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Efficacy of pre-emergence herbicides for control of weeds in wheat

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ABSTRACT

Phalaris minor Retz., a grassy weed, poses a significant threat to wheat production in the northwestern Indian plains due to its growing resistance to herbicides. The paper explores the effectiveness of pre-emergence (PE) herbicides for managing herbicide-resistant *Phalaris minor* in wheat fields. It highlights the promising results of combining pyroxasulfone with flumioxazin at the rate 127.5 g/ha + 100 g/ha, which effectively controlled *Phalaris minor* population (14.7 m^{-2}) and dry weight (5 g m^{-2}), along with higher grain (63.7 q/ha) and straw yield (116.2 q/ha). Although it was comparatively less effective against broad-leaved weeds like M*edigaco denticulata* and *Rumex dentatus*. However, it still recorded lowest total weed density and dry weight among all the herbicidal treatments used in the investigation. The study emphasizes the judicious herbicide use to prevent further resistance development. This information can guide farmers and researchers in developing sustainable solutions for managing herbicide-resistant *Phalaris minor* in wheat fields of northwestern India.

***Key words**: Wheat, Herbicide resistance,* Phalaris minor*, Herbicide mixture, Flumioxazin, Pyroxasulfone, Oxyfluorfen.*

Introduction

Wheat (*Triticum aestivum* (L.) emend. Fiori & Paol.) is the second most widely consumed staple food grain crop of India, having a production of 112.74 MT from an area of about 31.86 Mha (IIWBR, 2023). India achieved this level of production from the augmentation of green revolution during late 1960's which involved the introduction of input intensive high yielding dwarf varieties. Although it significantly improved the cereal productivity, farmers income and food availability but created several second-generation issues, weed flora shift, mono cropping, herbicide resistance in weeds etc.

Among various constraints limiting wheat production and productivity, weeds infestation is the major problem as they cause around 25-30% yield losses. However, under extreme cases can also lead to complete crop failure (Malik and Singh, 1995; Chhokar *et al*., 2019). Thus, to achieve sustained wheat production for supporting exponentially increasing population, identifying efficient weed control strategies has become a pre-requisite, particularly herbicides because of their time and cost efficiency and reduced labour requirement compared to other modes of weed control.

However, at many instances during the past 3-4 decades it was seen that continuous use of herbicides belonging to same mode of action has led to the evolution of herbicide resistant weeds particu-

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larly multiple herbicide resistant *Phalaris minor.* It was not a problem before green revolution but became a serious threat to wheat productivity afterwards with the introduction of input intensive cropping system along with less competitive high yielding semi-dwarf varieties. This was mainly attributed to failure of mechanical weed control approach due to its morphological similarity to wheat and lack of effective herbicides at that time and hence it ultimately established itself as a problematic weed (Malik and Singh, 1998 and Chhokar *et al.,* 2012).

During 1990's several phenylurea herbicides were introduced however isoproturon was widespread adopted due to its greater efficacy than other herbicides as it effectively controlled annual grassy weeds, i.e. little seed can arygrass. However, due to faulty spray technology (over and under dosage) and its continuous use for many years led to the development of isoproturon resistant *Phalaris minor*. In the following similar instances were reported by many experts with other herbicides namely clodinafop-propargyl, fenoxaprop-ethyl, sulfosulfuron, isoproturon, mesosulfuron-methyl, pinoxaden, pyroxsulam etc (Chhokar and Sharma, 2008; Heap, 2024). Therefore, it is necessary to screen the available herbicides with different mode of action for identifying the effective combination and implementation of herbicide rotation, and the study was undertaken with this objective.

Materials and Methods

This research comprised of field experiment which was conducted at main research farm of ICAR – Central Soil and Salinity Research Institute, Karnal (29°45'N, 76°58'E and 245 m AMSL), laid out in randomized block design consisting of 14 herbicidal treatments replicated thrice. Prior to the experiment the field site was under rice and quinoa rotation during 2022- 2023. The soil of experimental field was sandy loam in texture and slightly alkaline in reaction (pH – 7.65), having organic carbon of 0.60 %. All the data pertaining to wheat crop were taken at 30,60 and 90 DAS at meter row length, where the same for weeds were taken at 70 DAS by placing a quadrant of 25 cm x 25 cm at two places in the plot and all the weeds in the quadrant were independently counted and then their biomass was measured after cutting their roots and drying (firstly in shade for a week and then in oven at 65±5 °C for 2-3 days).

The field was prepared with a pre sowing irrigation to get field to fine tilth to augment wheat germination. Seed drill was used to sow 100 kg/ha of seeds of DBW – 222 and fertilizer application consisted of 150 kg N, 60 P_2O_5 and 40 K_20/ha, of which one third N and full dose of P and K were applied at the time of sowing while the remaining 2/3rd of N was applied in two splits, i.e. at 21 and 45 DAS respectively.

Results and Discussion

Weed density and weed dry weight

Data pertaining to weed dry weight and density has been presented in Table 1. The main weeds infesting the research field were *Phalaris minor* and *Medicago denticulate* and rest all were included on other weeds. Among them the most dominant weed was *Phalaris minor*. Mean density and dry weight of *Phalaris* in untreated plots (weedy check) was 501.3 m^{-2} and 235.7 g/m^2 respectively. *Medicago* was second most dominant weed of the experiment recording a density and dry weight of 19.3 m^{-2} and 5.3 g m^{-2} separately from the weedy check plot.

Among various herbicidal treatments tank mixed application of pyroxasulfone + flumioxazin at the rate 127.5 + 100 g/ha recorded significantly lower *Phalaris minor* and total weed density and dry weight amounting to 14.7 m^{-2}, 25.3 m^{-2} and 5 g m^{-2}, 7.7 g m^{-2} respectively. However lowest *Medicago* density and dry weight were observed with alone applied flumioxazin 125 g/ha (2.7 m^{-2} and 1 g/m^2) and mixture application of oxyfluorfen 300 g/ha + flumioxazin 100 g/ha (2.7 m^{-2} and 0.8 g/m^2). The results were in accordance with the finding of Chhokar *et al.,* (2019) and (2023) stating that pyroxasulfone and flumioxazin are effective alternative herbicides to control diverseweed flora in wheat especially grassy weeds like *Phalaris mnor*.

Based on data pertaining to total other weeds it was inferred that there was no significant difference between among various treatments in terms of density and dry weight however highest density and dry weight was recorded from weedy check plot (22.7 m^{-2} and 4.4 g m^{-2}) whereas the lowest was in weed free check followed by tank mix applied oxyfluorfen 300 g/ha + metribuzin 300 g/ha (0.7 m^{-2}and 0.1 g m^{-2}).

Plant growth parameters

With regards to effect of various herbicidal treat-

Table 1. Effect of different herbicides on density and dry weight of weeds at 70 DAS

S. No	Treatments	Weed density				Weed dry weight			
		Phalaris minor	Medicago denticulate	Total other weeds	Total Weeds	*Phalaris minor*	Medicago denticulate weeds	Total other	Total Weeds
1	Pyroxasulfone – 127.5 g/ha	5.12(26)	6.09(37.3)	4.41(24.7)	9.41(88)	3.08(8.6)	3.85(14.3)	2.47(6.3)	5.49(29.2)
2	Flumioxazin - 125 g/ha	6.7(45.3)	1.9(2.7)	2.67(8)	7.38(56)	4.02(15.3)	1.39(1)	1.44(1.2)	4.28(17.5)
3	Oxyfluorfen - 300 g/ha	14.07(204)	2.04(3.3)	3.28(11.3)	14.58(218.7)	9.32(88.4)	1.3(0.7)	2.29(4.6)	9.59(93.7)
4	Pendimethalin - 1500 g/ha	13.28(184)	6.07(36.7)	2.11(4.7)	14.87(225.3)	8.95(82.6)	3.52(11.7)	1.41(1.2)	9.7(95.4)
5	Metribuzin - 300 g/ha	14.09(202)	2.73(6.7)	3.71(14.7)	14.83(223.3)	9.03(81.7)	1.21(0.5)	1.45(1.3)	9.13(83.5)
6	Pyroxasulfone 127.5 g/ha + Pendimethalin 1500 g/ha	4.03(15.3)	5.71(33.3)	2.78(8)	7.48(56.7)	2.57(5.7)	3.57(12.1)	1.24(0.6)	4.39(18.3)
7	Pyroxasulfone 127.5 g/ha + Flumioxazin 100 g/ha	3.74(14.7)	2.32(4.7)	2.63(6)	5.06(25.3)	2.28(5)	1.41(1)	1.56(1.7)	2.87(7.7)
8	Pyroxasulfone 127.5 g/ha + Metribuzin 300 g/ha	4.59(20.7)	4.62(20.7)	3.49(11.3)	7.29(52.7)	3.03(8.2)	3.05(8.5)	2.01(3.8)	4.58(20.5)
9	Pendimethalin 1500 g/ha + Metribuzin 300 g/ha	12.02(149.3)	3.28(10)	2.85(8.7)	12.75(168)	7.91(66.5)	2.11(3.5)	1.29(0.7)	8.17(70.7)
10	Oxyfluorfen 300 g/ha + Metribuzin 300 g/ha	8.31(68.7)	3.92(14.7)	1.24(0.7)	9.2(84)	5.66(31.6)	2.35(4.6)	1.04(0.1)	6.06(36.3)
11	Pendimethalin 1500 g/ha + Flumioxazin 100 g/ha	11.17(124)	2.1(4)	1.87(4)	11.53(132)	7.3(52.4)	1.39(1)	1.47(1.6)	7.48(55)
12	Oxyfluorfen 300 g/ha + Flumioxazin 100 g/ha	6.26(42.7)	1.9(2.7)	2.18(4.7)	6.92(50)	3.67(13.7)	1.13(0.3)	1.23(0.6)	3.81(14.6)
13	Weed free check	1(0)	1(0)	1(0)	1(0)	1(0)	1(0)	1(0)	1(0)
14	Weedy check	22.41(501.3)	4.46(19.3)	4.68(22.7)	23.32(543.3)	15.34(235.7)	2.5(5.3)	2.24(4.4)	15.64(245.4)
	F - test	**S**	**S**	**NS**	**S**	**S**	**S**	**NS**	**S**
	Sem ±	1.136	0.438	0.872	1.102	0.787	0.235	0.392	0.779
	Cd at 5%	**3.32**	**1.28**	**-**	**3.222**	**2.301**	**0.668**	**-**	**2.276**

ments on growth parameters of wheat it was inferred that at 90 DAS weed free plot recorded significantly higher no. of tillers (104.00/mrl) and plant dry weight (205.30 / mrl) as presented in Table 2. Whereas among the various herbicidal treatments it was the mixture application of oxyfluorfen 300 g/ha with metribuzin 300 g/ha that recorded the highest dry weight at 90 DAS, while that of tiller (103.33/mrl) was recorded with the tank mix applied pyroxasulfone + flumioxazin at the rate 127.5 + 100 g/ha. Similar results were also reported by Chhokar *et al.,* (2019) signifying that application of flumioxazin in the range 125-150 g/ha gave higher tillers per running meter row length along with other growth parameters and yield.

Yield attributes of wheat

Grain and straw yield are the result of the interaction of many factors and is a crucial metric for assessing and comparing the efficacy of various herbicidal treatments as shown in the Figure 1. The growth of weeds during the crop-growing season causes significant reduction in grain yield of wheat however noticeably higher grain yields *viz.,*63.7 q/hawas recorded with the mixture application of pyroxasulfone + flumioxazin at 127.5 + 100 g/ha (63.7 q/ha). Similarly, data presented in figure1 indicated that straw yield was significantly increased with various weed control treatments over weedy check (116.2 q/ha). Among the herbicidal treatments, the maximum straw yield, (164.7 q ha^{-1}) was obtained under PE application of pyroxasulfone + flumioxazin 127.5 + 100 g/ha. The results were in accordance with Chhokar *et al.,* (2019), that is compared with the un-weeded control (weedy check) and the plots that received the pendimethalin treatments, the treatments with flumioxazin, at 125-150 g a.i./ha, produced much higher grain yields (i.e., up to 159% and up to 49% increased yield gain, respectively).

Conclusion

On the basis of investigation, it is concluded that pyroxasulfone in combination with flumioxazin is quite effective for control of grassy weed namely *Phalaris minor* but com-

Table 2. Effect of different herbicide treatments on tillers and plant dry weight at 90 DAS

Sr. No	Treatments	Tillers (/mrl)	Plant dry weight(/mrl)
1	Pyroxasulfone – 127.5 g/ha	101.33	195.92
2	Flumioxazin - 125 g/ha	100.67	193.79
3	Oxyfluorfen - 300 g/ha	86.67	174.49
4	Pendimethalin - 1500 g/ha	87.33	172.20
5	Metribuzin - 300 g/ha	86.00	171.15
6	Pyroxasulfone 127.5 g/ha + Pendimethalin 1500 g/ha	101.40	197.46
7	Pyroxasulfone 127.5 g/ha + Flumioxazin 100 g/ha	103.33	194.32
8	Pyroxasulfone 127.5 g/ha + Metribuzin 300 g/ha	102.67	198.79
9	Pendimethalin 1500 g/ha + Metribuzin 300 g/ha	97.33	178.18
10	Oxyfluorfen 300 g/ha + Metribuzin 300 g/ha	102.33	196.76
11	Pendimethalin 1500 g/ha + Flumioxazin 100 g/ha	96.67	180.82
12	Oxyfluorfen 300 g/ha + Flumioxazin 100 g/ha	99.33	186.20
13	Weed free check	104.00	205.30
14	Weedy check	73.33	160.44
	F - test	**S**	**S**
	Sem ±	2.691	7.50
	Cd at 5%	**7.866**	**21.92**

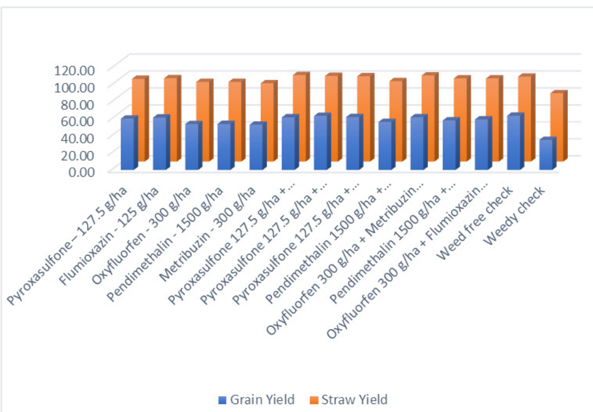

Fig. 1. Effect of herbicides on grain and straw yield of wheat at 90 DAS

paratively poor against broad-leaved weeds (*Medicago denticulata* and *R. dentatus*). Compared to pendimethalin, pyroxasulfone has wider application window as it can be applied as pre-plant in combination with different herbicide with minimum to none antagonistic effect. Among herbicidal treatments, pre-plant tank-mix combination of pyroxasulfone + flumioxazin at 127.5 + 100 g/ha was found the most effective combination for controlling diverse weed flora in wheat fields, recording lowest total weed density (8.7, 25.3 and 25.3 /m^2) and dry weight (0.7, 7.7 and 16.1 /m^2) at 45, 70 and 105 DAS respectively, along with grain yield (63.7 q/ha) and straw yield (164.7 q/ha).

Conflict of Interest- None

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