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Weed management by herbicide combinations in transplanted rice

A. Hossain* and D.C. Mondal
Palli Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal 731 235

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ABSTRACT

Field experiments were conducted in transplanted rice at Visva-Bharati, Sriniketan during *Kharif* seasons of 2012 and 2013. The predominant weed species were: *Ludwigia parviflora*, C*yanotis axillaris*, *Commelina diffusa* and *Spilanthes acmella*. Pre-emergence application of pretilachlor + bensulfuron at 660 g/ha and post-emergence application of bispyribac-sodium + metsulfuron-methyl + chlorimuron-ethyl at 4 g/ha effectively controlled grassy weed population. Post-emergence application of bispyribac + metsulfuron-methyl + chlorimuron-ethyl was found to be most effective in controlling broad-leaved weeds and it was closely *fb* bispyribac + ethoxysulfuron applied as post-emergence. Application of bispyribac-sodium + metsulfuron-methyl + chlorimuron-ethyl as post-emergence and pyrazosulfuron-ethyl as pre-emergence were effective in controlling sedge population. Post-emergence application of bispyribac + ethoxysulfuron, pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl, pyrazosulfuron *fb* manual weeding, pretilachlor + bensulfuron and weed-free check recorded more grain yield. The highest net returns and B:C ratio were recorded with bispyribac + metsulfuron-methyl + chlorimuron-ethyl and pre-emergence application of pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl. Herbicides applied in combination recorded more net returns and B:C ratio as compared to sole application of herbicides.

Key words: Economics, Herbicides combination, Transplanted rice, Weed management

Rice is the world's most important food among all staple food crops and more than half of the world's population depends on rice for food, calories and protein, especially in developing countries. Like other cereal crops, rice also suffers severly from weed competitions (Rao *et al.* 2007). Uncontrolled weeds compete with rice and cause yield losses to the tune of 50-65% under wet-seeded rice (Subbaiah and Sreedevi 2000) and up to 76% in transplanted rice (Singh *et al.* 2004). The farmers generaly do 2-3 hand weedings in transplanted rice. Post-emergence application of metsulfuron-methyl + chlorimuron-ethyl and early post-emergence application of ethoxysulfuron showed promising results in achieving more grain yield of transplanted rice (Pal *et al.* 2008). Pre-emergence application of pyrazosulfuron, penoxulam (Chauhan and Seth 2013) and post-emergence bispyribac (Khaliq *et al.* 2012) herbicides were considered to be an alternative/supliment to hand weeding. Therefore, the present experiment was conducted to find out the effective herbicides or herbicide mixtures for weed control in transplanted rice.

MATERIALS AND METHODS

The field experiments were conducted in Agricultural Farm of Institute of Agriculture, Visva-Bharati, Sriniketan during *Kharif* seasons of 2012 and 2013. The soil was sandy loam, slightly acidic in nature with medium N and P and low in K. The experiment was laid out in randomized block design with 10 treatments and 3 replications. The rice variety '*IR-64*' was transplanted. The treatments were bispyribac-sodium 25 g/ha at 20 DAT, pretilachlor 1000 g/ha at 3 DAT, penoxsulam 22.5 g/ha at 10 DAT, pyrazosulfuron 20 g/ha at 3 DAT, bispyribac + ethxy-sulfuron 25 + 18.75 g/ha at 25 DAT, bispyribac-sodium + metsulfuron-methyl + chloromuron-ethyl (20 + 4) g/ha at 25 DAT, pretilachlor at 750 g/ha at 3 DAT *fb* ethoxy-sulfuron 18.75 g/ha at 25 DAT, pretilachlor 750 g/ha at 3 DAT *fb* metsulfuron-methyl + chloromuron-ethyl 4 g/ha + bensulfuron 660 g/ha at 5 DAT. Weed free check (hand weeding at 25 and 45 DAT) and weedy check were also included. The weed density, weeds biomass, crop growth parameters, yield and yield attributes were recorded.

***Corresponding author:** ahossaindwsrc@yahoo.in

RESULTS AND DISCUSSION

Weed flora

During 2012, the experimental rice field was infested with 18 weed species out of which 4 grasses, 12 broad-leaved and 2 sedges were recorded but in *Kharif* 2013, 17 weeds species prevailed in the experimental field, out of which there were 4 grasses, 11 broad-leaf and 2 sedges. The pre-dominant weed species were *Ludwigia parviflora*, C*yanotis axillaris*, *Commelina diffusa* and *Spilanthes acmella*.

Effect on weeds

Among the different herbicidal treatments, pretilachlor + bensulfuron 660 g/ha as pre-emergence and bispyribac + metsulfuron-methyl + chlorimuron-ethyl as post-emergence effectively controlled grassy weed density (Table 1). This treatment was statistically at par with bispyribac + ethoxysulfuron 25 + 18.75 g/ha applied at 25 DAT during *Kharif* 2012. During *Kharif* 2013, in addition to above, herbicides combinations, pyrazosulfuron followed by (*fb*) manual weeding also showed best performance in controlling grassy weeds. Post-emergence application of bispyribac-sodium + metsulfuron-methyl + chlorimuron-ethyl was found to be most effective against broad-leaved weeds and it was closely *fb* bispyribac-sodium + ethoxysulfuron applied as post-emergence. Application of bispyribac-sodium + metsulfuron-methyl +chlori-muron-ethyl as post-emergence and pyrazosulfuron-ethyl as pre-emergence were found effective in controlling sedges. Regarding suppression of total weed density, post-emergence application of bispyribac-soidum + metsulfuron-methyl + chlorimuron-ethyl was found to be most effective and this was closely *fb* bispyribac-sodium + ethoxysulfuron as post-emergence and pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl. The sole application of bispyribac-sodium, pretilachlor and pyrazosulfuron were found comparatively less effective in reducing the weeds density. Similar trend was also noticed with biomass of grass, broad-leaved and total weeds.

Effect on crop

There were significant differences on rice height, density and biomass at 60 DAT. During both the years, highest number of rice plant population/ m^2 was noticed with post-emergence application of bispyribac-spodium + ethoxysulfuron which was closely *fb* bispyribac-sodium + metsulfuron-methyl + chlorimuron-ethyl, pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl, pyrazosulfuron *fb* manual weedings, pretilachlor + bensulfuron and weed free check . At 60 DAT, crop biomass was highest in weed free check and this was closely *fb* bispyribac-sodium + metsulfuron-methyl + chlorimuron-ethyl, bispyribac-soidum + ethoxysulfuron, pretilachlor *fb* ethoxysulfuron/ metsulfuron-methyl + chlorimuron-ethyl and pyrazosulfuron *fb* manual weeding.

Effect on yield

Among the yield attributes, number of effective tillers/m^2 and number of grains/panicle differed significantly but there were no significant differences in test weight during both the years. Post-emergence application of bispyribac + metsulfuron-methyl + chlorimuron-ethyl produced highest number of effective tillers and number of grains/panicle and this was closely *fb* bispyribac + ethoxysulfuron, pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl, pyrazosulfuronfb manual weeding, pretilachlor + bensulfuron and weed free check.

Table 1. Effect of treatments on weed density at 60 DAT

Treatment	Weed density/m^2							
	Grasses		Broad-leaved weeds		Sedges		Total	
	2012	2013	2012	2013	2012	2013	2012	2013
Bispyribac	2.8(7.3)	2.8(7.7)	6.9(47.3)	6.2(38.3)	2.0(3.7)	2.3(4.7)	7.7(58.3)	7.1(50.7)
Pretilachlor	1.7(2.3)	1.9(3.0)	9.1(82.3)	8.5(72.3)	2.5(6.0)	2.9(7.7)	9.5(90.7)	9.1(83.0)
Penoxsulam	2.5(5.7)	2.7(7.0)	6.1(37.0)	6.0(35.3)	1.7(2.3)	1.8(2.7)	6.7(45.0)	6.7(45.0)
Pyrazosulfuron	2.3(4.7)	2.6(6.3)	8.9(79.3)	9.4(88.0)	0.7(0.0)	0.7(0.0)	9.2(84.0)	9.7(94.3)
Bispyribac + ethoxysulfuron	1.3(1.3)	1.7(2.3)	4.1(16.7)	4.7(21.7)	1.6(2.0)	1.7(2.3)	4.5(20.0)	5.2(26.3)
Bispyribac + metsulfuron-methyl + chlorimuron-ethyl	0.7(0.0)	0.7(0.0)	3.7(13.7)	3.5(11.7)	0.7(0.0)	0.7(0.0)	3.7(13.7)	3.5(11.7)
Pretilachlor *fb* ethoxysulfuron	1.6(2.3)	1.8(2.7)	6.8(46.0)	6.4(40.7)	2.3(5.0)	2.4(5.3)	7.3(53.3)	7.0(48.7)
Pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl	2.8(7.3)	2.8(7.3)	4.7(22.0)	4.4(19.7)	1.9(3.0)	2.0(3.7)	5.7(32.3)	5.6(30.7)
Pyrazosulfuron *fb* manual weeding	0.7(0.0)	0.7(0.0)	6.8(46.0)	6.9(47.3)	0.7(0.0)	0.7(0.0)	6.8(46.0)	6.9(47.3)
Pretilachlor + bensulfuron	0.7(0.0)	0.7(0.0)	5.9(34.0)	5.5(29.3)	2.0(3.3)	2.3(4.7)	6.1(37.3)	5.9(34.0)
Weed free	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)
Weedy check	11.2(124)	11.1(123)	14.3(205)	14.7(214)	7.2(51.7)	8.5(72)	19.5(380)	20.3(410)
LSD (P=0.05)	0.6	0.5	0.8	0.9	0.4	0.4	0.8	0.9

Figures in the parentheses indicate the actual values, data subjected to square root transformation, transformed value = $\sqrt{x + 0.5}$

Table 2. Effect of treatments on weed biomass at 60 DAT

Treatment	Weed biomass (g/m^2)							
	Grasses		Broad-leaved weeds		Sedges		Total	
	2012	2013	2012	2013	2012	2013	2012	2013
Bispyribac	1.5(1.8)	1.5(1.9)	3.0(8.4)	2.9(7.7)	1.6(2.0)	1.6(2.0)	3.5(12.1)	3.5(11.6)
Pretilachlor	1.4(1.4)	1.5(1.8)	3.1(9.0)	3.4(10.8)	1.4(1.4)	1.5(1.7)	3.5(11.8)	3.8(14.3)
Penoxsulam	1.3(1.3)	1.3(1.2)	2.8(7.1)	2.7(6.8)	1.2(1.0)	1.2(0.9)	3.1(9.4)	3.0(8.9)
Pyrazosulfuron	1.1(0.8)	1.1(0.8)	3.6(12.5)	3.9(15.0)	0.7(0.0)	0.7(0.0)	3.7(13.3)	4.0(15.8)
Bispyribac + ethoxysulfuron	1.0(0.5)	1.0(0.5)	1.6(2.0)	2.0(3.4)	1.6(2.0)	1.5(1.6)	2.2(4.6)	2.5(5.6)
Bispyribac + metsulfuron-methyl + chlorimuron-ethyl	0.7(0.0)	0.7(0.0)	1.4(1.5)	1.5(1.7)	0.7(0.0)	0.7(0.0)	1.4(1.5)	1.5(1.7)
Pretilachlor *fb* ethoxysulfuron	1.2(1.1)	1.2(1.0)	2.6(6.4)	2.8(7.6)	1.8(2.6)	1.8(2.9)	3.3(10.2)	3.4(11.5)
Pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl	1.9(3.4)	2.2(4.2)	1.5(1.8)	1.5(1.9)	1.2(1.0)	1.4(1.4)	2.6(6.2)	2.8(7.5)
Pyrazosulfuron *fb* manual weeding	0.7(0.0)	0.7(0.0)	2.4(5.4)	2.5(6.0)	0.7(0.0)	0.7(0.0)	2.4(5.4)	2.5(6.0)
Pretilachlor + bensulfuron	0.7(0.0)	0.7(0.0)	2.2(4.4)	2.5(5.7)	2.0(3.5)	2.2(4.3)	2.9(7.9)	3.2(10.0)
Weed free	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)
Weedy check	3.9(15.0)	4.6(21.1)	9.3(87.0)	9.9(96.9)	2.8(7.3)	3.5(11.5)	10.5(109)	11.4(129)
LSD (P=0.05)	0.4	0.3	0.4	0.5	0.3	0.3	0.4	0.6

Figures in the parentheses indicate the actual values

Table 3. Effect of treatments on crop growth at 60 DAT, yield and yield of rice

Treatment	Plant height (cm)		Plant population/m^2		Biomass (g/m^2)		Effective tillers/m^2		No. of grains/panicle		Grain yield (t/ha)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Bispyribac	107	106	410	411	572	322	315.0	69.3	69.3	72.7	4.62	4.45
Pretilachlor	102	104	397	399	581	305	296.7	65.0	65.0	69.0	4.39	4.16
Penoxsulam	102	106	402	405	583	305	296.0	67.3	67.3	61.3	4.38	4.15
Pyrazosulfuron	102	102	373	376	609	313	291.0	67.7	67.7	61.7	4.50	4.31
Bispyribac + ethoxysulfuron	102	103	455	451	672	350	353.3	78.7	78.7	75.0	5.03	4.83
Bispyribac + metsulfuron-methyl + chlorimuron-ethyl	98	103	450	448	715	364	362.7	84.0	84.0	83.7	5.23	5.12
Pretilachlor *fb* ethoxysulfuron	103	105	407	400	665	318	298.3	73.3	73.3	68.7	4.57	4.37
Pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl	98	99	442	439	635	347	346.7	75.7	75.7	74.3	5.06	4.81
Pyrazosulfuron *fb* manual weeding	106	105	437	431	670	347	336.7	72.7	72.7	69.0	4.96	4.76
Pretilachlor + bensulfuron	99	101	433	429	605	338	329.3	73.3	73.3	67.0	4.93	4.71
Weed free	104	104	447	437	729	360	353.3	82.3	82.3	79.3	5.17	4.80
Weedy check	102	99	372	363	504	248	242.3	56.7	56.7	58.3	3.57	3.27
LSD (P=0.05)	6.8	3.5	35.1	53.6	96.9	76.7	32.2	48.4	7.6	13.5	0.46	0.81

Post-emergence application of bispyribac + metsulfuron-methyl + chlorimuron-ethyl recorded the highest grain yield (5.12 t/ha). Post-emergence application of bispyribac + ethoxysulfuron (4.83 t/ha), pretilachlor *fb* metsulfuron- methyl + chlorimuron-ethyl (4.81 t/ha), pyrazosulfuron *fb* manual weeding (4.76 t/ha), pretilachlor + bensulfuron (4.71 t/ha) and weed free (4.80 t/ha) check recorded more grain yield and these were at par with the best treatment. The sole application of bispyribac sodium, pretilachlor and pyrazosulfuron produced less grain yield. Early post-emergence of penoxsulam also produced lower grain yield due to its phyto toxic effect on crop. The lowest grain yield (3.265 t/ha) was recorded under weedy check.

Table 4. Effect of different weed control treatments on economics

Treatment	Cost of cultivation (x10^3 `/ha)	Gross returns (x10^3 `/ha)	Net returns (x10^3 `/ha)	B:C ratio
Bispyribac	26.80	59.41	32.61	2.22
Pretilachlor	25.10	56.01	30.91	2.23
Penoxsulam	25.90	55.85	29.95	2.16
Pyrazosulfuron	24.90	57.73	32.83	2.32
Bispyribac + ethoxysulfuron	27.50	64.55	37.05	2.35
Bispyribac + metsulfuron-methyl + chlorimuron-ethyl	26.70	67.73	41.04	2.54
Pretilachlor *fb* ethoxysulfuron	26.00	58.57	32.57	2.25
Pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl	25.70	64.65	38.95	2.52
Pyrazosulfuron *fb* manual weeding	26.90	63.68	36.78	2.37
Pretilachlor + bensulfuron	25.60	63.14	37.54	2.47
Weed free	29.20	65.27	36.07	2.24
Weedy check	23.60	44.74	21.14	1.90
LSD (P=0.05)	-	6.43	6.43	0.25

Price of rice – ` 13,100/t

Post-emergence application of tank-mix of bispyribac-sodium at 20 g + metsulfuron-methyl + chlorimuron-ethyl 4 g/ha and pre-emergence application of pretilachlor at 750 g *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g/ha has been found effective in controlling weed population and achieving higher profitability in transplanted rice.

Economics

The highest net returns (` 41,036/ha) and B:C ratio (2.54) was recorded under bispyribac + metsulfuron-methyl + chlorimuron-ethyl. Pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl also recorded higher net return (` 38,953/ha) and B:C ratio (2.52). Due to high weeding cost in weed free check, the net return (` 36,073/ha) and B:C ratio (2.24) were narrow. The herbicides applied in combination recorded more net returns and B:C ratio compared to sole application of herbicides.

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