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Mixed weed flora management by bispyribac-sodium in transplanted rice

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ABSTRACT

Different doses of bispyribac-sodium 20, 25 and 30 g/ha were evaluated against mixed weed flora in transplanted rice under mid-hill conditions of Himachal Pradesh during 2010 and 2011. Major associated weeds were *Echinochloa colona* (31.1%) and *Commelina benghalensis* (7.3%) among grasses, *Cyperus iria* (26.9%) and *Scripus* (9.3%) among sedges and *Ammania baccifera* (8.8%) among broad-leaved weeds. Bispyribac-sodium 20-30 g/ha effectively controlled *E. colona*. Cyhalofop-butyl/butachlor *fb* metsulfuron-methyl was comparable to bispyribac-sodium in controlling *C. benghalensis*. Bispyribac-sodium brought about significant reduction in the count of *Cyperus* sp. up to 60 days after transplanting (DAT). Bispyribac-sodium 30 g/ha behaving statistically similar with bispyribac-sodium 20 and 25 g/ha resulted in significantly lower total weed count and total weed dry weight. There was no phytotoxicity of bispyribac-sodium on rice and no residual toxicity on succeeding crop of wheat. Bispyribac-sodium, farmer's practice, cyhalofop-butyl *fb* metsulfuron-methyl and cyhalofop-butyl *fb* 2,4-D were comparable in influencing rice grain yield. Rice grain yield was positively associated with plant height, panicle length, effective tillers and spikelets/panicle and was negatively associated with weed count and weed biomass. With one weed per m^2 increase up to harvest, grain yield of rice was expected to decrease by 15.3 kg/ha. Bispyribac-sodium at 30 kg/ha was the best in terms of net returns due to weed management. Cyhalofop-butyl *fb* metsulfuron-methyl gave the highest net profit/rupee invested. Herbicide efficiency index (HEI) was highest and weed index was lowest under bispyribac-sodium 30 g/ha. Weed management index (WMI) and agronomic management index (AMI) were highest under cyhalofop-butyl *fb* metsulfuron-methyl.

Key words: Bispyribac-sodium, Impact assessment, Transplanted rice, Weeds

Rice is an important cereal crop of Himachal Pradesh occupying an area of 81 thousand hectares with a production of 115.3 thousand tonnes. Among various factors responsible for low production of rice in Himachal Pradesh, inadequate weed control is the major one. Weeds cause 28-45% yield losses in transplanted rice (Singh *et al*. 2003, Kumar *et al*. 2008, Yadav *et al*. 2009). In recent past, a number of pre and post-emergence herbicides have been recommended for controlling weeds in rice. Butachlor and cyhalofop-butyl are popular among farmers. But these herbicides are less effective against sedges and broad leaved weeds. Therefore 2,4-D is recommended as a followed by application. It makes the weed control technology cumbersome and costly. This situation warrants for initiating research efforts to evaluate and identify suitable post-emergence herbicide against complex weed flora in transplanted rice. Bispyribac-sodium, is a post-emergence broad spectrum herbicide. It is effective against grasses, sedges and broad-leaved weeds in rice fields (Schmidt *et al.* 1999, Walia *et al.* 2008, Yadav *et al*. 2009). Bispyribac-sodium applied mid to late post-emergence at 20 to 23 g/ha has been reported to control barnyard grass 98%, however, when applied late post-emergence to three-tiller barnyard grass, the control was reduced to 70% (Williams 1999). Therefore, the present study was undertaken to standardize its dose against complex weed flora in transplanted rice under mid-hill conditions of Himachal Pradesh.

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MATERIALS AND METHODS

The efficacy of bispyribac-sodium with other herbicides were evaluated during the rainy season (*Kharif*) 2010 and 2011 at Palampur. The area represents the mid-hill wet temperate zone of Himachal Pradesh. The soil was silty clay loam in texture, acidic in reaction) (pH 5.7), medium in organic carbon (0.7%), available N (380 kg/ha) and available P (20.4 kg/ha) and high in available K (256 kg/ha). The experiment was laid out in randomized block design with 3 replications. The treatments consisted of three doses of bispyribac-sodium (20, 25 and 30 g /ha) at 25 days after sowing, cyhalofop-butyl 90 g/ha (15 DAT) and butachlor 1.5 kg/ha (pre.) *fb*. 2,4-D 1.0 kg/ha and

metsulfuron-methyl 4 g/ha at 30 DAS, farmer's practice and unweeded check. Rice variety '*HPR-2143*' was transplanted on July11, 2010 and July 4, 2011 with recommended package of practices except treatments. Herbicides were applied with knapsack power sprayer using 600 L water per hectare. Data on density and dry weight of weeds was recorded on 60 days after transplanting (DAT) and at harvest and was subjected to square root transformation. Data on crop phyto-toxicity were recorded at 15 and 30 DAT. The crop was harvested on October 20, 2010 and October 15, 2011. Residual toxicity of bispyribac-sodium was also recorded on succeeding crop of wheat. Economics of the treatments was computed based on prevalent market prices. Impact assessment was carried out as per Walia (2003).

RESULTS AND DISCUSSION

Effect on weeds

The major weed flora of the experimental field was consisted of *Echinochloa colona* (31.1%) and *Commelina benghalensis* (7.3%) among grasses, *Cyperus iria* (26.9%) and *Scripus* (9.3%) among sedges, and *Ammania baccifera* (8.8%) among broad-leaved weeds. *Aeschynomene indica, Monochoria vaginallis* and *Bulbostylis barbata* were the other broad-leaf weeds as a whole constituted 16.6% of the total weed flora.

Weed control treatments brought about significantly variation in the count of *E. colona* (Table 1). Bispyribac-sodium-S 20-30 g/ha has effectively controlled *E. colona* upto harvest during 2010 and upto 60 DAT during 2011. Effective control of barnyard grass (*Echinochloa* sp) with bispyribac-sodium has been reported (Williams 1999). Application of cyhalofop/butachlor *fb* 2,4-D/metsulfuron was as good as bispyribac-sodium in influencing the count of *E. colona* at harvest during 2011. All treatments were significantly superior to weedy check in reducing the count of *C. benghalensis* at 60 DAT during 2010. Excepting butachlor + 2,4-D all the other treatments were comparable to each other in influencing the count of *Commelina benghalensis.* There was significant variation in the count of *Cyperus iria*. Bispyribac-sodium brought about significant reduction in its count upto 60 DAT during both the years. Count of *Cyperus* sp. under cyhalofop *fb* metsulfuron-methyl and butachlor *fb* 2,4-D at 60 DAT during 2010 was not significantly different from that under weedy check. Count of *Scripus* sp. and *Ammania baccifera* was not significantly affected (data not given). Bispyribac-sodium also significantly reduced the count of other broad-leaved weeds (*Aeschynomene indica, Monochoria vaginallis, Bulbostylis barbata*) during 2011. Other treatments except farmer's practice could not bring down the count of other broad-leaved weeds over weedy check upto 60 DAT.

Table 1. Effect of treatments on weed count (no./m^2) in transplanted rice

Treatment	Dose (g/ha)	*Echinochloa*				*Commelina*		*Cyperus*				Broad-leaved		
		60 DAT		60 DAT		60 DAT		60 DAT		Harvest		60 DAT	Harvest	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2011	2010	2011
Bispyribac-sodium	20	1.0 (0.0)	1.0 (0.0)	1.4 (1.3)	2.7 (6.7)	1.7 (2.7)	1.0 (0.0)	1.0 (0.0)	2.7 (6.7)	2.9 (9.3)	3.4 (10.7)	2.3 (4.3)	2.2 (6.7)	2.9 (9.3)
Bispyribac-sodium	25	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	2.5 (5.3)	1.0 (0.0)	1.0 (0.0)	1.7 (2.7)	2.2 (4.0)	2.3 (5.3)	3.2 (9.3)	1.4 (1.3)	2.5 (6.7)	2.4 (6.0)
Bispyribac-sodium	30	1.0 (0.0)	1.0 (0.0)	1.8 (2.7)	1.8 (2.7)	1.0 (0.0)	1.0 (0.0)	1.4 (1.3)	1.8 (2.7)	1.7 (2.7)	2.7 (6.7)	1.4 (1.3)	1.0 (0.0)	2.5 (6.7)
Cyhalofop-butyl *fb* 2, 4-D	90 *fb* 1000	2.3 (5.3)	2.0 (5.3)	3.4 (10.7)	3.0 (8.0)	2.1 (4.0)	1.0 (0.0)	2.1 (4.0)	2.5 (5.3)	1.0 (0.0)	3.9 (14.7)	2.3 (5.3)	1.0 (0.0)	5.4 (28.0)
Cyhalofop-butyl *fb* metsulfuron-methyl	90 *fb* 4	3.6 (12.0)	2.1 (4.0)	2.5 (6.7)	3.2 (9.3)	1.0 (0.0)	1.4 (1.3)	3.5 (14.7)	2.7 (6.7)	3.2 (9.3)	4.1 (16.0)	2.3 (5.3)	1.7 (2.7)	5.7 (32.0)
Butachlor*fb* 2, 4-D	1500 + 1000	3.1 10.7)	2.3 (5.3)	3.2 (9.3)	3.2 (9.3)	2.5 (6.7)	1.0 (0.0)	3.1 (10.7)	3.0 (8.0)	1.0 (0.0)	4.0 (15.3)	2.3 (5.3)	1.0 (0.0)	3.4 (13.3)
Butachlor *fb* metsulfuron-methyl	1500 *fb* 4	2.9 (8.0)	1.9 (4.0)	3.0 (8.0)	3.4 (10.7)	1.0 (0.0)	1.0 (0.0)	2.1 (4.0)	3.0 (8.0)	1.4 (1.3)	4.1 (16.0)	2.3 (5.3)	1.0 (0.0)	4.8 (22.7)
Farmer's practice		1.0 (0.0)	1.4 (1.3)	2.5 (5.3)	3.4 (10.7)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	3.0 (8.0)	2.5 (6.7)	4.7 (21.3)	3.2 (9.3)	1.9 (4.0)	2.8 (13.3)
Unweeded check		4.1 (16.0)	3.8 (13.3)	5.4 (28.0.)	5.2 (26.7)	4.6 (20.0)	1.0 (0.0)	3.4 (10.7)	3.8 (13.3)	3.4 (10.7)	6.3 (38.7)	4.1 (16.0)	1.0 (0.0)	5.5 (29.3)
LSD (P=0.05)		1.2	1.6	1.1	1.9	1.2	NS	0.8	0.7	1.6	0.9	1.5	NS	2.4

Values in the parentheses are the original in means, *fb* - Followed by, DAT - Days after transplanting

All the weed control treatments recorded significantly lower total weed count and total weed dry weight as compared to unweeded check (Table 2). Owing to species-wise reduction in the count of weeds, bispyribac-sodium 30 g/ha behaving statistically similar with bispyribac-sodium 20 and 25 g/ha resulted in significantly lower total weed count and total weed dry weight. The effective control of grasses, sedges and broad-leaved weeds with bispyribac-sodium in rice fields has been reported (Schmidt *et al.* 1999, Walia *et al.* 2008, Yadav *et al*. 2009). However, bispyribac-sodium was also statistically similar with cyhalofop-butyl/butachlor *fb* metsulfuron-methyl/2,4-D.

Effect on crop

There was no phytotoxicity of bispyribac-sodium on rice. Also, there was no residual toxicity on succeeding crop of wheat during both the years of experimentation (data not given). Plant height was significantly influenced during 2010 (Table 3). Bispyribac-sodium 30 g/ha behaving statistically similar with bispyribac-sodium 20 and 25 g/ha and farmer's practice resulted in significantly taller plants as compared to other weed control treatments. Effective tillers and spikelets per panicle were also significantly influenced during 2010. Panicle length of rice was significantly influenced during 2011. Bispyribac-sodium 20-30 g/ha produced effective tillers statistically similar to cyhalofop- butyl *fb* metsulfuron methyl. Bispyribac-sodium 30 g/ha behaving statistically similar with bispyribac-sodium 20 and 25 g/ha, butachlor *fb* 2,4-D, butachlor *fb* metsulfuron-methyl and farmer's practice produced significantly more spikelet's per panicle as compared to other weed control treatments.

Weeds when allowed to grow throughout the crop season caused 48.1% yield reduction. Bispyribac-sodium 30 g/ha behaving statistically alike with bispyribac-sodium 20 and 25 g/ha and farmer's practice during both the years, cyhalofop-butyl *fb* metsulfuron-methyl during 2010 and cyhalofop-butyl *fb* 2,4-D during 2011, resulted in significantly higher rice grain yield as compared to other weed control treatments. The increased yield in these treatments was due to significant reduction in dry matter accumulation by the weeds and higher number of effective tillers, panicle length and plant height when compared to other treatments. These results are in close conformity with the findings of Walia *et al*. (2008). Rice grain yield was positively associated with plant height (r= 0.759), panicle length (r = 0.664), effective tillers (r = 0.715) and spikelets/panicle (r = 0.844). Whereas, it was negatively associated with weed count (r= -0.750 to -0.967) and weed bio mass (r= -0.684 to -0.994). With one weed/m^2 increase until harvest, grain yield of rice was expected to

Table 2. Effect of treatments on total weed count and dry weight in transplanted rice

Treatment	Dose (g/ha)	Total weed count (no./m^2)				Total weed dry weight (g/m^2)			
		60 DAT		At harvest		60 DAT		At harvest	
		2010	2011	2010	2011	2010	2011	2010	2011
Bispyribac-sodium	20	5.0 (24.3)	4.7 (21.7)	6.6 (44.0)	6.2 (37.3)	1.9 (2.6)	3.8 (13.3)	2.9 (4.3)	5.4 (28.3)
Bispyribac-sodium	25	4.5 (20.0)	3.5 (12.0)	6.2 (37.3)	5.3 (27.3)	1.7 (2.0)	2.8 (7.0)	2.5 (5.8)	4.6 (21.0)
Bispyribac-sodium	30	4.9 (24.0)	2.7 (6.7)	5.0 (24.3)	4.7 (21.3)	1.9 (2.5)	2.2 (4.3)	2.0 (3.2)	4.1 (15.5)
Cyhalofop-butyl *fb* 2, 4-D	90 *fb* 1000	6.4 (40.0)	4.9 (24.0)	5.9 (34.7)	8.0 (64.0)	2.2 (3.8)	3.4 (10.6)	2.3 (4.3)	5.6 (30.7)
Cyhalofop-butyl *fb* metsulfuron-methyl	90 *fb* 4	6.4 (40.0)	4.8 (22.7)	5.1 (25.3)	8.5 (72.0)	3.0 (8.3)	4.1 (16.0)	1.8 (2.2)	5.6 (31.1)
Butachlor*fb* 2, 4-D	1500 + 1000	7.1 (50.7)	5.3 (28.0)	5.5 (30.7)	6.5 (43.3)	2.8' (7.0)	4.3 (18.7)	2.2 (4.4)	5.4 (28.7)
Butachlor*fb* metsulfuron-methyl	1500 *fb* 4	6.5 (42.7)	4.7 (22.7)	4.9 (26.7)	8.6 (74.7)	2.4 (5.1)	4.6 (20.0)	1.9 (2.9)	5.5 (29.9)
Farmer's practice		2.8 (7.0)	5.9 (33.3)	6.2 (37.3)	7.4 (54.7)	1.0 (0.0)	4.5 (19.0)	1.9 (2.7)	5.5 (29.8)
Unweeded check		9.2 (86.7)	8.5 (70.7)	10.1 (101.3)	10.8 (116.0)	4.5 ‘(19.7)	7.0 (48.0)	4.6 (19.9)	8.9 (78.3)
LSD (P=0.05)		2.2	2.0	1.7	1.5	1.0	1.6	0.8	1.3

Values in the parentheses are the original means, DAT - Days after transplanting

Table 3. Effect of treatments on yield attributes and grain yield of transplanted rice

Treatment	Dose (g/ha)	Plant height (cm)		Panicle length (cm)		Effective tillers (no./m^2)		Spikelets/ panicle		Grain yield (t/ha)	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Bispyribac-sodium	20	57.1	94.9	21.5	23.1	50.8	45.3	8.8	12.8	2.78	2.54
Bispyribac-sodium	25	57.1	99.3	20.9	22.9	51.2	49.9	8.9	13.4	2.90	2.67
Bispyribac-sodium	30	58.4	102.0	21.6	23.5	51.3	45.8	9.2	13.6	3.09	2.87
Cyhalofop-butyl *fb* 2, 4-D	90 *fb* 1000	56.4	93.3	21.5	23.3	49.2	43.6	8.7	12.7	2.08	2.50
Cyhalofop-butyl *fb* metsulfuron-methyl	90 *fb* 4	56.3	98.7	21.3	22.9	39.7	48.4	8.8	13.1	3.00	2.49
Butachlor *fb* 2, 4-D	1500 + 1000	55.5	100.4	21.4	23.9	47.2	45.1	8.3	12.7	2.28	2.57
Butachlor *fb* metsulfuron-methyl	1500 *fb* 4	56.2	100.2	21.5	22.5	47.0	44.9	8.9	13.3	2.57	2.61
Farmer's practice		57.3	90.5	21.5	22.9	50.0	49.2	8.8	12.3	2.52	2.54
Unweeded check		55.1	91.7	19.8	22.5	39.3	43.6	8.7	11.8	1.55	1.61
LSD (P=0.05)		1.8	NS	0.8	NS	1.2	NS	NS	0.9	0.34	0.38

Values in the parentheses are the original in means

Table 4. Economics and other impact indices of treatments in transplanted rice

Treatment	Dose (g/ha)	GR (x10^3 `/ha)	GR$_{WC}$ (x10^3 `/ha)	CWC (x10^3 `/ha)	NR$_{WC}$ (x10^3 `/ha)	MBCR	WMI	AMI	HEI	WI
Bispyribac-sodium	20	21.92	8.86	3.08	5.78	1.88	2.52	1.52	2.05	-5.1
Bispyribac-sodium	25	22.98	9.92	3.68	6.24	1.69	2.42	1.42	2.79	-10.2
Bispyribac-sodium	30	24.54	11.48	4.29	7.19	1.67	2.33	1.33	4.63	-17.7
Cyhalofop-butyl *fb* 2, 4-D	90 *fb* 1000	18.93	5.88	2.75	3.12	1.13	2.25	1.25	1.25	9.6
Cyhalofop-butyl *fb* metsulfuron-methyl	90 *fb* 4	22.55	9.49	2.33	7.17	3.08	2.62	1.62	2.16	-8.3
Butachlor*fb* 2, 4-D	1500 + 1000	20.01	6.96	2.66	4.29	1.61	2.31	1.31	1.58	4.3
Butachlor*fb* metsulfuron-methyl	1500 *fb* 4	21.36	8.31	2.24	6.07	2.71	2.46	1.46	1.91	-2.3
Farmer's practice		20.88	7.82	4.40	3.42	0.78	2.39	1.39	1.81	0.0
Unweeded check		13.05	-	-	-	-	-	-	-	37.5

GR - Gross returns, GR$_{WC}$ - Gross returns due to weed control, CWC - Cost of weed control, NRWC - Net returns due to weed control, MBCR - Marginal benefit : cost ratio, WMI - Weed management index, AMI - Agronomic management index, HEI - Herbicide efficiency index, WI - Weed index.

decrease by 15.3 kg/ha (Y=3250-15.3 x, R^2=0.855 where Y is grain yield in kg/ha and x is weed density/m^2). Every g/m^2 increase of weed biomass by harvest would results in 32.5 kg/ha grain yield reduction of rice (Y= 31.29-32.5 x, R^2=0.870).

Impact assessment

The weed control treatments registered 1.03 to 3.08 times higher gross returns than weedy check (Table 4). Total gross and additional gross returns over weedy check were highest under bispyribac-sodium 30 g/ha followed by bispyribac-sodium 25 and 20 g/ha, cyhalofop-butyl *fb*. 2,4-D, farmers' practice and cyhalofop-butyl *fb* metsulfuronmethyl. Bispyribac-sodium at 30 kg/ha was the best in terms of net returns due to weed management. This was followed by cyhalofop-butyl *fb* 2,4-D, bispyribac-sodium 20 g/ha and bispyribac-sodium 25 g/ha. However, cyhalofop-butyl *fb* metsulfuron-methyl gave the highest net profit/rupee invested. It was followed by butachlor + metsulfuron-methyl and bispyribac-sodium 20 g/ha. It was mainly due to low herbicide cost ultimately leading to lower application cost. The cost of weed control with new herbicide was more than the recommended herbicidal treatments which could be offset with increased grain yield. However, the cost of the new treatment was not more than the farmer's practice. Herbicide efficiency index (HEI), which indicates weed killing potential and phytotoxicity on the crop (Walia 2008), was highest under bispyribac-sodium 30 g/ha. In terms of weed index (WI), bispyribac-sodium 30 g/ha was superior than other

treatments. Bispyribac-sodium 30 g/ha was followed by bispyribac-sodium 25 g/ha, cyhalofop-butyl *fb* metsulfuron-methyl and bispyribac-sodium 20 g/ha both for HEI and WI. Weed management index (WMI) and agronomic management index (AMI) were highest under cyhalopfop-butyl *fb* metsulfuron-methyl which was followed by bispribac 20 g/ha, butachlor *fb* metsulfuron-methyl, bispyribac-sodium 25 g/ha and farmers' practice.

Based on the results of present investigation, it was concluded that post-emergence application of bispyribac-sodium at 30 g/ha could be a suitable herbicide for effective control of mixed weed flora in transplanted rice.

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