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Research Communication

Efficacy of different herbicides against complex weed flora in direct-seeded *basmati* rice (*Oryza sativa*)

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ABSTRACT

A field experiment was carried out during the rainy (*kharif*) season of 2013 at the Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Karnal, India, to evaluate the different combinations of herbicides as alone and tank-mix to control the dynamic and complex weed flora in direct-seeded *basmati* rice (*Oryza sativa* L.). Bispyribac-Na was the most effective against grassy weed *Echinochloa crus-galli,* and pyrazosulfuron, azimsulfuron and ethoxysulfuron against broad-leaf weeds and sedges. Tank-mix application of fenoxaprop showed antagonistic effect on efficacy of bispyribac against weeds. Among the herbicidal treatments, application of pendimethalin 1,000 g/ha (PRE) followed by(*fb*) tank-mix combination of bispyribac-sodium 25 g/ha with pyrazosulfuron 25 g/ha or azimsulfuron 20 g/ha or ethoxysulfuron 18.0–37.5 g/ha (weed-control efficiency at 60 DAS: 93.3–95.6%) were found to be the best combinations for control of complex weed flora in direct-seeded rice, with significant improvement in effective tillers (71.3–73/m row length), grain yield (4,013–4,103 kg/ha), net returns (₹108,856–113,485/ha) and benefit: cost ratio (2.45–2.53) as compared to weedy check (35.0/m row length, ₹1,552 kg/ha, 1,590/ha and 1.02 respectively).

Key words **:** *Basmati,* Direct-seeded rice, Economics, Grain yield, Herbicides, Weeds-control efficiency

In most of South Asia, common practice of establishing rice in the rice–wheat system is through puddling followed by manual transplanting. Puddling benefits rice by reducing water percolation losses, controlling weeds, facilitating easy seedling establishment and creating anaerobic conditions to enhance nutrient availability but besides being costly, cumbersome and time-consuming, it results in degradation of soil and other natural resources, (Pathak *et al.* 2011) and subsequently poses difficulties in seed bed preparation for succeeding wheat crop in rotation. Under such situations, intervention in the form of mechanized transplanting or direct-seeding of rice (DSR) is the need of hours to avoid puddling or manual transplanting. Weeds are one of the major biological constraints in direct-seed rice (Pathak *et al.*, 2011). Aerobic systems are subject to much higher weed pressure than conventional puddle transplanting system (Rao *et al.,* 2007) due to the absence of a size differential between the crop and weeds and the suppressive effect of standing water on weed growth at time of crop-establishment (Chauhan *et al.,* 2011). Considering the importance of herbicides in weed management, pendimethalin as pre-emergence in sequence with bispyribac–Na at 15–25 days after sowing (DAS) or bispyribac-Na in combination with 2, 4-D, metsulfuron, ethoxysulfuron or premix of chlorimuron + metsulfuron have been already recommended against complex weed flora infesting direct-seeded rice (DSR) (Yadav *et al*., 2011a). But in spite of the usage of all such herbicidal combinations, control failures, lot of escapes or regeneration in some of the weed species have been recently noticed at many locations in DSR. Therefore, considering the long window of emergence of diverse type of weeds in rainy (*kharif*) season, the purpose cannot be solved by one-time application of herbicide alone. Considering these problems, we have application of several herbicides in combination or in sequence, other than the already used combinations, which can provide more useful solution in controlling complex and diverse weed flora in DSR.

The field experiment was conducted at the research farm of Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Uchani, Karnal, to

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evaluate the efficiency of different herbicides against complex weed flora and crop in direct-seeded *basmati* rice. The soil was clay loam and slightly alkaline (*p*H 8.2) having electrical conductivity 0.35 dS/m. It was low in organic carbon (0.38%), available N (142 kg/ha) and P_2O_5 (20.1 kg/ha) but medium in K_2O (170.4 kg/ha).Twenty treatments (T_1, pendimethalin 1,000 g/ha; T_2, bispyribac–Na 25 g/ha; T_3, bispyribac 25 g/ha+ pyrazosulfuron 25 g/ha; T_4, bispyribac 25 g/ha+ azimsulfuron 20 g/ha; T_5–T_7, bispyribac 25 g/ha+ ethoxysulfuron 18.8, 28.0, 37.5 g/ha; T_8, bispyribac 25 g/ha+ fenosxarop (with safener) 60 g/ha; T_9, penoxsulam + cyhalofop (ready-mix) 150 g/ha; T_{10}, T_1, followed by (fb) T_2; T_{11}, T_1 fb T_3; T_{12}, T_1 fb T_4; T_{13}–T_{15}; T_1 fb T_5–T_7; T_{16}, T_1 fb T_8; T_{17}, T_1 fb azimsulfuron 20 g/ha fb T_8; T_{18}, T_{10} fb 1 hand-weeding, along with weed-free and weed checks) were laid out in randomized block design with 3 replications. Seeds of rice cultivar 'Pusa Basmati 1121' were drilled in lines 20, cm apart, using zero-till seed-cum-fertilizer drill fitted with inclined plate seed-metering system using the seed rate of 30 kg/ha, which was followed by thinning and gap filling at 15 DAS to maintain proper plant population. Herbicides were applied as spray in an aqueous medium at the rate of 500 litres water/ha for pre-emergence herbicides and 300 litres water/ha for post-emergence herbicides, using a knap-sack-sprayer with flat-fan nozzle. Data on weed count and weed biomass from an area enclosed in a quadrate of 0.25 m^2 at 2 places under different treatments were recorded 60 days after sowing (DAS). Data on individual weed and total weed density and weed dry weight were subjected to square-root transformation ($\sqrt{X+1}$). In order to calculate the net returns for each treatment, total cost of cultivation was subtracted from the gross returns. Total cost of cultivation and gross returns were estimated as per the prices prevailing at the time of conduct of experiment and benefit: cost ratio was calculated from gross return to cost of cultivation.

Experimental field was dominated with grassy weeds like *Echinochloa crus-galli* (18.9), *Eragrostis tenella* (13.0) and

Table 1. Effect of weed-control treatments on the population of the different weeds at 60 DAS in direct-seeded *basmati* rice

Treatment	Dose (g/ha)	Density* of the different weeds (Nos./m^2)					
		Echinochloa crus-galli	*Eragrostis tenella*	*Dactyloctenium aegyptium*	*Cyperus rotundus*	*Ammannia baccifera*	Total BLW
Pendimethalin	1,000	5.1 (24.7)	2.1 (3.3)	1.0 (0.0)	6.7 (44.0)	4.2 (16.7)	6.0 (34.7)
Bispyribac-Na	25	1.2 (0.7)	4.4 (18.0)	2.1 (3.3)	5.2 (26.0)	4.7 (20.7)	6.5 (41.3)
Bispyribac + pyrazosulfuron	25 + 25	1.5(1.3)	4.3 (17.3)	2.1 (3.3)	2.1 (3.3)	2.1 (3.3)	2.8 (6.7)
Bispyribac + azimsulfuron	25 + 20	2.6 (6.0)	4.4 (18.0)	2.1 (3.3)	2.1 (3.3)	2.1 (3.3)	2.8 (6.7)
Bispyribac + ethoxysulfuron	25 + 18.8	2.5 (5.3)	4.4 (18.0)	2.2 (4.0)	2.1 (3.3)	2.2 (4.0)	3.2 (9.3)
Bispyribac + ethoxysulfuron	25 + 28	2.5 (5.3)	4.3 (17.3)	2.1 (3.3)	2.1 (3.3)	2.1 (3.3)	2.8 (6.7)
Bispyribac + ethoxysulfuron	25 + 37.5	2.8 (6.7)	4.5 (19.3)	2.1 (3.3)	1.7 (2.0)	2.1 (3.3)	3.2 (9.3)
Bispyribac + fenoxaprop (with safener)	25 + 60	5.8 (32.7)	3.0 (8.0)	1.7 (2.0)	6.7 (44.0)	5.1 (24.7)	7.4 (53.3)
Penoxsulam + cyhalofop (ready-mix)	150	3.2 (9.3)	3.1 (8.7)	1.7 (2.0)	4.4 (18.0)	3.6 (12.0)	5.2 (26.0)
Pendimethalin fb bispyribac	1,000/25	1.9 (2.7)	2.1 (3.3)	1.0 (0.0)	5.9 (33.3)	3.3 (10.0)	5.2 (26.0)
Pendimethalin fb bispyribac + pyrazosulfuron	1,000/25 + 25	1.7 (2.0)	1.9 (2.7)	1.0 (0.0)	2.5 (5.3)	2.2 (4.0)	3.0 (8.0)
Pendimethalin fb bispyribac + azimsulfuron	1,000/25 + 20	2.2 (4.0)	1.7 (2.0)	1.0 (0.0)	2.2 (4.0)	2.1 (3.3)	2.8 (6.7)
Pendimethalin fb bispyribac + ethoxysulfuron	1,000/25 + 18.8	2.3 (4.7)	1.7 (2.0)	1.0 (0.0)	2.5 (5.3)	2.0 (3.3)	2.7 (6.7)
Pendimethalin fb bispyribac + ethoxysulfuron	1,000/25 + 28	2.6 (6.0)	1.9 (2.7)	1.0 (0.0)	2.1 (3.3)	2.2 (4.0)	3.0 (8.0)
Pendimethalin fb bispyribac + ethoxysulfuron	1,000/25 + 37.5	2.5 (5.3)	1.8 (2.7)	1.0 (0.0)	1.9 (2.7)	2.1 (3.3)	3.1 (9.3)
Pendimethalin fb bispyribac + fenoxaprop (with safener)	1,000/25 + 60	3.8 (13.3)	1.5 (1.3)	1.0 (0.0)	6.6 (42.0)	4.4 (18.0)	6.3 (38.7)
Pendimethalin fb azimsulfuron*fb*bispyribac + fenoxaprop (with safener)	1,000/20/25 + 60	3.7 (12.7)	1.2 (0.7)	1.0 (0.0)	1.0 (0.0)	2.6 (6.0)	3.6 (12.0)
Pendimethalin *fb* bispyribac *fb* 1 hand-weeding (HW)	1,000/25/HW	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
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	–	6.8 (45.3)	4.7 (20.7)	2.4 (4.7)	6.9 (47.6)	6.1 (36.7)	9.0 (80.0)
SEm±		0.2	0.2	0.1	0.2	0.2	0.3
CD (P=0.05)		0.5	0.5	0.4	0.4	0.4	0.8

*Original values in parentheses were subjected to square-root transformation ($\sqrt{X+1}$) before statistical analysis; BLW, broad leaf weeds; HW, hand-weeding

Dactyloctinum aegyptium (6.7); broad leaf weeds like *Ammannia baccifera* (16.9); and sedges like *Cyprus rotundus* (19.2). Pendimethalin 1,000 g/ha significantly controlled aerobic grassy weeds, but its efficacy was low against grass weeds like *Echinochloa crus-galli* and sedges like *Cyperus rotundus* (Godara *et al*., 2012), while pyrazosulfuron, azimsulfuron and ethoxysulfuron were effective against broad-leaf weeds and sedges (Yadav *et al.,* 2011a). Pendimetalin and bispyribac-sodium-alone and in sequential application did not provide effective control of all weeds (sedges). But sequential applications of bispyribac 25 g/ha tank-mix with pyrazosulfuron 25 g/ha, azimsulfuron 20 g/ha or ethoxysulfuron 18.8–37.5 g/ha after pendimethalin 1,000 g/ha were found superior to their individual applications in respect of density, dry weight and weed-control efficiency (93.3–95.6%) (Tables 1, 2) to complex weed flora. (Yadav *et al*., 2011b). Fenoxaprop (with safener) had antagonistic effect on the efficacy of bispyribac-sodium against all type of weeds, as visible from their density, dry weight and weed-control efficiency. Integration of 1 hand-weeding with pendimethalin fb bispyribac also resulted in almost complete control of all type of weeds.

Among the herbicidal treatments, pendimethalin fb bispyribac + pyrazosulfuron or azimsulfuron or ethoxysulfuron resulted in higher number of effective tillers and grain yield, at par with weed-free check (Table 2). Pendimethalin 1,000 g/ha or oxadiargyl 100 g/ha as pre-emergence application fb bispyribac-Na 25 g/ha at 25 DAS proved best combinations in providing satisfactory control of all types of weeds with significant improvement in grain yield of direct- seeded *basmati* rice (Yadav, 2012). Bispyribac alone and in sequence with pendimethalin resulted in higher grain yield in DSR, as also reported by Walia *et al.,* (2009). Highest net returns and benefit: cost ratio were obtained under pendimethalin 1,000 g/ha fb bispyribac-Na 25 g/ha + pyrazosulfuron 25 g/ha (Table 2).

It was concluded that weeds can also be effectively controlled by combinations as

Table 2. Effect of weed-control treatmentson dry-matter, weed-control efficiency and yield attributes and grain yield in direct seeded *basmati* rice

Treatments	Dose (g/ha)	Dry-matter accumulation (g/m^2)	Weed control efficiency (%)	Effective tillers (No./m row length)	Grain yield (t/ha)	Net returns (×10³₹/ha)	Benefit : Cost ratio
Pendimethalin	1,000	136.4	69.8	58.3	3.07	69.6	1.97
Bispyribac-Na	25	76.8	83.0	61.7	3.67	96.7	2.34
Bispyribac + pyrazosulfuron	25 + 25	60.8	86.5	67.7	3.78	100.1	2.38
Bispyribac + azimsulfuron	25 + 20	70.3	84.4	65.0	3.63	93.0	2.26
Bispyribac + ethoxysulfuron	25 + 18.8	78.2	82.7	64.0	3.55	90.3	2.24
Bispyribac + ethoxysulfuron	25 + 28	75.4	83.3	64.7	3.53	89.3	2.22
Bispyribac + ethoxysulfuron	25 + 37.5	70.2	84.5	64.3	3.54	89.3	2.22
Bispyribac + fenoxaprop (with safener)	25 + 60	234.6	48.1	55.0	2.56	44.4	1.61
Penoxsulam + cyhalofop (ready-mix)	150	76.4	83.1	65.3	3.75	99.8	2.38
Pendimethalin fb bispyribac	1,000/25	40.0	91.1	68.0	3.89	104.7	2.42
Pendimethalin fb bispyribac + pyrazosulfuron	1,000/25 + 25	19.7	95.6	73.3	4.10	113.4	2.53
Pendimethalin fb bispyribac + azimsulfuron	1,000/25 + 20	26.9	94.0	71.3	4.09	111.8	2.49
Pendimethalin fb bispyribac + ethoxysulfuron	1,000/25 + 18.8	30.2	93.3	72.0	4.04	110.8	2.49
Pendimethalin fb bispyribac + ethoxysulfuron	1,000/25 + 28	21.2	95.3	73.3	4.05	111.1	2.49
Pendimethalin fb bispyribac + ethoxysulfuron	1,000/25 + 37.5	19.9	95.6	73.0	4.01	108.8	2.45
Pendimethalin fb bispyribac + fenoxaprop (with safener)	1,000/25 + 60	51.7	88.6	62.3	3.68	94.0	2.26
Pendimethalin fb azimsulfuron fb bispyribac + fenoxaprop (with safener)	1,000/20/25 + 60	34.8	92.3	65.7	3.70	93.4	2.22
Pendimethalin fb bispyribac fb 1 hand-weeding (HW)	1,000/25/HW	0.0	100.0	76.0	4.20	112.6	2.42
Weed-free	–	0.0	100.0	77.7	4.36	112.2	2.28
Weedy check	–	451.8	0.0	35.0	1.52	15.9	1.02
SEm±	–	6.9	-	3.0	0.11	–	-
CD (P=0.05)	–	19.5	-	8.7	0.33	–	-

pendimethalin 1,000 g/ha as pre-emergence fb tank-mix application of bispyribac-Na 25 g/ha with pyrazosulfuron 25 g/ha or azimsulfuron 20 g/ha or ethoxysulfuron 18.8 g/ha at 60 DAS in direct-seeded *basmati* rice.

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