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Efficacy of pre-emergence herbicides for control of complex weed flora in transplanted rice

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ABSTRACT

A field experiment was conducted at Chiplima, Sambalpur, Odisha during the rainy season of 2014 and 2015 to study the effect of sand-mix application of pre-emergence herbicides on weed population yield and economics of transplanted rice (*Oryza sativa* L.). Application of chlorimuron + metsulfuron 4 g/ha, bensulfuron 60 g/ha and pyrazosulfuron 16 g/ha alone was selectively effective on broad-leaf weeds while pretilachlor 500 g/ha was effective on grasses. Pre-emergence application of pyrazosulfuron with pretilachlor (16 + 500 g/ha) was more effective in minimizing the density (10/m^2), biomass (4.8 g/m^2) of weeds and enhancing the weed control efficiency (89.3%), grain yield (6.14 t/ha), net returns (` 53.2 x 10^3/ha) and benefit: cost ratio (1.37) than pretilachlor alone.

Key words: Bensulfuron-methyl, Chlorimuron-ethyl + metsulfuron-methyl, Herbicide mixture, Pretilachlor, Pyrazosulfuron-ethyl, Transpalnted rice, Weed control

Weed management is one of the important factors affecting rice yield. Uncontrolled weeds cause 35-55% reduction in grain yield under transplanted conditions (Manhas *et al.* 2012 and Rao and Chauhan 2015). Therefore, timely weed control is imperative for realizing desired level of productivity. Weed shift from grasses to broad-leaf weeds and sedges is being observed in transplanted rice fields due to continuous use of pretilachlor, butachlor or oxadiargyl in major rice growing areas of the country (Singh *et al.* 2004, Sunil *et al.* 2010). This undesirable ecological change in weed species is to be checked to avoid crop losses due to weeds. Such changes beyond a certain level may become unmanageable. Therefore, to widen weed control spectrum, there is necessity to combine the pretilachlor, which is being widely used as pre-emergence herbicide in transplanted rice with other broad-leaf weeds controlling herbicides. Bensulfuron-methyl + pretilachlor herbicide combination at 3 days after transplanting (DAT) was reported to provide effective control of broad-leaf weeds, sedges and grasses without any phytotoxic effect on rice (Rao *et al.* 2015, Bhat *et al.* 2017). Therefore, present study was undertaken to find suitable broad-leaf controlling herbicides to use with pretilachlor for widening the weed control spectrum in transplanted rice during *Kharif* season.

MATERIALS AND METHODS

The study was undertaken at Regional Research and Technology Transfer Station, Orissa University of Agriculture and Technology, Chiplima, Sambalpur, Odisha during *Kharif* 2014 and 2015. The soil of the experimental field was sandy clay loam with pH 6.6, organic carbon 0.43% and available N ($KMnO_4$ method), P (Olsen) and K (NH_4OHC method) content of 268, 13.4 and 132 kg/ha, respectively. The experiment was laid out in randomized block design with 3 replications and 9 treatments. The treatments consisted of pretilachlor 500 g/ha, bensulfuron methyl 60 g/ha, pyrazosulfuron-ethyl 16 g/ha, chlorimuron-ethyl + metsulfuron-methyl 4 g/ha, pretilachlor 500 g/ha + chlorimuron-ethyl + metsulfuron-methyl 4 g/ha, pretilachlor 500 g/ha + pyrazosulfuron-ethyl 16 g/ha, pretilachlor 500 g/ha + bensulfuron-methyl 60 g/ha, weed-free and weedy-check. All the herbicides were applied as sand – mix at 3 days after transplanting (DAT). Herbicide was mixed with 50 kg of sand per hectare on the day of application and applied uniformly to the field in 2.5 cm depth of water. Water was not drained for 2 days from the field and fresh irrigation was not given. Rice cultivar '*MTU 1001*' of 135 days duration was transplanted at spacing of 20 x 15 cm on July 27, 2014 and August 8, 2015. A common fertilizer dose of 80, 40 and 40 kg of N, P_2O_5 and K_2O/ha, respectively was applied. Full dose of P_2O_5 and K_2O and half dose of N were applied as 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 irrigation was provided as and when required. Weed density (no./m^2) and weed biomass (g/m^2) were measured by sampling randomly at 2

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places using 0.25 m^2 quadrate at 40 DAT. Weed density data was analyzed after subjecting to square root transformation. Yield and yield attributes of rice were recorded at crop harvest. Weed control efficiency was also calculated on the basis of dry matter production of weeds.

$$\text{Weed control efficiency (WCE)} = \frac{(\text{WDc} - \text{WDt})}{\text{WDc}} \times 100$$

Where, WDc is the biomass of weeds in weedy plots, WDt is the biomass of weeds in treated plots

Economics was computed using the prevailing market prices for inputs and outputs such as rice grain (` 14,100/t), rice straw (` 800/t) and manual labour (` 200/day).

RESULTS AND DISCUSSION

Effect on weeds

The major weed flora in the experimental field comprised of grasses *Digitaria sanguinalis* (L.) Scop., *Echinochloa crus-galli* (L.), *Echinochloa colonum* (L.) Link, *Panicum repens* (L.), *Leptochloa chinensis* (L.); sedges *Cyperus difformis* (L.), *Cyperus iria* (L.), *Fimbristylis miliacea* (L.) Vahal and broad-leaved weeds (BLW) *Ammania baccifera* (L.), *Ludwigia paraviflora* (L.), *Eclipta prostrata* (L.), *Eclipta alba* (L.), *Lippa nodiflora* Nich, *Marsilea quadrifolium* (L.), *Sphenoclea zeylanica* Gaertn., *Commelina benghalensis* (L.). The composition of grasses, sedges and broad-leaf weeds in weedy check plot was 48.6, 30.4 and 20.9%, respectively. Emergence of BLW was noticed earlier as compared to sedges and grasses.

Sole application of pretilachlor was the best in controlling grasses (18/m^2), while pyrazosulfuron, bensulfuron and chlorimuron + metsulfuron were most effective in controlling sedges and broad-leaf weeds (**Table 1**). Grassy weed population was more (36/m^2) in the plot treated with chlorimuron + metsulfuron as compared to pretilachlor alone. This may be due to differential selectivity of herbicides towards grassy and broad-leaf weeds. The results are in agreement with (Singh *et al.* 2004).

Mixed application of pretilachlor and pyrazosulfuron was more effective than pretilachlor alone. Sedges could be completely controlled with combined application of pretilachlor with any of the 3 herbicides. All the combinations were significantly superior to the sole application of the herbicide and over weedy check. Bhat *et al.* (2017) also recorded lower weed density with ready mix application of pretilachlor with pyrazosufuron and bensulfuron.

Total weed biomass (**Table 1**) ranged between 17.7 to 23.3 g/m^2 with sole application of herbicides, whereas weed biomass of herbicide mixture varied between 4.8 to 9.2 g/m^2, the lowest being with pretilachlor + pyrazosulfuron. The highest weed control efficiency (89.3%) was found with pretilachlor + pyrazosulfuron followed by pretilachlor + bensulfuron (85.5%) and pretilachlor + chlorimuron + metsulfuron (79.5%). This showed that all the herbicide combinations tested in this experiment were compatible with higher efficiency over sole application without any phytotoxic effect causing adversity.

Effect on crop

Plant height was not affected by any of the tested treatments. But the herbicide treatments increased the yield attributing parameters of rice. Effective tillers/m^2 (363), grains/panicle (127), panicle length (26.6 cm) and test weight (24.1 g) were the highest with pretilachlor + pyrazosulfuron and were at par with weed free treatment (**Table 2**). The complex weed flora comprised of grasses, sedges and broad-leaf weeds caused 40.6% rice grain yield reduction in the weedy check compared to weed free treatment (6.33 t/ha). Sole application of pyrazo-sulfuron, bensulfuron and chlorimuron + metsulfuron

Table 1. Effect of herbicides on weed density, weed biomass and weed control efficiency at 40 days after transplanting in rice (mean data of 2 years)

Treatment	Weed density (no./m^2)				Weed biomass (g/m^2)				WCE (%)
	Grasses	Sedges	BLWs	Total	Grasses	Sedges	BLWs	Total	
Pretilachlor	18(4.4)	16(4.1)	8(3.0)	42(6.6)	8.7(3.1)	6.4(2.7)	2.6(1.9)	17.7(4.3)	60.5
Bensulfuron	34(5.9)	9(3.2)	6(2.6)	49(7.1)	16.5(4.2)	3.6(2.1)	1.9(1.7)	22.0(4.8)	50.8
Pyrazosulfuron	32(5.7)	8(3.0)	4(2.2)	44(6.7)	15.5(4.1)	3.2(2.0)	1.3(1.5)	20.0(4.6)	55.4
Chlorimuron + metsulfuron	36(6.1)	10(3.3)	6(2.6)	52(7.3)	17.4(4.3)	4.0(2.2)	1.9(1.7)	23.3(4.9)	47.9
Pretilachlor + chlorimuron + metsulfuron	17(4.2)	0(1.0)	3(2.0)	20(4.6)	8.3(3.0)	0(1.0)	0.9(1.4)	9.2(3.2)	79.5
Pretilachlor + pyrazosulfuron	10(3.3)	0(1.0)	0(1.0)	10(3.3)	4.8(2.4)	0(1.0)	0(1.0)	4.8(2.4)	89.3
Pretilachlor + bensulfuron	12(3.6)	0(1.0)	2(1.7)	14(3.9)	5.8(2.6)	0(1.0)	0.7(1.3)	6.5(2.7)	85.5
Weed-free	0(1.0)	0(1.0)	0(1.0)	0(1.0)	0(1.0)	0(1.0)	0(1.0)	0(1.0)	100
Weedy check	51(7.2)	32(5.7)	22(4.8)	105(10.3)	24.7(5.1)	12.8(3.7)	7.3(2.9)	44.8(6.8)	0
LSD (p=0.05)	1.4	1.5	0.2	2.7	0.1	0.3	0.2	1.7	-

($\sqrt{x+1}$) transformed values are given in parentheses, BLW- Broad-leaf weeds, WCE-Weed control efficiency

Table 2. Effect of herbicides on yield attributes, yield and economics of rice (mean data of 2 years)

Treatment	Plant height (cm)	Effective tillers (no./m^2)	Panicle length (cm)	Grains/ panicle	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Cost of cultivation (x10^3 `/ha)	Net returns (x10^3 `/ha)	Benefit : cost ratio
Pretilachlor	117.4	353	26.2	124	23.7	4.97	5.96	38.4	36.5	0.95
Bensulfuron	103.4	340	25.1	120	23.1	4.35	5.22	38.5	27.1	0.70
Pyrazosulfuron	111.6	338	25.3	123	23.1	4.87	5.84	38.2	35.1	0.92
Chlorimuron + metsulfuron	116.8	295	24.4	113	22.6	4.05	4.86	38.3	22.7	0.59
Pretilachlor + chlorimuron + metsulfuron	120.1	342	25.7	125	29.9	5.53	6.08	38.8	44.5	1.13
Pretilachlor + pyrazosulfuron	118.7	363	26.6	127	24.1	6.14	6.25	38.8	53.2	1.37
Pretilachlor + bensulfuron	116.4	357	26.6	126	23.9	5.68	6.24	39.0	46.0	1.18
Weed-free	122.1	368	26.9	128	24.3	6.33	6.96	47.6	47.2	0.99
Weedy check	108.3	203	23.3	112	22.4	3.76	4.88	37.6	19.3	0.51
LSD (p=0.05)	NS	27.4	2.3	10	1.1	1.77	1.84	-	-	-

recorded lower grain yield as compared to their sand-mix application with pretilachlor due to their ineffectiveness in controlling grassy weeds, resulting lower weed control efficiency (**Table 1** and **2**). Singh *et al.* (2004) also reported that pretilachlor did not provide any control of sedges and broad-leaf weeds.

Among the herbicides combinations, the highest grain yield (6.14 t/ha) was recorded with pretilachlor + pyrazosulfuron, which was at par with weed free treatment. Pyrazosulfuron, bensulfuron and chlorimuron + metsulfuron application in combination with pretilachlor resulted in an average increase of 38.7, 33.8 and 32%, respectively in the grain yield as compared to weedy check. Combined application of pretilachlor with pyrazosulfuron, bensulfuron and chlorimuron + metsulfuron resulted in significantly higher yield than their sole application due to better control of all grasses, sedges and broad-leaf weeds. Pyrazosulfuron, bensulfuron and chlorimuron + metsulfuron were compatible with pretilachlor, as their site of action is different in the plant. Pyrazosulfuron, bensulfuron and chlorimuron + metsulfuron inhibits the plant enzyme acetolactate synthase (ALS), which is essential for the synthesis of branched chain amino acids. Inhibition of amino acid production subsequently inhibits cell division. Pretilachlor belongs to chloroacetamide group which inhibits cell division. Bhat *et al.* (2017) observed that pre-emergence application of pretilachlor with bensulfuron or pyrazosulfuron was as effective as weed free treatment. None of the treatments had any toxicity on the rice crop in terms of crop stand, crop growth, yellowing, necrosis, scorching, epinasty and hyponasty.

All the herbicides applied in combination with pretilachlor recorded higher monetary returns than their sole application and weedy check (**Table 2**). Among the tested treatments, pretilachlor + pyrazosulfuron gave the maximum net return (` 53.2 x 10^3/ha) and benefit:cost ratio (1.37), followed by pretilachlor + bensulfuron owing to low cost and high grain yield as compared to other pre-emergence herbicides. Kaur *et al.* (2016) also reported similar findings with tank mix application of herbicides. Weed free treatment though registered higher grain yield (6.33 t/ha), recorded lower monetary returns (` 47.2 x 10^3/ha) than application of pretilachlor + pyrazosulfuron mixture, due to high cost incurred in manual weeding to keep the crop weed free.

It can be concluded that pyrazosulfuron, bensulfuron and chlorimuron + metsulfuron were compatible with pretilachlor and there was no adverse effect on crop growth. Their combination successfully controlled the complex weed flora in rice. Pretilachlor with pyrazosulfuron was the most remunerative and effective herbicide mixtures for controlling the complex weed flora in transplanted rice.

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