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Optimization of Dose and Time of Application of Bispyribac Sodium for Weed Control in Direct Seeded Rice

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Abstract

Bispyribac 25 g/ha was the best among all the herbicides for control of *Echinochloa crus-galli* while azimsulfuron was quite good against sedges at both the stages of application (15 and 25 DAS) during *kharif* seasons of 2007 and 2008. Penoxsulam 25 g/ha and azimsulfuron 30 g/ha resulted in lower density and dry weight of grassy weeds at 15 DAS than their application at 25 DAS. In general, the post-emergence herbicides bispyribac, penoxsulam and azimsulfuron provided lower density and dry weight of BLW and sedges at 15 DAS stage than 25 DAS; however, the differences were not always significant. Azimsulfuron 30 g/ha at 15 DAS was the best treatment among the post-emergence herbicides against the BLW. Penoxsulam 25 g/ha at 15 DAS provided excellent control of sedges and was as good as weed free check. Azimsulfuron at 15 DAS provided complete control of sedges during both the years. Pretilachlor + safener 500 g/ha and pendimethalin 1000—1500 g/ha did not provide satisfactory control of weeds. There was no phyto-toxicity of bispyribac, penoxsulam, azimsulfuron, pretilachlor (with safener) on the rice crop; while pendimethalin at 1000—1500 g/ha caused 87—95% injury to the crop when applied as spray during 2007 and 45—77% toxicity when applied as sand-mix during 2008. Bispyribac 25 g/ha at both stages of application provided yields at par with weed free plots. Penoxsulam and azimsulfuron resulted in yields lower than weed free check. Pretilachlor + safener and pendimethalin yielded significantly lower than other herbicidal treatments.

Key words : Bispyribac sodium, Weed control, Direct seeded rice.

In north-west India, common practice of growing rice is by manual transplanting in puddle fields. Due to problems such as deteriorating soil health, declining water table, scarcity and increasing labour cost associated with puddle transplanted rice (PTR), there is a need of water efficient and less labor intensive systems of rice establishment like direct seeding. Looking into these problems under PTR, there is certainly increasing interest of growers in direct seeding in Haryana (1). But, weed infestation is one of the major constraints in direct seeded rice (2, 3). Earlier efforts for weed control in direct seeded rice (DSR) elsewhere made through pre-emergence herbicides like pendimethalin and pretilachlor (with safener) indicated that these herbicides alone were not suitable due to comparatively less efficacy against broad spectrum of weed flora and/or phyto-toxicity particularly in wet DSR. This situation warrants for initiating research efforts to evaluate and identify suitable post-emergence herbicide(s) in DSR. Bispyribac-sodium, a pyrimidinyl carboxy herbicide, is effective to control many annual and perennial grasses, sedges, and broad-leaved weeds in rice fields (4—6).Since it is a new post-emergence herbicide in rice in India, the present study was undertaken to standardize its dose and time of application against complex weed flora in direct seeded rice.

Methods

A field experiment was conducted at CCS Haryana Agricultural University Regional Research Station, Karnal during *kharif* of 2007 and 2008. Scented (*basmati*) rice cultivar CSR30 was sown with drum seeder (18 cm row spacing) using pre-germinated seed on 29 June and 14 July under unpuddle and puddle conditions during 2007 and 2008, respectively. 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

Table 1. Effect of different herbicide treatments on density and weight of weeds in wet direct seeded rice. *Original figures in parentheses were subjected to square root transformation (√X+1) before statistical analysis, ^fb, followed by, #BLW, broadleaf weeds; †DAS, days after sowing.

Treatment	Dose (g/ha)	Time (DAS)†	Weed density* (No./m²)			
			Grassy		BLW#	
			2007	2008	2007	2008
Bispyribac	20	15	2.32 (4.7)	3.78 (13.3)	6.33 (40.7)	7.93 (62.0)
Bispyribac	25	15	1.90 (2.7)	2.51 (5.3)	5.38 (28.0)	7.11 (50.0)
Bispyribac	30	15	1.00 (0.0)	1.79 (2.7)	5.41 (28.7)	6.54 (42.0)
Bispyribac	20	25	3.24 (10.0)	2.68 (6.7)	6.35 (40.0)	8.99 (80.7)
Bispyribac	25	25	2.56 (6.0)	1.41 (1.3)	6.18 (38.0)	8.18 (66.0)
Bispyribac	30	25	1.49 (1.3)	1.41 (1.3)	5.99 (35.3)	7.09 (50.0)
Penoxsulam	25	15	2.68 (6.7)	2.83 (7.9)	6.01 (36.0)	7.40 (54.7)
Penoxsulam	25	25	3.49 (11.3)	3.77 (13.3)	7.48 (56.0)	9.97 (98.7)
Azimsulfuron	30	15	3.31 (10.0)	3.49 (11.2)	4.60 (20.7)	3.51 (12.0)
Azimsulfuron	30	25	2.95 (8.0)	4.82 (22.7)	6.83 (46.7)	6.84 (46.0)
Pretilachlor+ safener	500	5	3.59 (12.)	4.41 (18.7)	6.19 (38.7)	7.78 (60.7)
Pendimethalin fb^ bispyribac	1000 fb 25	7 fb 25	1.90 (2.7)	–	5.92 (34.7)	–
Pendimethalin fb 2, 4-D	1000 fb 500	7 fb 25	4.19 (16.7)	–	1.49 (1.3)	–
Pendimethalin	1500	7	3.28 (10.0)	3.19 (9.3)	6.48 (43.3)	5.92 (34.7)
Pendimethalin	1000	7	3.60 (12.0)	3.58 (12.0)	5.29 (28.0)	8.68 (75.3)
Weed free	–	–	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)
Weedy check	–	–	4.71 (21.3)	6.49 (41.2)	5.96 (34.7)	8.55 (72.7)
CD at 5%	–	–	0.89	1.00	1.69	1.44

Table 1. Continued.

Treatment	Dose (g/ha)	Time (DAS)	Weed dry weight (g/m²)							
			Sedges		Grassy		BLW		Sedges	
			2007	2008	2007	2008	2007	2008	2007	2008
Bispyribac	20	15	5.43 (29.3)	5.52 (30.0)	78.0	66.5	11.5	22.3	5.8	19.9
Bispyribac	25	15	1.91 (3.3)	5.30 (27.3)	36.3	20.1	6.9	10.4	0.3	11.1
Bispyribac	30	15	2.10 (4.0)	3.58 (12.0)	0.0	8.5	7.7	6.1	0.9	8.2
Bispyribac	20	25	5.17 (26.7)	6.38 (40.0)	73.9	33.7	12.1	23.0	4.0	7.9
Bispyribac	25	25	4.85 (23.3)	6.06 (36.0)	48.1	9.8	9.7	18.2	3.1	8.0
Bispyribac	30	25	4.04 (16.0)	5.72 (32.0)	8.5	0.9	9.8	10.1	3.0	5.5
Penoxsulam	25	15	2.33 (5.3)	1.24 (0.7)	58.4	44.1	5.8	10.1	1.9	0.8
Penoxsulam	25	25	3.12 (9.3)	4.41 (19.3)	86.1	57.5	12.9	17.6	1.5	3.3
Azimsulfuron	30	15	1.00 (0.0)	1.00 (0.0)	142.3	80.1	3.2	2.5	0.0	0.0
Azimsulfuron	30	25	1.55 (2.0)	2.19 (6.7)	98.7	166.0	7.4	5.5	0.8	0.6
Pretilachlor+ safener	500	5	2.56 (6.0)	4.85 (22.7)	176.4	129.9	18.1	9.9	2.9	18.9
Pendimethalin fb^ bispyribac	1000 fb 25	7 fb 25	5.94 (34.7)	–	68.5	–	20.8	–	10.6	–
Pendimethalin fb 2, 4-D	1000 fb 500	7 fb 25	7.84 (62.0)	–	426.9	–	0.4	–	20.9	–
Pendimethalin	1500	7	8.45 (71.3)	5.72 (32.7)	307.7	132.0	28.3	19.9	55.4	45.9
Pendimethalin	1000	7	6.52 (42.7)	5.92 (35.3)	296.8	134.0	19.7	24.4	22.0	54.1
Weed free	–	–	1.00 (0.0)	1.00 (0.0)	0.0	0.0	0.0	0.0	0.0	0.0
Weedy check	–	–	3.54 (12.0)	7.58 (56.7)	354.5	268.5	14.2	26.5	11.1	48.3
CD at 5%	–	–	1.69	1.40	61.3	31.1	8.5	7.2	6.5	8.4

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 in 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 in 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 main crop. The treatments included bispyribac 20, 25 and 30 g/ha at 15 and 25 DAS, penoxsulam 25 g/ha at 15 and 25 DAS, azimsulfuron 30 g/ha at 15 and 25 DAS, pretilachlor + safener 500 g/ha at 5 DAS, pendimethalin 1000 and 1500 g/ha at 7 DAS, pendimethalin 1000 g/ha at 7 DAS followed by bispyribac 25 g/ha or 2, 4-D 500 g/ha at 25 DAS. Different herbicidal 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 liters/ha water; whereas, pendimethalin and pretilachlor were 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

Echinochloa crus-galli galli (L.) P. Beauv. was the predominant weed along with other broadleaf weeds like *Ammannia baccifera* L. and sedges like *Cyperus rotundus* L., *C. difformis* L., *Fimbristylis miliacea* (L.) Vahl.

Effect on Weeds

Control of *E. crus-galli* increased with increase in dose of bispyribac-sodium from 20 to 30 g/ha as indicated by the weed density and dry weight (Table 1). Minimum density and dry weight of *E. crus-galli* was observed at bispyribac 30 g/ha. Bispyribac 25 g/ha resulted in lower density of *E. crus-galli* than the lower dose (20 g/ha) except at 25 Das during 2008. However, the differences among different doses of bispyribac in respect of dry weight were significant only during 2008 at 15 DAS. Bispyribac was the best among all the herbicides for control of *E. crus-galli* while azimsulfuron was quite good against sedges at both the stages of application. Bispyribac 25—30 g/ha at 15 DAS and 25 DAS was as good as weed free check in respect of dry weight of *E. crus-galli*. During 2007, efficacy of bispyribac in respect of density and dry weight of *E. crus-galli* was almost similar at both stages of application; while during 2008, application of bispyribac at 25 DAS was slightly better than 15 DAS. Efficacy of bispyribac against *Echinochloa* sp. in DSR has been reported satisfactory earlier as well (1, 6—8).

Penoxsulam 25 g/ha at 15 DAS also provided satisfactory control of all type of weeds (Table 1). Penoxsulam 25 g/ha and azimsulfuron 30 g/ha resulted in lower density and dry weight of grassy weeds at 15 DAS than their application at 25 DAS. During 2007,penoxsulam 25 g/ha at 15 DAS was at par with bispyribac 20—25 g/ha in respect of density and all doses of bispyribac in respect of dry weight of grassy weeds. During 2008, penoxsulam 25 g/ha at 15 DAS was at par with bispyribac 20 g/ha in respect of density and with bispyribac 20—25 g/ha at 15 DAS and 25 g/ha at 25 DAS in respect of dry weight of *Echinochloa*; but inferior to higher doses of bispyribac at 25 DAS. However, penoxsulam at 25 DAS was inferior to all the bispyribac treatments except 20 g/ha. Earlier works confirm the efficacy of penoxsulam in wet DSR (6). Among herbicidal treatments, maximum dry weight of *E. crus-galli* was under the pendimethalin alone or in combination with 2, 4-D. This was due to the space available to the weed plants because of phyto-toxicity of pendimethalin on crop. Pendimethalin 1000—1500 g/ha alone or 1000 g/ha in sequence with 2, 4-D were the poorest treatments in respect of dry weight of *E. crus-galli* and were inferior to all other herbicidal treatments except pretilachlor + safener and azimsulfuron 30 g/ha at 25 DAS during 2008 being at par or inferior to it.

In general, the post-emergence herbicides bispyribac, penoxsulam and azimsulfuron provided lower density and dry weight of BLW and sedges at 15 DAS stage than 25 DAS; however, the differences were not always significant (Table 1). During 2007, all bispyribac treatments were at par with each other in respect of density and dry weight of BLW. During 2008, density and dry weight of BLW decreased with increase in dose of bispyribac with 30 g/ha being superior to 20 g/ha at both stages of application. Penoxsulam at 15 DAS was at par or superior to

Table 2. Effect of different herbicide treatments on phyto-toxicity, yield and yield attributes of wet direct seeded rice. *DAS, days after sowing, # mrl, meter row length, *fb, followed by.

Treatment	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
Bispyribac	20	15	0.0	0.0	101.1	81.7	75.5	44.5	22.5	19.7	2340	1113
Bispyribac	25	15	0.0	0.0	101.7	82.7	78.3	49.2	22.3	20.2	2580	1452
Bispyribac	30	15	0.0	0.0	101.2	84.0	80.0	51.5	23.3	20.1	2484	1500
Bispyribac	20	25	0.0	0.0	100.7	84.7	78.0	43.7	22.8	19.7	2298	1162
Bispyribac	25	25	0.0	0.0	101.0	86.5	81.2	48.3	22.5	19.9	2687	1524
Bispyribac	30	25	0.0	0.0	101.1	86.6	81.0	45.7	22.3	20.1	2537	1500
Penoxsulam	25	15	0.0	0.0	101.5	87.1	81.8	47.0	22.3	20.5	2208	1367
Penoxsulam	25	25	0.0	0.0	101.1	85.1	80.0	45.8	23.6	20.2	1969	1186
Azimsulfuron	30	15	0.0	0.0	101.1	84.4	80.2	38.3	22.8	19.8	2112	944
Azimsulfuron	30	25	0.0	0.0	100.9	86.0	78.0	35.5	22.4	19.9	2064	895
Pretilachlor + safener	500	5	0.0	0.0	101.5	70.2	62.7	21.5	22.4	20.5	1799	823
Pendimethalin fb^ bispyribac	1000 fb 25	7 fb 25	95.0	–	100.6	–	17.5	–	22.4	–	949	–
Pendimethalin fb 2, 4-D	1000 fb 500	7 fb 25	95.0	-	100.8	–	15.0	–	22.0	–	872	–
Pendimethalin	1500	7	95.0	76.7	100.9	74.9	9.2	9.3	22.1	20.3	699	169
Pendimethalin	1000	7	86.7	45.0	100.5	77.2	24.3	18.8	22.5	20.0	1039	194
Weed free	–	–	0.0	0.0	102.1	86.4	83.0	47.3	23.1	20.2	2926	1500
Weedy check	–	–	0.0	0.0	101.1	73.2	53.5	12.3	21.7	19.7	1624	97
CD at 5%	–	–	5.8	–	NS	10.5	10.8	7.4	NS	0.5	395	305

bispyribac treatments in respect of BLW density and dry weight. During 2007, azimsulfuron 30 g/ha at 15 DAS was superior to bispyribac 20 g/ha in respect of density at both stages of application and at 25 DAS application in respect of dry weight of BLW. Other post-emergence herbicidal treatments were at par with it. While during 2008, azimsulfuron 30 g/ha at 15 DAS was superior to all other herbicidal treatments except bispyribac 30 g/ha at 15 DAS being at par in respect of dry weight. During 2008, pendimethalin 1000—1500 g/ha were at par with weedy check in respect of density and dry weight of BLW. Pretilachlor+safener 500 g/ha was at par with weedy check in respect of density and dry weight of BLW during 2007 but better during 2008. Azimsulfuron 30 g/ha at 15 DAS was the best treatment among the post-emergence herbicides against the BLW.

Control of sedges increased with increase in dose of bispyribac at both stages of application (Table 1). Bispyribac 25—30 g/ha during 2007 and 30 g/ha during 2008 applied at 15 DAS provided significantly lower density of sedges than other bispyribac treatments. However, dry weight of sedges was at par under all the bispyribac treatments except 20 g/ha at 15 DAS being inferior to others. Dry weight of sedges under bispyribac 30 g/ha at 15 DAS was better than lower doses, whereas at 25 DAS all the bispyribac treatments were at par with each other. Penoxsulam 25 g/ha at 15 DAS provided excellent control of sedges and was at par with weed free check in respect of density and dry weight of sedges. Azimsulfuron at 15 DAS provided complete control of sedges during both the years. Azimsulfuron at both the stages of application was at par with weed free check in respect of density and dry weight of sedges. Earlier reports have also established supremacy of azimsulfuron in controlling the sedges in DSR (6, 8). Pendimethalin did not provide satisfactory control of sedges and density and dry weight under these treatments was maximum among all the herbicidal treatments. Pretilachlor+ safener provided satisfactory control of sedges and was at par with weed free check in 2007 but not in 2008.

Effect on Crop

Plant height was similar under all the herbicidal treatments, except pretilachlor+ safener 500 g/ha and

pendimethalin 1500 g/ha being inferior to weed free check and bispyribac 20 g/ha at both the stages during 2008 (Table 2). Panicle length was similar under all the treatments; except bispyribac 20 g/ha at both stages being inferior to weed free checks during 2008. All the herbicidal treatments, except pretilachlor+ safener 500 g/ha and pendimethalin treatments during both the years, and azimsulfuron treatments during 2008 being inferior, resulted in number of tillers at par with weed free checks. Among post-emergence herbicides, azimsulfuron resulted in less number of tillers. Minimum tillers were observed under pendimethalin treatments due to phyto-toxicity on the crop. All treatments of bispyribac, penoxsulam and azimsulfuron were at par with each other with respect to tillering during both the years.

Bispyribac 25 g/ha at both stages of application provided yields at par with weed free plots. Penoxsulam, azimsulfuron, pretilachlor+ safener and pendimethalin treatments resulted in yields lower than weed free checks. Penoxsulam 25 g/ha at 15 DAS provided grain yields similar to all the bispyribac treatments, except bispyribac 25 g/ha at 25 DAS during 2007 being superior. Penoxsulam 25 g/ha at 15 DAS provided lower yields than weed free check during 2007 but at par during 2008. Azimsulfuron gave yield lower than bispyribac treatments except lowest dose of 20 g/ha being at par. Pretilachlor+ safener gave yield similar to weedy check during 2007 but higher during 2008. Pretilachlor+ safener gave yield similar to azimsulfuron. Pendimethalin treatments provided yields similar or even lower than the weedy check plots.

Phyto-Toxicity

There was no visual phyto-toxicity of bispyribac, penoxsulam, azimsulfuron, pretilachlor+ safener on the rice crop (Table 2). While pendimethalin at 1000—1500 g/ha caused 87—95% injury to the crop when applied as spray during 2007 and 45—77% toxicity when applied as sand-mix during 2008. Phyto-toxicity due to pendimethalin in wet DSR has been reported earlier as well (9). However, some reports have established suitability of pendimethalin under wet pre-germinated direct seeded rice (10, 11). But our finding rule out the use of pendimethalin in wet DSR with pre-germinated seed.

Conclusion

Bispyribac sodium at 25 g/ha at 15—25 DAS was the best treatment combination for effective weed control in wet direct seeded rice where *E. crus-galli* was the predominant weed. Penoxsulam 25 g/ha at 15 DAS also provided satisfactory control of all type of weeds and resulted in good yields. Azimsulfuron 30 g/ha at 15—25 DAS was excellent against sedges, but efficacy against *E crus-galli* was low. There is need for further evaluation of its higher doses or in combination with other herbicides for broad spectrum of weed control. Efficacy of pretilachlor+ safener 500 g/ha at 5 DAS was satisfactory. Spray or sand-mix application of pendimethalin 1000—1500 g/ha at 7 DAS was highly phyto-toxic to the wet direct seeded *basmati* rice under puddle or unpuddle conditions; hence its use under such situation is ruled out

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