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Efficacy of different clodinafop-propargyl formulations against littleseed canarygrass in wheat

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ABSTRACT

Field experiments were conducted in three successive seasons (*Rabi* 2010–11, 2011-12 and 2012–13) to evaluate the efficacy of clodinafop-propargyl formulations (wettable powder and emulsifiable concentrate) applied as post-emergence against *Phalaris minor* in wheat crop. All formulations of herbicide reduced the density of *Phalaris minor* over the weedy check however treated plots yielded below than the state average yield of wheat crop. These new clodinafop formulations/brands failed to provide effective control of resistant *P. minor* prevailing in wheat field during all years, and gave only 27-32% control of *Phalaris minor* over the weedy check. These new formulations also yielded similar to clodinafop-p-propargyl applied as standard check. Per cent control of *Phalaris minor* was found to be reduced from 60 to 40% over unsprayed check with delay in application time of clodinafop from 35 to 60 DAS.

Key words: Application time, Clodinafop, Formulations, *Phalaris minor*, Resistance

Littleseed canarygrass (*Phalaris minor* Retz.) is the most common and predominant weed of wheat under rice-wheat cropping system in the North-Western Indo-Gangetic Plains (IGP) of India. In Punjab, *P. minor* is a major weed of wheat crop. The crop suffers a yield loss of 25-30% due to infestation of this weed (Yadav and Malik 2005). *P. minor* is the predominant weed species found in wheat with importance value index of 34.80 in Kapurthala and 28.45 in Ludhiana districts in *Rabi* 2007-08 and Importance value index (IVI) of this weed has been found to increase to 94.40 in Kapurthala and 75.90 in Ludhiana districts, in *Rabi* 2011-12, demonstrating its supremacy as a major weed in wheat crop (Anonymous 2008, 2012).

Resistance to isoproturon–a substituted urea herbicide is the most serious case of herbicide resistance in the world (Malik and Singh 1995), spread in more than 10 lakh ha of the rice-wheat cropping system (Singh 2007) and cause complete wheat crop failure, particularly under heavy infestation of 2000-3000 *P. minor* plants/m^2, posing a serious threat to the sustainability of this system. Resistant biotypes from Haryana have been reported to require up to eleven times the pre-susceptible dose of isoproturon to achieve 50% growth reduction (Yadav and Malik 2005) and this resistance was also found to be of metabolic in nature.

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Alternative herbicides belonging to group I [(acetyl co-A carboxylase (ACCase) inhibitors] and group II [acetolactate synthase (ALS) inhibitors] were recommended for management of *P. minor*. Clodinafop-propargyl, an aryloxyphenoxy propionates applied as post-emergence was recommended for for grass control, *viz. P. minor and A. fatua etc.* in spring hexaploid and tetraploid wheat. Clodinafop-propargyl is absorbed by the leaves and rapidly translocated to the growing points of leaves and stems. It interferes with the production of fatty acids needed for plant growth in susceptible grassy weeds. It has been used extensively in wheat for the last several years. The new herbicides brought the *P. minor* infestation under control and restored yields to their previous levels. But red signals of resistance against these alternate herbicides have also been speculated in 2002 and thereafter.

Recently, poor or no control of *P. minor* by application of clodinafop-propargyl has been observed in large areas, which could be related to cross-resistance or multiple resistance (Das *et al.* 2014) but new formulations are coming in market. Farmers delay application of clodinafop-propagy after two months of sowing either owing to late emergence of weed after first irrigation or to control two flushes of *P. minor* by one spray. Keeping this in mind, different new brands and formulations of clodinafop-propargyl and its time of application have been evaluated in respect to its bio-efficacy against *P. minor* in wheat crop.

MATERIALS AND METHODS

Field experiment was conducted at Research Farm Punjab Agricultural University, Ludhiana, Punjab during three successive winter seasons of 2010-11, 2011-12 and 2012-13. The experimental site was situated in Trans-Gangetic Agro-Climatic zone, representing the Indo-Gangetic Alluvial plains (IGP) at 30° 56' N latitude, 75° 52' E longitude and at an altitude of 247 m above mean sea level. The soil of the experimental site was loamy sand (coarse loamy, mixed hyperthermic, Typic ustipsamments) with normal soil reaction (pH=7.8) and electrical conductivity (0.17 dS/m). The soil was low in organic carbon (0.32 %) and available N (251.7 kg/ ha) and medium in available P (13.9 kg/ha) and K (167.3 kg/ha).

Experiment was laid out in randomized complete block design with 3 replications. Wheat cv. '*PBW 343*' in 2010-11, '*PBW 621*' in 2011-12 and '*HD 2967'* in 2013-14 were sown in mid-November in all three seasons. '*PBW 343*' was withdrawn from package of practices of Punjab and so, new variety, '*PBW 621*' was used in second year of study. In third year of study, variety "*HD 2967*" was taken for study due to its wide adaptability and acceptability at farmers' field. The new herbicide brands (Columbus and Markclodina in 15% wettable powder form) of coldinafop-propagyl 60 g/ha and variable doses of new formulation of clodinafop-propagyl (26.7% EC) 53.4, 66.75, 80.10 and 133.5 g/ha were applied at 30 days after sowing (DAS) using 375 litre of spray solution per hectare with hand operated knapsack sprayer fitted with flat fan nozzle. The crop was raised with recommended package of practices. *Phalaris minor* density and its biomass data was recorded at 30 days after spray or at 60 DAS with 50 x 50 cm quadrat.

In third year of study, application time of clodinafop-propargyl was also evaluated and late application at 60 days after sowing (DAS) was tested against recommended time of 35 DAS and unsprayed check during *Rabi* 2013-14. Per cent control of weed was reported over unsprayed check at 30 days after spray application or at 90 DAS. The weed data were subjected to square root transformation before analysis. Data on yield attributes and yield were determined at harvest. The data were statistically analyzed by using statistical procedures and comparisons were made at 5% level of significance.

RESULTS AND DISCUSSION

The experimental field contained only *P. minor* as grassy weed. Columbus, a brand formulation was evaluated for its bio-efficacy against *P. minor* in wheat crop in 2010-11. The application of clodinafop-propargyl (both brands- Columbus and Topik 15 WP) yielded significantly higher grain yield (3.46 and 3.43 t/ha) over the weedy check (2.80 t/ha) and recorded 31 and 25% control of *P. minor* over the weedy check. However, the new brand of clodinafop-propargyl (Columbus) recorded grain yield statistically at par with earlier recommended brand of clodinafop-propargyl (Topik) (Table 1). The new brand of clodinafop (Columbus) also failed miserably at Agronomy Research Farm as wheat average yield was much below the state average yield of 5.50 t/ha.

Another emulsifiable concentrate formulation of clodinafop-propagyl was evaluated for its bioefficacy against *P. minor* in wheat in 2011-12. Different doses of clodinafop from 53.4 to133.5 g/ha (commercial formulation dose of 200-500 ml/ha) also resulted statistically similar density of *P. minor* as well as grain yield at all the doses. Clodinafop-propargyl 26.7 EC provided only 58-64% control of *P. minor* over the weedy check (Table 2). All the doses of emulsifiable concentrate formulation of clodinafop-propargyl recorded statistically similar grain yield over the weedy situation as well as earlier recommended wettable powder formulation of clodinafop-propargyl (Topik) and both yielded below the state average yield of wheat crop. Markclodina- another brand of clodinafop-propargyl recorded statistically similar

Table 1. Effect of clodinafop on weeds and other yield attributing characters of wheat during *Rabi* 2010-11

Treatment	Dose (g/ha)	*P. minor* at 60 DAS		Effect on crop at harvest		
		Population (no./m^2)	Dry matter (g/m^2)	Plant height (cm)	Effective tillers/m^2	Grain yield (t/ha)
Columbus 15 WP (clodinafop)	60	8.9 (97)	9.4 (87)	76.7	241.1	3.46
Topik 15 WP (clodinafop)	60	11.2 (126)	9.8 (95)	76.5	239.6	3.43
Weedy check	-	13.6 (185)	11.4 (127)	71.6	226.7	2.80
Weed free	-	1.0 (0)	1.0 (0)	80.5	321.7	5.63
LSD (P=0.05)		2.9	1.1	3.0	7.7	0.45

Data is square root transformed, Figure within parentheses is original means

Table 2. Bio-efficacy of new formulation of clodinafop for control of grass weeds in wheat during *Rabi* 2011-12

Treatment	Dose (g/ha)	*P. minor* at 60 DAS		Effect on crop at harvest		
		Population (no./m^2)	Biomass (g/m^2)	Plant height (cm)	Effective tiller/m^2	Grain yield (t/ha)
Clodinafop 26.7% EC	53.40	6.2 (38)	6.0 (36)	72.2	255	3.95
Clodinafop 26.7% EC	66.75	5.4 (31)	5.6 (31)	66.2	256	4.00
Clodinafop 26.7% EC	80.10	5.4 (31)	5.4 (29)	74.7	257	4.13
Clodinafop 26.7% EC	133.50	5.8 (33)	5.5 (31)	70.1	262	4.28
Clodinafop 15% WP	60	6.0 (36)	5.1 (26)	69.7	261	3.99
Weedy		8.4 (69)	9.2 (85)	67.5	221	3.49
Weed free		1.0 (0)	1.0 (0)	75.5	341	5.93
LSD (P=0.05)		2.2	1.39	NS	36	0.82

Data is square root transformed, Figure within parentheses are original means

Table 3. Effect of clodinafop for control of grassy weeds in wheat during *Rabi* 2013-14

Treatment	Dose (g/ha)	*Phalaris minor* at 60 DAS		Effect on crop at harvest		
		Population (no./m^2)	Dry matter (g/m^2)	Plant height (cm)	Effective tillers/m^2	Grain yield (t/ha)
Markclodina 15 WP (clodinafop)	60	4.3 (18)	4.5 (19)	84.3	294	43
Topple 15 WP (clodinafop)	60	4.3 (17)	4.6 (20)	78.9	294	42
Unsprayed check	-	4.8 (23)	5.2 (26)	77.7	221	36
Weed free	-	1.0 (0)	1.0 (0)	86.0	330	57
LSD (P=0.05)		0.3	0.2	5.0	42	3

Data is square root transformed. Figure within parentheses are original means.

grain yield (4.27 t/ha) with earlier recommended brand of clodinafop-propargyl namely Topple (4.20 t/ha), which recorded 27% control of *P. minor* as compared to unweeded check during *Rabi* 2013-14 (Table 3). These results were in conformity to findings by Hamada *et al.* (2013).

Some farmers in Punjab have started using higher dose (2 to 3 times) than the recommended dose or used tank-mix of these herbicides for effective control of *P. minor* in wheat. The multiple herbicide-resistant populations had a low level of sulfosulfuron resistance but a high level of resistance to clodinafop-propargyl and fenoxaprop-p-ethyl (Chhokar and Shar 2008). From weed survey conducted during *Rabi* 2012-13 and 2013-14 in Moga, Patiala, Ropar, Sangrur, Kapurhala, Jalandhar and Ludhiana districts, it was found that the farmers were using either tank-mix application of 600 g/ha (1.5 times higher than the recommended dose 400 g/ha) of clodinafop-propargyl with recommended dose (32.5 g/ha) of sulfosulfuron for controlling *P. minor* or spraying sulfosulfuron before first irrigation and application of 1600 g/ha (four times higher than the recommended dose) of clodinafop at 60 DAS and moreover, farmers delayed this spray up to 60 DAS (Table 4).

Probable reason for poor control of weed at farmers fields were identified as adoption of faulty spray techniques, use of inappropriate nozzle, to and fro movement of spray lance while spraying, *etc*. or there was presence of clodinafop resistant population of *P.minor*. Clodinafop used for 4 years increased the chance of resistance evolving, whereas its rotation with sulfosulfuron reduced the chance of resistance evolving (Das *et al*. 2014). The further use of clodinafop would lead to the spread of resistance in larger areas through the dispersal of resistant seeds. Repeated use of same group of herbicide and either lower or higher application dose of herbicides with low volume of water used by farmers than recommended package and practices were the major causes of rapid evolution of herbicide resistance in *P. minor* populations of North West region of India. Navjyot-Kaur *et al*. (2015) also reported that the application of clodinafop, fenoxaprop-p-ethyl and

Table 4. Control of *P. minor* with clodinafop in different districts during *Rabi* 2012-13 and 2013-14 at farmers' field

District	No. of locations with poor control of *Phalaris minor*
Moga	12 (12)*
Patiala	10 (15)
Ropar	12 (20)
Sangrur	6 (20)
Kapurthala	8 (15)
Jalandhar	12 (20)
Ludhiana	20 (30)

*Figures in parentheses denote total number of locations.

pinoxaden is giving <40% control of *P. minor.* There was significant reduction in grain yield and per cent control of *P. minor* over unsprayed check which was reduced from 60 to 40% with delay in application time of clodinafop from 35 to 60 DAS (Table 5).

Table 5. Effect of time of application of clodinafop on control of *P. minor* and wheat grain yield during *Rabi* 2013-14

Treatment	Control of *P. minor* over unsprayed check (%)	Grain yield (t/ha)
Clodinafop 60 g/ha at 35 DAS	60.0[a]	4.85[a]
Clodinafop 60 g/ha at 60 DAS	40.0[b]	4.26[b]
Unsprayed check	-	3.22[c]

Figures with the different letters are significantly different from each other at 5% probability.

So, for effective control of *P. minor*, clodinafop group of herbicides should be replaced with alternate herbicides-sulfosulfuron 25 g/ha or pinoxaden 5.0 t/ha in areas where *P. minor* has developed resistance against clodinafop-propargyl. Besides, where *P. minor* has not evolved resistance, the yearly rotation of sulfosulfuron with clodinafop-propargyl or pinoxaden might delay the evolution of resistance.

REFERENCES

Anonymous. 2008. *Annual Report.* All India Coordinated Project on Weed Control, Department of Agronomy, PAU Ludhiana.

Anonymous. 2012. *Annual Report.* All India Coordinated Project on Weed Control. Department of Agronomy, PAU Ludhiana.

Das TK, Ahlawat IPS and Yaduraju NT. 2014. Littleseed canarygrass (*P. minor*) resistance to clodinafop-propagyl in wheat fields in north-western India: Appraisal and management. *Weed Biology and Management* **14**: 11-20.

Hamada SHE, Abdel-Lateef MF, Abdelmonem AE, El-Kholy RMA, Helalia AAR. 2013. Efficiency of certain clodinafop-propargyl formulations in controlling annual grassy weeds in wheat. *Annals of Agricultural Science* **58**(1): 13-18.

Malik RK and Singh S. 1995. Littleseed canarygrass (*Phalaris minor* Retz.) resistant to isoproturon in India. *Weed Technol*ogy **9:** 419-425.

Navjyot-Kaur, Tarundeep-Kaur, Simerjeet-Kaur and Bhullar Makhan S. 2015. Development of cross resistance in *Phalaris minor* Retz. in Punjab. (unpublished data).

Singh S. 2007. Role of management practices on control of isoproturon-resistant littleseed canarygrass (*Phalaris minor*) in India. *Weed Technology* **21:** 339-346.

Yadav A and Malik RK. 2005. *Herbicide Resistant Phalaris minor in wheat–Sustainability issue*. Resource Book. Department of Agronomy and Directorate of Extension Education, CCSHAU, Hisar, India.