

## **Evaluation of Bispyribac in Combination with other Herbicides for Post-Emergence Control of Complex Weed Flora in Direct Seeded Rice**

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### **Abstract**

A field experiment was conducted during *kharif* of 2008 through 2009 to evaluate bispyribac in combination with other herbicides (2, 4-D, chlorimuron + metsulfuron and ethoxysulfuron) for control of complex weed flora in wet direct seeded basmati rice. Bispyribac-sodium 25 g/ha at 15—25 DAS provided effective control of *Echinochloa* sp. Application of chlorimuron + metsulfuron 4 g/ha, ethoxysulfuron 18.75 g/ha, 2, 4-D ester or amine 500 g/ha in combination with bispyribac resulted in improvement in control of BLW and sedges. Sequential application was observed to be better than tank-mixture, particularly in 2, 4-D and ethoxysulfuron, which could possibly due to antagonistic effect on the efficacy of bispyribac against *Echinochloa*. Bispyribac alone or in combination did not provide any control of aerobic grassy weeds (*Leptochloa* sp, *Eragrostis* sp, *Eleusine* sp. and *Dactyloctenium aegyptium*). As a broad consensus, sequential application of bispyribac 25 g/ha *fb* chlorimuron + metsulfuron 4 g/ha, ethoxysulfuron 18.75 g/ha, 2, 4-D ester or amine 500 g/ha at 15 and 25 DAS were better than their tank-mixtures in terms of yield and yield attributes of rice. Pretilachlor (with or without safener) although provided good control of aerobic grassy weeds but due to its poor efficacy against prominent weeds (*Echinochloa* sp, BLW and sedges), its effects were not visible in terms of grain yield. There was no phytotoxicity of any of the herbicides and their combinations on the crop during both the years.

**Key words :** Bispyribac, Post-emergence control, Weeds, 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 labor 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 phyto-toxicity particularly in wet DSR. This situation warrants for initiating re-

search efforts to evaluate and identify suitable post-emergence herbicide(s) in DSR. Bispyribac-sodium, has been found very effective against *Echinochloa* sp. in direct seeded rice, but control of some of broadleaf weeds (BLW) and sedges was marginal (4). Hence, the present study was undertaken to evaluate bispyribac-sodium in combination with other broadleaf killing herbicides for effective control of broad spectrum of weeds in direct seeded rice.

### **Methods**

A field experiment was conducted at CCS Haryana Agricultural University Regional Research Station, Karnal during *kharif* of 2008 through 2009. 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). During 2009,

**Table 1.** Effect of bispyribac alone and in combination with other herbicides on density of weeds in wet direct seeded rice. \*Original figure in parentheses were subjected to square root transformation before statistical analysis. \*\*BPB, bispyribac; CMU + MSM, chlorimuron + metsulfuron (ready-mix); ESN, ethoxysulfuron; 2, 4-DE, 2, 4-D Ester; 2, 4-DA, 2, 4-D Amine; fb (followed by).

Treatment**	Dose (g/ha)	Time (DAS)	Weed density* (no./m <sup>2</sup> )						
			<i>Echinochloa</i> sp.		Aerobic grassy weeds 2009	BLW		Sedges	
			2008	2009		2008	2009	2008	2009
BPB	25	15	2.5 (5.3)	1.00 (0.0)	7.83 (60.7)	7.1 (50.0)	7.22 (51.3)	5.3 (27.3)	2.67 (8.0)
BPB	25	25	1.4 (1.3)	1.24 (0.7)	7.05 (48.7)	8.2 (66.0)	7.96 (63.3)	6.1 (36.0)	5.30 (28.0)
BPB fb MSM+ CMU	25/4	15/25	1.2 (0.7)	1.00 (0.0)	8.82 (77.3)	5.4 (29.3)	4.58 (20.7)	1.0 (0.0)	1.00 (0.0)
BPB fb ESN	25/18.75	15/25	2.1 (3.3)	1.00 (0.0)	7.69 (58.7)	4.2 (22.7)	5.80 (33.3)	1.0 (0.0)	1.00 (0.0)
BPB fb 2, 4-DE	25/500	15/25	1.7 (2.0)	1.41 (1.3)	8.44 (78.7)	1.7 (2.7)	1.00 (0.0)	1.2 (0.7)	2.29 (6.0)
BPB fb 2, 4-DA	25/500	15/25	–	1.66 (2.0)	8.46 (71.3)	–	1.00 (0.0)	–	1.00 (0.0)
BPB+MSM+ CMU	25+4	25	1.5 (1.3)	2.71 (8.0)	7.45 (54.7)	5.0 (26.0)	6.41 (40.7)	1.0 (0.0)	1.00 (0.0)
BPB + ESN	25+18.75	25	1.5 (1.3)	4.39 (18.7)	7.38 (54.0)	5.8 (34.0)	7.45 (54.7)	2.0 (4.7)	1.00 (0.0)
BPB + 2, 4-DE	25+500	25	3.0 (8.0)	5.34 (28.0)	7.27 (52.7)	1.7 (2.0)	1.00 (0.0)	7.9 (61.3)	4.07 (16.0)
BPB + 2, 4-DA	25+500	25	–	4.16 (16.7)	6.47 (42.0)	–	1.00 (0.0)	–	1.41 (1.3)
BPB fb CMU+ MSM	25/4	25/30	1.4 (1.3)	2.32 (5.3)	7.21 (52.7)	5.4 (38.7)	4.34 (18.7)	2.5 (9.3)	1.00 (0.0)
BPB fb ESN	25/18.75	25/30	1.9 (4.0)	1.77 (3.3)	8.08 (65.3)	7.0 (48.0)	7.27 (52.7)	1.0 (0.0)	1.41 (1.3)
BPB fb 2, 4-DE	25/500	25/30	1.5 (2.0)	1.77 (3.3)	7.37 (54.7)	1.0 (0.0)	1.24 (0.7)	4.3 (23.3)	2.20 (4.0)
BPB fb 2, 4-DA	25/500	25/30	–	2.02 (4.0)	7.57 (58.0)	–	1.00 (0.0)	–	1.00 (0.0)
Pretilachlor + safener	500	5	4.4 (18.7)	–	–	7.8 (60.7)	–	4.9 (22.7)	–
Pretilachlor	1000	10	–	5.04 (24.7)	2.95 (15.3)	–	4.99 (28.0)	–	3.40 (10.7)
Weed free	–	–	1.0 (0.0)	1.00 (0.0)	1.00 (0.0)	1.0 (0.0)	1.00 (0.0)	1.0 (0.0)	1.00 (0.0)
Weedy check	–	–	6.5 (41.2)	5.76 (32.7)	6.99 (48.0)	8.6 (72.7)	8.41 (70.7)	7.6 (56.7)	8.01 (64.0)
CD 5%	–	–	1.1	1.42	2.55	2.7	1.59	1.9	1.12

the field was medium in organic carbon (0.53%), low in phosphorus (8 kg/ha) and high in potassium (321 kg/ha) with alkaline in reaction (pH 8.6). During 2008, the treatments included bispyribac 25 g/ha at 15 or 25 DAS; sequential application of bispyribac 25 g/ha fb chlorimuron + metsulfuron-methyl (ready-mix) 4 g/ha, ethoxysulfuron 18.75 g/ha, 2, 4-D ester 500 g/ha at 15 fb 25 DAS or 25 fb 30 DAS; their tank-mix application at 25 DAS; pretilachlor + safener 500 g/ha at 5 DAS along with weed free and weedy checks. During 2009, 2, 4-D Amine 500 g/ha was also used as sequential or tank-mix herbicide with bispyribac, and pretilachlor + safener 500 g/ha at 5 DAS was replaced with pretilachlor 1000 g/ha at 10 DAS. The experiment was laid out in randomized block design with three replicates. Basmati rice cultivar CSR30 was sown with drum seeder (18 cm row spacing) on 14 July in 2008 and 18 June in 2009 using pre-germinated seed (20 and 25 kg/ha during 2008 and 2009, respectively) under

puddle conditions. Seed was also treated with 1 g carbendazim solution in 1 liter of water per kilogram of seed by soaking for 24 hours. The gross and net plot size was 4.8 m × 2.16 m and 3.5 m × 1.86 m, respectively during 2008 and 5.5 m × 2.16 m and 3.0 m × 1.44 m, respectively during 2009. Post-emergence herbicides were applied as spray with flat-fan nozzle using 300 liter/ha water, whereas pre-emergence herbicide (pretilachlor) as sand-mix in 150 kg sand/ha. Fertilizers were applied as in case of main crop according to recommended package of practices by the state university. Crop phyto-toxicity was recorded at 10 and 20 days after application. As there was no phyto-toxicity of any of the herbicides on the crop, hence data on this aspect is not given. Data on weeds were recorded at 80 DAS in 2008 and 90 DAS in 2009; and yield and yield attributes were recorded at harvest. Crop was harvested on 10 November 2008 and 16 November 2009.

**Table 2.** Effect of bispyribac alone and in combination with other herbicides on dry weight of weeds in wet direct seeded rice. \*BPB, bispyribac; CMU+MSM, chlorimuron+metsulfuron (ready-mix); ESN, ethoxysulfuron; 2, 4-DE, 2, 4-D ester; 2, 4-DA, 2, 4-D amine; fb (followed by).

Treatment*	Dose (g/ha)	Time (DAS)	Dry weight of weeds (g/m <sup>2</sup> )						
			<i>Echinochloa</i> sp		Aerobic grassy weeds 2009	BLW		Sedges	
			2008	2009		2008	2009	2008	2009
BPB	25	15	20.1	0.0	118.2	10.4	11.5	11.1	4.2
BPB	25	25	9.8	1.1	122.7	18.2	13.3	8.0	12.3
BPB fb MSM+CMU	25/4	15/25	0.5	0.0	151.6	4.3	2.5	0.0	0.0
BPB fb ESN	25/18.75	15/25	13.3	0.0	110.5	4.5	4.4	0.0	0.0
BPB fb 2, 4-DE	25/500	15/25	7.8	2.6	130.0	1.2	0.0	0.5	1.2
BPB fb 2, 4-DA	25/500	15/25	–	4.4	148.5	–	0.0	–	0.0
BPB + MSM + CMU	25+4	25	5.0	20.2	151.0	1.5	4.4	0.0	0.0
BPB + ESN	25 + 18.75	25	2.3	53.5	140.0	8.5	12.3	1.4	0.0
BPB + 2, 4-DE	25 + 500	25	22.7	92.5	102.7	0.5	0.0	21.9	6.6
BPB + 2, 4-DA	25 + 500	25	–	62.3	120.4	–	0.0	–	2.0
BPB fb CMU+MSM	25/4	25/30	0.1	18.7	128.7	1.6	1.2	2.8	0.0
BPB fb ESN	25/18.75	25/30	8.3	2.5	135.4	4.1	7.4	0.0	1.1
BPB fb 2, 4-DE	25/500	25/30	1.5	4.1	120.8	0.0	0.6	8.1	3.6
BPB fb 2, 4-DA	25/500	25/30	–	4.4	137.3	–	0.0	–	0.0
Pretilachlor + safener	500	5	129.9	–	–	9.9	–	18.9	–
Pretilachlor	1000	10	–	249.6	10.7	–	13.2	–	27.0
Weed free	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weedy check	–	–	268.5	230.6	114.8	26.5	11.4	48.3	49.7
CD 5%	–	–	27.9	21.8	50.0	5.6	4.5	7.2	3.7

## Results and Discussion

During 2008, *Echinochloa crus-galli* (L.) P. Beauv. was the predominant weed along with broad-leaf weeds like *Ammannia baccifera* L. (Vahl), and sedges like *Cyperus rotundus* L., *C. difformis* L., *Fimbristylis miliacea* (L.) Vahl. During 2009 in addition, other grassy weeds like *Echinochloa colona* (L.) Link, *Leptochloa* sp and *Eragrostis* sp, *Eleusine* sp and *Dactyloctenium aegyptium* L. were also present.

### Effect on Weeds

In general, density and dry weight of *Echinochloa crus-galli* was slightly lower under bispyribac 25 g/ha at 25 DAS as compared to 15 DAS during 2008; while reverse was true for 2009 (Tables 1 and 2). During 2008, application of other herbicides with bispyribac did not have much effect on the density and dry weight of *Echinochloa* as compared to bispyribac alone except tank-mix application of 2, 4-D ester being inferior; however, the differences in dry

weight were not significant. During 2009, sequential application of other herbicides with bispyribac did not have much effect on the density and dry weight of *Echinochloa* sp. as compared to bispyribac alone; however, tank-mix application of ethoxysulfuron, 2, 4-D ester or 2, 4-D amine resulted in significant increase in density and dry weight of *Echinochloa*. Tank-mix application of chlorimuron + metsulfuron resulted in increased density and dry weight but differences in dry weight were not significant. Among herbicidal treatments, maximum density and dry weight of *Echinochloa* sp was obtained under pretilachlor (with safener) 500 g/ha at 5 DAS during 2008 and pretilachlor 1,000g/ha at 10 DAS. Efficacy of bispyribac against *Echinochloa* sp in DSR has been reported excellent earlier as well (1, 5–7).

During 2009, bispyribac alone or in any combination did not provide any control of other aerobic grassy weeds like *Leptochloa* sp, *Eragrostis* sp, *Eleusine* sp, *Dactyloctenium* sp during 2009 (Tables 1 and 2). Pretilachlor 1,000 g/ha provided good control of these grasses but it was poor against *Echinochloa* sp.

**Table 3.** Effect of bispyribac alone and in combination with other herbicides on yield and yield attributes in wet direct seeded basmati rice. \*BPB, bispyribac; CMU+MSM, chlorimuron+metsulfuron (ready-mix); ESN, ethoxysulfuron; 2, 4-DE, 2, 4-D ester; 2, 4-DA, 2, 4-D amine; fb (followed by). \*\*mrl, meter row length.

Treatment*	Dose (g/ha)	Time (DAS)	Plant height (cm)		Effective tillers/mrl**		Panicle length (cm)		Grain yield (kg/ha)	
			2008	2009	2008	2009	2008	2009	2008	2009
BPB	25	15	82.7	111.5	49.2	84.3	20.2	22.0	1452	2021
BPB	25	25	86.5	107.1	48.3	83.3	19.9	21.9	1524	1966
BPB fb MSM+ CMU	25/4	15/25	86.6	107.5	48.7	82.2	19.9	21.6	1632	2102
BPB fb ESN	25/18.75	15/25	83.0	107.9	48.3	83.2	20.2	21.9	1489	2102
BPB fb 2, 4-DE	25/500	15/25	87.8	111.0	43.8	87.3	20.3	22.0	1566	2148
BPB fb 2, 4-DA	25/500	15/25		108.7		78.5		21.5		2011
BPB + MSM+CMU	25+4	25	86.6	107.5	41.3	78.2	19.9	21.9	1458	1873
BPB + ESN	25 + 18.75	25	84.1	106.1	39.7	74.2	20.2	21.7	1411	1703
BPB + 2, 4-DE	25 + 500	25	85.0	106.7	41.8	70.8	20.1	21.5	1356	1580
BPB + 2, 4-DA	25+500	25		106.4		75.3		21.7		1721
BPB fb MSM+CMU	25/4	25/30	84.3	105.9	51.0	78.7	20.1	21.8	1664	1889
BPB fb ESN	25/18.75	25/30	82.4	105.9	46.8	79.2	20.3	21.6	1466	1812
BPB fb 2, 4-DE	25/500	25/30	85.8	108.3	46.7	82.2	20.1	21.5	1444	1958
BPB fb 2, 4-DA	25/500	25/30		109.7		82.3		21.8		1954
Pretilachlor+safener	500	5	70.2	–	21.5	–	20.5	–	823	–
Pretilachlor	1000	10		101.6		57.2		20.7		772
Weed free	–	–	86.4	109.4	47.3	87.3	20.2	22.1	1500	2694
Weedy check	–	–	73.2	96.8	12.3	40.3	19.7	20.0	97	695
CD 5%	–	–	9.3	6.9	10.5	10.3	NS	0.8	282	297

In general, sequential and tank-mix application of herbicides lowered the density and dry weight of the broad-leaf weeds during both the years (Tables 1 and 2). During 2008, sequential or tank-mix application of bispyribac with 2, 4-D ester was as good as weed free and better than ethoxysulfuron and chlorimuron + metsulfuron in respect of density of BLW. Chlorimuron + metsulfuron 4 g/ha, ethoxysulfuron 18.75 g/ha and 2, 4-D ester 500 g/ha in different combinations with bispyribac being at par resulted in dry weight of BLW better than bispyribac alone and as good as weed free check, except tank-mixture of ethoxysulfuron. During 2009, sequential or tank-mix application of bispyribac with 2, 4-D ester or 2, 4-D amine 500 g/ha provided almost complete control of BLW and were better than ethoxysulfuron and chlorimuron + metsulfuron in respect of density and tank-mix or delayed sequence of ethoxysulfuron in respect of dry weight of BLW.

Similarly, sequential and tank-mix application of herbicidal combinations lowered the density of the sedges as compared to bispyribac alone and were as good as weed free check, except 2, 4-D ester as tank mix and as sequential application being inferior dur-

ing 2008; and 2, 4-D ester/amine as tank-mix and sequential application at 30 DAS being slightly inferior to ethoxysulfuron and chlorimuron + metsulfuron during 2009 (Tables 1 and 2).

#### Yield and Yield Attributes

Plant height was similar under all the bispyribac alone and combination treatments which was at par with weed free and better than weedy check and pretilachlor+safener 500 g/ha and pretilachlor 1000 g/ha (Table 3). Effective tillers under all the alone or tank-mix treatments of bispyribac were at par with weed free check except tank-mix of bispyribac + ethoxysulfuron, 2, 4-D ester or 2, 4-D amine being inferior during 2009. Panicle length was not influenced by different treatments.

All the treatments of bispyribac alone and in combination provided grain yield of rice at par with weed free check during 2008 but lower than weed free check during 2009 (Table 3). During 2008, maximum grain yield was obtained with bispyribac fb chlorimuron + metsulfuron at 25 and 30 DAS which was significantly better than bispyribac+2, 4-D at 25 DAS. While dur-

ing 2009, maximum grain yield was obtained with bispyribac fb 2, 4-D ester at 15 and 25 DAS, which was significantly better than tank-mix application of bispyribac with ethoxysulfuron, 2, 4-D ester and 2, 4-D amine at 25 DAS, and sequential application with ethoxysulfuron at 30 DAS. All the other treatments of bispyribac were at par with each other. Pretilachlor+ safener resulted in grain yield of rice lower than all other herbicidal treatments and better than weedy check. Among herbicidal treatments, the lowest grain yield was obtained under pretilachlor+ safener 500 g/ha during 2008 and pretilachlor 1,000 g/ha during 2009. Pretilachlor resulted in grain yield of rice as low as weedy check during 2009.

#### Phytotoxicity

There was no phytotoxicity of any of the herbicides and their combinations on the crop during both the years (data not given).

#### Conclusion

Bispyribac-sodium 25 g/ha at 15—25 DAS provided effective control of *Echinochloa* sp. However, application of chlorimuron+metsulfuron 4 g/ha, ethoxysulfuron 18.75 g/ha, 2, 4-D ester or amine 500 g/ha in combination with bispyribac resulted in improvement in control of BLW and sedges. Sequential application was observed to be better than tank-mixture, particularly in case of 2, 4-D and ethoxysulfuron, which could possibly due to antagonistic effect on

the efficacy of bispyribac against *Echinochloa*. Bispyribac alone or in combination did not provide any control of *Leptochloa* sp., *Eragrostis* sp., *Eleusine* sp. and *Dactyloctenium aegyptium*.

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