The Pharma Innovation Journal 2023; SP-12(8): 277-281

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(8): 277-281

www.thepharmajournal.com
Received: 08-06-2023
Accepted: 19-07-2023

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Evaluation of herbicide resistance in different *Phalaris minor* biotypes from the Rice-Wheat cropping system of Haryana, India

Sushil Kumar, Todar Mal, RS Dadarwal and Pardeep Kumar

Abstract
In order to assess the resistance of different populations of *Phalaris minor* Retz. in Haryana to clodinafop as well as to other effective herbicides *i.e.* sulfosulfuron, mesosulfuron + iodosulfuron (RM) and pinoxaden, a screen house study was carried out at CCS Haryana Agricultural University, Hisar during *Rabi* season 2020-21 and 2021-22. *P. minor* seeds were planted in pots, where 20 plants were kept alive. All of the herbicides were sprayed to *P. minor* at the 2-3 leaf stage, or around 30-35 DAS. Herbicides were administered at four different graded doses: 1/2X, X (recommended dose), 2X, and 4X. With the application of various herbicides at their recommended doses, *P. minor* populations varied in fresh weight accumulation and number of leaves. Resistant population had significantly higher fresh weight and number of leaves in comparison to susceptible one. Majority of the population where found resistant to clodinafop while Jammu, Kharian, Beri and Nirjan biotype was not able to survive at 60 DAT at recommended dose of clodinafop. Recommened dose of sulfosulfuron was not sufficient to control the various *P. minor* biotypes At recommended dose of sulfosulfuron, Jammu, Ikkas and Nirjan biotypes were fully controlled at 60 DAT during both the years of study. Rasidan and Aanta bitypes were resistant to mesosulfuron + iodosulfuron (RM). The development of resistant to sulfosulfuron and mesosulfuron + iodosulfuron (RM) (ALS inhibtors) is less when compared to clodinafop. However, efficacy of all the herbicides decreased against various *P. minor* biotypes which indicates the development of multiple herbicide resistance.

Keywords: *P. minor*, wheat, biotypes, ACCase and ALS inhibitors, multiple herbicide resistance

Introduction
Wheat (*Triticum aestivum* L.) is the second most important food grain crop grown in India after rice on an area of 31.76 million hectares with a production of 108.75 million tonnes (Anonymous 2021). Weeds are the main problem in wheat, as they can reduce the yield up to 40% (Das 2008) [6]. *Phalaris minor* Retz., a prominent weed of wheat, in rice-wheat system (Singh *et al*. 1992). *Phalaris minor* density of 2000–3000 plants/m^2, can cause complete failure of crop (Das *et al*. 2014) [5] and yield was reduced by 30% with density of 150 plants/m^2 (Balyan and Malik 1989) [3]. Manual weeding is a time-consuming, expensive, tiresome, and unsuccessful practise since *P. minor* can escape detection because of its phenotypic similarity to wheat, even though professionals can easily distinguish it due to its early-stage pink stem coloration. Because using pesticides to control weeds is relatively more affordable, farmers want to do so. Since 1977, isoproturon had been advised for the successful management of *P. minor* in wheat (Gill *et al*. 1978) [7]. However, the ongoing use of the same herbicide, isoproturon, to control weeds in wheat has resulted in the development of resistance in *P. minor*, which is a significant problem since it was first noted in the early 1990s. Due to increased degradation by N-dealkylation and ring alkyl oxidation by reduced nicotinamide adenine dinucleotide phosphate (NADPH)-cytochrome P-450 monooxygenase, it has been discovered that *Phalaris minor* has developed resistance against isoproturon (Singh *et al*. 1998) [14]. In wheat, an analogous P-450 monooxygenase mechanism breaks down isoproturon. Cross-resistance or multiple resistance against herbicides with various mechanisms of action may evolve as a result of this form of resistance (Singh 2007, Chhokar and Sharma 2008) [16, 4]. To suppress the resistant populations of *P. minor*, the alternative herbicides clodinafop-propargyl, fenoxaprop-pethyl, sulfosulfuron, and tralkoxydim were advised in 1997–1998 (Das 2008) [6]. Later, resistance in *Phalaris minor* to several herbicides was also found, with fenoxaprop-pethyl being the first herbicide (Abbas *et al*. 2016) [1].

Other herbicides have also demonstrated limited effectiveness, and *P. minor* has been found to exhibit multiple herbicide resistance. The proliferation of herbicide-resistant *Phalaris minor* populations throughout Haryana's rice-wheat growing regions raises severe questions about the long-term viability of the rice-wheat cropping system (Punia *et al*. 2020) [11]. *P. minor*, wild oat, and some broad-leaved weeds can all be successfully controlled with the help of herbicides mixed into the combinations. *Avena ludoviciana* and *Phalaris minor* were controlled to an extent of 85-90 percent by a tank mixture of clodinafop and sulfosulfuron (3: 1) 60 g/ha and fenoxaprop + sulfosulfuron (4: 1 and 5: 1) 120 g/ha, whereas 60 percent control of broad-leaved weeds such *Chenopodium album*, *Rumex retroflexus* and *Melilotus indica* were observed (Punia *et al*. 2005) [12].

Utilizing alternative herbicides, herbicide mixes, rotating herbicide applications, and other techniques can all help to lessen selection pressure. To manage *P. minor* populations successfully, it is necessary to continuously assess the level of herbicide resistance among those populations. Consequently, a study was carried out to evaluate the effectiveness of several herbicides in controlling *P. minor* populations in relation to herbicide resistance.

Materials and Methods

The experiment was carried out at the screen houses of the Department of Agronomy, CCS Haryana Agricultural University, Hisar, during winter season 2020-21 and 2021-22. On the basis of issues raised by the farmers, the seeds of *P. minor* populations were gathered from their wheat fields between April 2020 and April 2021. The rice-wheat agricultural system served as the source of all populations. The different populations of *P. minor* were: Jammu (J & K), Rasidan (Jind), Aanta (Panipat), Kharian (Sirsa), Beri (Jhajjar), Ikkas (Jind), Kheri Raiwali (Kaithal), Kanheri (Fathehabad), Kalwan (Jind), Urlana Kalan (Panipat), Majra (Narnaund), Teek (Kaithal), Balambha (Rohtak) and Nirjan (Jind). Jammu population was taken as susceptible check. In order to get the right effect of the tested herbicides, the soil for the pot experiment was taken from CCSHAU farm where no herbicide application had been made for the previous two years. Before filling the containers, the soil was sieved. Vermicompost - 4:1 soil mixture was used to fill 1020 pots with an 8-inch diameter, which were then surface-seeded with *P. minor* seeds. The pots were then watered to ensure proper germination. The *P. minor* populations were reduced after germination to 20 plants per container. According to need, pots were periodically watered. At 2-3 leaf stage of *P. minor*, all herbicides were sprayed between 30-35 DAS as a post-emergence treatment. For comparison purposes, herbicide-free control (56 pots) with four replications were kept for each *P. minor* population. For the 14 populations with 4 replications, a total of 896 pots were used. Different herbicide treatment detail is as follow: clodinafop 30 g/ha (1/2 X); clodinafop 60 g/ha (recommended) (X); clodinafop 120 g/ha (2X) and clodinafop 240 g/ha (4X); sulfosulfuron 12.5 g/ha (1/2 X); sulfosulfuron 25 g/ha (recommended) (X); sulfosulfuron 50 g/ha (2X) and sulfosulfuron 100 g/ha (4X); mesosulfuron + iodosulfuron (RM) 7.2 g/ha (1/2 X); mesosulfuron + iodosulfuron (RM) 14.4 g/ha (recommended) (X); mesosulfuron + iodosulfuron (RM) 28.8 g/ha (2X) and mesosulfuron + iodosulfuron (RM) 57.4 g/ha (4X). For the application of herbicide, the pots were placed outside the screen house. These pots were placed in a designated location, and a manually powered knapsack sprayer was used to apply 300 L/ha of water (already calibrated) together with the necessary herbicide dosages. At 60 DAT, for measuring the fresh weight five plants from each pot was taken and weighed. Average of five plant was taken as fresh weight of *P. minor* (g/plant). Number of leaves were counted from the five randomly selected plants from each replication and average was taken as number of leaves per plant. Data taken was analgised with OP Stat online software of CCS HAU, Hisar.

Results and Discussion

Fresh weight (g/plant) and number of leaves per plant

Average of data over different doses of clodinafop revealed that significantly higher fresh weight and number of leaves was reported from Rasidan biotype during 2020-21 and 2021-22 respectively. Fresh weight and number of leaves were significantly higher (6.3 and 7.0 g/plant) in Rasidan biotype at 60 DAT during both the years of study when mean of data was taken over different doses of clodinafop. Jammu, Kharian, Beri and Nirjan biotype was not able to survive at 60 DAT. Biotypes of Aanta, Kharian, Beri, Ikkas, Kheri Raiwali and Majra were also completely controlled at recommended dose of clodinafop at 60 DAT during both the years of study. Fresh weight in Urlana Kalan (3.8 g/plant) and Teek biotype (3.9 g/plant) was statistically comparable with each other during 2020-21. Previous studies in India and abroad found that the majority of the populations tested for clodinafop had lost their sensitivity (Kaur *et al*., 2022; Kamboj *et al*., 2021; Das *et al*., 2014) [10, 8, 5]

With increase in the dose of sulfosulfuron, fresh weight (g/plant) was decreased significantly. At 60 DAT, Rasidan biotype had significantly maximum fresh weight (7.8 and 8.4 g/plant) in comparison to rest of the biotypes followed by Teek (6.1 and 6.7 g/plant), Kanheri (5.3 and 6.0 g/plant) and Urlana Kalan (4.8 and 5.4 g/plant) respectively, during 2020-21 and 2021-22, when mean data of different doses of sulfosulfuron was observed. At recommended dose of sulfosulfuron, Jammu, Ikkas and Nirjan biotypes were fully controlled at 60 DAT during both the years of study. Significantly maximum number of leaves per plant (15.8 and 17.2) were recorded from Rasidan biotype when data was averaged over sulfosulfuron doses during both the years of study, respectively, followed by Teek, Urlana Kalan, Kanheri and Kalwan. With increase in the dose of sulfosulfuron number of leaves per plant decreased significantly. Higher fresh weight and poor control of resistant *P. minor* biotypes due to sulfosulfuron was also reported by Kaur *et al*. (2022) and Kamboj *et al*. (2021) [10, 8].

At 60 DAT, fresh weight was maximum in Urlana Kalan (5.1 and 5.5 g/plant) followed by Aanta biotype (4.8 and 5.1 g/plant) and it was significantly higher than remaining biotypes during both the years of the experiment at mean of different doses of mesosulfuron + iodosulfuron. At recommended dose of mesosulfuron + iodosulfuron, Kheri Raiwali (6.0 and 6.2 g/plant) & Kharian (5.9 and 6.3 g/plant), Urlana Kalan (5.3 and 5.6 g/plant) & Balambha (5.4 and 5.7 g/plant) had statistically similar fresh weight with each other during 2020-21 and 2021-22, respectively. At 60 DAT, significantly maximum number of leaves per plant were reported from Aanta biotype (10.4 and 12.9 leaves per plant) and it was followed by Rasidan biotype (8.3 and 10.6 leaves per plant) when mean data over mesosulfuron + iodosulfuron (RM) doses was observed. Half dose of mesosulfuron +

iodosulfuron (RM) was not enough to control the *P. minor* biotype. In comparison to susceptible populations, resistant populations have higher plant fresh weight and number of leaves (Punia *et al*., 2012) [13]. Similar results were reported by Kaur *et al*. (2016) [9] and Chhokar and Sharma (2008) [4].

Table 1: Fresh weight (g/plant) of *P. minor* populations as influenced by various doses of clodinafop at 60 DAT

Populations	Fresh weight (g/plant) at 60 DAT									
	2020-21					2021-22				
	Clodinafop (g/ha)					Clodinafop (g/ha)				
	30	60	120	240	Mean	30	60	120	240	Mean
Jammu (J & K)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rasidan (Jind)	9.8	6.4	5.3	3.5	6.3	11.2	7.2	5.6	3.8	7.0
Aanta (Panipat)	3.5	0.0	0.0	0.0	0.9	4.7	0.0	0.0	0.0	1.2
Kharian (Sirsa)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beri (JJR)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ikkas (Jind)	4.0	0.0	0.0	0.0	1.0	5.7	0.0	0.0	0.0	1.4
Kheri Raiwali (Kaithal)	5.4	0.0	0.0	0.0	1.4	5.0	0.0	0.0	0.0	1.2
Kanheri (Fatehabad)	9.6	3.6	2.6	2.4	4.6	10.8	5.6	4.7	3.4	6.1
Kalwan (Jind)	6.0	3.7	2.2	1.3	3.3	6.9	3.9	2.4	1.6	3.7
Urlana Kalan (Panipat)	5.4	4.6	3.6	1.6	3.8	5.9	4.6	3.8	1.7	4.0
Majra (Narnaund)	7.3	0.0	0.0	0.0	1.8	10.7	0.0	0.0	0.0	2.7
Teek (Kaithal)	7.4	4.3	2.4	1.7	3.9	8.4	4.8	2.4	1.8	4.4
Balambha (Rohtak)	2.6	1.6	0.0	0.0	1.1	4.4	2.4	0.0	0.0	1.7
Nirjan (Jind)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	4.4	1.7	1.1	0.8		5.3	2.0	1.4	0.9	
Factors	C.D. (p=0.05)		SE(m) ±			C.D. (p=0.05)		SE(m) ±		
Population	0.08		0.03			0.16		0.06		
Clodinafop	0.04		0.02			0.08		0.03		
Factor (Population X Clodinafop)	0.16		0.06			0.31		0.11		

Table 2: Number of leaves (per plant) of *P. minor* populations as influenced by various doses of clodinafop at 60 DAT

Populations	Number of leaves per plant at 60 DAT									
	2020-21					2021-22				
	Clodinafop (g/ha)					Clodinafop (g/ha)				
	30	60	120	240	Mean	30	60	120	240	Mean
Jammu (J & K)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rasidan (Jind)	14.0	10.5	7.0	6.0	9.4	16.9	11.9	7.8	6.5	10.8
Aanta (Panipat)	5.5	0.0	0.0	0.0	1.4	7.6	0.0	0.0	0.0	1.9
Kharian (Sirsa)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beri (JJR)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ikkas (Jind)	6.5	0.0	0.0	0.0	1.6	6.9	0.0	0.0	0.0	1.7
Kheri Raiwali (Kaithal)	4.5	0.0	0.0	0.0	1.1	7.8	0.0	0.0	0.0	2.0
Kanheri (Fatehabad)	11.5	8.0	6.5	6.0	8.0	13.4	9.1	6.7	6.5	8.9
Kalwan (Jind)	11.0	8.5	6.5	5.0	7.8	13.4	9.1	7.8	5.4	8.9
Urlana Kalan (Panipat)	10.0	6.5	8.0	5.0	7.4	12.3	9.1	8.9	5.4	8.9
Majra (Narnaund)	12.0	0.0	0.0	0.0	3.0	13.1	0.0	0.0	0.0	3.3
Teek (Kaithal)	10.5	8.5	6.0	5.0	7.5	12.3	9.7	6.1	5.4	8.4
Balambha (Rohtak)	8.0	5.5	0.0	0.0	3.4	11.7	9.1	0.0	0.0	5.2
Nirjan (Jind)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	6.7	3.4	2.4	1.9		8.3	4.1	2.7	2.1	
Factors	C.D. (p=0.05)		SE(m) ±			C.D. (p=0.05)		SE(m) ±		
Population	0.78		0.28			0.99		0.36		
Clodinafop	0.42		0.15			0.53		0.19		
Factor (Population X Clodinafop)	1.56		0.56			1.98		0.71		

Table 3: Fresh weight (g/plant) of *P. minor* populations as influenced by various doses of sulfosulfuron at 60 DAT

Populations	Fresh weight (g/plant) at 60 DAT									
	2020-21					2021-22				
	Sulfosulfuron (g/ha)					Sulfosulfuron (g/ha)				
	12.5	25	50	100	Mean	12.5	25	50	100	Mean
Jammu (J & K)	3.0	0.0	0.0	0.0	0.7	4.5	0.0	0.0	0.0	1.1
Rasidan (Jind)	9.7	8.6	6.4	6.3	7.8	11.7	8.9	6.6	6.6	8.4
Aanta (Panipat)	8.5	3.2	2.3	0.0	3.5	10.4	3.5	2.3	0.0	4.1
Kharian (Sirsa)	4.3	1.5	0.0	0.0	1.5	5.6	1.6	0.0	0.0	1.8
Beri (Jhajjar)	7.5	3.2	0.0	0.0	2.7	9.2	3.5	0.0	0.0	3.2
Ikkas (Jind)	5.6	0.0	0.0	0.0	1.4	7.4	0.0	0.0	0.0	1.8
Kheri Raiwali (Kaithal)	5.4	4.5	0.0	0.0	2.5	6.9	4.8	0.0	0.0	2.9

Kanheri (Fatehabad)	7.4	6.4	4.4	3.1	5.3	9.0	6.8	4.8	3.4	6.0
Kalwan (Jind)	5.3	5.4	3.3	2.4	4.1	7.1	5.7	3.6	2.4	4.7
Urlana Kalan (Panipat)	5.9	6.3	3.7	3.5	4.8	7.3	6.6	4.1	3.6	5.4
Majra (Narnaund)	8.5	4.6	0.0	0.0	3.3	10.3	5.0	0.0	0.0	3.8
Teek (Kaithal)	9.6	6.7	4.4	3.8	6.1	11.2	6.9	4.7	3.8	6.7
Balambha (Rohtak)	9.6	4.9	0.0	0.0	3.8	11.3	5.9	0.0	0.0	4.3
Nirjan (Jind)	5.1	0.0	0.0	0.0	1.3	5.5	0.0	0.0	0.0	1.4
Mean	6.8	4.0	1.8	1.4		8.4	4.2	1.9	1.4	
Factors	C.D. (p=0.05)		SE(m) ±			C.D. (p=0.05)		SE(m) ±		
Population	0.17		0.06			0.13		0.05		
Sulfosulfuron	0.09		0.03			0.07		0.03		
Factor (Population X Sulfosulfuron)	0.32		0.12			0.27		0.10		

Table 4: Number of leaves (per plant) of *P. minor* populations as influenced by various doses of sulfosulfuron at 60 DAT

Populations	**Number of leaves per plant at 60 DAT**									
	2020-21					**2021-22**				
	Sulfosulfuron (g/ha)					**Sulfosulfuron (g/ha)**				
	12.5	**25**	**50**	**100**	**Mean**	**12.5**	**25**	**50**	**100**	**Mean**
Jammu (J & K)	4.0	0.0	0.0	0.0	1.0	6.2	0.0	0.0	0.0	1.5
Rasidan (Jind)	19.5	17.0	15.0	11.5	15.8	22.7	19.0	14.5	12.5	17.2
Aanta (Panipat)	13.0	9.0	7.0	0.0	7.3	14.6	8.5	6.3	0.0	7.4
Kharian (Sirsa)	7.5	7.0	0.0	0.0	3.6	8.6	6.9	0.0	0.0	3.9
Beri (Jhajjar)	12.0	7.0	0.0	0.0	4.8	15.3	9.0	0.0	0.0	6.1
Ikkas (Jind)	11.5	0.0	0.0	0.0	2.9	15.3	0.0	0.0	0.0	3.8
Kheri Raiwali (Kaithal)	13.5	8.0	0.0	0.0	5.4	14.0	10.5	0.0	0.0	6.1
Kanheri (Fatehabad)	11.0	9.0	10.0	9.5	9.9	14.7	8.3	7.7	7.2	9.5
Kalwan (Jind)	11.0	10.0	9.0	6.5	9.1	12.6	13.3	7.0	6.4	9.8
Urlana Kalan (Panipat)	13.0	12.0	8.5	7.5	10.3	14.6	14.8	7.0	5.9	10.6
Majra (Narnaund)	11.5	9.5	0.0	0.0	5.3	14.0	10.1	0.0	0.0	6.0
Teek (Kaithal)	11.5	14.0	11.0	6.5	10.8	15.3	13.3	8.9	5.9	10.8
Balambha (Rohtak)	13.0	8.0	0.0	0.0	5.3	16.6	10.1	0.0	0.0	6.7
Nirjan (Jind)	7.5	0.0	0.0	0.0	1.9	8.0	0.0	0.0	0.0	2.0
Mean	11.4	7.9	4.3	3.0		13.7	8.8	3.7	2.7	
Factors	C.D. (p=0.05)		SE(m)±			C.D. (p=0.05)		SE(m) ±		
Population	0.98		0.35			1.15		0.41		
Sulfosulfuron	0.52		0.19			0.62		0.22		
Factor (Population X Sulfosulfuron)	1.96		0.70			2.30		0.82		

Table 5: Fresh weight (g/plant) of *P. minor* populations as influenced by various doses of mesosulfuron + iodosulfuron (RM) at 60 DAT

Populations	**Fresh weight (g/plant) at 60 DAT**									
	2020-21					**2021-22**				
	Mesosulfuron + Iodosulfuron (RM) (g/ha)					**Mesosulfuron + Iodosulfuron (RM) (g/ha)**				
	7.2	**14.4**	**28.8**	**57.6**	**Mean**	**7.2**	**14.4**	**28.8**	**57.6**	**Mean**
Jammu (J & K)	4.6	0.0	0.0	0.0	1.1	5.0	0.0	0.0	0.0	1.2
Rasidan (Jind)	4.9	3.5	3.1	1.8	3.3	5.8	3.7	3.2	1.9	3.6
Aanta (Panipat)	8.8	4.5	3.8	2.2	4.8	9.5	4.7	3.7	2.4	5.1
Kharian (Sirsa)	9.2	5.9	0.0	0.0	3.8	10.0	6.2	0.0	0.0	4.0
Beri (Jhajjar)	9.1	0.0	0.0	0.0	2.3	9.8	0.0	0.0	0.0	2.5
Ikkas (Jind)	8.7	4.2	0.0	0.0	3.2	9.4	4.5	0.0	0.0	3.5
Kheri Raiwali (Kaithal)	8.3	6.0	0.0	0.0	3.6	10.0	6.3	0.0	0.0	4.1
Kanheri (Fatehabad)	5.9	4.4	3.6	2.6	4.1	5.9	4.7	3.6	2.3	4.1
Kalwan (Jind)	5.6	3.6	0.0	0.0	2.3	6.0	3.9	0.0	0.0	2.5
Urlana Kalan (Panipat)	8.6	5.3	4.5	2.3	5.1	9.2	5.6	4.6	2.4	5.5
Majra (Narnaund)	7.5	4.6	0.0	0.0	3.0	8.1	4.8	0.0	0.0	3.2
Teek (Kaithal)	5.5	3.9	0.0	0.0	2.3	5.9	4.2	0.0	0.0	2.5
Balambha (Rohtak)	6.5	5.4	0.0	0.0	3.0	7.1	5.7	0.0	0.0	3.2
Nirjan (Jind)	5.1	0.0	0.0	0.0	1.3	5.6	0.0	0.0	0.0	1.4
Mean	7.0	3.7	1.1	0.6		7.7	3.9	1.1	0.6	
Factors	C.D. (p=0.05)		SE(m) ±			C.D. (p=0.05)		SE(m) ±		
Population	0.25		0.09			0.20		0.07		
Meso + Iodo	0.14		0.05			0.11		0.04		
Factor (Population X Meso + Iodo)	0.50		0.18			0.39		0.14		

Table 6: Number of leaves (per plant) of *P. minor* populations as influenced by various doses of mesosulfuron + iodosulfuron (RM) at 60 DAT

Populations	Number of leaves per plant at 60 DAT									
	2020-21					2021-22				
	Mesosulfuron + Iodosulfuron (RM) (g/ha)					Mesosulfuron + Iodosulfuron (RM) (g/ha)				
	7.2	14.4	28.8	57.6	Mean	7.2	14.4	28.8	57.6	Mean
Jammu (J & K)	8.0	0.0	0.0	0.0	2.0	10.1	0.0	0.0	0.0	2.5
Rasidan (Jind)	9.5	9.0	7.5	7.0	8.3	12.1	11.5	10.4	8.6	10.6
Aanta (Panipat)	15.0	9.5	9.0	8.0	10.4	18.4	13.2	10.4	9.8	12.9
Kharian (Sirsa)	14.5	11.0	0.0	0.0	6.4	17.8	13.8	0.0	0.0	7.9
Beri (Jhajjar)	14.5	0.0	0.0	0.0	3.6	17.8	0.0	0.0	0.0	4.5
Ikkas (Jind)	12.0	9.5	0.0	0.0	5.4	15.0	12.1	0.0	0.0	6.8
Kheri Raiwali (Kaithal)	11.5	11.0	0.0	0.0	5.6	14.4	13.8	0.0	0.0	7.0
Kanheri (Fatehabad)	9.6	8.0	7.3	5.5	7.6	15.0	12.1	10.4	6.9	11.1
Kalwan (Jind)	12.0	8.5	0.0	0.0	5.1	15.0	10.9	0.0	0.0	6.5
Urlana Kalan (Panipat)	11.0	10.0	9.0	8.0	9.5	15.5	13.2	11.5	9.8	12.5
Majra (Narnaund)	9.0	7.5	0.0	0.0	4.1	11.5	10.4	0.0	0.0	5.5
Teek (Kaithal)	12.0	10.0	0.0	0.0	5.5	15.0	13.8	0.0	0.0	7.2
Balambha (Rohtak)	13.0	12.0	0.0	0.0	6.3	16.1	12.7	0.0	0.0	7.2
Nirjan (Jind)	11.0	0.0	0.0	0.0	2.8	11.5	0.0	0.0	0.0	2.9
Mean	11.6	7.6	2.3	2.0		14.6	9.8	3.0	2.5	
Factors	C.D. (p=0.05)		SE(m) ±			C.D. (p=0.05)		SE(m) ±		
Population	0.74		0.27			1.24		0.44		
Meso + Iodo	0.40		0.14			0.66		0.24		
Factor (Population X Meso + Iodo)	1.49		0.53			2.47		0.89		

Conclusion

Based on the screen house study it can be concluded that most of the *P. minor* biotypes were resistant to application of clodinafop. All of the herbicides examined have significantly lost their effectiveness against *P. minor* in Haryana. Due to ongoing reliance on a single herbicide, clodinafop has the lowest efficacy against *P. minor* populations. The use of several herbicides with the same mechanism of action has also decreased the efficacy of sulfonylureas (sulfosulfuron and mesosulfuron + iodosulfuron (RM)).

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Abbas T, Nadeem MA, Tanveer A, Ahmad R. Evaluation of fenoxaprop-p-ethyl resistant littleseed canarygrass (*Phalaris minor*) in Pakistan. Planta Daninha. 2016;34:833-838.
2. Anonymous. AICRP on Wheat and Barley, Progress Report, Social Sciences, 2021. ICAR–Indian Institute of Wheat and Barley Research, Karnal (Haryana), 2021. Available online at https://iiwbr.icar.gov.in
3. Balyan RS, Malik RK. Influence of nitrogen on competition of wild canary grass. Pestology. 1989;13:5-6.
4. Chhokar RS, Sharma RK. Multiple herbicide resistance in littleseed canarygrass (*Phalaris minor*): a threat to wheat production in India. Weed Biology and Management. 2008;8:112-123.
5. Das TK, Ahlawat IPS, Yaduraju NT. Littleseed canarygrass (*Phalaris minor*) resistance to clodinafop propargyl in wheat fields in north western India: Appraisal and management. Weed Biology and Management. 2014;14:11-20.
6. Das TK. Weed Science: Basics and Applications, 1st Ed., Jain Brothers, New Delhi; c2008.
7. Gill HS, Walia US, Brar LS. Control of *Phalaris minor* Retz. and wild oat in wheat with new herbicides. Pesticides. 1978;12:53-56.
8. Kamboj P, Punia SS, Yadav DB. Multiple herbicide resistance in *Phalaris minor* Retz. in Haryana, India. Indian Journal of Weed Science. 2021;53(4):411-416.
9. Kaur N, Kaur T, Kaur S, Bhullar MS. Development of cross resistance in isoproturon resistant *Phalaris minor* Retz. in Punjab. Agricultural Research Journal. 2016;53(1):69-72.
10. Kaur S, Kaur N, Bhullar MS. Quantification of multiple herbicide resistance in *Phalaris minor* Populations of the North-Western Indo-Gangetic Plains of India. Agricultural Research. 2022;11(1):104-111.
11. Punia SS, Kamboj P, Manjeet, Yadav DB. Inheritance of resistance against alternate herbicides in various biotypes of *Phalaris minor* from different parts of Haryana. pp 8 In: ISWS Biennial Conference on Weed Management for Enhancing Farmer Income and Food Security, February 5-7, 2020, ICAR, CCARI, Goa, India, 2020.
12. Punia SS, Shoeran P, Dahiya S, Arya BS. Efficacy of tank mixtures of sulfosulfuron with clodinafop and fenoxaprop on weeds in wheat (*Triticum aestivum* L.). Indian Journal of Weed Science. 2005;37:6-8.
13. Punia SS, Singh S, Yadav DB, Yadav A. Survey on efficacy of herbicides against resistant population of *Phalaris minor* in wheat at Farmer's field in Haryana, p. 22. In: Proceedings of ISWS Biennial Conference on Weed Threat to Agriculture, Biodiversity and Environment, April 19-20, 2012, KAU, Thrissur, India. 2012.
14. Singh S, Kirkwood RC, Marshall G. Effect of the monoxygenase inhibitor piperonyl butoxide on the herbicidal activity and metabolism of isoproturon in herbicide resistant and susceptible biotypes of *Phalaris minor* and wheat. Pesticide Biochemistry and Physiology. 1998;59:143-153.
15. Singh S, Malik RK, Balyan RS, Singh S. Weed survey of wheat in Haryana. pp. 11. In: ISWS International Symposium on herbicide resistance, HRAC, CCS Haryana Agricultural Univeristy, Hisar, India, 1992.
16. Singh S. Role of management practices on control of isoproturon-resistant littleseed canarygrass (*Phalaris minor*) in India. Weed Technology. 2007;21:339-346.