# Resistance to isoproturon in *Phalaris minor* Retz. in Punjab

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## Summary

**Investigations were conducted during 1993-94 and 1994-95 to study the occurrence of resistance in *Phalaris minor* Retz. to isoproturon and to find out effective alternative herbicides to control the resistant biotypes. Seeds of different phalaris biotypes were collected from farmer's fields where poor or no control of this weed was noticed over the last three to four years with post-emergence application of isoproturon. Most of the biotypes were not controlled by isoproturon even at double the recommended dose (1.88 kg ha$^{-1}$) although it showed phyto-toxic effects on the wheat crop. All the biotypes were controlled by the post-emergence application of tralkoxydim 0.35 kg ha$^{-1}$ and diclofop-methyl 0.90 kg ha$^{-1}$ applied at 2–3 leaf stage of phalaris. These studies clearly show that phalaris populations have developed resistance to isoproturon. All (resistant and susceptible) biotypes when grown in association with wheat suffered severe competition reflected in greatly reduced shoot biomass as compared to phalaris monoculture. This implies that crop can assert a large smothering effect on phalaris thus aiding in better weed control.**

## Introduction

Wheat crops occupy a prime position in Indian agriculture. In North India, the infestation of *Phalaris minor* has posed a serious threat to its successful cultivation. At present, *P. minor* is being controlled by the application of isoproturon which has been in use since 1982. By and large this herbicide provided acceptable control of *P. minor* for about one decade. Because of the sole reliance on isoproturon over the last 14 years, there are frequent reports of inadequate control of phalaris primarily from areas where rice-wheat rotation is followed. The poor control of this weed was initially attributed to non-adoption of proper herbicide use technology and changes in physico-chemical conditions of the soil in the rice-wheat system. However, the phenomenon of herbicide resistance could not be ruled out.

Worldwide 107 herbicide resistant weed biotypes have been reported from various locations. This includes 57 weed species resistant to triazine herbicides and 50 species resistant to 14 other classes of herbicides (LeBaron 1993). The experiment reported here was planned to investigate the development of resistance to isoproturon in phalaris and to explore the suitability of alternative herbicides for use against this weed.

## Materials and methods

The present investigations were conducted at the Research Farm of the Department of Agronomy, Punjab Agricultural University, Ludhiana during 1993–94 and 1994–95. Seeds of phalaris biotypes were collected form fields where it was not controlled by isoproturon for the last three to four years. During 1993–94, a preliminary unreplicated trial was conducted by growing eight biotypes of phalaris. In 1994–95 sixteen biotypes were grown and their tolerance to isoproturon and other herbicides was compared with the susceptible biotype, PAU Ludhiana. Two rows of each biotype were sown alone in the field during 1993–94. During 1994–95 two rows of each biotype were sown in monoculture and in a mixture with wheat. The soil of the field was a sandy loam in texture and neutral in reaction.

These biotypes were sprayed with five herbicide treatments viz. isoproturon 0.94 kg ha$^{-1}$ (R=recommended), isoproturon 1.41 kg (1.5 × R), isoproturon 1.88 kg (2 × R), diclofop-methyl 0.90 kg ha$^{-1}$ (R) and tralkoxydim 0.35 kg ha$^{-1}$ (R). During 1994–95 isoproturon at the recommended level was followed by a late application of metoxuron at 1.5 kg ha$^{-1}$ (R). For comparison an untreated plot was also kept. These herbicides were sprayed when phalaris was at 2–3 leaf stage (30–35 days after sowing) at a volume of 500 L ha$^{-1}$. Spraying pressure of 60 psi was maintained during the spray. These trials were laid out in a split plot design with six herbicide treatments in the main plots and phalaris biotypes in the sub-plots. Biotypes were sown on 5 December 1993 and 11 November 1994. Gross main plot size in 1993–94 was 33 m$^2$ and during 1994–95, 23.6 m$^2$ in phalaris alone trial and 32.2 m$^2$ in phalaris plus wheat trial (cv. HD 2329) trial. In the first year treatments were unreplicated, whereas in the second year there were three replications of phalaris alone and four of phalaris and wheat association experiment. Dry matter of phalaris was recorded from a 2 m row length in phalaris alone and in association with wheat trial. Ear length was measured from 10 phalaris plants in each plot. Net wheat plot harvested was 1.35 m$^2$. Data was subjected to analysis of variance and means were compared by using LSD at 5% level of significance.

## Results

### *Experiment 1*

Preliminary investigation conducted during 1993–94 gave indications of resistance in phalaris to isoproturon with ineffective control observed even at double the recommended rate. However, post-emergence application of diclofop-methyl and tralkoxydim gave a complete control of all biotypes (Table 1).

### *Experiment 2*

**Phalaris shoot dry matter** In an experiment where phalaris biotypes were grown alone, application of tralkoxydim and diclofop-methyl significantly reduced final dry matter of phalaris as compared to untreated (control) treatment. In cropping situations (phalaris and wheat grown in association) all the herbicides significantly reduced the dry matter of phalaris biotypes compared to untreated (control) crop (Table 2).

In respect of dry matter production, different biotypes behaved differently particularly when sown alone (without crop). Most of the biotypes ($B_3$–$B_{15}$) produced significantly more dry matter than susceptible biotype of PAU, which being at par with $B_1$ and $B_2$. The dry matter of various biotypes was greatly reduced when grown in association with wheat.

**Table 1. Effect of herbicide treatments on various morphological characteristics of phalaris biotypes during 1993–94.**

| Herbicide | Rate (kg ha$^{-1}$) | Dry matter phalaris (kg ha$^{-1}$) | Final height of phalaris (cm) | Tillers of phalaris m$^{-1}$ row length | Length of ear (cm) |
|---|---|---|---|---|---|
| Isoproturon (R) | 0.94 | 2560 | 50.2 | 65 | 5.2 |
| Isoproturon (1.5R) | 1.41 | 2960 | 50.4 | 38 | 4.7 |
| Isoproturon (2R) | 1.88 | 2260 | 46.2 | 27 | 4.1 |
| Diclofop (R) | 0.90 | 0 | 0.0 | 0.0 | 0.0 |
| Tralkoxydim (R) | 0.35 | 0 | 0.0 | 0.0 | 0.0 |
| Control (unweeded) | – | 8540 | 66.6 | 129 | 7.2 |

**Ear length** Ear length of phalaris biotypes was not influenced by various herbicide treatments when grown without wheat (Table 2). However, these differences were significant when wheat was grown in association with phalaris biotypes. All the herbicides significantly reduced ear length of phalaris as compared to control treatment. Diclofop-methyl reduced the length of phalaris ears to a minimum of 1.4 cm and was significantly less than isoproturon 1.5 R and 2 R. Among the various biotypes $B_6$, $B_7$ and $B_{11}$ had same ear length as that of PAU biotype ($B_{16}$). Biotype $B_{10}$ had the longest ear (4.0 cm).

**Grain yield** Grain yield of the crop treated with either diclofop-methyl or tralkoxydim were significantly higher than the untreated crop and all the treatments of isoproturon (Table 3). The grain yield of wheat growing with most of the biotypes was at par with that of wheat growing with susceptible biotype. Lowest grain yield of 3510 kg ha$^{-1}$ was recorded in wheat grown in association with $B_{10}$ which was significantly lower than all biotypes-crop associations excepting $B_{12}$.

The interaction effect of herbicides × biotypes for grain yield was also significant (Table 3). Most of the biotypes had a variable effect on wheat grain yield in response to applied herbicides. Tralkoxydim decreased the grain yield of wheat significantly in $B_{10}$, $B_{13}$ to $B_{15}$ and diclofop-methyl increased grain yield of wheat associated with $B_8$ compared to PAU biotype ($B_{16}$). On the other hand application of isoproturon followed by metoxuron significantly reduced grain yield of wheat associated with $B_{12}$ and isoproturon at 2 R in $B_1$ treatment as compared to $B_{16}$, showing thereby differential behaviour to herbicides.

**Table 2. Effect of herbicide treatments on dry matter and ear length of phalaris biotypes.**

| Treatments | Final dry matter of phalaris biotypes (kg ha$^{-1}$) | | Length of phalaris ear (cm) | |
|---|---|---|---|---|
| | alone | with wheat | alone | with wheat |
| Main plots (Herbicides) | | | | |
| Isoproturon (R) f.b. Metoxuron (R) | 3130 | 190 | 5.3 | 2.1 |
| Isoproturon (1.5R) | 4520 | 370 | 6.1 | 3.1 |
| Isoproturon (2R) | 3970 | 530 | 5.6 | 3.7 |
| Diclofop (R) | 1470 | 260 | 4.3 | 1.4 |
| Tralkoxydim (R) | 1840 | 290 | 6.5 | 1.7 |
| Untreated | 4590 | 710 | 6.6 | 6.3 |
| LSD at 5% | 2150 | 100 | ns | 1.6 |
| Sub-plots (Biotypes) | | | | |
| **Dist. Faridkot** | | | | |
| $B_1$ Korewal | 1780 | 420 | 5.4 | 3.5 |
| $B_2$ Khai | 2380 | 450 | 5.6 | 3.7 |
| $B_3$ Kilichalan | 3520 | 470 | 5.4 | 3.7 |
| $B_4$ Tharaj | 4370 | 420 | 5.6 | 3.7 |
| **Dist. Kapurthala** | | | | |
| $B_5$ Hadrabad Bet | 4060 | 420 | 5.4 | 3.2 |
| $B_6$ Tiba | 2800 | 360 | 5.6 | 2.5 |
| $B_7$ Muktramwala | 2480 | 270 | 5.6 | 1.5 |
| **Dist. Amritsar** | | | | |
| $B_8$ Batara Singhwala | 3460 | 330 | 5.8 | 3.1 |
| $B_9$ Rajoke | 4390 | 340 | 5.5 | 3.3 |
| $B_{10}$ Rajoke | 3580 | 400 | 5.6 | 4.0 |
| $B_{11}$ Naushehra Pannua | 3820 | 440 | 5.5 | 2.4 |
| $B_{12}$ Khasian | 3430 | 480 | 5.6 | 3.5 |
| $B_{13}$ Sarhali Jandoke | 3820 | 370 | 5.5 | 2.8 |
| **Dist. Fatehgarh** | | | | |
| $B_{14}$ Fatehgarh | 3950 | 260 | 5.7 | 2.7 |
| **Dist. Ludhiana** | | | | |
| $B_{15}$ Kum Kalan | 2910 | 420 | 5.7 | 3.3 |
| $B_{16}$ Research Farm PAU Ludhiana | 1300 | 230 | 3.4 | 1.6 |
| LSD 5% | 1150 | ns | ns | 0.9 |
| LSD for interaction | ns | ns | ns | ns |

## Discussion

As indicated by dry matter production of *Phalaris minor* Retz., isoproturon at all the rates failed to control various biotypes effectively. Poor control of these biotypes by isoproturon resulted in lower grain yield of wheat. This may be due to the development of resistance in phalaris to isoproturon owing to continuous use of this herbicide for more than a decade. These studies corroborate the findings of Malik and Singh (1993) who reported that phalaris has started possessing resistance mechanism(s) in its self-defence against isoproturon. Isoproturon at higher doses proved toxic to the crop and crop growth was arrested. Hence due to less canopy pressure phalaris produced significantly more dry matter than with other herbicides. Tralkoxydim and diclofop-methyl gave good control of phalaris biotypes. Tralkoxydim reduced the grain yield of wheat in association with few biotypes which does not, however, tally with their dry matter production. This implies that yield reduction was not on account of poor control of these biotypes but due to

**Table 3. Herbicide × biotype interaction for grain yield (kg ha$^{-1}$).**

| Herbicide treatments | Biotypes[A] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $B_1$ | $B_2$ | $B_3$ | $B_4$ | $B_5$ | $B_6$ | $B_7$ | $B_8$ | $B_9$ | $B_{10}$ | $B_{11}$ | $B_{12}$ | $B_{13}$ | $B_{14}$ | $B_{15}$ | $B_{16}$ | Mean |
| Iso(R) f.b. Metox(R) | 4000 | 3740 | 3890 | 3790 | 3440 | 3550 | 3590 | 3870 | 3440 | 3590 | 3640 | 3220 | 4050 | 3900 | 4010 | 3800 | 3720 |
| Isoproturon (1.5R) | 3740 | 3700 | 3870 | 4180 | 3740 | 3720 | 3500 | 3940 | 4000 | 3380 | 3870 | 3490 | 3570 | 3720 | 4200 | 3710 | 3770 |
| Isoproturon (2R) | 3050 | 3810 | 3500 | 3590 | 3960 | 4020 | 3840 | 4120 | 3740 | 3380 | 3680 | 3420 | 3550 | 4160 | 3960 | 3810 | 3720 |
| Diclofop (R) | 4050 | 4370 | 4090 | 4220 | 4270 | 4200 | 4000 | 4550 | 4090 | 3720 | 3680 | 3940 | 4330 | 4530 | 4010 | 4040 | 4130 |
| Tralkoxydim (R) | 4670 | 4130 | 4070 | 4180 | 4250 | 3940 | 4410 | 4060 | 3920 | 3680 | 4220 | 4180 | 3870 | 3890 | 3870 | 4400 | 4110 |
| Untreated | 3880 | 4420 | 3320 | 3970 | 4010 | 3700 | 4000 | 3720 | 4380 | 3350 | 3690 | 3520 | 3500 | 3840 | 3820 | 4000 | 3820 |
| Mean | 3900 | 4030 | 3790 | 3990 | 3950 | 3860 | 3910 | 4040 | 3930 | 3510 | 3800 | 3630 | 3810 | 4010 | 3980 | 3960 | |

LSD for herbicide treatments = 260.
LSD for biotypes = 190.
LSD for interaction = 500.
[A] Biotype detail as in Table 2.

some other reasons, possibly partial shading by trees growing near the boundary. On average, the application of tralkoxydim and diclofop-methyl significantly improved the wheat grain yield compared with all treatments of isoproturon and the untreated crop. Higher yield is due to the better control potential of most biotypes as indicated by dry matter production data.

Dry matter production by phalaris biotypes was severely reduced by the smothering effect of crop apart from herbicide killing. Different biotypes accumulated variable dry matter in phalaris monoculture. Dry matter accumulation by PAU biotype was significantly less than most of the tested biotypes. However, at the time of harvest, the dry matter production of all the biotypes in association with wheat was statistically at par, which is due to the smothering effect provided by the crop (Table 2). On average, dry matter of phalaris biotypes was reduced by ten times in association with crop compared to phalaris monoculture indicating that crop has a large smothering potential.

Diclofop-methyl and tralkoxydim seem to be best alternatives to isoproturon. Since resistance to diclofop-methyl in blackgrass (in UK) and in ryegrass (in Australia) has already been reported (Moss and Cussans 1993, Heap 1993). There is a strong fear of resistance developing in phalaris to these herbicides. Hence, there is a need for development of rational integrated weed management programmes, through research, in order to extend the useful life of these alternative herbicides. Besides new herbicides various cultural practices viz. competitive cultivars, crop density, crop geometry (Singh 1996) etc. could be exploited to increase the crop smothering potential.

## References

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