HERBICIDE RESISTANCE IN WILD OATS IN SOUTHERN NEW SOUTH WALES

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Abstract

Samples of wild oat (*Avena*? spp.) seed collected in a random survey of farms in 1991 and 1994 across a 400 km by 150 km transect in southern New South Wales were screened to detect resistance to three wild oat herbicides. Of 108 samples collected in 1991, three were found to be resistant to diclofop-methyl. One of these samples as well as a new population was found when the sites were resurveyed in 1994. No resistance at a commercial level to flamprop-methyl or triallate was detected in either survey. However, one plant was detected with resistance to flamprop-methyl. Resistance to diclofop-methyl appeared to be associated with continuous cropping, repeated use of 'fop' or 'dim' herbicides; practices which had also resulted in resistance in annual ryegrass (*Lolium rigidum*) at the same sites. Two of the resistant wild oat populations were confirmed as *Avena ludoviciana* and two as *A. fatua*.

Keywords: Herbicide resistance, wild oats, Avena spp.

Wild oats (*Avena* spp.) are important weeds in the southern Australia wheat belt (4). There is a range of control techniques that can be utilised to control wild oats in crops. Unfortunately, many of these techniques are either costly or inefficient and herbicides remain the favoured strategy as they provide an immediate and cost effective method of control (6).

The dependence on selective herbicides has led to the development of resistance in many weeds including wild oats. The first report in Australia of resistance in wild oats was in 1985 when a population of *A. fatua* in Western Australia was observed to be poorly controlled by diclofop-methyl (9, 10, 3).

The aim of this survey was to determine the incidence of herbicide resistance in wild oats to three herbicides, triallate (Avadex BW?), diclofop-methyl (Hoegrass?), and flamprop-methyl (Mataven?) in southern NSW in 1991 and to quantify any increase in the level of resistance to these herbicides in 1994.

Materials and methods

Wild oat seed was collected in a random survey in late 1991 from 108 sites in southern New South Wales, across a transect approximately 400 km by 150 km in southern NSW from Cowra in the north to Oaklands in the south (Fig. 1). The survey was repeated in 1994, but due to drought conditions only 41 of the original 108 sites had wild oat infestations from which samples could be collected (Fig. 1).

Due to the large number of samples and space limitations testing was carried out at different times (Table 1), with replication occurring over time for all herbicides for the 1991 samples only. Because of smaller numbers of samples collected in 1994, all replicates were screened concurrently. However, because of dormancy effects germination was variable and staggered and samples were rescreened if plants survived treatment at the recommended dose rate. Twenty seeds of each sample were sown into trays and thinned to 10 seedlings prior to spraying in the case of the early post emergence herbicides (Table 1). Chemicals were applied in a spray cabinet at 0 (control), 0.5, 1.0 or 2.0 times the recommended rate (R), with the respective rates of active ingredient as indicated in Table 1. In the case of triallate the herbicide was incorporated by raking the soil several times prior to sowing seeds within the raked layer after which the soil was re-raked.

Twenty one days after spraying (in the case of the 1991 survey) and 28 days (in the case of the 1994 survey) the plants were cut at the soil surface, dried at 70^{o}C for 72 hours and then weighed. Dry weights as percentage relative to the untreated controls (0R) were calculated for each herbicide and rate as a measure of efficacy/resistance. Data were arcsine transformed and analysed as a two-way ANOVA.

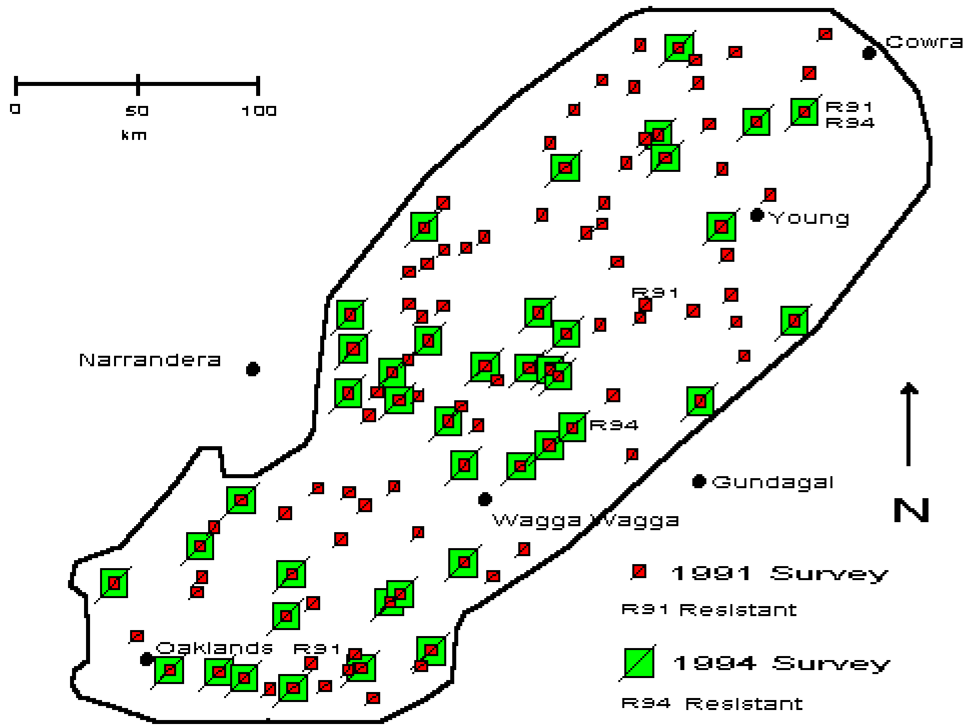

Figure 1: Map of survey area showing location of sample sites

Table 1: Details of testing periods, stage of wild oat growth and dose rates of herbicides applied.

Herbicide	Testing period	Treated		Dose rate
		days after planting	Zadoks	g a.i./ha
diclofop-methyl	May 1994 - May 1996	24-30	12-13	0, 281, 563, 1125
flamprop-methyl	August 1994 - October 1996	29-35	21-23	0, 225, 450, 900
triallate	October 1994 - June 1996	pre-emergence		0, 400, 800, 1600

?

Results and discussion

Although far fewer of the paddocks sampled in 1991 (108) yielded samples in 1994 (41) due to drought, these were distributed throughout the original range of locations (Fig. 1). Given this 'common' range across a number of districts, each with independent advisory personnel, the two surveys probably captured a similar cross section of management practices. This was borne out by the result that all the cases of wild oats resistance detected in the two surveys coincided with at least some of the sites where resistance to diclofop-methyl in annual ryegrass (*Lolium rigidum*) had been detected (11).

Using the criterion outlined by Heap and Knight (1) for annual ryegrass, whereby plants treated with the recommended dose rate of a herbicide were considered to be tolerant if biomass exceeded 80% of the untreated, it was found that three samples of wild oats were resistant to diclofop-methyl in 1991 (Table 2) and two samples in 1994.

Irrespective of dose rate, the majority of samples produced less than 60% relative dry matter when treated with diclofop-methyl (Table 2). However, three samples (2.8%) produced greater than 80% relative dry matter at the recommended rate of diclofop-methyl. Two of these also fell into this category at 0.5R, and both of these at 2R either produced 60 to 80% or greater than 80% relative dry matter. Inadequate seed prevented the third sample from being tested at these rates.

In the 1994 survey, two samples were classified as resistant, one of which was classed as resistant in the 1991 survey. The second sample was only tested at 1R and at that rate had a survival percentage of 56% while the dry matter production of this sample was only 30% of control. Although this sample did not meet the criterion used in the 1991 survey for resistance (>80 % dry matter production relative to control) it was significantly more resistant than other samples (survival % P<0.001, l.s.d. = 11.4).

Table 2: Number of samples per category of dry matter production, relative to the control of each sample, for three rates of diclofop-methyl application for seed collected in 1991.

	Number of samples			
Rate of diclofop-methyl	*0.5R*	*1R*	*2R*	*Over all rates*
% dry matter				
0-59.9	*97 (92.4%)*	*105 (97.2%)*	*103 (98.2%)*	*105 (97.2%)*
60-79.9	*6 (5.7%)*	*0*	*1 (0.9%)*	*0*
80 +	*2 (1.9%)*	*3 (2.8%)*	*1 (0.9%)*	*3 (2.8%)*

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Two of the three populations displaying resistance to diclofop-methyl in 1991 were identified as *Avena ludoviciana* and the third, which was tested only at the recommended rate was *A. fatua*. The sample detected as resistant in 1994 was *A. fatua*. Two of the resistant populations came from paddocks which had been cropped continuously for 12 years prior to the 1991 survey. Eleven applications of either a 'fop' or a 'dim' herbicide had been used on one site whilst the other had received eight.

The 1991 survey obtained seed from the same sites as the annual ryegrass survey conducted by Pratley et al. (11). In that survey 14% of annual ryegrass seed samples were classed as resistant to diclofop-methyl. This survey found only 3% of wild oat seed samples to be resistant to diclofop-methyl. This compares to survey findings in South Australia (1993) where 4% of cropping paddocks contained diclofop-methyl resistant wild oats (7) and in Victoria (1992), 6% of paddocks (M.Walsh, *pers. comm*.). Herbicide resistance has developed quicker in annual ryegrass than in wild oats due to factors such as cross pollination, quicker seed bank turnover, less staggered germination and shorter dormancy (3).

Flamprop-methyl is widely used in the northern cropping region of Australia, but little in the southern winter rainfall areas.? As a herbicide which has a different mode of action to the majority of wild oat post emergent herbicides it is potentially useful as part of a chemical management program to reduce the risk of herbicide resistance developing.? However, since Kibite and Harker (2) found resistance to flamprop-methyl in a number of other Avena spp. there is every likelihood that heavy usage of this herbicide could also select for resistance. This possibility is upheld by the recording of resistance to a closely related herbicide, flamprop-iso-propyl, in the United Kingdom (5).

Applications of flamprop-methyl resulted in very little plant mortality, but there was notable retardation of growth prior to harvesting. At the recommended rate of application the highest relative dry matter production recorded for the 1991 samples was 53% compared with 62% for the 1994 samples and regardless of dose rate mean biomass was generally reduced by two thirds (Table 3). In comparison to other post emergent herbicides, plants sprayed with flamprop-methyl produce a larger proportion of biomass prior to spray application due to its later time of application.

Table 3: Mean and highest dry matter production of wild oat seedlings for three rates of flamprop-methyl in seed collected in 1991 and 1994.

	1991 Survey		1994 Survey	
Rate of flamprop-methyl	Highest (%)	Mean (%)	Highest (%)	Mean (%)
05R	59.0	35.29	64.67	33.12
1R	53.33	33.73	62.33	36.8
2R	45.67	33.09	52.33	26.46

Table 4: Mean and highest dry matter production for three rates of triallate in wild oat seedlings from the 1991 and 1994 collections.

	1991 Survey		1994 Survey	
Rate of triallate	Highest (%)	Mean (%)	Highest (%)	Mean (%)
05R	38.33	10.57	26.55	10.27
1R	21.0	3.91	12.56	3.08
2R	11.0	1.36	8.33	0.8

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One plant sampled during 1991 showed no inhibition to flamprop-methyl and seed from it was grown on and re-tested. When evaluated six weeks after spraying with the recommended rate of flamprop-methyl all individuals from this clone were found to have survived with no visual difference in plant health. No measurements of biomass were obtained from these plants to allow for seed collection.

There were significant differences in relative biomass between the highest and lowest producing samples for flamprop-methyl and triallate, however, no sample produced sufficient biomass to be classed as resistant. Several, but not all, of the populations which had high bio- mass production for flamprop-methyl or triallate at one herbicide rate also produced high levels of biomass at the other treatment rates. While this may be a sign of enhanced tolerance, it is compounded by the varying amounts of early growth and its impact on the level of biomass production relative to that of the control.

Biomass was markedly reduced in all populations sampled in both 1991 and 1994, irrespective of the dose rate of triallate. At the recommended rate the highest relative biomass was 21% and 13% for 1991 and 1994 samples, respectively, and overall biomass was always reduced by more than approximately 90% (Table 4).

O'Donovan *et al.* (8) found that a history of continuous cropping and continuous triallate use was needed for resistance to triallate to develop in Canada and the USA. In this survey area the highest number of triallate applications to any paddock between 1980 and 1991 was three and that paddock had been in pasture for nine of the twelve years.

Conclusions

The level of resistance to diclofop-methyl increased from three percent in 1991 to five percent in 1994 but remains at a relatively low level. This finding however reinforces the need for farmers to monitor herbicide performance for wild oat control and have seed tested regularly for resistance status.

Acknowledgments

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