

Efficacy of Azimsulfuron alone and as Tank-Mix with Metsulfuron-Methyl for Weed Control in Wet Direct Seeded Rice

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Abstract

Two field experiments were conducted during *kharif* 2006 to 2008 to evaluate the efficacy of azimsulfuron alone and as tank-mix with metsulfuron-methyl along with some of promising herbicides for post-emergence control of weeds in wet direct seeded rice (DSR). In the first experiment conducted only during *kharif* of 2006, maximum control of weeds particularly *Echinochloa crus-galli* with azimsulfuron was obtained with its highest dose of 30 g/ha alone or in combination with metsulfuron 2 g/ha in wet direct seeded rice under puddle and unpuddle conditions. In general, the efficacy of azimsulfuron was higher under puddle as compared to unpuddle conditions. Bispyribac 30 g/ha and penoxsulam 25 g/ha at 24 DAS provided maximum control of weeds. Under both the situations, the maximum grain yield was obtained with bispyribac 30 g/ha followed by penoxsulam 25 g/ha and azimsulfuron 30 g/ha, which were at par with weed free checks. Fenoxaprop (with safener) 56 g/ha, cyhalofop 90 g/ha, clodinafop 30 g/ha did not provide satisfactory control of *E. crus-galli*. Addition of chlorimuron + metsulfuron had antagonistic effect on weed control by fenoxaprop but not on cyhalofop. Fenoxaprop and clodinafop had some phytotoxic effects on the crop also. In the second experiment during *kharif* of 2007 and 2008, control of weeds increased with increase in dose of azimsulfuron up to the highest dose of 30 g/ha during 2007 and 40 g/ha during 2008. Azimsulfuron was not as good against *E. crus-galli* but it was excellent against sedges including *Cyperus rotundus* even at the lower doses. Hence it may be a good choice in fields dominated by sedges. Efficacy of azimsulfuron appeared to be better when applied at 15 DAS than 25 DAS. Addition of metsulfuron improved the control of broadleaf weeds, but had not much influence on grain yields. However, it may be useful under situations where broadleaf weeds are dominant. There was no phyto-toxicity of azimsulfuron on the crop, hence could be safely used up to 40 g/ha in wet DSR. Pretilachlor was phyto-toxic to the crop, hence should not be used in wet direct seeded rice.

Key words : Azimsulfuron, Metsulfuron-methyl, Weed control, Rice, Efficacy.

In India, rice is grown over an area of 43 m ha with total production of 87 m tones amounting to 41.8% of total food grain. Out of 30 important cropping systems identified in India, the systems those are considered to be the major contribution to national food basket are : Rice-wheat (10.5 m ha), rice-rice (5.9 m ha) and coarse grain based systems (10.8 m ha). Out of all these systems, share of rice and wheat together is the highest, contributing about 65% to the food grain production (1), while rice-wheat system contributes 40%. Unfortunately, most of the high productivity systems are cereal-based, having high resource demand and continuously practiced over the decades in major parts of the country. In most of the South Asia, common practice of establishing rice in the rice-wheat systems is through puddling followed by trans-

planting. Labor scarcity and drudgery among women workers are some of the other disadvantages associated with puddle transplant rice (PTR). Looking into these problems, there is certainly increasing interests of growers in direct seeding. There is need for more water efficient and less labor intensive systems of rice establishment like direct seeding for obtaining optimum plant population. Weed infestation is one of the major constraints in direct seeded rice (2, 3). As the pre-emergence herbicides like pendimethalin and pretilachlor + safener alone can not provide satisfactory control of weeds in direct seeded rice and use of pendimethalin in wet direct seeded rice is ruled out due to phyto-toxicity on the crop (4). Hence, the present study was conducted at CCS Haryana Agricultural University Regional Research Station, Karnal

Table 1. Effect of different herbicides on density and dry weight of weeds, and yield and yield attributes of wet direct seeded rice (kharif 2006). *mrl, meter row length ; **PDL, puddle ; ***UPDL, unpuddle.

Treatments	Dose (g/ha)	Density of weeds (no./m ²)		Dry weight of weeds (g/m ²)		Plant height (cm)	
		PDL**	UPDL***	PDL	UPDL	PDL	UPDL
Azimsulfuron	22.5	3.31 (10.0)	5.43 (28.7)	199.6	441.3	70.5	69.6
Azimsulfuron	25	3.28 (10.0)	4.72 (22.0)	152.8	353.5	70.6	70.8
Azimsulfuron	27.5	2.69 (6.7)	3.60 (12.0)	120.7	261.0	70.2	71.3
Azimsulfuron	30	2.08 (4.0)	3.20 (9.3)	68.1	223.6	70.8	71.3
Azimsulfuron + metsulfuron	25 + 2	2.65 (6.0)	3.58 (12.0)	131.7	301.5	70.6	71.2
Azimsulfuron + metsulfuron	27.5 + 2	2.07 (3.3)	2.83 (7.3)	110.3	199.3	70.3	71.1
Azimsulfuron + metsulfuron	30 + 2	1.79 (2.7)	2.73 (6.7)	43.2	168.7	71.1	73.2
Metsulfuron	1	5.25 (26.7)	5.96 (34.7)	389.1	699.2	68.1	69.3
Cyhalofop	90	4.79 (22.0)	4.66 (21.3)	328.6	415.5	69.9	69.7
Fenoxaprop (with safener)	56	4.20 (16.7)	2.99 (8.0)	295.0	180.4	69.5	71.3
Cyhalofop + (Chlorimuron + metsulfuron)	90 + 4	3.95 (14.7)	4.60 (20.7)	255.8	334.2	69.1	70.7
Fenoxaprop (with safener) + (Chlorimuron + metsulfuron)	56 + 4	4.72 (21.3)	4.84 (22.7)	493.5	423.2	68.4	69.7
Bispyribac	30	1.41 (1.3)	1.00 (0.0)	19.1	0.0	70.8	70.9
Penoxsulam	25	1.49 (1.3)	1.67 (2.7)	35.1	13.3	71.1	71.6
Clodinafop	30	5.83 (33.3)	5.61 (30.7)	425.3	573.6	69.0	69.1
Weed free	-	1.00 (0.0)	1.00 (0.0)	0.0	0.0	70.5	72.7
Weedy check	-	5.38 (28.0)	6.24 (38.0)	452.4	691.0	68.3	69.1
CD 5%	-	1.59	1.07	64.5	236.8	1.9	2.2

Table 1. Continued.

Treatments	Dose (g/ha)	Effective tillers/ mrl*		Panicle length (cm)		Grain yield (kg/ha)	
		PDL	UPDL	PDL	UPDL	PDL	UPDL
Azimsulfuron	22.5	52.3	39.0	18.4	18.5	3514	1284
Azimsulfuron	25	55.2	40.5	18.9	18.5	3614	2092
Azimsulfuron	27.5	55.3	44.2	18.7	18.6	4078	2536
Azimsulfuron	30	59.0	52.0	18.7	18.9	4211	3804
Azimsulfuron + metsulfuron	25 + 2	47.2	50.7	18.8	18.4	3254	2663
Azimsulfuron + metsulfuron	27.5 + 2	49.0	53.8	18.5	18.5	3423	3011
Azimsulfuron + metsulfuron	30 + 2	54.7	53.2	19.0	18.9	3624	3370
Metsulfuron	2	34.2	26.5	18.1	17.9	1247	613
Cyhalofop	90	42.2	43.2	18.4	18.0	2191	993
Fenoxaprop (with safener)	56	44.2	50.7	18.5	18.7	3043	2156
Cyhalofop + (Chlorimuron + metsulfuron)	90 + 4	38.8	37.7	18.1	18.4	1986	1152
Fenoxaprop (with safener) + (Chlorimuron + metsulfuron)	56 + 4	34.5	37.3	17.4	18.2	1246	930
Bispyribac	30	59.5	59.0	18.7	18.7	4698	4414
Penoxsulam	25	56.3	55.8	18.8	19.4	4550	4087
Clodinafop	30	37.2	24.0	18.1	17.7	1743	680
Weed free	-	60.5	57.2	18.8	18.9	4836	4529
Weedy check	-	32.0	24.7	18.4	18.0	1394	616
CD 5%	-	16.1	9.5	0.6	0.7	905	814

during *kharif* of 2006 to 2008 to evaluate azimsulfuron alone and with metsulfuron along with some of promising herbicides for post-emergence control of weeds in DSR.

Methods

Two field experiments were conducted at CCS Haryana Agricultural University Regional Research

Station, Karnal during *kharif* of 2006 to 2008. In the first experiment during *kharif* of 2006, coarse grain rice cultivar Gobind was sown with drum seeder on 40 July using pre-germinated seed under puddle and un-puddle conditions. Seed rate was 40 kg/ha. The field was medium in organic carbon (0.60%), low in phosphorus (10 kg/ha) and high in potassium (321 kg/ha) with slightly alkaline in reaction (pH 8.2). Different herbicidal treatments including azimsulfuron 22.5–30.0 g/ha with or without metsulfuron-methyl 2 g/ha; fenoxaprop (with safener) 56 g/ha and cyhalofop 90 g/ha with or without chlorimuron + metsulfuron (ready-mix) 4 g/ha; bispyribac sodium 30 g/ha, penoxsulam 25 g/ha, clodinafop 30 g/ha, metsulfuron at 4 g/ha along with weedy and weed free checks were laid out in randomized block design with three replicates. All the herbicides were sprayed at 24 days after sowing (DAS) with flat-fan nozzle using 300 liter/ha water. Data on weed density and dry weight were recorded at 85 DAS. Yield and yield attributes were recorded at maturity of crop. Crop was harvested on 16 October 2006.

The second experiment was conducted during *kharif* of 2007 and 2008 using scented (*basmati*) rice cultivar CSR30 sown with drum seeder (18 cm row spacing) using pre-germinated seed on 29 June under unpuddle condition during 2007 and on 14 July under puddle condition during 2008. Seed rate was 50 kg/ha and 20 kg/ha during 2007 and 2008, respectively. During 2007, thinning was done once at 20 days after sowing (DAS) for maintaining proper plant population. The field was medium in organic carbon (0.53%), low in phosphorus (10 kg/ha) and high in potassium (336 kg/ha) with slightly alkaline reaction (pH 8.0) during 2007. In 2008, the field was low in organic carbon (0.35%), medium in phosphorus (11 kg/ha) and potassium (284 kg/ha) with slightly alkaline reaction (pH 8.2). For initial 30 days, fertilizer was applied as per requirement of nursery crop, while later on fertilizer was applied as in case of main crop. The treatments during *kharif* of 2007 included azimsulfuron 25, 27.5 and 30 g/ha with or without metsulfuron 2 g/ha at 15 and 25 DAS, pretilachlor 50EC 1000 g/ha at 7 DAS alone or followed by ethoxysulfuron 18.75 g/ha, pretilachlor 40EW 1000 g/ha, along with weed free and weedy checks. The treatments were modified based on the experiences of the previous year. During *kharif* of 2008, the doses of azimsulfuron were 30,

35 and 40 g/ha with or without metsulfuron 2 g/ha at 15 or 25 DAS. Other treatments remained same except deletion of pretilachlor 40EW. The treatments were laid out in randomized block design with three replicates. The plot size was 5.80 × 2.16 m in 2007 and 4.80 × 2.16 m in 2008. Post-emergence herbicides were applied by spray with flat-fan nozzle using 300 liter/ha water; whereas, pretilachlor was applied as spray in 2007 and as sand-mix using 150 kg/ha sand in 2008. Data on weed density and dry weight were recorded at 90 DAS during 2007 and 80 DAS during 2008. Yield and yield attributes were recorded at maturity of crop. Crop was harvested on 13 November 2007 and 10 November 2008.

Results and Discussion

Effect on Weeds

Experiment I. Echinochloa crus-galli (L.) P. Beauv. was the predominant weed in the field. Under both puddle and unpuddle conditions, control of weeds increased with increase in dose of azimsulfuron alone or in combination with metsulfuron (Table 1). All the herbicidal treatments except metsulfuron 4 g/ha, clodinafop 30 g/ha and fenoxaprop (with safener) 56 g/ha + chlorimuron + metsulfuron 4 g/ha significantly decreased the weed density and dry weight as compared to weedy check. Among different doses of azimsulfuron, maximum control of weeds was obtained with the highest dose of 30 g/ha alone or in combination with metsulfuron. Efficacy of azimsulfuron was better under puddle as compared to unpuddle conditions, probably due to high moisture conditions. Bispyribac 30 g/ha and penoxsulam 25 g/ha provided maximum control of weeds. Effective control of *E. crus-galli* with bispyribac followed by penoxsulam in wet DSR has been reported earlier as well (4–7). Fenoxaprop, cyhalofop and clodinafop did not provide satisfactory control of *E. crus-galli*. Addition of chlorimuron + metsulfuron had antagonistic effect on weed control by fenoxaprop but not on cyhalofop.

Experiment II. E. crus-galli was the predominant grassy weed along with broadleaf weeds like *Ammannia baccifera* L. and sedges like *Cyperus rotundus* L., *C. difformis* L., *Fimbristylis miliacea* (L.) Vahl. Density and dry weight of *E. crus-galli* decreased with increase dose of azimsulfuron during both the years (Table 2). All the herbicidal treatments

Table 2. Effect of azimsulfuron alone and in mixture with metsulfuron on density and dry weight of weeds in wet direct seeded rice (kharif of 2007 and 2008). *Original figures in parentheses were subjected to square-root transformation before statistical analysis.

Treatments	Dose (g/ha)		Time (DAS)	Density of weeds (no./m ²)*					
	2007	2008		Grassy		BLW		Sedges	
				2007	2008	2007	2008	2007	2008
Azimsulfuron	25	30	15	3.0 (8.0)	4.9 (23.3)	5.9 (34.0)	5.7 (31.3)	1.0 (0.0)	1.0 (0.0)
„	27.5	35	15	2.7 (6.7)	4.1 (16.0)	5.4 (28.0)	4.8 (22.0)	1.0 (0.0)	1.0 (0.0)
„	30	40	15	2.7 (6.7)	4.2 (16.7)	4.8 (22.7)	4.6 (20.7)	1.0 (0.0)	1.0 (0.0)
„	25	30	25	3.7 (12.7)	5.4 (28.0)	6.2 (37.3)	6.2 (37.3)	1.7 (2.7)	1.0 (0.0)
„	27.5	35	25	2.9 (7.3)	4.6 (20.7)	5.7 (31.3)	5.3 (28.0)	1.4 (1.3)	1.0 (0.0)
„	30	40	25	2.9 (7.3)	3.7 (12.7)	5.3 (28.7)	4.3 (18.0)	1.0 (0.0)	1.0 (0.0)
Azimsulfuron + metsulfuron	25+2	30+2	15	3.0 (8.0)	4.9 (23.3)	4.7 (22.0)	2.2 (4.0)	1.0 (0.0)	1.0 (0.0)
„	27.5+2	35+2	15	2.7 (6.7)	4.2 (16.7)	3.6 (12.7)	1.8 (3.3)	1.0 (0.0)	1.0 (0.0)
„	30+2	40+2	15	2.5 (5.3)	3.8 (14.0)	3.1(8.7)	1.8 (3.3)	1.0 (0.0)	1.0 (0.0)
„	25+2	30+2	25	3.2 (9.3)	5.1 (24.7)	5.9 (34.7)	3.2 (12.0)	1.8 (2.7)	1.0 (0.0)
„	27.5+2	35+2	25	3.3 (10.0)	4.6 (21.3)	5.2 (26.7)	3.4 (13.3)	1.4 (1.3)	1.0 (0.0)
„	30+2	40+2	25	3.1 (8.7)	4.0 (15.3)	3.9 (14.7)	1.4 (1.3)	1.4 (1.3)	1.0 (0.0)
Pretilachlor 50EC	1000	1000	7	3.5 (11.3)	6.0 (34.7)	5.4 (28.7)	14.8(218.0)	2.9(8.7)	2.4(6.0)
Pretilachlor 50EC fb ethoxysulfuron	1000/ 18.75	1000/ 18.75	7/25	3.6 (12.0)	4.6 (20.0)	3.9 (14.7)	2.8 (8.7)	2.3 (5.3)	1.0 (0.0)
Pretilachlor 40EW	1000		7	3.5 (11.3)	-	4.8 (22.0)	-	3.1 (10.0)	-
Weed free	-	-	-	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
Weedy check	-	-	-	4.6 (20.0)	7.8 (60.7)	5.8 (32.7)	14.6(211.3)	4.0(16.7)	9.8 (96.0)
CD 5%	-	-	-	0.7	1.0	1.2	1.5	1.3	0.8

Table 2. Continued.

Treatments	Dose (g/ha)		Time (DAS)	Dry weight of weeds (g/m ²)					
	2007	2008		Grassy		BLW		Sedges	
				2007	2008	2007	2008	2007	2008
Azimsulfuron	25	30	15	123.2	184.9	4.1	2.9	0.0	0.0
„	27.5	35	15	92.1	173.9	2.6	2.1	0.0	0.0
„	30	40	15	61.3	81.0	4.3	0.8	0.0	0.0
„	25	30	25	114.5	143.5	4.7	7.5	0.0	0.0
„	27.5	35	25	97.3	126.3	4.9	2.3	0.5	0.0
„	30	40	25	97.4	48.1	4.8	2.2	0.3	0.0
Azimsulfuron + metsulfuron	25+2	30+2	15	122.1	209.2	1.3	0.9	0.0	0.0
„	27.5+2	35+2	15	100.1	158.8	1.1	0.4	0.0	0.0
„	30+2	40+2	15	58.7	83.4	2.1	0.4	0.0	0.0
„	25+2	30+2	25	100.4	151.7	1.9	0.7	0.4	0.0
„	27.5+2	35+2	25	101.7	137.3	4.3	0.7	0.4	0.0
„	30+2	40+2	25	92.1	87.8	1.1	0.2	0.3	0.0
Pretilachlor 50EC	1000	1000	7	221.3	290.0	17.7	20.0	2.8	2.5
Pretilachlor 50BC fb ethoxysulfuron	1000/ 18.75	1000/ 18.75	7/25	223.7	234.3	4.5	4.0	1.6	0.0
Pretilachlor 40EW	1000		7	251.6	-	11.9	-	7.4	-
Weed free	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
Weedy check	-	-	-	304.6	323.1	13.1	27.9	10.3	52.7
CD 5%	-	-	-	50.8	59.2	4.2	6.7	1.8	18.1

resulted in lower density and dry weight of *E. crus-galli* than weedy check but higher than weed free plots. During 2007, azimsulfuron 30 g/ha alone or as

tank mix with metsulfuron 2 g/ha at 15 DAS was significantly better than pretilachlor treatments in respect of density of *E. crus-galli*. During 2008, azimsulfuron

Table 3. Effect of azimsulfuron alone and in mixture with metsulfuron on yield and yield attributes of wet direct seeded rice (*kharif* of 2007 and 2008). *mrl, meter row length.

Treatments	Dose (g/ha)		Time (DAS)	Phyto-toxicity (%)		Plant height (cm)		Effective tillers/mrl*		Panicle length (cm)		Grain yield (kg/ha)	
	2007	2008		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Azimsulfuron	25	30	15	0.0	0.0	100.7	80.7	73.5	28.8	22.5	19.9	2250	916
„	27.5	35	15	0.0	0.0	101.9	77.3	72.2	34.7	22.3	20.3	2489	1050
„	30	40	15	0.0	0.0	100.8	80.8	74.4	47.7	22.3	20.5	2567	1204
„	25	30	25	0.0	0.0	101.2	78.5	67.5	34.0	22.0	19.9	2154	1033
„	27.5	35	25	0.0	0.0	100.6	76.9	67.2	39.0	22.3	20.4	2513	1075
„	30	40	25	0.0	0.0	101.9	81.1	74.0	44.2	22.9	20.3	2394	1254
Azimsulfuron + metsulfuron	25+2	30+2	15	0.0	0.0	101.2	77.8	68.7	33.2	22.2	20.1	2125	1024
„	27.5+2	35+2	15	0.0	0.0	101.7	77.4	71.2	34.7	22.6	20.5	2418	1101
„	30+2	40+2	15	0.0	0.0	101.2	80.9	78.8	42.7	23.3	20.5	2513	1279
„	25+2	30+2	25	0.0	0.0	101.5	80.8	69.0	30.2	22.2	20.2	2178	1019
„	27.5+2	35+2	25	0.0	0.0	101.6	78.1	67.0	37.2	21.8	20.2	2130	1044
„	30+2	40+2	25	0.0	0.0	101.3	75.8	72.2	47.7	21.9	20.5	2418	1241
Pretilachlor 50EC 1000	1000	1000	7	40.0	70.0	100.8	60.6	43.7	8.0	22.3	19.5	1507	231
Pretilachlor fb ethoxysulfuron	1000/18.75	1000/18.75	7/25	35.0	75.0	101.3	66.3	57.7	5.8	21.6	19.5	1764	103
Pretilachlor 40EW 1000			7	41.7	-	101.3	-	40.0	-	22.9	-	1572	-
Weed free	-	-	-	0.0	0.0	101.6	79.9	77.2	53.2	22.9	20.5	2968	1655
Weedy check	-	-	-	0.0	0.0	100.6	58.7	52.8	7.7	21.9	19.6	1722	180
CD 5%	-	-	-	11.1	-	NS	9.9	20.8	11.0	NS	0.7	404	213

35-40 g/ha alone or as tank mix with metsulfuron of both the stages of application was significantly better than pretilachlor treatments in respect of density of *E. crus-galli*. However, the dry weight of *E. crus-galli* was lower than pretilachlor of *E. crus-galli*. However, the dry weight of *E. crus-galli* was lower than pretilachlor treatments under all treatments of azimsulfuron during both the years. All the treatments of azimsulfuron were inferior to weed free check in respect of density and dry weight of *E. crus-galli* except dry weight under azimsulfuron 40 g/ha at 25 DAS being at par with weed free check during 2008.

Density and dry weight of broadleaf weeds was lower when metsulfuron was tank-mixed with azimsulfuron except dry weight during 2008 being similar under azimsulfuron treatments with or without metsulfuron (Table 2). Density of BLW under azimsulfuron treatments was also not at par with weed free check except azimsulfuron 30-40 g/ha + metsulfuron 2 g/ha at 15 DAS and azimsulfuron 40 g/ha + metsulfuron 2 g/ha at 25 DAS during 2008. However, the dry weight of BLW under tank-mix treatments of azimsulfuron with metsulfuron was at par with weed free checks during both the years. During

2008, azimsulfuron alone also provided dry weight of BLW similar to weed free check except 30 g/ha at 25 DAS.

All the treatments of azimsulfuron provided complete control of sedges including *C. rotundus* in respect of density and dry weight of weeds when applied at 15 DAS during 2007 and at both stages during 2008 ; however all the azimsulfuron treatments were at par with weed free check in respect of density and dry weight of sedges during both the years (Table 2). Earlier reports have also established supremacy of azimsulfuron in controlling the sedges, however it was reported weak against *Echinochloa* sp. in DSR (4, 6). Pretilachlor provided good control of *Leptochloa chinensis* L. and *Eragrostis* sp ; however their infestation was very low in the experimental plots (data not given).

Effect on Crop

Experiment I. In puddle conditions, plant height under all the herbicidal treatments, except metsulfuron 4 g/ha, fenoxaprop (with safener) 56 g/ha + chlorimuron + metsulfuron 4 g/ha, was at par with

weed free checks (Table 1). Plant height under metsulfuron 4 g/ha, cyhalofop 90 g/ha, fenoxaprop 56 g/ha alone or in mixture, and clodinafop 30 g/ha was similar to weedy check plots. In unpuddle situations, plant height under all the herbicidal treatments except metsulfuron, fenoxaprop + chlorimuron + metsulfuron, cyhalofop, clodinafop and azimsulfuron 22.5 g/ha was at par with weed free checks.

In unpuddle conditions, effective tillers under metsulfuron, cyhalofop and fenoxaprop alone or in mixture with chlorimuron + metsulfuron, and clodinafop were significantly lower than weed free check and at par with weedy check (Table 1). Azimsulfuron 22.5—30 g/ha alone, azimsulfuron 25—30 g/ha + metsulfuron 2 g/ha, bispyribac 25 g/ha and penoxsulam 25 g/ha provided effective tillers at par with weed free check under unpuddle conditions. Among herbicides, maximum tillers were obtained with bispyribac 30 g/ha followed by azimsulfuron 30 g/ha and penoxsulam 25 g/ha. In unpuddle conditions, effective tillers under clodinafop and metsulfuron were at par with weedy check and significantly lower than weed free check. Azimsulfuron 30 g/ha alone, azimsulfuron 25—30 g/ha + metsulfuron 2 g/ha, bispyribac 30 g/ha, penoxsulam 25 g/ha, fenoxaprop 56 g/ha were at par with weed free check in respect to effective tillers under unpuddle situations. Among herbicides, maximum tillers were obtained with bispyribac 30 g/ha followed by penoxsulam 25 g/ha and azimsulfuron at higher doses.

Under both the situations (puddle and unpuddle), maximum grain yield was obtained with bispyribac 30 g/ha followed by penoxsulam 25 g/ha and azimsulfuron 30 g/ha, which were at par with weed free check (Table 1). There was increase in grain yield of rice with increase in dose of azimsulfuron. Lower grain yields were obtained under fenoxaprop 56 g/ha + chlorimuron + metsulfuron 4 g/ha, metsulfuron 4 g/ha, clodinafop 30 g/ha, cyhalofop 90 g/ha alone and tank-mix with chlorimuron+metsulfuron 4 g/ha, which were at par with weedy check. There was significant reduction in grain yield due to tank-mixing of chlorimuron + metsulfuron with fenoxaprop. In general, performance of azimsulfuron was higher under puddle as compared to un-puddle conditions in respect of yield and yield attributes of crop.

Experiment II. During 2007, plant height and panicle length did not differ significantly due to dif-

ferent treatment (Table 2). Whereas plant height and panicle length were similar under all the azimsulfuron treatments (30—40 g/ha alone or as tank-mix with metsulfuron 2 g/ha at 15 or 25 DAS) and were at par with weed free check and plant height under azimsulfuron treatments was better than pretilachlor and weedy check during 2008. All the azimsulfuron treatments (25—30 g/ha alone and tank-mix with metsulfuron 2 g/ha at 15 or 25 DAS) produced effective tillers similar to weed free plots during 2007. Whereas in 2008, azimsulfuron 40 g/ha alone and as tank-mix with metsulfuron at both stages of application resulted in number of effective tillers at par with weed free check. Less numbers of tillers were observed under pretilachlor treatments during both the years, attributed to the phyto-toxicity of the chemical.

Grain yield increased with increase in dose of azimsulfuron up to highest dose (30 g/ha in 2007 and 40 g/ha in 2008). Maximum grain yield was obtained under azimsulfuron 30 g/ha alone at 15 DAS in 2007 which was at par with weed free check also ; while other treatments were inferior to weed free check. During 2008, more grain yields among azimsulfuron treatments were obtained with azimsulfuron 40 g/ha alone or in combination with metsulfuron at both the stages of application ; however none of the herbicidal treatments could produce yield at par with weed free check. Tank-mix application of metsulfuron with azimsulfuron had no significant advantage in terms of grain yield of the crop. All treatments of azimsulfuron gave significantly higher yield than the pretilachlor 1000 g/ha alone (both EC and EW formulations) at 7 DAS and weedy check during both the years. Yields under pretilachlor treatments were similar to weedy check plots.

Phyto-Toxicity

There was no phyto-toxicity of the azimsulfuron 22.5—30 g/ha and metsulfuron 2 g/ha alone as tank-mix, cyhalofop 90 g/ha, chlorimuron + metsulfuron 4 g/ha, bispyribac 30 g/ha and penoxsulam 25 g/ha applied as spray at 24 DAS on the coarse grain rice (cultivar 'Gobind') during 2006. While fenoxaprop 56 g/ha and clodinafop 30 g/ha were slightly phyto-toxic to the crop. Azimsulfuron up to 40 g/ha alone or as tank-mix with metsulfuron 2 g/ha did not have any

phyto-toxic effects on the scented rice (cultivar CSR 30). However, pretilachlor (50 EC and 40 EW) 1000 g/ha applied as spray or sand-mix at 7 DAS had about 35—42% phyto-toxicity on the crop during 2007 and 70—75% during 2008.

Conclusion

Control of *E. crus-galli* increased with increase in dose of azimsulfuron applied as post-emergence (15—25 DAS). Efficacy of azimsulfuron was better under puddle conditions with high soil moisture than the unpuddle conditions. However, still it was not quite effective against *E. crus-galli* even up to 40 g/ha. Hence it may not be suitable for direct seeded rice where *E. crus-galli* is the dominant weed. Azimsulfuron provided almost complete control of sedges even at the lowest doses and at both the stages of application, hence is a good choice where sedges are dominant. Addition of metsulfuron 2 g/ha resulted in increased control of BLW, but did not result in improvement in yield. However, it may be important in situations where BLW are predominant. Bispyribac 30 g/ha had the best efficacy against *E. crus-galli* followed by penoxsulam 25 g/ha and azimsulfuron at higher doses. Cyhalofop 90 g/ha, fenoxaprop (with safener) 56 g/ha, clodinafop 30 g/ha did not provide satisfactory control of *E. crus-galli* in wet DSR; rather fenoxaprop and clodinafop had slight phyto-toxicity on the crop also. Addition of chlorimuron + metsulfuron was antagonistic to fenoxaprop but compatible with cyhalofop. There was no phyto-toxicity of azimsulfuron on the crop, hence

can be safely used up to 40 g/ha. Pretilachlor was phyto-toxic to the crop, hence should not be used in wet seeded direct seeded rice.

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