



Little seed canary grass resistance to clodinafop in Punjab: farmers' perspective

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ABSTRACT

Little seed canary grass (*Phalaris minor* Retz.) is the dominant grass weed of wheat especially in rice-wheat cropping system in the North-Western Indo-Gangetic Plains of India. It developed resistance to isoproturon herbicide in early 1990's. Alternate herbicides, viz. clodinafop, sulfosulfuron and fenoxaprop were recommended for its control and were widely adopted by the farmers. Complaints of poor efficacy of these alternate herbicides started appearing at farmers' field, after decades of their use. Performance of these alternate herbicides was assessed, to study the occurrence of cross resistance in *P. minor*, through farmers' field survey. The survey was conducted in 2011 at 73 farmers' field in six districts viz. Patiala, Fatehgarh Sahib, Ludhiana, Moga, Jalandhar and Ropar in Punjab. The survey indicated that clodinafop and sulfosulfuron are widely used by the farmers. The farmers used to apply field rates of these herbicides till 2008-09 and were getting effective control of *P. minor* (>85%). During 2009-10, clodinafop started showing signs of reduced efficacy and >30% farmers used 1.5 times of field dose and control was still poor (<65%); few farmers (<10%) used 2 times the field dose with little success. In 2010-11, the farmers (<50%) used 2 times and <30% used 3 times or higher dose of clodinafop alone/tank mix of clodinafop + sulfosulfuron/both herbicides in sequence and control was still poor (0- <60%); re-growth recorded in Patiala, Fatehgarh Sahib, Ludhiana and Moga districts. Sulfosulfuron efficacy also showed declining trend (<60%) during 2010-11. Reduced efficacy of sulfosulfuron was more prevalent in fields having history of continuous use of sulfosulfuron but poor efficacy of clodinafop was even recorded in fields having continuous use of sulfosulfuron. The spray methodology adopted by the farmers was better than they were using in the previous years, hence cannot be related to the reduced herbicide efficacy. The survey results pointed towards the development of cross resistance in *P. minor* to clodinafop and indicated that sulfosulfuron was likely to meet the same fate in the near future. Proper and regular monitoring of all the existing herbicides is desirable before the situation comes out of control at farmers' field.

Key words: Clodinafop, Cross resistance, Farmer field, Sulfosulfuron

Rice-wheat is the dominant cropping system in the North-Western Indo-Gangetic Plains of India. *Phalaris minor* is the dominant grassy weed of wheat, particularly in this cropping system. It evolved resistance to isoproturon in Haryana, Punjab and Uttar Pradesh in the early 1990s (Malik and Singh 1993, Walia *et al.* 1997). On an average, a loss of 25 to 50 % in wheat yield was quite common. By 1999, it was estimated that herbicide-resistant biotypes had infested around 1 million ha area in these three states (Yaduraju 1999). The resistant biotypes have been reported to require 2- 8 times more isoproturon than susceptible ones for same level of control (Malik and Singh 1995, Walia *et al.* 1997). Alternate herbicides viz. clodinafop, sulfosulfuron and fenoxaprop were then recommended for the control of resistant *P. minor*. These alternate

herbicides brought *P. minor* infestation under control and widely adopted in the resistant affected areas. However, the complaints of poor field efficacy of these herbicides have been reported from farmers' field during last four- five years. Looking into the present scenario, it seems that in near future, the problem of herbicide resistance in this weed may again pose a serious threat to the sustainability of wheat productivity. The field efficacy of these herbicides at farmers' field was assessed through field survey to study the occurrence of cross resistance, if any, in *P. minor* against these herbicides.

MATERIALS AND METHODS

A survey proforma was prepared for studying the herbicide use pattern and efficacy against *P. minor* over the years. The survey was conducted during February 2011 in six districts, viz. Patiala, Fatehgarh Sahib, Ludhiana, Moga, Jalandhar and

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Roopnagar. The first four districts have dominant rice-wheat system having medium to heavy textured soils while in Jalandhar and Roopnagar districts, many farmers practiced maize-wheat and maize-potato-wheat rotations also. Farmers were interviewed about dose, time and method of application and efficacy of different herbicides being used by them over the years. In all, 73 farmers were interviewed in all the six districts in Punjab. The selected farmers have reported problem with control of *P. minor*. The team visited majority of the farmers' field and held discussions with farmers and made on the spot assessments regarding the efficacy of the herbicides against *P. minor*.

RESULTS AND DISCUSSION

The survey indicated that clodinafop and sulfosulfuron are widely used by the farmers for control of *P. minor*; clodinafop being safe for succeeding crops was preferred over sulfosulfuron. During 2008-09, all the surveyed farmers used recommended doses of clodinafop and sulfosulfuron and got effective control (>85%) of *P. minor* (Tables 1-6). The herbicide

use pattern indicated that in Patiala and Moga districts, 50-62% farmers used clodinafop and 38-43% used sulfosulfuron while in Fatehgarh Sahib, Ludhiana, Jalandhar and Roopnagar districts, 81-100 % farmers used clodinafop and 8-25% used sulfosulfuron. During 2009-10, clodinafop started showing signs of reduced efficacy and >30% farmers used 1.5 times of field dose and control was still poor (<65%); few farmers (<10%) used 2 times the field dose with little success. In Moga and Patiala districts, 9- 28% farmers used 1.5 to 2.0 times doses of clodinafop and 26% in Moga district used tank mixtures of clodinafop and sulfosulfuron at their field doses and also mixed metribuzin and still recorded poor control (<65%) of *P. minor* (Table 2 and 4). The farmers in Fatehgarh Sahib, Ludhiana, Jalandhar and Roopnagar districts used field doses of both the herbicides, however, the efficacy of clodinafop reduced from 85 to 65% which was below satisfaction; sulfosulfuron performance also declined as compared to previous year (Tables 1, 3, 5 and 6). The situation became alarming in 2010-11 when clodinafop at field dose did not show any affect against

Table 1. Herbicide use pattern and efficacy against *P. minor* in Patiala district

Herbicide	Dose (g/ha)	2008-09		2009-10		2010-11	
		%	%	%	%	%	%
		farmers	control	farmers	control	farmers	control
Clodinafop	60	50	90.1	50	64.1	7	25.2
Clodinafop	90	0		21	60.6	7	50.5
Clodinafop	120	0		7	60.2	14	37.5
Clodinafop <i>fb</i> clodinafop	60 and 60	0		0		14	60.5
Clodinafop <i>fb</i> clodinafop	120 and 120	0		0		7	30.0
Clodinafop <i>fb</i> clodinafop + sulfosulfuron	60 and 60 + 25	0		0		14	50.5
Clodinafop <i>fb</i> clodinafop + metribuzin	120 <i>fb</i> 120 + 50	0		0		14	30.0
Fenoxaprop	100	7	90.0	0		0	
Sulfosulfuron	25	43	85.0	21	66.3	0	
Sulfosulfuron + clodinafop <i>fb</i> clodinafop	25 +60 <i>fb</i> 120	0		0		14	25.0
Sulfosulfuron <i>fb</i> sulfrosulfruon	37.5 <i>fb</i> 37.5	0		0		7	65

Table 2. Herbicide use pattern and efficacy against *P. minor* in Fatehgarh Sahib district

Herbicide	Dose (g/ha)	2008-09		2009-10		2010-11	
		%	%	%	%	%	%
		farmers	control	farmers	control	farmers	control
Clodinafop	60	81	85.0	45	65.0	9	30.0
Clodinafop	90	0		9	70.0	0	
Clodinafop	120	0		9	60.0	18	42.0
Clodinafop <i>fb</i> clodinafop	60 and 60	0		0		9	25.0
Clodinafop <i>fb</i> clodinafop	60 and 120	0		0		9	0
Clodinafop <i>fb</i> clodinafop + sulfosulfuron	120 <i>fb</i> 120 + 25	0		0		18	15.0
Clodinafop <i>fb</i> sulfosulfuron	120 <i>fb</i> 25	0		9	60.0	9	65.0
Sulfosulfuron	25	19	80.0	27	75.0	9	85.0
Sulfosulfuron <i>fb</i> clodinafop	25 <i>fb</i> 60	0		0		18	40.0

No. of farmers:11

Table 3. Herbicide use pattern and efficacy against *P. minor* in Ludhiana district

Herbicide	Dose (g/ha)	2008-09		2009-10		2010-11	
		% farmers	% control	% farmers	% control	% farmers	% control
Clodinafop	60	92	85.0	77	65.2	0	
Clodinafop	90	0		0		0	
Clodinafop	120	0		0		23	55.0
Clodinafop <i>fb</i> clodinafop	90 and 90	0		0		15	30.0
Clodinafop <i>fb</i> clodinafop	120 <i>fb</i> 120	0		0		15	40.0
Clodinafop <i>fb</i> clodinafop	120 <i>fb</i> 60	0		0		8	0
Clodinafop <i>fb</i> sulfosulfuron	120 <i>fb</i> 37.5	0		0		8	75.0
Sulfosulfuron	25	8	83.6	23	85.2	8	70.0
Sulfosulfuron + clodinafop	25+ 60	0		0		23	75.0

No. of farmers:13

Table 4. Herbicide use pattern and efficacy against *P. minor* in Moga district

Herbicide	Dose (g/ha)	2008-09		2009-10		2010-11	
		% farmers	% control	% farmers	% control	% farmers	% control
Clodinafop	60	62	85.5	33	60.2	0	
Clodinafop	90	0		9	60.0	9	40.0
Clodinafop	120	0		0		14	45.0
Clodinafop <i>fb</i> clodinafop	120 and 90	0		0		9	20.0
Clodinafop + sulfosulfuron + metribuzin	120 + 25 + 50	0		5	45.0	0	
Clodinafop <i>fb</i> clodinafop + metribuzin	120 <i>fb</i> 60 + 75	0		0		5	30.0
Clodinafop <i>fb</i> sulfosulfuron	60 <i>fb</i> 25	0		0		21	30.0
Sulfosulfuron	25	38	75.0	33	62.2	14	25.0
Sulfosulfuron <i>fb</i> clodinafop	25 <i>fb</i> 60	0		0		0	
Clodinafop + sulfosulfuron	60 + 25	0		21	65.0	14	40.5
Clodinafop <i>fb</i> sulfosulfuron + clodinafop	90 <i>fb</i> 25 + 120	0		0		9	35.0
Sulfosulfuron <i>fb</i> clodinafop <i>fb</i> clodinafop	25 <i>fb</i> 60 <i>fb</i> 120	0		0		9	30.0

No. of farmers:21

Table 5. Herbicide use pattern and efficacy against *P. minor* in Jalandhar district

Herbicide	Dose (g/ha)	2008-09		2009-10		2010-11	
		% farmers	% control	% farmers	% control	% farmers	% control
Clodinafop	60	100	85.0	100	60.5	80	50.2
Clodinafop	90	0		0		0	
Clodinafop	120	0		0		20	10.0

No. of farmers:5

P. minor and the farmers (<50%) used 2 times and <30% used 3 times or higher dose of clodinafop alone/tank mix of clodinafop + sulfosulfuron/both herbicides in sequence and control was still poor (0- <60%); regrowth was recorded in fields particularly in Patiala, Fatehgarh Sahib, Ludhiana and Moga districts. Few farmers (<8%) used higher (1.5 times) dose of sulfosulfuron in Patiala and Moga districts only. Sulfosulfuron efficacy also showed declining trend (<60%) during 2010-11; reduced efficacy was more prevalent in fields having history of continuous use of sulfosulfuron but poor efficacy of clodinafop was even recorded in field having continuous use of sulfosulfuron. The spray technology adopted by the farmers was better than in previous years; from 2008-

09 to 2010-11, the farmers have increased the volume of water used for spray and also more farmers apply the herbicides within normal period of 30- 40 days of wheat sowing as compared to previous years (Tables 7 and 8). It indicated that farmers are aware and following appropriate herbicide application technology, hence cannot be related to the reduced herbicide efficacy. The survey results pointed towards the evolution of cross resistance in *P. minor* to clodinafop. Poor efficacy of sulfosulfuron in Moga district, where farmers had history of sulfosulfuron use, indicated that even sulfosulfuron is prone to reduced efficacy with continuous use, as observed for clodinafop, and was likely to meet the same fate in the near future.

Table 6. Herbicide use pattern and efficacy against *P. minor* in Roopnagar district

Herbicide	Dose (g/ha)	2008-09		2009-10		2010-11	
		% farmers	% control	% farmers	% control	% farmers	% control
Clodinafop	60	75	85.0	62	85.0	25	70.0
Sulfosulfuron	24	25	85.0	25	75.0	12	60.0
Clodinafop + isoproturon	60 + 1000	0		12	75.0	37	75.0
Clodinafop	90	0		0		25	70.0

No. of farmers: 8

Patiala, Ludhian, Moga and Fatehgarh Sahib are typically rice-wheat cropping areas where *P. minor* is a major weed in wheat and farmers use herbicides every year to control this weed. In Jalandhar and Roopnagar areas, many farmers grow maize and potato crops in rotation with wheat. In maize and potato, weeds are controlled by triazine herbicides which effectively controlled all the winter season weed. The farmers, in general, do not spray any herbicide when wheat follows potato, hence in these districts the rotation of crops and herbicides keeps the *P. minor* under check and existing herbicides are still working well. In rice-wheat cropping areas, *P. minor* germinates in abundance and farmers apply herbicides every year to control this weed; the farmers, in general, adopt herbicide which provides effective control of weeds and use the same herbicide over the years which results in evolution of resistance in the weeds, as is happening in case of clodinafop and sulfosulfuron which are being used continuously for control of *P. minor* in wheat. Evolved multiple resistance in *P. minor* to herbicides of different modes of action in India, Israel, Mexico, South Africa and USA suggests that no single herbicide will be able to control *P. minor* for long time and we need to swiftly change our strategy than *P. minor* to arrest its proliferation and economic loss (Singh 1996). Immediate steps are required to tackle this problem by integrating all possible resistance management options. Continuous monitor-

Table 7. Time of application of herbicides at farmers field

Application time	No. of farmers		
	2008-09	2009-10	2010-11
Normal (30-40 DAS)	41 (56)	46 (63)	52 (71)
Late (40 -60 DAS)	32 (44)	27 (37)	21 (29)

Figures in brackets indicate percentage of farmers

Table 8. Volume of water used for spraying herbicides

Volume of water (L/ha)	No. of farmers		
	2008-09	2009-10	2010-11
225	20 (27)	18 (25)	11(15)
300	43 (59)	47 (64)	49 (67)
375	10 (14)	8 (11)	13 (18)

Figures in brackets indicate percentage of farmers

ing and extensive research from understanding the biology, ecology and population dynamics of resistance biotypes, through investigating the molecular mechanisms responsible for endowing herbicide resistance in these biotypes is very essential to achieve long term sustainable weed control.

The survey indicated that clodinafop and sulfosulfuron are widely used by the farmers in the state. The efficacy of both these herbicides is on the decrease with every passing year. The farmers have started using 2.0 to 3.0 times recommended dose of clodinafop or sequence application/tank-mix of clodinafop and sulfosulfuron but control is not satisfactory. The reduced efficacy of sulfosulfuron was more prevalent in fields having history of continuous use of sulfosulfuron but poor efficacy of clodinafop was even recorded in fields having continuous use of sulfosulfuron. The spray methodology adopted by the farmers was better than they were using in the previous years hence these can not be related to the reduced herbicide efficacy over the years. The survey results point clearly towards the development of cross resistance in *P. minor* in clodinafop to a large extent and that sulfosulfuron was likely to meet the same fate in the near future.

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