major period of crop growth and development due to deep percolation of water in direct seeded rice. At harvest, the weed density in combined application of butachlor + almix treatment was reduced by 77%. The use of butachlor alone reduced weed population by 64.7%. Similar findings were reported by Subramanian and Martin (2006).

Table 3: Effect of crop establishment methods and weed management practices on weed density, weed dry weight and weed control efficiency in rice

Treatment	Weed density (No. m^2)		Dry weight ($g\ m^{-2}$)		Weed control efficiency (%)	
	60 DAS	At harvest	60 DAS	At harvest	60 DAS	At harvest
Crop establishment methods						
Direct seeded	23.38 (4.52)	35.90 (5.30)	32.20 (5.19)	66.0 (7.48)	63.5 (7.47)	61.39 (7.34)
Transplanted	16.54 (3.82)	21.76 (3.85)	28.16 (4.84)	58.5 (7.01)	66.1 (7.63)	64.38 (7.52)
$CD_{0.05}$	1.68 (0.07)	1.65 (0.51)	1.74 (0.08)	3.07 (0.19)	2.83 (0.17)	1.65 (0.10)
Weed control practices						
Weedy check	57.16 (7.54)	81.33 (9.25)	86.20 (9.30)	167.7 (12.96)	0.0 (0.70)	0.00 (0.70)
Two hand weedings	23.06 (4.82)	38.16 (6.15)	30.35 (5.53)	68.2 (8.28)	63.5 (7.99)	59.39 (7.73)
Butachlor	15.83 (4.00)	20.32 (4.45)	22.53 (4.78)	59.1 (7.71)	73.4 (8.57)	63.76 (8.01)
Pendimethalin	16.66 (4.92)	30.33 (5.35)	31.15 (5.62)	62.6 (8.54)	64.8 (8.07)	63.65 (8.00)
Butachlor + 2,4-D	13.50 (3.70)	18.83 (3.86)	21.63 (4.69)	39.8 (6.18)	74.7 (8.68)	76.16 (8.81)
Butachlor + Almix	10.16 (3.24)	12.84 (3.14)	19.58 (4.47)	38.4 (6.33)	77.2 (8.80)	76.25 (8.75)
Weed free	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.0 (0.70)	100.0 (10.25)	100.00 (10.25)
$CD_{0.05}$	3.17 (0.32)	3.08 (0.98)	3.25 (0.30)	5.76 (0.62)	5.30 (0.30)	3.08 (0.18)

The values in parenthesis are transformed values

Weed dry weight

In field the dry matter of weeds was significantly low in transplanting method than DSR method of crop establishment (Table 3), thus indicating that DSR creates favourable environment for weed growth. Transplanting of rice resulted in 11.3% reduction in weed dry matter in comparison to direct seeding. The low dry matter of weeds in transplanting could have increased efficiency of treatment in controlling the weeds. Among the herbicides, butachlor followed by almix recorded low weed dry matter which was at par with butachlor + 2,4-D, but significantly lower than other treatments during all crop growth stages. At harvest, butachlor + almix reduced the final weed dry matter by 77 and 35% as compared to control and butachlor alone, respectively. The results are in line with Subramanian and Martin (2006).

Weed control efficiency

Transplanting method proved significantly efficient crop establishment method in controlling the weeds at all crop growth stages than DSR (Table 3). Butachlor + almix following next to weed free treatment proved efficient in controlling the weeds at 60 DAS and at harvest (77.17 and 76.25). The treatments viz., two hand weeding at 20 and 40 DAS/DAT and pendimethalin use were at par in their effectiveness in controlling the weeds. The results are in conformity with Subramanian and Martin (2006).

Amylose and protein contents in rice grains

The crop establishment methods did not cause any significant change in amylose and protein contents of rice grain (Table 2). However, transplanting method recorded 0.65% increase in amylose content over DSR method. This can be attributed to the fact that quality parameters being greatly a varietal character. However, apart from the weed free treatment the herbicidal application of almix + butchalor

resulted in increase in both amylose and protein contents in rice. This may be due to better partitioning and allocation of sugars in weed free environment wherein less competition is observed. Similar results were reported by Khana *et al.* (2002).

Table 4: Economics of DSR and transplanted rice under different crop establishment methods and weed management practices

Treatments	Cost of cultivation (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Direct seeded rice (DSR)			
Weedy check	28,634	34,316	1.20
Two hand weedings	34,684	50,696	1.46
Butachlor	29,234	57,086	1.95
Pendimethalin	29,134	39,096	1.34
Butachlor + 2,4-D	29,634	57,876	1.96
Butachlor + Almix	29,734	62,486	2.10
Weed free	40,684	54,316	1.33
Transplanted rice			
Weedy check	29,500	40,320	1.36
Two hand weedings	35,500	53,290	1.50
Butachlor	30,100	59,370	1.97
Pendimethalin	29,950	50,550	1.68
Butachlor + 2,4-D	30,450	60,510	1.98
Butachlor + Almix	30,550	66,640	2.16
Weed free	38,500	61,160	1.58

Economics of cultivation

The transplanting method proved more economical than DSR method of crop establishment (Table 4). Amongst the different weed control measures highest benefit cost ratio (2.16) was recorded in butachlor + almix treated plots under transplanted rice, followed by butachlor + almix under DSR (2.10). Thus the combined application of butachlor + almix proved economically beneficial for higher yields of rice in both methods of crop establishment. Better economic benefits are due to significantly higher rice grain yield realized with butachlor + almix @ 1.5 kg *a.i.* ha^{-1} + 4 g *a.i.* ha^{-1}, respectively.

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