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Effect of chemical weed-control methods on productivity of transplanted rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted during the rainy seasons of 2000 and 2001 on transplanted rice (*Oryza sativa* L.) at Chiplima, Orissa, to evaluate the efficiency of different herbicides and herbicide mixtures. Application of almix 0.004 kg tank-mixed with butachlor (1.0 kg/ha) 3 days after transplanting (4.80 t grains/ha) or application of butachlor (1.0 kg) at 3 days after transplanting (DAT) followed by sequential application of almix 0.004 kg/ha at 25 DAT (4.69 t grains/ha) was as good as hand-weeding twice at 20 and 40 DAT (4.84 t grains/ha) in controlling weeds and achieving grain yield. Application of almix 0.004 kg + butachlor 1.0 kg/ha and butachlor 1.0 kg, followed by almix 0.004 kg/ha increased the grain yield by 36.8 and 33.6%, respectively, over the unweeded check. There was a negative linear relationship between weed dry weight and grain yield (r=-0.74).

Key words : Crop protection, Herbicidal weed control, Transplanted rice

One of the major reasons of low productivity of rice in the command area of the Hirakud major irrigation project in Orissa is the severe weed infestation. Transplanted rice faces diverse types of weed flora, consisting of grasses, broad-leaf weeds and sedges. Competition of these weeds brings reduction in yield of transplanted rice by about 50% (Mukherjee and Singh, 2005). Hand-weeding is effective and most common method to control weeds in this crop. However, scarcity and high wages of labour, particularly during peak period and early crop-weed competition make this operation difficult and uneconomic. Different herbicides are thus used to eliminate weed species, but most of these are effective against narrow range of weed species (Narayana *et al.*, 1999). Further, most of the pre emergence herbicides are effective up to 20 days after transplanting (Balusamy and Pothiraj, 1989). Application of herbicide mixture may be useful, particularly in the absence of an effective broad-spectrum herbicide in rice to control highly diverse population of weed flora (Rao and Singh, 1997). However, not much study has been made on the efficacy of herbicidal mixtures and sequential application of herbicides. Therefore, the present study was undertaken to evaluate a few herbicides, herbicide mixtures and sequential application of herbicides on both grassy as well as broad-leaf weeds and their effects on transplanted rice in Hirakud command area of western Orissa.

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MATERIALS AND METHODS

The field experiment was conducted at Chiplima, Orissa, during the rainy season (*kharif*) 2000 and 2001. The soil was sandy clay loam with pH 6.4, organic C 0.43% and available N, P and K content of 272, 13.8 and 136 kg/ha respectively. The experiment consisted of 17 treatments, viz. butachlor (Machete) 1.5 kg/ha at 3 days after transplanting (DAT), tank-mix of cinmethylin 0.375 kg and 2,4-DEE 0.4 kg/ha at 7 DAT, tank-mix of cinmethylin 0.5 kg and 2,4-DEE 0.4 kg/ha at 7 DAT, flufenacet 0.09 kg/ha at 5 DAT, flufenacet 0.12 kg/ha at 5 DAT, tank-mix of anilophos 0.312 kg and ethoxysulfuron 0.012 kg/ha at 10 DAT, fenoxaprop-*p*-ethyl 0.056 kg/ha at 15 DAT, acetachlor 0.10 kg/ha at 3 DAT, acetachlor 0.15 kg/ha at 3 DAT, pyrazosulfuron-ethyl 0.01 kg/ha at 8 DAT, pyrazosulfuron-ethyl 0.015 kg/ha at 8 DAT, alkombo 0.204 kg/ha at 3 DAT, tank-mix of almix 0.004 kg and butachlor (Machete) 1.0 kg/ha at 3 DAT, butachlor (Machete) 1.0 kg/ha at 3 DAT followed by almix 0.004 kg/ha at 25 DAT, weed-free check, 2 hand-weedings at 20 and 40 DAT and unweeded control. The experiment was laid out in randomized block design with 3 replications. Rice cultivar 'Lalat' maturing in 125 days was the test crop.

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Thirty days old seedlings were transplanted during the third week of July in both the years, with a spacing of 15 cm × 15 cm. A common fertilizer dose of 80, 17.5 and 33.2 kg of N, P and K/ha, respectively, was applied. Full dose of P and K and half dose of N were applied basal and remaining N was top-dressed in 2 equal splits, at maximum tillering and panicle-initiation stages of the crop. Plant-protection measures and irrigations were provided as and when required. The required quantity of herbicides was applied with manually operated knapsack sprayer using a spray volume of 500 litres water/ha. A thin film of water was maintained in the field at the time of application of herbicides.

Weed counts (number/m^2) and weed dry weight (g/m^2) were sampled randomly at 2 places with the help of 0.25 m^2 quadrates at 60 days and at harvest. Yield and yield attributes of rice were recorded at crop harvest. Weed control efficiency (WCE) was also calculated on the basis of dry-matter production of weeds.

RESULTS AND DISCUSSION

Weed flora

Major weed flora in the experimental field consisted of grasses, viz. *Digitaria sanguinalis* (L.) Scop., *Echinochloa crus-galli* (L.) P. Beauv., *Echinochloa colonum* (L.) Link, *Panicum repens* (L.), *Cynodon daectylon* (L.) Pers.; sedges *Cyperus rotundus* (L.), *Cyperus iria* (L.), *Cyperus difformis* (L.), *Fimbristylis miliacea* (L.) Vaha; and broad-leaf weeds (BLW) *Ammania baccifera* (L.), *Ludwigia parviflora* (L.), *Eclipta prostrata* (L.), *Eclipta alba* (L.), *Lippa nodiflora* Nich, *Marsilea quadrifoliata* (L.), *Sphenoclea zeylanica* Gaertn. and *Commelina benghalensis* (L.). The composition of grasses, sedges and broad-leaf weeds in weedy check plot was 27, 35 and 38% respectively. Emergence of broad-leaf weeds was noticed earlier than of sedges and grasses.

Weed density and weed dry weight were higher at 60 days after transplanting (DAT) than at harvest. This was perhaps due to death of some of the weeds like *Digitaria sanguinalis, Echinochloa colonum, Cyperus difformis, Marsilea quadrifoliata* and *Commelina benghalensis* and the shading effect of the tall weeds like *Echinochloa crus-galli* and crop plants on short-stature weeds. At both the stages of observation unweeded check recorded significantly higher weed population and weed dry weight than any other treatment (Table 1).

Two hand-weedings at 20 and 40 DAT recorded the minimum weed population and dry weight and the highest weed-control efficiency at both the stages. Among the herbicidal treatments, application of almix 0.004 kg/ha mixed with butachlor 1.0 kg/ha at 3 DAT recorded the minimum weed population and dry weight and the highest weed-control efficiency. This treatment was closely followed by application of butachlor 1.0 kg/ha at 3 DAT followed by

Table 1. Effect of herbicides and herbicide mixtures on yield economics, weed biomass and WCE of transplanted rice (pooled data of 2000 and 2001)

Treatment	Dose (kg/ha)	Time of application (DAT)	Panicles/ m^2	yield (t/ha)		Net returns (Rs.)	Benefit : cost ratio	Total weed dry weight (g/m^2)		WCE (%)	
				Grain	Straw			60 DAT	At harvest	60 DAT	At harvest
Butachlor	1.5	3	342	4.45	7.22	6,614	1.32	48.3	40.6	60.0	64.9
Cinmethylin + 2,4-DEE	0.375+0.4	7	266	3.74	4.41	3,371	1.18	40.5	36.4	66.4	68.5
Cinmethylin + 2,4-DEE	0.5+0.4	7	290	3.96	4.62	3,625	1.18	35.6	31.4	70.5	72.9
Flufenacet	0.09	5	302	4.08	6.00	5,742	1.30	53.9	44.8	55.3	61.3
Flufenacet	0.12	5	318	4.12	6.19	5,971	1.31	42.6	37.8	64.7	67.3
Anilophos + ethoxysulfuron	0.312+0.012	10	325	4.28	6.26	5,013	1.24	44.8	38.6	62.9	66.6
Fenoxaprop-*p*-ethyl	0.056	15	312	4.10	5.89	4,209	1.20	47.6	39.4	60.5	66.0
Acetachlor	0.10	3	335	4.38	6.14	7,251	1.38	50.3	43.0	58.3	62.8
Acetachlor	0.15	3	351	4.62	6.53	7,971	1.40	46.5	40.4	61.2	65.1
Pyrazosulfuron-ethyl	0.01	8	338	4.42	6.41	6,500	1.32	50.4	43.6	58.2	62.3
Pyrazosulfuron-ethyl	0.015	8	348	4.56	6.38	6,779	1.33	46.8	41.8	61.2	63.9
Alkombo	0.204	3	298	4.06	6.02	4,340	1.21	38.8	33.9	67.8	70.7
Almix + butachlor	0.004+1.0	3	364	4.80	6.60	9,634	1.50	20.2	17.4	83.2	84.9
Butachlor fb almix	1.0 fb 0.004	3 fb 25	359	4.69	6.22	8,736	1.45	22.2	18.3	81.6	84.2
Weed-free check			380	5.02	6.90	8,233	1.38				
Two hand-weedings		20 fb 40	372	4.84	6.71	8,262	1.40	18.7	16.0	84.5	86.1
Unweeded control			260	3.51	4.21	1,215	1.06	120.8	115.9		
SEm±			6	0.07	0.09			1.4	1.3		
CD (P=0.05)			18	0.19	0.27			4.2	3.7		

fb, followed by (applied sequentially); +, tank mixed; DAT, days after transplanting

almix 0.004 kg/ha at 25 DAT (sequential application). These 2 treatments were comparable to hand-weeding twice. The reduced weed density and dry weight may be attributed to broad-spectrum and season-long weed-control properties exhibited by the herbicide mixtures or sequential application. Mukherjee and Singh (2005) also found almix + 2,4-DEE to be the best treatment in reducing the total weed density and increasing the weed-control efficiency. Unweeded control plot recorded the highest weed population and dry weight. Among the herbicidal treatments, application of flufenacet 0.09 kg/ha at 5 DAT recorded higher weed population and dry weight and lower weed-control efficiency, indicating its ineffectiveness. Application of pyrazosulfuron-ethyl 0.01 kg/ha at 8 DAT or acetachlor 0.10 kg/ha at 3 DAT were also equally ineffective.

Effect on rice

All the herbicidal treatments significantly influenced panicles/m^2 grain and straw yields compared with unweeded check (Table 1). However, 1,000-seed weight was not significantly influenced by treatments. Weed-free check recorded the highest grain and straw yield which were comparable to those obtained with 2 hand-weedings. Among the herbicides, application of almix 0.004 kg/ha mixed with butachlor 1.0 kg/ha recorded the highest grain yield, which was on a par with application of butachlor 1.0 kg/ha at 3 DAT, followed by almix 0.004 kg/ha at 25 DAT and these 2 treatments were comparable with 2 hand-weedings. The hand-weedings twice, almix 0.004 kg + butachlor 1.0 kg/ha and butachlor 1.0 kg followed by almix 0.004 kg/ha increased the grain yield by 37.9, 36.8 and 33.6%, respectively, over the unweeded check. The increased grain yield in these treatments was owing to reduced weed density, weed dry weight and better weed-control efficiency and higher panicles/unit area (Table 1). The minimum yield and yield attributes in unweeded check were the result of severe weed competition by the uncontrolled weed growth. Straw yield followed almost similar trend as that of grain yield. Rao and Singh (1997) and Narwal *et al.* (2002) also reported increased grain yield by herbicide mixtures and sequential herbicide application respectively. Application of almix 0.004 kg/ha tank-mixed with butachlor 1.0 kg/ha at 3 DAT and application of butachlor 1.0 kg/ha at 3 DAT followed by almix 0.004 kg/ha at 25 DAT recorded the highest net return and maximum benefit : cost ratio (Table 1). This could be due to high weed-control efficiency and higher grain yield obtained owing to application of effective herbicide dose. Mukherjee and Singh (2005) also found almix + 2,4-DEE to be the best herbicidal dose for increasing the grain yield and net return of transplanted rice.

Regression analysis indicated that there was a significant negative linear relationship between the grain yield and the weed dry weight at 60 DAT. The sample linear regression $Y = 4.85 - 0.012\ X$ was obtained from pooled data, where Y, the expected grain yield (t/ha) and X, the observed weed dry weight (g/m^2) at 60 DAT. The correlation coefficient 'r' value was – 0.74, indicating a high degree of negative correlation between the weed dry weight and the grain yield. Rao and Singh (1997) also observed negative linear relationship between weed dry weight and grain yield in transplanted rice.

Thus application of almix 0.004 kg tank-mixed with butachlor 1.0 kg/ha at 3 days after transplanting or application of butachlor 1.0 kg at 3 DAT followed by application of almix 0.004 kg/ha at 25 DAT proved more effective in checking the weed population and their growth and increasing the grain yield, and may be recommended for the irrigated transplanted wet-season rice.

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