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Herbicides combinations for control of complex weed flora in transplanted rice

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ABSTRACT

The puddled transplanted rice is infested with mix of grasses, sedges and broad-leaf weeds in Northern India. For control of mixed weed flora, different herbicide combinations were evaluated in a field experiment conducted in summer of 2012 and 2013 at Ludhiana. The experimental field was infested with *Echinochloa* spp., *Ischaemum rugosum*, *Caesulia axillaris*, *Cyperus iria* and *Ammania baccifera*. The performance of pre- or early post-emergence herbicides applied alone was poorer during 2012 (dry year). The differential rainfall during both the years influenced the efficacy of herbicides. The herbicide treatments integrated with hand weeding recorded good weed control during both the years. Pre-emergence application of pyrazosulfuron-ethyl at 20 g/ha + one hand weeding or bispyribac-sodium 25 g/ha applied as alone or as tank-mix with ethoxysulfuron 18.7 g/ha recorded the highest weed control efficacy, rice grain yield and net returns during both the years and seemed to be the best ways of controlling complex weed flora and enhancing productivity and profitability from transplanted rice.

Key words: Herbicides, Rainfall, Tank-mixture, Transplanted rice, Weeds

Rice (*Oryza sativa* L.) is the second major crop of Punjab, after wheat. It is traditionally raised by transplanting seedings in a puddled field. It was cultivated on 2.9 million hectares area with total production of 16.7 million tonnes during 2014-15 (Anonymous 2016). The water resources of the state, however, could support 1.6 million hectare area only. The deficit had to be met by extracting the water from ground water resources putting these resources under stress. This over-exploitation of ground water has resulted in decline in water table at the rate of 0. 74 cm/year (Vashisht 2008). This situation becomes worse in years of deficit and/or erratic monsoon. In the absence of adequate water supply, the weeds emerge at higher densities (35% more weed density and biomass) in the transplanted rice (Misra *et al.* 1981) and reduce the yield of transplanted rice by 15-20% (Reddy and Reddy 1999). Moreover, depth of the standing water influences the type and density of the weed flora (Kent and Johnson 2001, Kumar and Ladha 2011) and also efficacy of applied pre-emergence herbicides. The weed flora of transplanted rice consist of annual grasses, sedges and broad-leaf weeds. Pre-emergence herbicides like butachlor, pretilachlor, oxadiargyl, pyrazosulfuron, pendimethalin and anilofos require stagnation of water in fields for achieving effective weed control, which is not possible in all the areas owing to scarcity of irrigation water. Post-emergence application of bispyribac-sodium have been found to be effective against annual grasses and sedges; and metsulfuron-methyl, ethoxysulfuron-ethyl, bensulfuron-methyl, azimsulfuron against broad-leaf and sedges in transplanted rice. The continuous use of same herbicides having similar modes of action resulted in shift in weed problem (Rajkhowa *et al.* 2006) and development of herbicide resistance in weeds (Rao 1999). In a long term study at Ludhiana, continuous use of pretilachlor resulted in weed flora shift from *Echinochloa* spp. to *Ischaemum rugosum*, and of anilofos to *Caesulia axillaris* and *Cyperus iria* (Anonymous 2014). The use of tank-mix/ready-mix herbicide having dissimilar modes of action can be of an option for management of complex weed flora in transplanted rice (Yadav *et al.* 2008), which will not only reduce the total volume of herbicide use but also ease and economize its application. The present study was conducted to evaluate the efficiency of combination of herbicides against complex weed flora in transplanted rice.

MATERIALS AND METHODS

A field experiment was conducted at Punjab Agricultural University, Ludhiana, Punjab during summer season of 2012 and 2013. The experimental site is situated in Trans-Gangetic Agro-Climatic zone, representing the Indo-Gangetic Alluvial plains at 30°

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56' N latitude, 75° 52' E longitude and at an altitude of 247 m above mean sea level. The experimental soil was loamy sand with pH 7.43 and EC 0.22 dS/m and it was low in organic carbon (0.27%) and available N (170 kg/ha) and medium in available P (20.5 kg/ha) and available K (185 kg/ha). The experiment was laid out in randomized complete block design with 3 replications. The twelve weed control treatments comprised of bispyribac-sodium (10%) 25 g/ha, pretilachlor (50%) 1000 g/ha, penoxsulam (24%) 22.5 g/ha, pyrazosulfuron-ethyl (10%) 20 g/ha, tank-mix of bispyribac-sodium 25 g + ethoxysulfuron-ethyl (15%) 18.75 g/ha, bispyribac-sodium 20 g + metsulfuron-methyl (10%) + chlorimuron-ethyl (10%) 4 g/ha, pretilachlor 750 g followed by (*fb*) ethoxysulfuron-ethyl 18.75 g/ha, pretilachlor 750 g *fb* metsulfruon + chlorimuron 4 g/ha, pyrazosulfuron-ethyl 20 g/ha *fb* manual weeding, pretilachlor (6%) + bensulfuron (0.6%) 660 g/ha, hand weeding at 25 and 45 DAT and weedy check. One manual weeding was done at 25 days after transplanting (DAT). The 30 days old seedlings of rice cv. PR 114 (2012) and PAU 121 (2013) were transplanted in puddled field during third week of June. The pre-emergence herbicides-pretilachlor, pyrazosulfruon-ethyl and pretilachlor (6%) + bensulfuron (0.6%) were broadcasted uniformly in standing water by mixing with 150 kg sand/ha at 0-5 DAT. Early-post-emergence herbicide-penoxsulam was applied by spray using 375 litres of water at 10-12 DAT. Post-emergence herbicides-bispyribac-sodium, ethoxysulfuron-ethyl, and metsulfuron-methyl (10%) + chlorimuron-ethyl were applied with hand operated knap sack sprayer fitted with flat fan nozzle by mixing with 375 litres of water/ha at 25 DAT. The field was drained before spray of early post- and post-emergence herbicides and irrigation was given one day after spray. The crop was raised as per recommended package of practices except for weed control treatments. The data on weed population and dry matter, crop growth and yield was recorded. The crop was manually harvested during third week of October. Weed data was square-root transformed before statistical analysis. The data were analyzed by using standard statistical procedures and comparisons were made at 5% level of significance.

RESULTS AND DISCUSSION

Effect on weeds

The experimental field was infested with grasses namely *Echinochloa* spp., *Ischaemum rugosum;* sedges mainly *Cyperus iria;* and broad-leaf weeds namely *Caesulia axillaris* and *Ammania baccifera* (Table 1). The application of bispyribac-sodium either alone or tank-mixed with chlorimuron + metsulfuron or ethoxysulfuron at 25 DAT recorded effective control of mixed weed flora (Table 1 and 2) and it was at par with two hand weeded plots and pyrazosulfuron broadcasted at 0-3 DAT *fb* one hand weeding at 25 DAT. In 2012, the performance of pre- or early post-emergence herbicides applied alone was poor (with WCE varied form 1.3- 40.5%) while in 2013, all the herbicides recorded good control of weeds. In 2013, tank mix application of bispyribac with ethoxysulfuron and chlorimuron + metsulfuron

Table 1. Effect of weed control treatments on population of different weed species at 60 DAT in transplanted rice during 2012 and 2013

Treatment	Dose (g/ha)	*Echinochloa* spp.		*Ischaemum rugosum*		*Caesulia axillaris*		*Ammania*	*Cyperus iria*
		2012	2013	2012	2013	2012	2013	2013	2013
Bispyribac-Na	25	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	2.4 (9)	2.0 (5)	3.0 (17)	1.0 (0)
Pretilachlor	1000	3.0 (10)	1.7 (3)	4.4 (19)	2.1 (4)	5.6 (31)	2.0 (5)	1.0 (0)	3.1 (12)
Penoxsulam	22.5	3.1 (9)	2.4 (6)	4.8 (23)	2.3 (5)	3.8 (14)	5.8 (35)	1.7 (2)	2.4 (9)
Pyrazosulfuron	20	5.6 (30)	4.3 (19)	4.3 (18)	1.2 (1)	3.6 (15)	1.4 (1)	1.5 (2)	2.0 (5)
Bispyribac + ethoxysulfuron	25 + 18.75	3.3 (11)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Bispyribac + (chlorimuron 10% + metsulfuron 10%)	20 + 4	1.7 (3)	1.0 (0)	1.9 (4)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Pretilachlor *fb* ethoxysulfuron	750 *fb* 18.75	2.4 (6)	3.0 (10)	3.9 (15)	1.7 (3)	1.0 (0)	1.0 (0)	1.0 (0)	2.2 (7)
Pretilachlor *fb* (chlorimuron 10% + metsulfuron 10%)	750 *fb* 4	3.1 (10)	3.7 (13)	4.3 (19)	3.1 (9)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Pyrazusulfuron *fb* manual weeding	20 *fb* HW	1.5 (10)	3.1 (10)	3.1 (11)	2.1 (4)	1.0 (0)	1.0 (0)	1.0 (0)	4.0 (15)
Pretilachlor (6%) + bensulfuron (0.6%)	660	3.2 (9)	3.9 (15)	3.5 (13)	2.7 (7)	3.1 (11)	2.1 (4)	1.0 (0)	1.9 (4)
HW at 25 and 45 DAS	-	2.2 (5)	1.4 (1)	2.9 (9)	1.0 (0)	1.0 (0)	2.8 (9)	1.8 (3)	2.2 (7)
Weedy check	-	4.7 (22)	5.6 (31)	4.6 (20)	3 (9)	3.5 (15)	4.5 (20)	3.1 (9)	4.7 (23)
LSD (P=0.05)	-	1.9	1.6	1.8	1.2	2.3	2.0	NS	NS

Data is subjected to square root transformation. Figure in parentheses are original value

Table 2. Effect of weed control treatments on weed biomass at 60 DAT in transplanted rice during 2012 and 2013

Treatment	Dose (g/ha)	Weed biomass (g/m^2)					Weed control efficiency (%)	
		Grasses		Broad-leaves		Sedges		
		2012	2013	2012	2013	2013	2012	2013
Bispyribac-Na	25	1.0 (0)	1.0 (0)	4.9 (54)	1.0 (0)	3.4 (22)	93.2	96.3
Pretilachlor	1000	17.1 (300)	4.4 (25)	12.9 (172)	2.4 (9)	3.6 (15)	40.5	91.7
Penoxsulam	22.5	20.7 (444)	6.3 (41)	7.9 (62)	3.9 (20)	5.1 (36)	36.4	83.5
Pyrazosulfuron	20	26.4 (708)	11.1 (137)	7.2 (78)	2.2 (7)	1.9 (4)	1.3	74.8
Bispyribac + ethoxysulfuron	25 + 18.75	8.0 (64)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	92.0	100
Bispyribac + (chlorimuron 10% + metsulfuron 10%)	20 + 4	6.9 (66)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	91.7	100
Pretilachlor *fb* ethoxysulfuron	750 *fb* 18.75	12.0 (152)	8.3 (94)	1.0 (0)	2.3 (8)	2.8 (13)	80.9	80.4
Pretilachlor *fb* (chlorimuron 10% + metsulfuron 10%)	750 *fb* 4	16.5 (274)	9.8 (98)	1.0 (0)	1.0 (0)	1.0 (0)	65.6	83.3
Pyrazusulfuron *fb* manual weeding	20 *fb* HW	7.5 (76)	8.6 (75)	1.0 (0)	1.0 (0)	4.5 (21)	90.5	83.6
Pretilachlor (6%) + bensulfuron (0.6%)	660	14.4 (226)	11.5 (137)	7.6 (92)	1.9 (4)	1.8 (3)	60.1	75.5
HW at 25 and 45 DAS	-	6.8 (64)	2.3 (8)	1.0 (0)	2.8 (8)	1.9 (4)	92.0	96.6
Weedy check	-	26.4 (702)	23.1 (534)	8.2 (94)	3.9 (14)	5.8 (39)	-	-
LSD (P=0.05)	-	6.4	4.8	6.6	NS	NS	-	-

Data is subjected to square root transformation. Figure in parentheses are original value

provided complete control of complex weed flora including grasses, broad-leaves and sedges (Table 1); bispyribac alone and integrated use of pyrazosulfuron with one hand weeding were at par with these two treatments ultimately resulting into the highest weed control efficiency. The benefit of tank mix of these herbicides was not recorded in 2012. The poor efficacy of pre-emergence herbicides in 2012 might be related to dry weather as only 3.5 mm rainfall was received in June. The year 2013 turned out to be wet year as 296.4 mm rainfall was received in June 2013. However, the herbicide treatments integrated with hand weeding or hand weeding alone treatment recorded similar weed control during both the years. This differential effect of rainfall on herbicides and hand weeding treatments indicated the importance of good rainfall or good soil moisture for getting best weed control from the herbicides (Phogat *et al.* 1998, Kabir *et al* 2008) and increasing water depths also increased the herbicide's efficacy. The effective control of mixed weed flora with penoxsulam 25 g/ha applied at 0-5 DAT (Pal and Banerjee 2007, Prakash *et al*. 2013), of bispyribac-sodium at 20-30 g/ha as post-emergence against *Echinochloa colona* and *Cyperus* sp. (Yadav *et al*. 2009, Kumar *et al.* 2013) and of pyrazosulfuron-ethyl at 20 and 25 g/ha applied at 3 DAT against *C. iria* (Pal *et al.* 2012) has been reported earlier.

Effect on crop and economic returns

The phytotoxicity of different herbicides on crop was observed and found variable results in two years. Tank mix application of bispyribac-sodium with chlorimuron+metsulfuron recorded 92% weed control efficiency during 2012 (dry year) but it resulted in yellowing of foliage and suppression of plant growth, and resulting in lowered rice grain yield; whereas all the herbicides were found safe to the rice crop during 2013 (wet year). The environmental factors like solar radiation, temperature, relative humidity play a significant role on bio-efficacy and phyto-toxicity of herbicides. The effective weed control in different herbicidal and integrated weed control treatments increased the number of effective tillers and the plants produced longer panicles as compared to weedy check (Table 3). The sequential application of pyrazosulfuron and one hand weeding at 25 DAT recorded the highest rice grain yield, net returns and B:C ratio in 2012 (Table 3). Pyrazosulfuron and pretilachlor alone or when followed by chlorimuron+ metsulfuron or pre-mix of pretilachlor with bensulfuron recorded rice grain yield at par to weedy check which was attributed to higher weed pressure under these treatments. Another probable reason for lower rice grain yield in 2012 might be the incidence of sheath blight in rice crop in all the plots. In 2013, bispyribac alone and as tank mix with chlorimuron + metsulfruon or with ethoxysulfuron recorded the highest rice grain yield, net returns and B:C ratio (Table 3). Pre-emergence herbicides when applied in combination with either post-emergence herbicide or manual weeding recorded more weed control efficiency, net returns and B:C ratio as compared to their sole application. Hossain and Mondal (2014) also reported higher rice grain yield with post-emergence application of bispyribac + ethoxysulfuron, pretilachlor *fb* metsulfuron-methyl + chlorimuron-ethyl, pyrazosulfuron *fb*

Table 3. Effect of weed control treatments on grain yield and yield attributes of transplanted rice during 2012 and 2013

Treatment	Dose (g/ha)	Plant height at harvest (cm)		Effective tillers (no./m^2)		Panicle length (cm)		Grain yield (t/ha)		Benefit-Cost ratio	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Bispyribac-Na	25	59.7	67.6	328	363.3	22.5	25.7	4.67	7.14	1.83	2.55
Pretilachlor	1000	66.3	69.5	200	358.3	21.2	25.9	2.78	6.05	1.12	2.22
Penoxsulam	22.5	51.7	69.3	175	351.6	20.5	25.1	3.00	5.35	1.21	1.96
Pyrazosulfuron	20	54.3	63.5	113	203.3	21.4	23.3	2.72	3.29	1.10	1.21
Bispyribac + ethoxysulfuron	25 + 18.75	65.0	69.7	327	356.7	25.2	26.2	4.74	6.53	1.82	2.29
Bispyribac + (chlorimuron 10% + metsulfuron 10%)	20+4	61.1	70.9	328	368.3	23.7	26.6	3.22	7.33	1.20	2.48
Pretilachlor *fb* ethoxysulfuron	750 *fb* 18.75	55.8	69.0	241	341.7	20.5	25.3	4.44	5.87	1.79	2.15
Pretilachlor *fb* + (chlorimuron 10% + metsulfuron 10%)	750 *fb* 4	58.7	69.1	251	353.3	22.1	26.9	2.69	5.97	1.03	2.08
Pyrazusulfuron *fb* manual weeding	20 *fb* HW	59.5	68.8	331	338.3	24.4	26.6	5.89	6.68	2.13	2.20
Pretilachlor (6%) + bensulfuron (0.6%)	660	58.4	67.3	243	295.0	23.1	24.4	2.94	4.76	1.16	1.71
HW at 25 and 45 DAS	-	62.2	70.7	341	365.0	23.6	26.4	5.49	5.90	1.82	1.78
Weedy check	-	53.5	62.6	122	201.6	19.7	22.5	2.44	3.21	1.01	1.21
LSD (P=0.05)	-	NS	5.1	103.5	67.4	3.3	2.3	1.93	1.77	-	-

manual weeding, pretilachlor + bensulfuron and weed-free check than sole application of bispyribac-sodium, pretilachlor and pyrazosulfuron and early post-emergence application of penoxsulam.

The study concluded that post-emergence application of bispyribac alone and as tank-mix with ethoxysulfuron or chlorimuron + metsulfruon or pre-emergence pyrazosulfuron + one hand weeding seems to be the best ways of controlling complex weed flora and enhancing productivity and profitability from transplanted rice.

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