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Phalaris minor management in wheat by post-emergence application of metribuzin based tank-mixed herbicides in north-western Indo-Gangetic Plains

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ABSTRACT

Phalaris minor is the major problematic weed in wheat in the north-western Indo-Gangetic Plains including Punjab and Haryana regions. The accelerated development of herbicide resistance in weed species has narrowed down the chemical options with the wheat farmers for the effective control of weeds. In this regard, a study was conducted with different post-emergence (PoE) herbicides (clodinafop 60 g/ha, fenoxaprop 100 g/ha, sulfosulfuron 25 g/ha, pinoxaden 50 g/ha, mesosulfuron + iodosulfuron 14.4 g/ha, sulfosulfuron + metsulfuron 32 g/ha, clodinafop + metsulfuron 64 g/ha) alone and in combination with metribuzin (105 g/ha) at CCS Haryana Agricultural University, Regional Research Station Uchani, Karnal during 2018-19 and 2019-20. The metribuzin based tank mixed PoE herbicides application resulted in 70-89% weed control efficiency as compared to 17-54% with their application alone, during both the years. The tank mixed metribuzin based PoE herbicides application resulted in effective control of *P. minor* as well as broad-leaved weeds and also resulted in higher wheat grain yields (5.59 to 5.98 t/ha) when compared to sole application of PoE herbicides (4.18 to 5.19 t/ha). However, soil type, soil moisture and cultivars should be taken in to consideration while using the effective tank-mixed metribuzin based combinations.

INTRODUCTION

Wheat is an important crop in India cultivated over 30 million hectares with an annual production of 100 million tons (t) and average productivity of 3.22 t/ha (Anonymous 2019). After the green revolution, wheat productivity has increased many folds but currently the wheat productivity is declining or stagnated (Pathak *et al.* 2003). The competition for the resources by the weeds plays a significant role in reducing the wheat productivity. The wheat is invaded with composite weed flora consisting of grasses along with broad-leaved weeds. Amongst grasses: *Phalaris minor, Avena ludoviciana, Poa annua* and *Polypogon monspeliensis* are dominant. Amongst broad-leaved weeds, *Chenopodium album, C. murale, Rumex dentatus, R. spinosus, Coronopus didymus, Anagallis arvensis, Medicago denticulata, Melilotus indica, Malva parviflora* and *Convolvulus arvensis* are dominant (Singh *et al.* 1995, Chhokar *et al.* 2012). The cultural practices such as continuous adoption of rice-wheat system, delayed wheat sowing, excessive use of nitrogenous fertilizers, burning of rice residue *etc*. are mainly responsible for the heavy infestation of *P. minor* and other weeds in north-western Indo-Gangetic Plains (Singh *et al.* 2021). The *P. minor* mimics wheat and is very difficult to distinguish it during early stages. Further, due to labor scarcity and higher wages, farmers generally prefer chemical weed control in wheat and herbicides' role is indispensable. Herbicides play a major role in controlling the weeds in wheat.

The populations of *P. minor*, initially exposed to greater continuous application of single herbicide isoproturon for several years has enhanced the probability of development of herbicide resistance by imposing the strong selection pressure (Singh *et al.* 2021). Further, over reliance on herbicides with same mode of action has resulted in evolution of cross and multiple herbicide resistance in *Phalaris minor*

(Chhokar and Sharma 2008, Chhokar *et al.* 2018). The first case of resistance in *P. minor* to isoproturon was reported during 1995 in India and the task of managing *P. minor* in wheat is becoming more difficult with the evolution of multiple resistance over the years (Dhawan *et al.* 2009) due to inappropriate herbicide usage methods adoption by the farmers and not following the herbicide rotation (Malik and Singh 1995, Chhokar *et al.* 2018). *Phalaris minor* has developed multiple resistance to PS-II (photosynthesis at the photosystem-II site-A), Acetyl Coenzyme-A Carboxylase (ACCase) and Acetolactate Synthase (ALS) inhibitor herbicides (Chhokar *et al.* 2018). Further the problem of resistance has aggravated with the addition of *Rumex dentatus* in the list of herbicide resistant weeds in India. The resistance in *Rumex dentatus* to metsulfuron-methyl has been confirmed in Haryana and Punjab states of India (Chhokar *et al.* 2013, Chaudhary and Kaur 2018, Dhanda *et al.* 2020). For the management of herbicide resistant *Phalaris minor*, combination of herbicides with different modes of action may be an ideal strategy. Thus, there is need to identify effective herbicides with alternate modes of action and or tank-based mixtures for effective control of herbicide resistant weeds in wheat to ensure higher productivity. The earlier studies reported that tank-mix application of post-emergence herbicides like clodinafop, sulfosulfuron, fenoxaprop with metribuzin provided effective control of *P. minor* along with broad-leaved weeds (Yadav *et al*. 2016, Walia *et al*. 2011, Punia *et al*. 2017). The present study was conducted to find out the effect of different post-emergence (PoE) herbicides sprayed alone and as tank mixed with metribuzin on *P. minor* and other weeds, phyto-toxicity (if any) to wheat and wheat productivity, and to identify effective PoE herbicide combinations to recommend for better weed management in wheat.

MATERIALS AND METHODS

The study was conducted, during 2018-19 and 2019-20, at CCS Haryana Agricultural University, Regional Research Station, Uchani, Karnal, in the location with a history of poor control of *Phalaris minor* with clodinafop and sulfosulfuron. The wheat *cv* '*HD-2967*' and '*WH-1105*' were sown on 6 November 2018 and 7 November 2019, and harvested on 17 April and 20 April during 2018-19 and 2019-20, respectively. The soil of experimental site was clay loam in texture, low in organic carbon, nitrogen, medium in phosphorus and potassium. The weather data pertaining to the location during both the years of study presented in **Figure 1** (*Rabi* 2018-19)

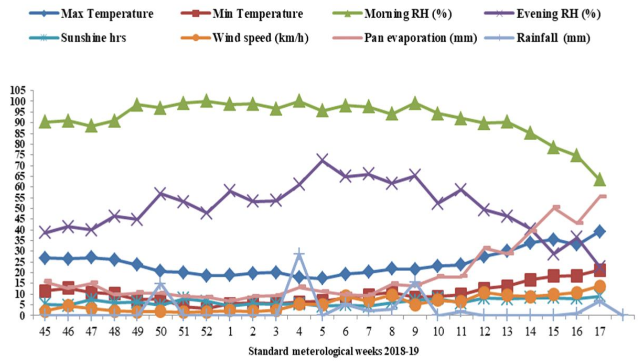

Figure 1. Weekly weather data of experimental site during *Rabi* 2018-19

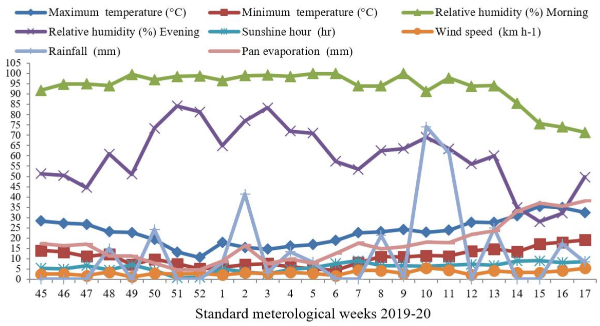

Figure 2. Weekly weather data of experimental site during *Rabi* 2019-20

and **Figure 2** (*Rabi* 2019-20). Field was prepared by conventional method *i.e*., harrowing followed by (*fb*) tiller and planking. Wheat was sown using seed rate of 100 kg/ha with row spacing 20 cm. The herbicidal treatments included clodinafop 60 g/ha, fenoxaprop 100 g/ha, sulfosulfuron 25 g/ha, pinoxaden 50 g/ha, mesosulfuron + iodosulfuron (ready mix [RM]) 14.4 g/ha, sulfosulfuron + metsulfuron (RM) 32 g/ha, clodinafop+metsulfuron (RM) 64 g/ha, clodinafop+ metribuzin 60 + 105 g/ha, fenoxaprop + metribuzin 100+105 g/ha, sulfosulfuron + metribuzin 25 + 105 g/ ha, pinoxaden + metribuzin 50 + 105 g/ha, mesosulfuron + iodosulfuron (RM) + metribuzin 14.4 + 105 g/ha, sulfosulfuron + metsulfuron (RM) + metribuzin 32 + 05 g/ha, clodinafop + metsulfuron (RM) + metribuzin 64 + 105 g/ha were evaluated along with weed free and weedy checks. The surfactant (S) was also added with herbicides sulfosulfuron, mesosulfuron+ iodosulfuron, sulfosulfuron+ metsulfuron, clodinafop+ metsulfuron at 1250 ml/ha, and 500 ml/ha with fenoxaprop. The experiment was laid out in randomized block design with three replications. The herbicides were sprayed at 35 days after sowing (DAS) with knapsack sprayer fitted with flat-fan nozzle using water volume of 500 l/ha. In weed free treatment, hand weeding was done whenever required and no weed management practice was taken in weedy check. All other agronomical practices were followed to raise the crop as per recommendation of the state university. The weed samples were collected at 75 DAS with the help of a quadrat (0.5 x 0.5 m) from two places in random manner from each plot. Each weed sample was separated as *P. minor*, broad-leaved weeds, counted and expressed as weed density (no./m^2). Weed samples from each plot were first sun dried and thereafter kept in oven at 65±5ºC until a constant weight was achieved to record the dry weight of weeds which was expressed as weed biomass (g/m^2). The data related to growth, yield attributes and yield were recorded at maturity. Benefit-cost ratio was calculated by dividing gross returns with total cost of cultivation. The statistical analysis was made with the help of OPSTAT software of CCSHAU (Sheoran *et al*. 1998), with least significant difference tested at 5% level of significance.

RESULTS AND DISCUSSION

Effect on weeds

The experimental site was primarily dominated by *P. minor, Rumex dentatus*, and *Melilotus indica* during both the years. The application of pinoxaden + metribuzin resulted in minimum density of *P. minor* during both the years (**Table 1**). The metribuzin based tank mix application of post-emergence herbicides provided effective control of *P. minor* and reduced the biomass of *P. minor* during 2018-19 (4.4 to 28.8 g/m^2) and 2019-2020 (4.6 to 12.7 g/m^2) as compared to their alone application (40.3 to 78.7 g/m^2 and 30.5 to 58.5 g/m^2 during 2018-19 and 2019-2020, respectively) and weedy check (94.9 g/m^2 and 73.6 g/m^2 during 2018-19 and 2019-2020, respectively). Not only *P. minor*, broad-leaved weeds were also effectively controlled with the metribuzin based tank mix application of post-emergence herbicides in comparison to their sole application. Yadav *et al.* (2016) also reported that the tank-mix application of metribuzin with clodinafop and sulfosulfuron caused effective control (99%) of all types of weed species in wheat. The application of fenoxaprop+metribuzin (88.5%) and sulfosulfuron + metribuzin (88.2%) resulted in maximum weed control efficiency (WCE) during 2018-19 and 2019-20, respectively (**Table 1**). Punia *et al.* (2017) also reported that application of fenoxaprop+metribuzin and clodinafop+metribuzin resulting in effective control of herbicide resistant biotypes of *P. minor.* The effective weed control in mixtures is due to combined action of herbicides with different modes of action. Pandey *et al.* (2006) reported the higher WCE with the application of metribuzin (86-94%) in wheat as compared to sulfosulfuron (55-87%). Pendimethalin and metribuzin based tank mixture as pre-emergence application was found to improve control of *P. minor*, *Medicago denticulata*, *Rumex dentatus* and *Chenopodium album* (Kaur *et al.* 2017)

Effect on crop

There was no phyto-toxicity of any of the herbicide combinations with metribuzin on wheat

Table 1. Effect of post-emergence herbicides alone and as tank mixed with metribuzin on density and biomass of *Phalaris minor* and other weeds and weed control efficiency (%) at 75 days after seeding (DAS) in wheat

Treatment	Dose (g/ha)	*P. minor* density (no./m^2) 75 DAS*		Weeds biomass (g/m^2) 75 DAS				Weed control efficiency (%)	
				P. minor		Broad-leaved			
		2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Clodinafop	60	5.02(25)	5.76(33)	63.2	56.0	5.2	7.7	29.7	22.9
Fenoxaprop	100	6.28(41)	6.41(41)	48.5	44.4	4.8	9.7	45.2	34.5
Sulfosulfuron	25	5.89(35)	6.95(49)	61.9	58.5	3.8	9.0	32.5	18.3
Pinoxaden	50	4.49(19)	4.99(24)	40.3	35.8	4.2	9.7	54.2	45.0
Mesosulfuron + iodosulfuron	14.4	6.74(45)	5.28(27)	66.3	30.5	5.0	9.0	26.7	52.2
Sulfosulfuron + metsulfuron	32	6.06(38)	7.32(53)	59.7	46.0	4.5	2.7	34.0	41.1
Clodinafop + metsulfuron	64	7.48(55)	6.16(37)	78.7	49.1	2.3	5.0	16.8	34.5
Clodinafop + metribuzin	60+ 105	4.59(21)	3.68(13)	23.4	10.7	5.1	7.0	70.7	78.6
Fenoxaprop + metribuzin	120+ 105	4.16(19)	4.10(16)	11.2	10.4	0.0	6.3	88.5	79.8
Sulfosulfuron + metribuzin	25+ 105	4.42(22)	3.39(11)	28.8	9.7	0.0	0.0	70.4	88.2
Pinoxaden + metribuzin	50+ 105	2.34(5)	3.18(9)	4.4	4.6	7.3	10.3	88.0	81.9
Mesosulfuron + iodosulfuron + metribuzin	14.4+105	4.08(17)	3.18(9)	14.9	6.7	2.0	5.7	82.6	85.0
Sulfosulfuron + metsulfuron + metribuzin	32+ 105	4.49(22)	4.43(19)	24.7	12.7	2.3	3.7	72.2	80.2
Clodinafop + metsulfuron + metribuzin	64+ 105	3.48(12)	3.23(10)	18.1	9.3	0.0	1.0	81.4	87.5
Weedy free		1.00(0)	1.00(0.0)	0.0	0.0	0.0	0.0	100.0	100.0
Weed check		7.13(53)	7.44(55)	94.9	73.6	2.4	9.0	0.0	0.0
LSD (p=0.05)		2.4	1.2	12.8	19.2	4.4	6.1	-	-

*Original values in parentheses subjected to square root transformation before data analysis

Table 2. Effect of post-emergence herbicides alone and as tank mixed with metribuzin on yield attributes and grain yield (t/ha) of wheat

Treatment	Dose (g/ha)	Plant height (cm)		Effective tillers/mrl		Spike length (cm)		Grain yield (t/ha)		Benefit cost ratio	
		2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Clodinafop	60	106	98	68	60	10	11	4.89	4.18	0.89	0.80
Fenoxaprop	100	107	98	72	63	10	11	5.16	4.46	0.94	0.84
Sulfosulfuron	25	106	98	70	61	9	11	4.98	4.40	0.92	0.86
Pinoxaden	50	106	99	74	67	10	11	5.19	4.74	0.94	0.91
Mesosulfuron + iodosulfuron	14.4	106	97	72	68	10	11	4.88	4.97	0.89	0.97
Sulfosulfuron + metsulfuron	32	107	99	73	62	10	10	5.08	4.68	0.93	0.91
Clodinafop + metsulfuron	64	106	99	72	63	10	11	4.87	4.67	0.87	0.89
Clodinafop + metribuzin	60+105	106	99	82	75	10	10	5.70	5.60	1.06	1.11
Fenoxaprop + metribuzin	120+105	108	98	80	74	10	10	5.98	5.59	1.12	1.09
Sulfosulfuron + metribuzin	25+105	107	98	79	75	10	11	5.76	5.68	1.10	1.14
Pinoxaden + metribuzin	50+105	106	97	80	77	10	11	5.95	5.85	1.10	1.11
Mesosulfuron + iodosulfuron + metribuzin	14.4+105	108	98	79	76	10	10	5.89	5.89	1.11	1.14
Sulfosulfuron + metsulfuron + metribuzin	32+105	106	97	79	75	10	11	5.70	5.71	1.06	1.13
Clodinafop + metsulfuron + metribuzin	64+105	107	97	80	76	10	11	5.80	5.92	1.07	1.17
Weedy free		106	99	84	80	10	11	6.01	6.07	0.88	0.96
Weed check		106	100	59	56	10	11	4.36	3.40	0.75	0.58
LSD (p=0.05)		NS	NS	6	8	NS	NS	0.50	0.30	-	-

Mrl: Meter row length

crop. Different herbicidal treatments did not have the influence on plant height and spike length of wheat during both the years. However, metribuzin based post-emergence herbicides treatments were found at par with each other with respect to number of effective tillers per meter row length (mrl) (74-82/mrl) along with weed free plots (80-84/mrl) but significantly higher to alone application of post-emergence herbicides (60-74/mrl) during both the years of study (**Table 2**).

The higher wheat grain yield was recorded with metribuzin based tank mix application of post-emergence herbicides (5.70–5.98 t/ha and 5.59 to 5.92 t/ha during 2018-19 and 2019-20, respectively) as compared to their application alone (4.87 to 5.19 t/ha and (4.18 to 4.97 t/ha during 2018-19 and 2019-20, respectively) without any toxicity on wheat crop (**Table 2**). The metribuzin based tank-mix applications resulted in 31-37% and 64-74% increase in grain yield of wheat as compared to weedy check during 2018-19 and 2019-20, respectively. The highest grain yield was obtained under tank mix of metribuzin with fenoxaprop in 2018-19 and clodinafop+ metsulfuron (RM) in 2019-20. However, all the metribuzin based tank-mix treatments were at par with each other. The higher wheat grain yield in metribuzin based tank-mix applications might be due to broad spectrum of weed control along with better control of *P. minor* as compared to application of herbicides alone. Walia *et al.* (2011) also reported that application of fenoxaprop-p-ethyl+metribuzin in wheat resulted in effective control of *P. minor* and broad-leaved weeds and increased the wheat grain yield by 59% in comparison to untreated control. The significantly higher wheat grain yield was also observed by Yadav *et al.* (2016) with the application of tank mix of metribuzin with clodinafop and sulfosulfuron. Higher benefit cost ratio (1.06-1.17) was observed with tank mix application of metribuzin with post-emergence herbicide as compared to alone application (0.80-0.97).

Based on this study, it may be concluded that application of metribuzin (105 g/ha) based tank-mixed post-emergence herbicides at recommended doses (clodinafop 60 g/ha, fenoxaprop 100 g/ha, sulfosulfuron 25 g/ha, pinoxaden 50 g/ha, mesosulfuron+ iodosulfuron 14.4 g/ha, sulfosulfuron + metsulfuron 32 g/ha, clodinafop+ metsulfuron 64 g/ha) provided effective control of *P. minor* and other broad-leaved weeds in wheat as their application resulted in 70-89% weed control efficiency, without any phyto-toxicity of metribuzin on wheat, as compared to 17-54% control with their sole application. The farmers' adoption of tank mix of herbicides with different modes of action or herbicide rotation along with other cultural practices may also delay the evolution of herbicide resistance in weeds, and help to achieve sustained wheat yield for national food security. However, soil type, soil moisture and cultivars should be taken in to consideration while recommending these combinations.

REFERENCES

Anonymous. 2019. Area, production and productivity of wheat in India. www.indiaagristat.com.

Chaudhary A and Kaur S. 2018. ALS/AHAS (Group B/2) inhibitors resistance in *Rumex dentatus* L. and *Chenopodium album* L. halting future wheat productivity of Haryana and Punjab, pp 45. In: *Proc*eedings of *ISWS Golden Jubilee International Conference 'Weeds and Society: Challenges and Opportunities'*. 21-24 November 2018, Directorate of Weed Research, Jabalpur, India.

Chhokar RS and Sharma RK. 2008. Multiple herbicide resistance in littleseed canarygrass (*Phalaris minor*): a threat to wheat production in India. *Weed Biology and Management* **8**: 112–123.

Chhokar RS, Chaudhary A and Sharma RK. 2018. Herbicide resistant weeds in India and their management, pp 288-308. In *Fifty Years of Weed Science Research in India*. (Eds. Sushilkumar and Mishra JS). Indian Society of Weeds Science, Jabalpur, India

Chhokar RS, Sharma RK and Sharma I. 2012. Weed management strategies in wheat-A review. *Journal of Wheat Research* **4**(2): 1–21.

Chhokar RS, Sharma RK, Garg R and Sharma I. 2013. Metsulfuron resistance in *Rumex dentatus*: *Wheat Barley Newsletter* **7:** 11.

Dhanda S, Chaudhary A, Kaur S and Bhullar MS. 2020. Herbicide resistance in *Rumex dentatus* against metsulfuron herbicide in Punjab and Haryana, India. *Indian Journal of Weed Science* **52**: 259–264.

Dhawan RS, Punia SS, Singh S, Yadav D and Malik RK. 2009. Productivity of wheat (*Triticum aestivum*) as affected by continuous use of new low dose herbicides for management of littleseed canarygrass (*Phalaris minor*) in India. *Indian Journal of Agronomy* **54**: 58–62.

Kaur S, Kaur T and Bhullar MS. 2017. Control of mixed weed flora in wheat with sequential application of pre-and post-emergence herbicides. *Indian Journal of Weed Science* **49**: 29–32.

Malik RK and Singh S. 1995. Littleseed canarygrass (*Phalaris minor*) resistance to isoproturon in India. *Weed Technology* **9**: 419–425.

Pandey AK, Gopinath KA and Gupta HS. 2006. Evaluation of sulfosulfuron and metribuzin for weed control in irrigated wheat (*Triticum aestivum*). *Indian Journal of Agronomy* **51:** 135–138.

Pathak H, Ladha JK, Aggarwal PK, Peng S, Das S, Singh Y, Singh B, Kamra SK, Mishra B, Sastri AS and Aggarwal HP. 2003. Trends of climatic potential and on-farm yields of rice and wheat in the Indo-Gangetic Plains. *Field Crops Research* **80**: 223–234.

Punia SS, Yadav DB, Kaur M and Sindhu VK. 2017. Post emergence herbicides for the control of resistant littleseed canarygrass in wheat. *Indian Journal of Weed Science* **49:** 15–19.

Sheoran OP, Tonk DS, Kaushik LS, Hasija RC and Pannu RS. 1998. Statistical software package for agricultural research workers, pp. 139–143. In: *Recent Advances in Information Theory, Statistics and Computer Applications* (Eds. Hooda DS and Hasija RC), Department of Mathematics & Statistics, CCS HAU, Hisar.

Singh R, Yadav DB, Yadav A and Punia SS. 2021. Characterization of herbicide use and factors responsible for herbicide resistance in *Phalaris minor* in wheat in Haryana, India. *Crop Protection* **144**: 105581.

Singh S, Malik RK, Balyan RS and Singh S. 1995. Distribution of weed flora of wheat in Haryana. *Indian Journal of Weed Science* **27**: 114–121.

Walia US, Kaur T, Nayyar S and Kaur R. 2011. Performance of ready-mix formulation of fenoxaprop + metribuzin for the control of grass and broadleaf weeds in wheat. *Indian Journal of Weed Science* **43**: 2–8.

Yadav DB, Yadav A, Punia SS and Chauhan BS. 2016. Management of herbicide-resistant *Phalaris minor* in wheat by sequential or tank-mix applications of pre-and post-emergence herbicides in north-western Indo-Gangetic Plains. *Crop Protection* **89**: 239–247.