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Evaluation of Tank-mix Combinations of Different Herbicides for Control of *Phalaris minor* in Wheat

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ABSTRACT

A field experiment was conducted at CCS Haryana Agricultural University Regional Research Station, Karnal during **rabi** 2006-07 and 2007-08 to evaluate the efficacy of tank-mix combinations of different herbicides against *Phalaris minor* in wheat. The experimental field was dominated mainly by grassy weed *P. minor* Retz. The major weeds among broad-leaved weeds (BLW) were *Coronopus didymus* L., *Anagallis arvensis* L., *Melilotus indica* All. Fl. Ped., *Medicago denticulata* L., *Rumex dentatus* L., *Vicia sativa* L. and *Lathyrus aphaca* L. Intra-group combinations of herbicides viz., ACCase inhibitor (clodinafop/fenoxaprop/pinoxaden) with ACCase inhibitor and ALS inhibitor (sulfosulfuron/ mesosulfuron+iodosulfuron) with ALS inhibitor were compatible and resulted in very effective control of *P. minor* and consequently yields of wheat (5552-5861 kg/ha in 2006-07 and 5510-5897 kg/ha in 2007-08) were comparable to weed free checks (5909 kg/ha in 2006-07 and 5850 kg/ha in 2007-08). While inter-group combinations (clodinafop/fenoxaprop/pinoxaden with sulfosulfuron/mesosulfuron+iodosulfuron) were not found compatible and resulted in lower control of *P. minor* with lower yields (5054-5239 kg/ha in 2006-07 and 4285-4976 kg/ha in 2007-08). Alone application and all combinations having sulfosulfuron or mesosulfuron + iodosulfuron provided good control of BLW even under inter-group combinations. There was no phyto-toxicity of any of the herbicidal treatments on wheat, except some recoverable symptoms under treatments having mesosulfuron+iodosulfuron during 2007-08.

Key words : Herbicides, *Phalaris minor,* tank-mix combinations, weed control, wheat

INTRODUCTION

Phalaris minor is the dominant weed in the rice-wheat cropping system of the north-western India including Haryana (Singh *et al.,* 1995). Alternate herbicides like clodinafop, sulfosulfuron, fenoxaprop, tralkoxydim, sulfosulfuron+ metsulfuron and mesosulfuron+ iodosulfuron have already been recommended during the last decade for the control of the isoproturon-resistant *P. minor*. Over the years, the efficacy of these herbicides has started declining and there is possibility of development of cross resistance, as increase in GR_{50} values of sulfosulfuron, fenoxaprop and clodinafop under continuous use of herbicides has been observed (Dhawan *et al*., 2009b). As the resistance in *P. minor* is metabolic in nature, there are every chances of cross resistance development against new herbicides as well. Pinoxaden has been introduced recently in India, but its performance has been reported to be decreasing within a short span of time (Chhokar and Sharma, 2008; Dhawan *et al*., 2009a). Alternate herbicides, change in crop rotation, early sowing with zero-till machine are some of the strategies to delay the development of cross resistance (Yadav and Malik, 2005; Singh, 2007). Herbicide mixtures may also be one of the options for management or delay of cross resistance development against these herbicides (Yadav and Malik, 2005; Dhawan *et al.*, 2009a). Weeds resistance to more vulnerable herbicides will be destroyed by the mixing partner or at least be rendered relatively unfit compared to wild types (Anon., 1990). Hence, this study was undertaken to examine the possibility of suitable tank-mix combinations of alternate herbicides (clodinafop, fenoxaprop, pinoxaden, sulfosulfuron and mesosulfuron+ iodosulfuron) for management of *P. minor* in wheat.

MATERIALS AND METHODS

A field experiment was conducted at CCS Haryana Agricultural University Regional Research

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Station, Karnal during **rabi** 2006-07 and 2007-08 to evaluate the efficacy of tank-mix combinations of different herbicides against *P. minor* in wheat. The soil of experimental field was clay loam in texture, low in available nitrogen, medium in available phosphorus and potassium with slightly alkaline in reaction. The treatments included alone application of clodinafop 60 g/ha, fenoxaprop 100 g/ha, sulfosulfuron 25 g/ha, mesosulfuron+iodosulfuron 14.4 g/ha and pinoxaden 50 g/ha; tank-mix combinations of all of these herbicides using their half doses, along with weed free and weedy checks. The experiment was laid out in randomized block design with three replications in a plot size of 5.4 x 2.2 m^2. All the herbicides were applied at 35 days after sowing (DAS) by knapsack sprayer fitted with flat fan nozzle using 500 litres of water per hectare. Wheat cultivar PBW 502 was sown on 20 November 2006 and 24 November 2007 using seed rate of 112.5 kg/ha with a row spacing of 20 cm. Crop was raised according to package of practices of the State University. Density and dry weight of weeds were recorded at 75 DAS, and yield and yield attributes at harvest of the crop. Data on crop phyto-toxicity were recorded at 15 and 30 days after treatment (DAT). There was no phyto-toxicity of any of the herbicidal treatments on the crop except some recoverable symptoms under mesosulfuron+iodosulfuron alone or tank-mix combinations during 2007-08 (1.3-2.3% at 15 DAT); hence, data in this respect have not been included herein. Crop was harvested on 21 April 2007 and 22 April 2008.

RESULTS AND DISCUSSION

The experimental field was dominated mainly by grassy weed *Phalaris minor* Retz. (89-95%). The major weeds among broad-leaved weeds (BLW) were *Coronopus didymus* L., *Anagallis arvensis* L., *Melilotus indica* All. Fl. Ped., *Medicago denticulata* L., *Rumex dentatus* L., *Vicia sativa* L. and *Lathyrus aphaca* L.

Effect on Weeds

During 2006-07, reductions in density and dry weight of *P. minor* due to clodinafop 60 g/ha, sulfosulfuron 25 g/ha, pinoxaden 50 g/ha and mesosulfuron+iodosulfuron 14.4 g/ha were similar except density under mesosulfuron+iodosulfuron being inferior to clodinafop and pinoxaden (Table 1). Fenoxaprop was inferior to all other alone herbicidal treatments in respect of density and dry weight of *P. minor.* Dry weight of *P. minor* due to clodinafop, sulfosulfuron and pinoxaden was reduced even to the level of weed free check. During 2007-08, clodinafop and pinoxaden performed better than sulfosulfuron, fenoxaprop and mesosulfuron+ iodosulfuron in respect of density and dry weight of *P. minor*. Clodinafop and pinoxaden were again similar to weed free check in terms of dry weight of weeds during 2007-08.

Tank-mix combinations of half the recommended doses of clodinafop/fenoxaprop/pinoxaden (ACCase inhibitors) were at par with each other and were similar or superior to their alone applications in reducing the density and dry weight of *P. minor* during both the years (Table 1). Similarly, tank-mix of half of the recommended doses of sulfosulfuron with mesosulfuron+iodosulfuron (ALS inhibitors) were also at par or superior to their alone applications. This indicated the compatibility of intra-group combinations of herbicides (ACCase inhibitors with ACCase inhibitors; ALS inhibitors with ALS inhibitors). Intra-group combinations resulted in dry weight of weeds at par with weed free checks except fenoxaprop+pinoxaden during 2006-07 and sulfosulfuron+(mesosulfuron+iodosulfuron) during 2007-08. Inter-group combinations (clodinafop/fenoxaprop/ pinoxaden with sulfosulfuron/mesosulfuron+ iodosulfuron) did not perform well and resulted in density and dry weight of *P. minor* even higher than their alone applications and the inter-group combinations; however, the differences in dry weight were non-significant during 2006-07. Lower performance of inter-group combinations might be due to use of half of the recommended dose for each herbicide, which needs to be studied at recommended doses for drawing final conclusion on effectiveness of such combinations. Mixing partners with different modes of action should be tried at normal field doses; however, it will increase the cost of treatment and may damage the crop (Gressel, 1992).

During both the years, alone and all combinations with sulfosulfuron or mesosulfuron+iodosulfuron resulted in density and dry weight of BLW at par with weed free check (Table 1). Clodinafop, fenoxaprop and pinoxaden alone and in combination with each other were as good as weedy check in respect of density and dry weight of BLW. There was no antagonistic effect of across group combinations on control of BLW.

Table 1. Effect of different herbicides applied alone or as tank-mixtures on density and dry weight of weeds in wheat

Treatments	Dose (g/ha)	Density of weeds (No./m^2)*				Dry weight of weeds (g/m^2)			
		Grassy		BLW		Grassy		BLW	
		2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Clodinafop	60	4.97 (24.0)	6.15 (37.3)	4.93 (23.3)	4.11 (16.0)	13.3	5.1	3.0	1.0
Sulfosulfuron	25	6.45 (40.7)	8.49 (71.3)	1.24 (0.7)	1.00 (0.0)	11.5	22.4	0.3	0.0
Fenoxaprop	100	8.75 (76.0)	7.69 (59.3)	3.78 (13.3)	3.19 (9.3)	75.7	28.9	1.9	1.3
Pinoxaden	50	4.47 (19.3)	4.99 (26.7)	4.85 (22.7)	3.67 (12.7)	9.3	2.7	2.5	1.5
Mesosulfuron+iodosulfuron	14.4	6.65 (44.0)	8.21 (67.3)	1.00 (0.0)	1.00 (0.0)	18.1	11.9	0.0	0.0
Clodinafop+sulfosulfuron	30+12.5	6.90 (47.3)	9.91 (97.3)	1.67 (2.7)	1.00 (0.0)	21.5	66.6	0.3	0.0
Clodinafop+fenoxaprop	30+50	3.08 (8.7)	6.18 (37.3)	3.65 (13.3)	3.68 (12.7)	11.6	3.1	2.2	1.3
Clodinafop+pinoxaden	30+25	2.95 (8.0)	5.53 (30.7)	3.77 (13.3)	3.71 (13.3)	4.5	2.5	3.8	1.8
Clodinafop+(mesosulfuron+iodosulfuron)	30+7.2	6.53 (42.7)	11.58 (133.3)	1.00 (0.0)	1.00 (0.0)	21.3	40.3	0.0	0.0
Sulfosulfuron+fenoxaprop	12.5+50	6.75 (44.7)	9.56 (90.7)	1.24 (0.7)	1.55 (2.0)	20.1	62.1	0.1	0.1
Sulfosulfuron+pinoxaden	12.5+25	6.77 (46.0)	7.91 (62.0)	1.00 (0.0)	1.24 (0.7)	25.1	51.0	0.0	0.1
Sulfosulfuron+(mesosulfuron+iodosulfuron)	12.5+7.2	3.70 (13.3)	6.52 (42.7)	1.00 (0.0)	1.00 (0.0)	3.5	14.7	0.0	0.0
Fenoxaprop+pinoxaden	50+25	4.31 (20.0)	6.00 (35.3)	3.32 (10.7)	3.68 (12.7)	15.3	7.2	1.6	1.1
Fenoxaprop+(mesosulfuron+iodosulfuron)	50+7.2	6.85 (46.0)	8.73 (75.3)	1.00 (0.0)	1.00 (0.0)	21.2	41.9	0.0	0.0
Pinoxaden+(mesosulfuron+iodosulfuron)	25+7.2	8.33 (69.3)	9.64 (92.7)	1.00 (0.0)	1.00 (0.0)	21.4	48.9	0.0	0.0
Weed free		1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	1.00 (0.0)	0.0	0.0	0.0	0.0
Weedy check		11.33 (128.0)	13.88 (192.7)	4.01 (15.3)	3.17 (9.3)	136.7	128.3	2.5	1.4
LSD (P=0.05)		1.59	1.68	0.88	0.77	13.6	8.8	1.1	0.4

*Original figures in parentheses were subjected to square root transformation (vX+1) before statistical analysis. BLW–Broadleaf weeds.

Table 2. Effect of different herbicides applied alone or as tank-mixtures on growth, yield and yield attributes of wheat

Treatments	Dose (g/ha)	Plant height (cm)		Effective tillers/ mrl		Earhead length (cm)		Grain yield (kg/ha)	
		2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Clodinafop	60	86.5	86.1	82.7	95.2	9.4	9.1	5528	5533
Sulfosulfuron	25	86.3	85.8	83.0	90.0	9.5	8.9	5456	5069
Fenoxaprop	100	86.1	85.1	73.3	88.2	9.4	8.9	4297	4957
Pinoxaden	50	86.6	86.5	82.7	95.2	9.6	9.1	5671	5622
Mesosulfuron+iodosulfuron	14.4	84.8	85.5	80.2	91.5	9.5	8.9	5266	5338
Clodinafop+sulfosulfuron	30+12.5	86.3	84.9	78.8	78.0	9.5	8.7	5194	4262
Clodinafop+fenoxaprop	30+50	85.8	86.1	84.0	94.7	9.8	9.1	5647	5488
Clodinafop+pinoxaden	30+25	86.3	86.3	84.5	94.8	9.7	9.0	5861	5897
Clodinafop+(mesosulfuron+iodosulfuron)	30+7.2	85.9	85.5	78.3	84.7	9.6	8.9	5239	4976
Sulfosulfuron+fenoxaprop	12.5+50	86.1	85.7	78.0	77.7	9.4	8.7	5215	4285
Sulfosulfuron+pinoxaden	12.5+25	85.9	85.3	78.3	79.2	9.4	8.7	5148	4464
Sulfosulfuron+ (mesosulfuron+iodosulfuron)	12.5+7.2	85.2	86.1	84.7	93.5	9.5	9.0	5623	5398
Fenoxaprop+pinoxaden	50+25	85.9	86.2	84.3	94.2	9.7	9.0	5552	5510
Fenoxaprop+(mesosulfuron+iodosulfuron)	50+7.2	84.7	84.7	79.2	84.8	9.2	8.9	5054	4707
Pinoxaden+(mesosulfuron+iodosulfuron)	25+7.2	86.8	84.9	79.5	80.8	9.5	8.8	5125	4618
Weed free		86.3	87.3	87.5	97.3	9.8	9.3	5909	5850
Weedy check		85.1	85.4	52.2	70.5	9.5	8.6	3367	3187
LSD (P=0.05)		NS	NS	7.7	6.0	NS	NS	638	467

mrl–metre row length. NS–Not Significant.

Effect on Crop

The effects of different treatments on plant height and earhead length of wheat were non-significant (Table 2). Clodinafop, pinoxaden, sulfosulfuron, mesosulfuron+ iodosulfuron alone resulted in effective tillers similar to weed free check during both the years except sulfosulfuron during 2007-08. During both the years, all the intra-group combinations were at par with weed free check in respect of effective tillers. Fenoxaprop was inferior to clodinafop, pinoxaden and sulfosulfuron. Intra-group combinations were superior to inter-group combinations and at par or even superior to their alone applications in respect of effective tillers.

Clodinafop and pinoxaden during both the years and sulfosulfuron during 2006-07 resulted in grain yield of wheat as good as weed free check (Table 2). All the herbicides when applied alone were similar to each other in respect of grain yield of wheat, with lowest yields under fenoxaprop which was inferior to all other herbicides during 2006-07 and to clodinafop and pinoxaden during 2007-08. All intra-group combinations of herbicides produced grain yield of wheat (5552-5861 kg/ha in 2006-07 and 5510-5897 kg/ha in 2007-08) at par with weed free checks (5909 kg/ha in 2006-07 and 5850 kg/ha in 2007-08). Grain yields under intra-group combinations were similar or even superior to their alone applications (4297-5671 kg/ha in 2006-07 and 4957-5622 kg/ha in 2007-08). While grain yield under inter-group combinations (5054-5239 kg/ha in 2006-07 and 4285-4976 kg/ha in 2007-08) was inferior to weed free check, alone application of herbicides and their intra-group combinations during both the years, however, the differences were more pronounced during 2007-08.

CONCLUSION

Intra-group combinations of herbicides viz., ACCase inhibitor (clodinafop/fenoxaprop/pinoxaden) with ACCase inhibitor and ALS inhibitor (sulfosulfuron/ mesosulfuron+iodosulfuron) with ALS inhibitor were compatible and resulted in effective control of *P. minor* producing grain yield of wheat almost similar to weed free situations. While inter-group combinations were not found suitable and resulted in poor control of *P. minor* with lower yields. Alone application and all combinations having sulfosulfuron or mesosulfuron+iodosulfuron provided good control of BLW even under inter-group combinations.

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