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Penoxsulam + butachlor: A new ready-mix herbicide for control of complex weed flora in transplanted rice

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ABSTRACT

A field experiment was conducted to evaluate the efficacy of penoxsulam 0.97%w/w (1.0%w/v) + butachlor 38.8% w/w (40% w/v) 41% SE applied as pre-emergence(0-7DAT) spray in standing water against complex weed flora in transplanted rice at CCS HAU Regional Research Station, Karnal during rainy (*Kharif*) seasons of 2015 and 2016. The crop was infested mainly with *Echinochloa crus-galli* (~15%), *Ammannia baccifera* (~70%), and *Cyperus difformis*, *Cyperus rotundus* and other sedges (~15 %). Penoxsulam + butachlor 41% SE at 820 g/ha being as good as weed free check provided almost complete control (98.1-98.5% WCE) of complex weed flora during both the years, and it was better than penoxsulam 22.5 g/ha (87-88%), butachlor 1500 g/ha (90%) and pretilachlor 1000 g/ha (91%). Penoxsulam + butachlor 820 g/ha resulted into the highest number of effective tillers and grain yield (5.43 t/ha in 2015 and 6.06 t/ha in 2016). It was superior to its lower doses (615 and 718 g/ha) and penoxsulam 22.5 g/ha during both the years, and butachlor 1500 g/ha during 2016. There was no crop phyto-toxicity of penoxsulam + butachlor 41% SE at 820 g/ha (X) and 1640 g/ha (2X). Weeds allowed to grow throughout the crop season reduced the grain yield to the extent of 27.3 and 32.9% during 2015 and 2016, respectively.

INTRODUCTION

Rice is the most important staple food crop of the world and Asia as well. It is grown over an area of about 44 mha in India with total production of 105 m tones, amounting to 40% of the total food grain in the country (Economic Survey 2015-16) supporting 600 million people. India is the second largest producer among the rice growing countries, but its productivity is still very low, and weed infestation is the major cause of yield reduction (27-68%) in transplanted rice (Singh *et al*. 2003, Yadav *et al*. 2009, Manhas *et al*. 2012, Duary *et al*. 2015, Yadav *et al*. 2018). *Echinochloa crus-galli* is the dominant weed in transplanted rice in north-western India. However, infestation of broad-leaf weeds and the sedges is also increasing nowadays. Butachlor, pretilachlor, anilofos and oxadiargyl are some of the most commonly sand mixed broadcast (in standing water) used pre-emergence herbicides in transplanted rice. Recently, bispyribac-sodium is also being used as post-emergence herbicide (Yadav *et al*. 2009). Penoxsulam 24% SC as early post-emergence herbicide applied 8-12 days after transplanting (DAT) is another quite effective herbicide against complex weed flora, specifically against the broad-leaf weeds and sedges. However, there are issues in spraying of this herbicide as early PoE due to standing water and small rice seedlings, thereby limiting its use in real field situations. Butachlor is quite effective against *Echinochloa* but slightly less efficacy against some of the broad-leaf weeds and sedges. Generally, single application of one herbicide does not provide satisfactory weed control throughout the crop season as some of the broad-leaf weeds and sedges are not controlled that effectively, and farmers are forced to apply either other sequential post-emergence herbicide(s) or follow manual weeding. This escalates the cost and energy for weed management. Farmers largely prefer to use pre-emergence herbicides in transplanted rice not only due to easiness in application but also to achieve effective weed management starting from at an early growth stage. Therefore, more convenient option would be single shot application of ready mix or tank mix combination of pre-emergence herbicide(s). Pretilachlor + pyrazosulfuron-ethyl (ready-mix) at

615 g/ha as pre-emergence has been reported very effective (91-96%) against complex weed flora in transplanted rice, with higher grain yield and B-C ratio (Yadav *et al.* 2018). Keeping these points in view, present study was conducted to evaluate the efficacy of a ready-mix combination of penoxsulam 0.97%w/w (1.0%w/v) + butachlor 38.8%w/w (40%w/v) 41% SE (Dow Agro Science) as pre-emergence (0-7 DAT) sprayed in standing water against complex weed flora in transplanted rice.

MATERIALS AND METHODS

Bio-efficacy studies

A field experiment was conducted at CCS HAU Regional Research Station, Karnal during *Kharif* seasons of 2015 and 2016 to evaluate the bio-efficacy of penoxsulam 0.97% w/w (1.0% w/v) + butachlor 38.8% w/w (40% w/v) 41% SE against complex weed flora in transplanted rice. The soil of the experimental filed was low in organic carbon available nitrogen, medium in available, phosphorus and potassium with slightly alkaline in reaction (pH 8.2). The treatments included penoxsulam+ butachlor 41% SE 615, 718 and 820 g/ha at 0-7 DAT, penoxsulam 24% SC 22.5 g/ha at 8-12 DAT, butachlor 50% EC 1500 g/ha at 0-3 DAT, pretilachlor 50% EC 1000 g/ha at 0-3 DAT along with weed free and weedy checks. The experiment was laid out in randomized block design with three replications. Transplanting of 35 days old seedlings of rice cultivar '*HKR 47*' was done on 10 July, 2015 and 12 July, 2016 at a spacing of 20 x 15 cm in a plot size of 6.5 x 2.4 m. Herbicides were applied by spray with knap-sack sprayer fitted with flat-fan nozzle using 300 liter water/ha. The soil was kept under saturated moisture conditions during spray, and field was re-irrigated after 24 hours of spray application. Data on weed count and weed dry weight were recorded at 60 days after transplanting (DAT), Yield and yield attributes at maturity crop was harvested on 24 October, 2015 and 22 October, 2016. Before statistical analysis, the data on density of weeds were subjected to square root $(\sqrt{x+1})$ transformation to improve the homogeneity of the variance. All the data were subjected to the analysis of variance (ANOVA) separately for each year. The significant treatment effect was judged with the help of 'F' test at the 5% level of significance. The 'OPSTAT' software of CCS Haryana Agricultural University, Hisar, India was used for statistical analysis (Sheoran *et al.* 1998).

RESULTS AND DISCUSSION

Weed flora

Weed flora composition of the experimental field during two years of investigation consisted of mainly grassy weed *Echinochloa crus-galli* (14.1-15.4%), broad-leaf weed *Ammannia baccifera* (69.2-71.8%) and around 15% sedges including *Cyperus difformis, Cyperus rotundus* and others.

Effect on density of weeds

All the herbicides reduced the density of *Echinochloa crus-galli, Ammannia baccifera* and all sedges significantly as compared to the untreated weedy check (**Table 1**). The density of grassy weed *Echinochloa crus-galli* at 60 DAT decreased with the corresponding increase in the dose of penoxsulam + butachlor (ready mix) during both the years (**Table 1**). Penoxsulam + butachlor at its higher dose (820 g/ha) reduced the density of *E. crus-galli* significantly more than its lower doses (615 and 718 g/ha) during

Table 1. Effect of different herbicidal treatments on density of weeds at 60 DAT in transplanted rice (*Kharif* 2015 and 2016)

Treatment	Dose (g/ha)	Density of weeds (no./m^2)*									
		Echinochloa crus-galli		*Ammannia baccifera*		*Cyperus difformis*		*Cyperus rotundus*		Total sedges	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Penoxsulam + butachlor 41% SE	615	2.20(4.0)	2.04(3.3)	5.62(30.7)	4.65(20.7)	1.49(1.3)	1.49(1.3)	1.73(2.0)	1.73(2.0)	2.07(3.3)	2.07(3.3)
Penoxsulam + butachlor 41% SE	718	2.07(3.3)	1.73(2.0)	5.32(27.3)	3.69(12.7)	1.24(0.7)	1.00(0)	1.49(1.3)	1.49(1.3)	1.66(2.0)	1.49(1.3)
Penoxsulam + butachlor 41% SE	820	1.24(0.7)	1.24(0.7)	3.60(12.0)	2.24(4.0)	1(0.0)	1.00(0)	1(0.0)	1.00(0)	1(0)	1.00(0)
Penoxsulam 24% SC	22.5	2.65(6.0)	1.66(2.0)	4.99(24.0)	3.31(10.0)	1.24(0.7)	1.00(0)	1.24(0.7)	1.00(0.0)	1.49(1.3)	1.00(0.0)
Butachlor 50% EC	1500	1.90(2.7)	1.49(1.3)	5.79(32.7)	4.49(19.3)	1.9(2.7)	1.73(2.0)	2.07(3.3)	1.90(2.7)	2.65(6.0)	2.37(4.7)
Pretilachlor 50% EC	1000	1.73(2.0)	1.24(0.7)	6.14(36.7)	4.57(20.0)	1.73(2.0)	1.73(2.0)	1.9(2.7)	1.66(2.0)	2.37(4.7)	2.20(4.0)
Weed free		1.00(0)	1.00(0)	1.00(0)	1.00(0)	1(0)	1.00(0)	1(0)	1.00(0)	1(0)	1.00(0)
Weedy check		4.58(20.0)	4.12(16.0)	10.14(102)	8.53(72.0)	2.37(4.7)	2.37(4.7)	2.51(5.3)	2.07(3.3)	3.31(10.0)	2.99(8.0)
LSD (p=0.05)		0.50	0.73	0.47	0.65	0.48	0.29	0.40	0.46	0.56	0.45

*The original figures in parentheses were subjected to square root transformation $(\sqrt{x+1})$ before statistical analysis

both years, being at par with pretilachlor during the both years. It was better than penoxulam and butachlor during 2015 only. Penoxsulam + butachlor at 820 g/ha also reduced the density of *A. baccifera* significantly more than its lower doses, penoxulam, butachlor and pretilachlor during both years. Penoxsulam + butachlor at 820 g/ha being similar to penoxulam 22.5 g/ha was statistically similar to its lower dose of 718 g/ha only against C. *differmis*, but superior to its lower doses of butachlor and pretilachlor against all other sedges during both the years. Pretilachlor 750 g/ha + pyrazosulfuron 25 g/ha as tank mix application at 3 DAT and pretilachlor + pyrazosulfuron-ethyl (ready mix) at 615 g/ha have already been reported very effective in reducing the density of complex weed flora in transplanted rice by Teja *et al.* (2016) and Yadav *et al.* (2018).

Effect on dry weight of weeds

All the herbicides reduced the dry weight of grassy weeds, broad-leaf weeds, sedges and total weeds significantly as compared to the untreated weedy check (**Table 2**). Penoxsulam + butachlor at its higher dose (820 g/ha) being as good as weed free reduced the dry weight of grassy weeds, broad-leaf weeds, sedges and total weeds significantly compared to all other herbicidal treatments during both years. Weed control efficiency of penoxsulam + butachlor increased with increase in its dose from 615 g/ha (75.8-78.4%) to 718 g/ha (81.8-84.0%) and 820 g/ha (98.1-98.5%) during both the years (**Table 2**). Weed control of efficiency of penoxsulam + butachlor 820 g/ha was higher than penoxsulam 22.5 g/ha (87-88%), butachlor 1500 g/ha (90%) and pretilachlor 1000 g/ha (91%). Thus, based on two years data, 820 g/ha was realized the most optimum dose of penoxsulam + butachlor. Pre-emergence application of herbicides used in combination have been reported very effective against mixed weed flora in transplanted rice earlier also (Manhas *et al.* 2012, Kumar *et al.* 2014, Duary *et al.* 2015, Teja *et al.* 2015, Teja *et al.* 2016, Yadav *et al.* 2018).

Effect on crop

There was no significant effect of herbicidal treatments on plant height and panicle length of the crop during both the years (**Table 3**). Penoxsulam + butachlor 820 g/ha resulted into highest number of effective tillers (486-488/m^2) and grain yield (5.43 t/ha in 2015 and 6.06 t/ha in 2016) among all the herbicidal treatments, which were at par with weed free check. Grain yield under penoxsulam + butachlor

Table 2. Effect of different herbicidal treatments on dry weight of weeds at 60 DAT in transplanted rice (*Kharif* 2015 and 2016)

Treatment	Dose (g/ha)	Dry weight of weeds (g/m^2)								Weed control efficiency (%)	
		Grassy weeds		Broad-leaf weeds		Sedges		Total weeds			
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Penoxsulam + butachlor 41% SE	615	17.0	12.1	6.0	4.3	1.9	2.1	24.8	18.5	75.8	78.4
Penoxsulam + butachlor 41% SE	718	13.4	9.8	4.6	2.9	0.8	1.0	18.7	13.7	81.8	84.0
Penoxsulam + butachlor 41% SE	820	1.2	1.3	0.8	0.0	0.0	0.0	2.0	1.3	98.1	98.5
Penoxsulam 24% SC	22.5	9.8	8.8	2.1	1.3	1.2	0.0	13.1	10.1	87.2	88.2
Butachlor 50% EC	1500	3.9	3.0	3.2	3.0	3.2	2.8	10.3	8.8	90.0	89.7
Pretilachlor 50% EC	1000	3.0	2.0	3.3	2.7	2.9	2.7	9.2	7.4	91.0	91.3
Weed free		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Weedy check		86.0	71.8	10.7	8.4	6.0	5.3	102.6	85.5	0.0	0.0
LSD (p=0.05)		4.4	4.0	1.6	1.5	0.9	0.4	4.9	3.9		

Table 3. Effect of different herbicidal treatments on yield and yield attributes of transplanted rice (*Kharif* 2015 and 2016)

Treatment	Dose (g/ha)	Plant height (cm)		Effective tillers (no./m^2)		Panicle length (cm)		Grain yield (t/ha)	
		2015	2016	2015	2016	2015	2016	2015	2016
Penoxsulam + butachlor 41% SE	615	109.7	113.0	408	454	21.7	22.6	4.80	5.46
Penoxsulam + butachlor 41% SE	718	110.3	112.9	440	462	21.9	23.1	5.01	5.61
Penoxsulam + butachlor 41% SE	820	110.1	114.2	486	488	22.3	23.7	5.43	6.06
Penoxsulam 24% SC	22.5	110.7	113.9	454	474	21.9	23.3	5.13	5.85
Butachlor 50% EC	1500	111.3	114.3	468	478	21.9	22.8	5.23	5.92
Pretilachlor 50% EC	1000	110.3	113.8	470	488	22.1	22.9	5.28	5.95
Weed free		110.9	113.6	497	489	22.1	23.5	5.48	6.17
Weedy check		111.8	112.9	339	329	21.6	22.4	3.99	4.13
LSD (p=0.05)		NS	NS	26	28	NS	NS	0.21	0.14

820 g/ha was superior to its lower doses and penoxsulam 22.5 g/ha during both the years, and butachlor 1500 g/ha during 2016. In comparison to weedy check during 2015, penoxsulam + butachlor 820 g/ha, penoxsulam 22.5 g/ha, butachlor 1500 g/ha and pretilachlor 1000 g/ha increased the grain yield of rice to the extent of 36.3, 28.7, 31.2 and 32.4%, respectively. Whereas, the corresponding figures during 2016 were 46.6, 41.5, 43.1 and 44.0%, respectively. Effective management of complex weeds consequently resulting into higher yields of transplanted rice due to combined application of herbicides has been realized earlier also (Kumar *et al*. 2014, Duary *et al*. 2015, Teja *et al*. 2015, Yadav *et al*. 2018). Weeds allowed to grow throughout the crop season reduced the grain yield to the extent of 27.3 and 32.9% during 2015 and 2016, respectively.

Based on two years field experimentation, it might be concluded that penoxsulam 0.97% w/w (1.0% w/v) + butachlor 38.8% w/w (40% w/v) 41% SE 820 g/ha applied as spray in 300 L water/ha at 0-7 DAT under saturated moist field conditions (re-irrigation 24 hours after spray) provided effective control of complex weed flora in transplanted rice with improved grain yields.

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