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Research Paper

Estimation of GR_{50} values of ACM-9 29WG (clodinafop + metribuzin) and Axial 5EC (pinoxaden) to control the herbicide resistant biotypes of *Phalaris minor Retz.* collected from different districts of Punjab

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ABSTRACT

An field experiment was conducted at the experimental farm of Department of Agronomy, LPU Phagwara, Punjab, during *Rabi* season of 2022–23 and 2023–24. To workout GR_{50} values of ACM-9 (174 g a.i/ha-R) and Axial (50 g a.i/ha-R) at variable levels on four resistant biotypes of *P. minor* collected from different districts of Punjab, five doses i.e. 0, 1/2R, R, 2R and 4R in main plots and four biotypes of Ferozepur, Ropar, Fazilka and Ludhiana in sub plots were kept. Among different herbicides, higher mortality percentage and less dry matter of *P. minor* was found in herbicide ACM-9 as compared to Axial during both years. At the recommended level of ACM-9 significantly higher mortality and less dry matter was obtained as compare to control. Axial was found less effective as very low mortality percentage was observed even at 4R level during both years. Also, significantly less dry matter of *P. minor* was obtained in 4R level of Axial which was significantly less than all other levels. At the recommended level (R) of Axial, the mortality percentage and dry matter of *P. minor* was significantly less than 2R indicating thereby that it is heading towards resistance. Different biotypes showed differential response. Fazilka biotype was found to be more sensitive during both years whereas Ferozepur biotype showed higher resistance to both herbicide during both the years.

Key words: Biotypes, Dry matter, GR_{50}, Herbicide, Mortality, *Phalaris minor,* Resistance

Wheat (*Triticum aestivum* L.) is a major staple food of Indian population and it is grown all over the country with total area of 341.57 lakh hectare, production 112.74 million tones and average yield of 3.56 t/ha (Ministry of Agriculture & Farmers Welfare). In Punab it is grown on 35.17 lakh hectare with average yield of 47.10 q/ha (Anonymous year 2024–2025). In India the major contributing states are Punjab and Haryana in which *Phalaris minor* is the major problematic weed especially in rice- wheat cropping system (Singh *et al.* 2024). Isoproturon provided very effective control of this weed for more than one decade and then resistance had developed to this herbicide due to continuous use of single group herbicides (Yin *et al.,* 2024). After this clodinafop, sulfosulfuron and fenoxaprop were used prominently by the farmers and these herbicides provided effective control of isoproturon resistant *P. minor*. Resistance also developed to these herbicides because of their continuous use of same group year after year by the farmers (Kumar *et al.,* 2023). The alternative herbicides i.e. ACM-9 (clodinafop + metribuzin) and Axial (pinoxaden) which were recommended as substitute of previous herbicides and were used by the farmers from last many years prominently. However these herbicides belongs to most sensitive and susceptible group which are prone to resistance and in few districts of Punjab resistance particularly to Axial has been observed, especially where these herbicides are continuously used by the farmers from last many years (Kaur *et al.,* 2022). The main reasons of resistance are lack of crop rotation, continuous use of same group on a particular field, use of unapproved brands of recommended herbicides, lack of proper spray technologies etc.

Estimation of GR_{50} (amount of herbicide required for the 50% growth reduction as compared to control) of resistant population of *P. minor*, which indicates the level of resistance and time required for the occurrence of resistance in the *P. minor* populations (Kamboj *et al.,* 2022). This study was done to estimate the GR50 values of ACM-9 (clodinafop +metribuzin) and Axial (pinoxaden) so that their level of resistance in different biotypes of *P. minor*

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can be worked out. This study also helps farmers for the selection of effective herbicide to control the *P. minor* population in their fields. Higher values for GR50 indicates that this particular herbicide will work for more years to control *P. minor* whereas less GR50 values indicates occurrence of resistance.

MATERIAL AND METHODS

Different biotypes of *Phalaris minor* were collected from four districts of Punjab i.e. from Ferozepur, Ropar, Fazilka and Ludhiana where herbicides for the control of *Phalaris minor* were frequently used by the farmers from last many years. The experiment was laid out in split plot design having 5 main plots (0,1/2R, R, 2R and 4R), 4 sub plots (biotypes from Ferozepur, Ropar, Fazilka and Ludhiana districts) with three replications. The recommended dose of ACM-9 and Axial were 174 g a.i/ha and 50 g a.i/ha.

The sowing of seeds of different biotypes of *P. minor* were done manually by maintaining 22.5 cm row to row spacing with gross main plot size of 4.5 sqm (1.5m×5.0m) for each treatment and four biotypes with four rows of each biotypes were sown randomly in one main plot. The trial was conducted in *P. minor* seed free land and no addition of FYM, poultry and other organic manures were made because these may act as main path for the seed dispersal.

Sowing of *P. minor* seeds of different biotypes was done during 17th of November each during 2022–23 and 2023–24 in adequate moist soil. The herbicide application was done when the *P. minor* were in 3-4 leaf stage (30–35 days after sowing). The graded levels of both herbicides were kept as 1/2R, R, 2R, 4R (R stands for recommended dose) along with untreated (control) treatment where no herbicide application was done which was kept with each herbicide treatment. Herbicide application was done manually with the help of knap-sack sprayer which was fitted with flat fan nozzle and the herbicide application was done 35 days after sowing on area basis by using 250 litre/ha of water. The observations on *Phalaris minor* like mortality (%), dry matter accumulation, no. of tillers per m. row length, height (cm) were recorded 75 DAS i.e. at time of termination of experiments.

RESULT AND DISCUSSION

The results of the experiment are being discussed under the following sub heads

Mortality percentage

Weed mortality was recorded 75 DAS during both the years with visual observations which were recorded from each experimental plot (Table 1). The results of both the year were almost similar for ACM-9 herbicide which indicates significantly more mortality percentage in R dose during both the years than ½ R. The mortality percentage increased with increase in dose of Axial during both years and the mortality percentage in1/2R dose during both years was found at par with untreated (control) treatment. Mortality percentage in R dose was found to be significantly more than 1/2R but it was significantly less than 2R and 4R dose of Axial. Dhawan *et al.* (2009) reported that mortal-

Table 1. Mortality % of ACM-9 and Axial as influenced by different doses of herbicide and biotypes

	Mortality %			
	ACM-9		Axial	
	2022–23	2023–24	2022–23	2023–24
Main plots				
Untreated	0.0	0.0	0.0	0.0
½ R	76.4	66.6	5.6	3.2
R	93.9	78.3	24.3	16.3
2R	99.9	93.6	55.2	36.6
4R	100.0	100.0	68.1	47.6
SEm±	1.03	1.09	2.05	4.04
CD (P=0.05)	4.9	6.1	10.7	18.2
Sub plots				
Ferozepur	72.1	55.6	7.5	6.0
Ropar	72.2	56.6	45.3	37.8
Fazilka	77.9	58.6	45.8	41.9
Ludhiana	73.9	53.3	23.9	19.6
SEm±	0.9	0.41	1.02	1.01
CD (P=0.05)	4.5	1.9	5.8	5.4

ity percentage of *Phalaris minor* was 100% in clodinafop and 85% in sulfosulfuron during 2001–02 and 2002–03. Mortality percentage was significantly more in Fazilka biotype during both years than other tested biotypes with the application of ACM-9. Among the biotypes significantly less mortality percentage with the application of Axial was observed in Ferozepur and Ludhiana biotype as compare to Ropar and Fazilka biotype. This holds good for both the years. More mortality percentage to Fazilka biotype when exposed to both herbicides may be due to the reason that its initial vigor was very less as compared to biotypes of other tried districts.

Dry matter of Phalaris minor

Dry matter of *Phalaris minor* was significantly less in R and above R doses of ACM9 herbicide during both the years as compared to 1/2R and untreated (control) treatments (Table 2 and Fig 1). ACM-9 performed very well at R dose as dry matter of *Phalaris minor* at this dose was found at par with 2R and 4R during both the years indicating that this herbicide may work very well in future also. Better control of all *Phalaris minor* biotypes in ACM-9 may be due to presence of two chemicals i.e. clodinafop and metribuzin in the formulated mixture. The percent reduction in dry matter of *Phalaris minor* sprayed with 1/2R

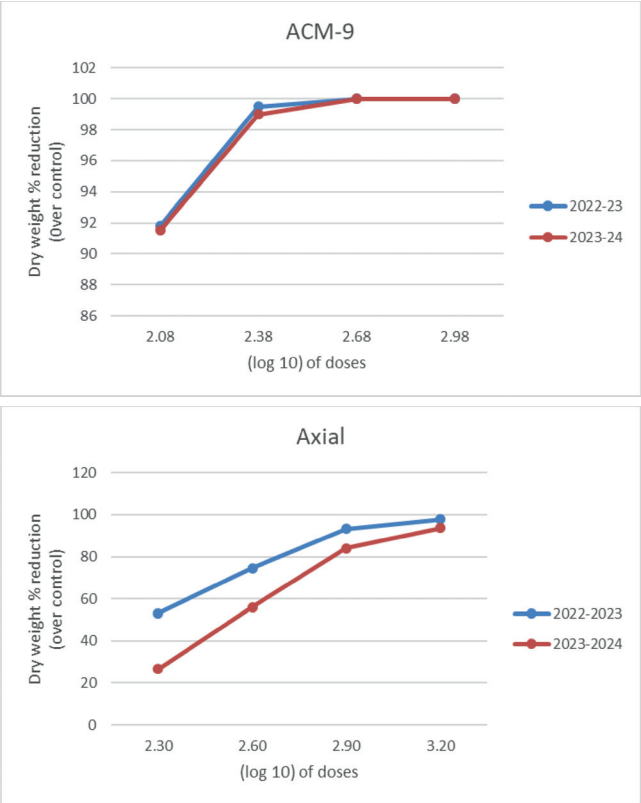

Fig. 1. Showing relationship of percent reduction in dry weight with different levels of herbicides

level of ACM-9 was 91.8% and 91.5% during 2022–23 and 2023–24 respectively which was significantly more than untreated (control) treatment indicating thereby that at present this herbicide is working very well even at 1/2R dose. So, the chances of devolpment of resistance are very less and hopefully this herbicide may work for many years in future. Among the biotypes, the percent reduction in dry matter of *Phalaris minor* of all biotypes was more than 50% as compared to untreated (control) indicating that ACM-9 herbicide is effective on all tested biotypes.

Dry matter of *Phalaris minor* decreased significantly during both years with increase in dose of Axial (Table 2 and Fig 1). Dry matter of *Phalaris minor* was significantly less in R level of Axial as compared 1/2R and untreated (control). The use of Axial at 2R and 4R levels during both years resulted in significant reduction in dry matter of *P. minor* than its R level. However dry matter was significantly higher in untreated (control) than all other herbicide levels during both years. Axial is heading towards resistance as satisfactory control of *Phalaris minor* was obtained only at 2R and 4R levels.

With the application of ACM-9, Fazilka and Ludhiana biotypes recorded significantly less dry matter of *P. minor* during 2022–23 and Fazilka biotype only during 2023–24 as compare to other biotypes. The results indicated that out of tested biotypes Ferozepur biotypes looked to be somewhat hardy biotype as dry matter (g/sqm) of *Phalaris minor* was significantly higher in Ferozepur compared to Ropar, Ludhiana, and Fazilka biotypes. Application of Axial showed significantly less dry matter in Fazilka biotype than others during both years indicating thereby that this was more susceptible biotype. Ferozepur biotype seems to the hardier due to significantly higher dry matter accumulation in this biotype than others. On the other hand percent reduction in dry matter of *Phalaris minor* with the application of Axial was more in Fazilka and Ludhiana biotype during both years. Less dry matter of *Phalaris minor* in Fazilka biotype irrespective of herbicide may be due to less initial vigor of this biotype than all other tested biotypes.

Tillers of Phalaris minor

In ACM-9 experiment number of total *Phalaris minor* tillers were significantly more in untreated (control) than other levels during both years (Table 3). Among herbicide treatments, recommended R and above levels recorded significantly less tillers than 1/2R during both years. During both years, number of tillers of *Phalaris minor* per meter row length were found to be significantly less in Fazilka biotype as compare to the other biotypes. During 2022–23 number of tillers in Ferozepur biotype were significantly higher than other biotypes and during 2023–24 number of

Table 2. Dry matter of *Phalaris minor* (g/m^2) as influenced by different doses of herbicides and biotypes

	Dry-matter (g/m^2)			
	ACM-9		Axial	
	2022–23	2023–24	2022–23	2023–24
Main plots				
Untreated	126.8	140.1	182.2	160.1
½ R	10.3 (91.8)	11.7 (91.5)	85.4 (53.1)	117.3 (26.7)
R	0.6 (99.5)	1.2 (99.0)	46.3 (74.5)	70.4 (56.0)
2R	0.0 (100)	0.0 (100)	12.2 (93.3)	25.4 (84.1)
4R	0.0 (100)	0.0 (100)	4.1 (97.7)	10.1 (93.6)
SEm±	1.2	0.9	6.1	14.04
CD (P=0.05)	5.2	4.1	27.3	53.0
Sub plots				
Ferozepur	36.1 (71.5)	56.3 (59.7)	94.2 (48.2)	105.0 (34.3)
Ropar	27.0 (78.7)	51.1 (63.5)	75.9 (58.3)	94.3 (41.0)
Fazilka	23.5 (81.4)	39.5 (71.8)	45.3 (75.1)	56.6 (64.6)
Ludhiana	23.4 (81.5)	51.1 (63.5)	54.9 (69.8)	66.8 (58.2)
SEm±	0.5	1.0	2.4	2.7
CD (P=0.05)	2.7	4.6	9.1	10.1

Figures within parenthesis are percent decrease of dry matter over control

Table 3. Tillers of *Phalaris minor* / m. row length as influenced by different doses of herbicides and biotypes

	No. of tillers/meter row length			
	ACM-9		Axial	
	2022–23	2023–24	2022–23	2023–24
Main plots				
Untreated	32.3	27.4	53.6	77.8
½ R	7.4 (77.0)	9.6 (64.9)	39.9 (25.5)	67.0 (13.8)
R	2.0 (93.8)	2.8 (89.7)	26.3 (50.9)	57.5 (26.0)
2R	0.0 (100)	0.0 (100)	13.5 (74.8)	23.5 (69.7)
4R	0.0 (100)	0.0 (100)	9.5 (82.2)	9.5 (87.7)
SEm±	1.01	0.5	2.7	1.3
CD (P=0.05)	3.7	2.1	11.5	4.6
Sub plots				
Ferozepur	14.2 (56.0)	8.3 (69.7)	40.8 (23.8)	54.1 (30.4)
Ropar	7.2 (77.7)	8.6 (68.6)	30.6 (42.9)	39.2 (49.6)
Fazilka	5.6 (82.6)	6.5 (76.2)	19.3 (63.9)	26.4 (66.0)
Ludhiana	6.8 (78.9)	8.5 (68.9)	23.5 (56.1)	33.6 (56.8)
SEm±	0.1	0.2	1.1	2.1
CD (P=0.05)	1.1	1.5	3.9	6.7

Figures within parenthesis are percent decrease of no. of tillers/m row length over untreated control

tillers in Ferozepur, Ropar and Ludhiana biotype were found at par and were significantly higher than Fazilka biotype. The percent reduction in number of tillers/ m row length were more in ACM-9 as compared to Axial herbicide. It was observed that percent reduction in tiller count was more than 90 percent at R, 2R and 4R level of ACM-9.

No. of tillers were significantly higher in untreated (control) than all other herbicide treatments of Axial. The recommended level of Axial produced significantly less tillers/

m row length than ½ R but these were significantly more than 2R and 4R levels during both years. Among the biotypes, tillers/m row length were found to be significantly less in Fazilka biotype than others during both the years. Ferozepur biotype recorded significantly more tillers/m row length than other biotypes during both the years indicating that it is hardier and heading towards resistance. The percent reduction in 2R and 4R level of Axial were above 70 percent during both the years whereas at recommended level it was very low. Among different biotypes, highest percent reduction of *P. minor* tillers with the application of 'ACM-9' and Axial was observed in Fazilka biotype as compared to biotypes of other districts. During initial stages, number of tillers/unit are of Fazilka biotype were less as compared to other biotypes and this may be the reason of its better control with both tried herbicides.

Height of Phalaris minor plants

Plant height of *Phalaris minor* (cm) during both years was significantly more in untreated (control) as compared to all levels of ACM-9 (Table 4). The recommended level recorded significantly less plant height than 1/2R but it was significantly higher than 2R and 4R treatments. This holds good for both years. The height of *P. minor* plants was significantly more in untreated (control) than all levels of Axial herbicide during both years. Plant height during both years in R dose of Axial was found to the significantly more than 2R and 4R levels.

The plant height was significantly less with the application of ACM-9 in Fazilka and Ludhiana and Ferozepur biotypes during 2022–23 and in Fazilka biotype during 2023–24 than all other biotypes. Among all the biotypes, significantly less plant height with the application of Axial during both years was recorded in Fazilka biotype than all other biotypes. During 2022–23, Ferozepur biotype recorded significantly more height than others and during 2023–24 the biotype of Ferozepur, Ropar and Ludhiana were found at par and recorded significantly more height of *Phalaris minor* than Fazilka biotype

The percent reduction in plant height (cm) of *Phalaris minor* was more in ACM-9 as compared to Axial. The percent reduction in plant height was more with the application of R,2R and 4R level of ACM-9 and with 2R and 4R level of Axial. The percent reduction in plant height with the application of ACM-9 varied from 57.0% to 75.4% during both years. However, reduction in height of *P. minor* was less in Axial which varied from 16.2% to 50.1 percent only during both years. Fazilka biotype during initial stages was less vigorous compared to other tested biotypes which resulted in less growth and subsequently less plant height.

It may be concluded that ACM-9 herbicide performed very well at its recommended dose but Axial failed to control *Phalaris minor* at its recommended or double the recommended dose indicating thereby that *Phalaris minor* had developed resistance to this herbicide. Different biotypes

Table 4. Height of *Phalaris minor* plants (cm) as influenced by different herbicides and biotypes

	Plant height in (cm)			
	ACM-9		Axial	
	2022–23	2023–24	2022–23	2023–24
Main plots				
Untreated	40.8	51.4	47.3	54.4
½ R	25.4 (37.7)	33.1	39.3 (16.9)	53.5 (1.6)
R	4.3 (89.40	13.4 (73.9)	33.1 (30.0)	47.8 (12.1)
2R	0.0 (100)	0.0 (100)	25.7 (45.6)	28.9 (46.8)
4R	0.0 (100)	0.0 (100)	18.3 (61.3)	23.1 (57.5)
SEm±	1.0	0.9	1.9	1.0
CD (P=0.05)	3.3	2.7	6.1	3.2
Sub plots				
Ferozepur	14.0 (65.6)	22.1 (57.0)	39.6 (16.2)	45.2 (16.9)
Ropar	16.0 (59.3)	20.7 (59.7)	35.5 (24.9)	44.6 (18.0)
Fazilka	13.7 (66.4)	12.6 (75.4)	23.6 (50.1)	38.6 (29.0)
Ludhiana	12.7 (68.8)	18.7 (63.6)	32.2 (31.9)	43.6 (19.8)
SEm±	0.5	0.3	1.2	0.7
CD (P=0.05)	2.1	1.8	4.0	2.5

Figures within parenthesis are percent decrease of plant height over untreated (control)

showed variable response. Fazilka biotype followed by Ludhiana biotype were found to be more sensitive whereas Ferozepur biotype showed resistance to both tried herbicide.

REFERENCES

Dhawan, R.S., Punia, S.S., Singh, S., Yadav, D. and Malik, R.K. 2009. Productivity of wheat (*triticum aestivum*) as affected by continuous use of new low dose herbicides for management of littleseed canarygrass (*phalaris minor*). *Indian Journal of Agronomy* **54**(1): 58–62.

Kamboj, N.K., V.S. Hooda, M. Sangwan and A. Karwasra 2022. Management of herbicide-resistant phalaris minor in wheat by integration of malathion and post-emergence herbicides. *Annals of Agricultural Research* **43**(2): 134–41.

Kaur, M., Punia, S.S., Singh, J. and Singh, S. 2020. Evaluation of multiple herbicide resistance in littleseed canarygrass (*phalaris minor*) populations from haryana in india. *Indian Journal of Agronomy* 265–269.

Kaur, T., Bhullar, M.S. and Kaur, S. 2019. Control of herbicide resistant *phalaris minor* by pyroxasulfone in wheat. *Indian Journal of Agronomy* 265–269.

Kaur, S., Dhanda, S., Yadav, A., Sagwal, P., Yadav, D.B. and Chauhan, B.S. 2022. Current status of herbicide-resistant weeds and their management in the rice–wheat cropping system of south asia. *Advances in Agronomy* **172**: 307–354.

Kumar, V., M. Singh, R. Kaur and A.J. Jhala. 2023. *The scenario of herbicide-resistant weeds: management challenges and perspectives*.

Singh, S.K., A.M. Singh, O.P. Gupta and P.K. Singh 2024. Wheat: origin, history, and production practices. In *Wheat Science* 1–32. Crc press.

Yin, Fan, Jinfang Jiang, Min Liao, Haiqun Cao, Zhaofeng Huang, and Ning Zhao 2024. "fenoxaprop-p-ethyl, mesosulfuron-ethyl, and isoproturon resistance status in beckmannia syzigachne from wheat fields across anhui province, china." *Pesticide biochemistry and physiology* **198** (january): 105,711.

Yadav, D.B., Punia, S.S., Yadav, A., Singh, S. and Lal, R. 2009. Pinoxaden: an alternate herbicide against littleseed canary grass (*Phalaris minor*) in wheat (*Triticum aestivum*). *Indian Journal of Agronomy* **54**(4): 433–437.