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Herbicides for weed management in direct dry-seeded rice

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ABSTRACT

A field experiment was conducted during *Kharif* seasons of 2010 and 2011 to evaluate the efficacy of different herbicides and their combinations in managing weeds of direct dry-seeded rice. The major weeds were *Echinochloa colona, Echinochloa crus*-galli, *Leptochloa chinensis* among grasses, *Caesulia axillaris* and *Trianthema monogyna* among broad-leaved weeds and *Cyperus rotundus* among sedge. The lowest total weed density was recorded with azimsulfuron 35 g/ha and cyhalofop-butyl + ready mix of chlorimuron + metsulfuron 60 + 20 g/ha, which were at par with each other followed by fenoxaprop + ethoxysulfuron 60 + 15 g/ha and twice hand weeding at 20 and 40 days after seeding (DAS). The lowest weed biomass was recorded with combined application of fenoxaprop + ethoxysulfuron 60 + 15 g/ha and fenoxaprop + ready mix of chlorimuron + metsulfuron 60 + 20 g/ha. The highest weed control efficiency was recorded with twice hand weeding at 20 and 40 DAS (89.9%) followed by fenoxaprop + ethoxysulfuron 60 + 15 g/ha, fenoxaprop + ready mix of chlorimuron + metsulfuron 60 + 20 g/ha, bispyribac-sodium 25 g/ha and fenoxaprop 60 g/ha over the weedy check. The higher grain yield (3.50 t/ha) was recorded with twice hand weeding (20 and 40 DAS), which was at par with fenoxaprop + ethoxysulfuron 60 + 15 g/ha followed by bispyribac-sodium 25 g/ha alone and fenoxaprop + ready mix of chlorimuron + metsulfuron 60 + 20 g/ha.

Key words: Chemical control, Direct dry-seeded rice, Grain yield, Herbicides, Weed control

Rice (*Oryza sativa* L.) is major food grain crop of the world and more than half of the population subsists on it. India is the second largest rice producing country in the world. Rice used to be predominantly grown by transplanting in puddled soil with continuous flooding (Sanches 1973). However, it deteriorates soil physical properties, which adversely affects the growth and productivity of succeeding wheat crop. The increasing cost of labour threatens the sustainability of transplanted rice within the rice-wheat system of Indo-Gangetic Plains. Direct-seeding is cost effective, can save water through rice crop establishment and allows early sowing of wheat (Ladha *et al.* 2003). All these factors have increased the interest of farmers to shift from the conventional practice of puddled transplanting to direct-seeded rice (DSR) especially dry-DSR. In dry direct-seeded rice (dry-DSR), dry seed is drilled into the non-puddled soil. Dry-DSR saves irrigation water by 12-35%, labour up to 60% and provides higher net returns (US$ 30-50/ha) with similar or slightly lower yield of rice (Kumar and Ladha 2011). Despite multiple benefits of dry-DSR, weed control remains one of the major challenges for its success (Kumar and Ladha 2011, Rao *et al*. 2007, Singh *et al*. 2008). Weed control is more difficult in dry-DSR than transplanted rice because of simultaneous emergence of both rice and weed seedlings in dry–DSR (Rao *et al*. 2007, Kumar and Ladha 2011). Post-emergence herbicides are used in DSR system for the selective control of weeds. The application of a single post-emergence herbicide in DSR systems often provides suboptimal weed control because of complex weed flora and long critical period of weed control (up to the first 5 to 7 weeks after crop establishment) (Khaliq *et al.* 2011, Awan *et al.* 2015). A single pre-emergence herbicide or a single post-emergence herbicide hardly provides satisfactory yield in DSR systems mainly because of the narrow spectrum of herbicide activity (Suria *et al.* 2011, Chauhan and Opena 2012). Therefore, the better weed control option in dry-DSR systems was found to be the applications of pre-emergence herbicide followed by (*fb*) a post-emergence herbicide or a mixture of post-emergence herbicides *fb* one hand weeding (Mahajan and Timsina 2011, Chauhan and Opena 2012). The objective of this study was to evaluate the herbicides and their combinations for effective management of grassy, broad-leaf weeds and sedges without the need for hand weeding.

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MATERIALS AND METHODS

A field experiment was conducted during *Kharif* season of 2010 and 2011 at N.E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture

& Technology Pantnagar, U.S. Nagar, Uttarakhand to evaluate the efficacy of pre- and post-emergence herbicides and their combinations in weed control in dry-DSR. The soil of experimental plot was silty clay loam in texture, medium in organic carbon (0.66%), available phosphorus (27.5 kg/ha) and potassium (243.5 kg/ha) with pH 7.3. The experiment was laid out in randomized block design with three replications. The treatments consisted of pyrazosulfuron 25 g/ha, pretilachlor 750 g/ha, cyhalofop-butyl 90 g/ha, fenoxaprop 60 g/ha, cyhalofop-butyl + ready mix of chlorimuron + metsulfuron 90 +20 g/ha, fenoxaprop + ready mix of chlorimuron + metsulfuron 60 + 20 g/ha, azimsulfuron 35 g/ha, bispyribac sodium 25 g/ha, tank mix of fenoxaprop + ethoxysulfuron 60 + 15 g/ha, oxyflurofen + 2,4-D 300 + 500 g/ha, twice hand weeding at 20 and 40 days after seeding (DAS) and weedy check. Rice variety "*Sarjoo 52*" was sown at row spacing of 20 cm on June 09, 2010 and June 14, 2011. Herbicides were sprayed with flat fan nozzle with 750 litres volume of water per hectare using knapsack sprayer. The observations on density and dry matter weight of weeds were taken at 30 and 60 DAS. Dry matter of weeds was recorded and expressed in g/m^2. The data on weed density and weed dry matter were analyzed after subjecting to square root transformation by adding 1.0 to original values prior to statistical analysis. Yield attributing characters and yield were recorded at harvest. Each experimental plot was threshed by rice thresher to determine grain yield and it is presented as t/ha.

RESULTS AND DISCUSSION

Effect on weeds

Common weed species infesting the experimental site during both the years were *Echinochloa colona, Echinochloa crus-galli* and *Leptochloa chinensis* among grasses, *Caesulia axillaris*, and *Trianthema monogyna* among broad-leaved weeds and *Cyperus rotundus* among sedge. Among different categories of weeds, sedges recorded in higher number followed by grassy and broad-leaved weeds at 30 and 60 DAS during 2010 and 2011, respectively. The density of weed was significantly influenced by weed control treatments in both the years at 30 and 60 DAS. The highest weed infestations were recorded in weedy check plot. All herbicides reduced the growth of weeds compared to those observed in weedy check plots.

At 30 DAS, sole application of fenoxaprop 60 g/ha caused significant reduction in the density of grassy weeds, *viz*. *E. colona*, *E. crus-galli* and *L. chinensis*, which was found at par with twice hand weeding at 20 and 40 DAS and fenoxaprop + ethoxysulfuron 60 + 15 g/ha (Table 1). The control of broad-leaved weeds was total with bispyribac-sodium 25 g/ha and fenoxaprop + ethoxysulfuron 60 + 15 g/ha and these treatments were statistically at par with azimsulfuron 35 g/ha and fenoxaprop 60 g/ha. Lowest population of *C. rotundus* was recorded with hand weeding at twice 20 and 40 DAS. Among the herbicidal treatments, combined application of

Table 1. Effect of different treatments on weed density and weed biomass in direct dry-seeded rice at 30 DAS (pooled data of 2010 and 2011)

Treatment	Weed density (no./m^2)			Total weed density (no./m^2)	Weed biomass (g/m^2)
	Grasses	Broad-leaved weeds	Sedges		
Pyrazosulfuron 25 g/ha (4 DAS)	11.3 (127.3)	2.0 (4.0)	9.2 (98.0)	15.0 (229.3)	7.5 (64.2)
Pretilachlor 750 g/ha (4 DAS)	7.3 (50.0)	2.2 (5.3)	11.9 (177.3)	14.4 (232.7)	8.1 (80.0)
Cyhalofop-butyl 90 g/ha (30 DAS)	9.3 (58.3)	1.6 (2.0)	13.7 (244.0)	17.3 (329.3)	6.4 (48.4)
Fenoxaprop 60 g/ha (30 DAS)	2.8 (7.3)	1.7 (2.7)	12.8 (202.0)	13.4 (212.0)	5.4 (34.1)
Cyhalofop-butyl + (chlorimuron + metsulfuron) 90 + 20 g/ha (30 DAS)	7.9 (64.0)	2.9 (3.3)	4.0 (15.3)	9.0 (82.7)	6.2 (45.5)
Fenoxaprop + (chlorimuron + metsulfuron) 60 + 20g/ha (30 DAS)	5.1 (26.0)	1.9 (3.3)	7.1 (49.3)	8.9 (78.7)	4.6 (21.6)
Azimsulfuron (50 % WP) 35g/ha (20 DAS)	5.2 (30.0)	1.6 (2.0)	9.7 (124.0)	11.2 (156.0)	5.9 (48.3)
Bispyribac- sodium 25 g/ha (20 DAS)	4.7 (26.0)	1.0 (0.0)	4.9 (24.0)	6.8 (50.0)	4.3 (22.0)
Fenoxaprop+ ethoxysulfuron g/ha (30 DAS)	3.5 (12.0)	1.0 (0.0)	6.6 (42.7)	7.4 (54.7)	4.5 (23.1)
Oxyflurofen +2,4-D 300+500 g/ha (4 *fb* 30 DAS)	8.4 (72.7)	1.2 (0.7)	9.3 (89.3)	12.6 (162.7)	6.4 (49.3)
Two hand weedings of 20 and 40 DAS	3.4 (14.7)	2.0 (4.0)	3.6 (12.0)	5.4 (30.7)	3.2 (10.8)
Weedy	10.7 (114.7)	4.6 (20.7)	8.5 (73.3)	14.3 (205.3)	12.2 (179.3)
LSD (P=0.05)	1.8	0.8	3.7	3.4	1.6

Values within parentheses are original. Data are subjected to square root transformation $(\sqrt{x+1})$; DAS = days after seeding

Table 2. Effect of different treatments on weed density and weed biomass in direct dry seeded rice at 60 DAS (pooled data of 2010 and 2011)

Treatment	Weed density (no./m^2)			Total weed density (no./m^2)	Weed biomass (g/m^2)	WCE (%)
	Grasses	Broad-leaved weeds	Sedges			
Pyrazosulfuron 25 g/ha (4 DAS)	7.4 (54.0)	1.2 (0.7)	5.4 (35.3)	9.5 (90.0)	18.0 (323.5)	34.8
Pretilachlor 750 g/ha (4 DAS)	5.8 (33.3)	1.2 (0.7)	9.0 (90.7)	11.2 (124.7)	17.4 (303.8)	38.8
Cyhalofop-butyl 90 g/ha (30 DAS)	5.4 (28.7)	1.2 (0.7)	12.8 (168.7)	14.0 (198.1)	15.2 (241.1)	51.4
Fenoxaprop 60 g/ha (30 DAS)	5.3 (27.3)	2.1 (4.7)	11.2 (135.3)	13.0 (167.3)	11.3 (126.1)	74.6
Cyhalofop-butyl + (chlorimuron + metsulfuron) 90 + 20 g/ha (30 DAS)	2.7 (7.3)	1.4 (1.3)	5.2 (28.0)	6.0 (36.6)	14.1 (203.6)	58.9
Fenoxaprop + (chlorimuron + metsulfuron) 60 + 20g/ha (30 DAS)	7.0 (49.3)	1.0 (0.0)	6.6 (46.7)	9.8 (96.0)	7.9 (60.9)	87.7
Azimsulfuron (50 % WP) 35 g/ha (20 DAS)	4.8 (22.7)	1.0 (0.0)	1.2 (0.7)	4.9 (23.4)	11.5 (141.0)	71.6
Bispyribac- sodium 25 g/ha (20 DAS)	4.2 (17.3)	1.0 (0.0)	7.5 (60.7)	8.6 (78.0)	9.4 (89.1)	82.1
Fenoxaprop + Ethoxysulfuron g/ha (30 DAS)	3.1 (9.3)	1.0 (0.0)	7.7 (58.7)	8.3 (68.0)	7.1 (51.3)	89.7
Oxyflurofen + 2,4-D 300 + 500 g/ha (4 *fb* 30 DAS)	7.1 (49.3)	1.0 (0.0)	6.9 (52.7)	10.1 (102.0)	15.8 (255.8)	48.5
Two hand weedings of 20 and 40 DAS	4.7 (21.3)	1.2 (0.7)	4.7 (25.3)	6.9 (47.3)	6.9 (50.3)	89.9
Weedy	7.6 (56.7)	3.4 (11.3)	13.3 (176.0)	15.5 (241.3)	22.3 (496.4)	-
LSD (P=0.05)	1.0	0.6	2.7	2.3	1.6	-

Values within parentheses are original. Data are subjected to square root transformation $(\sqrt{x+1})$; DAS = days after seeding

cyhalofop-butyl + ready mix of chlorimuron + metsulfuron 90 + 20 g/ha and bispyribac sodium 25 g/ha followed by fenoxaprop + ethoxysulfuron 60 + 15 g/ha and fenoxaprop + ready mix of chlorimuron + metsulfuron 90 + 20 g/ha, which were at par with each other. The lowest total weed density was recorded with hand weeding twice at 20 and 40 DAS, which was at par with bispyribac-sodium 25 g/ha and fenoxaprop + ethoxysulfuron 60 + 15 g/ha followed by fenoxaprop + ready mix of chlorimuron + metsulfuron 90 + 20 g/ha and cyhalofop-butyl + ready mix of chlorimuron + metsulfuron 90 + 20 g/ ha. Among herbicidal treatments, lowest weed biomass was recorded with bispyribac-sodium 25 g/ ha, which was statistically at par with fenoxaprop + ethoxysulfuron 60 + 15 g/ha, fenoxaprop + ready mix of chlorimuron + metsulfuron 90+20 g/ha and fenoxaprop 60 g/ha. These findings were in conformity with Brar and Bhullar (2012).

At 60 DAS, all the herbicidal treatments significantly reduced the density of weeds, broad-leaved weeds and sedges compared to weedy check (Table 2). Density of grassy weeds was significantly reduced by the combination of cyhalofop + ready mix of chlorimuron + metsulfuron 90 + 20 g/ha, which was at par with fenoxaprop + ethoxysulfuron 60 + 15 g/ha. Significant reduction in the density of sedges was recorded with sole application of azimsulfuron 35 g/ha. Total weed density was effectively reduced by azimsulfuron 35 g/ha and cyhalofop butyl + ready mix of chlorimuron + metsulfuron 60 + 20 g/ha, which were at par with each other followed by fenoxaprop + ethoxysulfuron 60 + 15 g/ha, bispyribac-sodium 25 g/ha and twice hand weeding at 20 and 40 DAS than other herbicidal treatments. The lowest weed biomass was recorded with twice hand weeding, which was at par with combined application of fenoxaprop + ethoxysulfuron 60 + 15 g/ha and fenoxaprop + ready mix of chlorimuron + metsulfuron 60 + 20 g/ha followed by bispyribac-sodium 25 g/ha and fenoxaprop 60 g/ha. The highest

Table 3. Effect of different treatments on yield and yield attributing characters of direct dry-seeded rice (pooled data of 2010 and 2011)

Treatment	Panicles (no./m^2)	Grains/ panicle	Grain yield (t/ha)
Pyrazosulfuron 25 g/ha (4 DAS)	48.0	135.0	0.59
Pretilachlor 750 g/ha (4 DAS)	39.2	117.0	0.53
Cyhalofop-butyl 90 g/ha (30 DAS)	89.2	143.9	1.37
Fenoxaprop 60 g/ha (30 DAS)	121.3	153.0	2.45
Cyhalofop-butyl + (chlorimuron + metsulfuron) 90 + 20 g/ha (30 DAS)	102.2	137.9	1.48
Fenoxaprop + (chlorimuron + metsulfuron) 60 + 20 g/ha (30 DAS)	156.0	149.3	3.00
Azimsulfuron (50 % WP) 35 g/ha (20 DAS)	163.4	149.4	2.08
Bispyribac- sodium 25 g/ha (20 DAS)	176.7	123.7	3.13
Fenoxaprop+ ethoxysulfuron g/ha (30 DAS)	161.5	157.5	3.48
Oxyflurofen + 2,4-D 300 + 500 g/ha (4 *fb* 30 DAS)	57.2	161.2	1.01
Two hand weedings of 20 and 40 DAS	169.0	164.3	3.50
Weedy	29.0	102.5	0.35
LSD (P=0.05)	21.0	65.9	0.37

DAS = Days after seeding

weed control efficiency was recorded with twice hand weeding at 20 and 40 DAS (89.9%) followed by fenoxaprop + ethoxysulfuron 60 + 15 g/ha, fenoxaprop + ready mix of chlorimuron + metsulfuron 60 + 20 g/ha, bispyribac-sodium 25 g/ha and fenoxaprop 60 g/ha. Ramchandiran and Balasubramanian (2012) also reported the higher weed control efficiency of fenoxaprop + ready mix of chlorimuron + metsulfuron in aerobic rice.

Effect on crop

All the weed control treatments produced significantly more number of panicles/m^2, grains per panicle and grain yield than weedy check (Table 3). The highest grain yield (3.50 t/ha) was recorded with hand weeding twice at 20 and 40 DAS which was statistically at par with fenoxaprop + ethoxysulfuron 60 + 15 g/ha (3.48 t/ha) and bispyribac-sodium 25 g/ha (3.13 t/ha). Uncontrolled weeds in weedy check plots caused an average reduction in yield to the extent of 89.9% in 2010 and 88.8% 2011 when compared with fenoxaprop + ethoxysulfuron 60 + 15 g/ha and bispyribac-sodium 25 g/ha mainly due to highest weed density and biomass in weedy check plots. The lowest yield (352 kg/ha) was recorded in weedy check.

It was concluded that among the herbicidal treatments, combination of fenoxaprop + ethoxysulfuron 60 + 15 g/ha applied at 20 DAS and fenoxaprop + ready mix of chlorimuron + metsulfuron 60 + 20 g/ha at 30 DAS were found more effective in controlling weeds and attaining higher yield of direct dry-seeded rice.

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