A survey of southern New South Wales to determine the level of herbicide resistance in brome grass and barley grass populations

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Summary Herbicide resistance has developed in many populations of the two major annual grass weed species, annual ryegrass and wild oats, found in the cropping region of southern New South Wales. In those weed species resistance is a major factor in weed management. Management practices for control of resistant annual ryegrass or wild oats may encourage the growth of brome or barley grass. Approximately 4 million ha of southern New South Wales were surveyed for herbicide resistance in 2007. Where present, samples of brome and barley grass were collected resulting in 10 brome grass and 13 barley grass samples from 22 locations. Each accession was screened with five herbicides (Groups A 'fop', A 'dim', C, L and M) with none found to be resistant to any of the tested herbicides. This was despite high levels of herbicide resistance in both the annual ryegrass and wild oat populations collected from the same paddocks. Resistance to a Group A 'fop' herbicide was recorded in 82% of annual ryegrass and 57% of wild oat accessions from these sites, while 21% of the annual ryegrass accessions tested were also resistant to the Group A 'dim' herbicide clethodim. While not all herbicides used for the control of annual ryegrass or wild oats are also used for brome grass and barley grass, many are. That no brome or barley grass populations were resistant, despite the selection pressure placed on them when targeting annual ryegrass and wild oats, shows that herbicide resistance is yet to develop in these two species in the surveyed area.

Keywords Herbicide resistance, brome grass, barley grass.

INTRODUCTION

Herbicide resistant weeds are a major problem in the cropping regions of Australia. Resistance was first reported in Australia in 1980, in annual ryegrass to the herbicide diclofop-methyl (Heap and Knight 1982), and subsequently in wild oats (*Avena fatua* L.) in 1985, again to diclofop-methyl (Piper 1990) and in two species of barley grass (*Hordeum glaucum* Steud. and *H. leporinum* Link) to paraquat in 1982 and 1987 respectively (Powles 1986, Tucker and Powles 1991).

Since these initial findings many paddocks throughout the Australian cropping region have been found to contain herbicide resistant weeds. Surveys of annual ryegrass in Western Australia have found 68% of samples resistant to diclofop-methyl (Group A 'fop'), 88% to sulfometuron (Group B) and 8% to clethodim (Group A 'dim') (Owen *et al.* 2007). In southern New South Wales the levels found in 2007 were 81%, 70% and 21% for diclofop-methyl, sulfonylurea (Group B) and clethodim, respectively (Broster *et al.* in press). Similar levels of resistance have also been detected in regions of South Australia and Victoria (C. Preston unpublished data).

Similarly, the level of resistance in wild oats to Group A 'fop' herbicides has been recorded at 13% in South Australia and 17% in Victoria (C. Preston unpublished data), 38% in southern New South Wales (J.C. Broster unpublished data) and 71% in Western Australia (Owen and Powles 2009). Surveys of brome grass (*Bromus* spp.) have detected resistance to haloxyfop-R methyl in 33% of samples in Victoria and 2% in South Australia (C. Preston unpublished data).

Populations of both brome grass and barley grass resistant to selective herbicides have been recorded in Australia previously. Brome grass populations resistant to Group A 'fop' herbicides have been detected in both Victoria and South Australia and many of these populations are also resistant to the group A 'dim' herbicides (Heap 2009). Barley grass populations resistant to Group A 'fop' herbicides have been found in South Australia (Heap 2009), while a population from New South Wales, within the area of this survey, was found to be highly resistant to both Group A 'fop' and 'dim' herbicides (Heap 2009).

With the high incidence of herbicide resistance in annual ryegrass, alternative weed control methods are being used for the control of resistant populations (McGillion and Storrie 2006). These methods have been specifically adopted to manage annual ryegrass populations and may not be as effective on other weed species, for example, chaff carts for wild oats collection (Walsh and Powles 2007) and this may lead to increases in some weed species when annual ryegrass populations are reduced (Matthews and Powles 1996).

Prior to the research described here, no surveys to determine the resistance status of brome grass or barley grass had been conducted in southern New South Wales. This paper describes the results of a survey to provide this information.

MATERIALS AND METHODS

Sample collection Cropping paddocks in an area of southern New South Wales between Dubbo in the North and the Victorian border in the south were surveyed over a 4 week period in November and December 2007 prior to the commencement of harvest. Paddocks were randomly selected at 10 km intervals, alternating left and right hand side of the survey transect where possible. The location of all sites was recorded using a GPS unit.

The paddocks were sampled by two people walking across them for a 10–15 minute period. Mature seed heads were collected from plants along the sampling path. After collection the samples obtained by the two people were bulked to obtain a single sample for the paddock. A total of 181 paddocks were visited, collecting 137 annual ryegrass and 112 wild oat (*Avena* spp.) samples. While this survey targeted annual ryegrass and wild oat samples, 10 brome grass and 13 barley grass (*Hordeum* spp.) samples were also collected from paddocks spread across the surveyed area.

Immediately after collection the seed samples were stored in a glasshouse until February 2008 when they were threshed and cleaned.

Resistance screening In August 2009 pots were sown with 25 seeds of either brome grass or barley grass. For all samples three replicates were sown. Two weeks after sowing all samples in the post-emergent herbicide treatments were counted and thinned to a maximum of 10 plants per pot. Pots were kept in a temperature controlled glasshouse (10°C minimum, 25°C maximum) and watered and fertilised as required. For the post-emergent herbicides the pots were filled with a 50:50 peat:sand mix and for the pre-emergent herbicide a soil mix (50:50 loam:river wash sand).

The samples were screened with four post-emergent herbicides across Groups A, L and M. Haloxyfop-R methyl, clethodim, paraquat + diquat and glyphosate were all applied when the plants were at growth stage Z12–13 (Zadoks *et al.* 1974). The pre-emergent herbicide simazine (Group C) was also tested. In this experiment, the pots were sprayed, the herbicide incorporated, the seeds were then sown and incorporated again. Herbicides were applied at the label recommended rate (Table 1).

At the recommended stage of growth, all herbicides were applied using an automated laboratory-sized cabinet sprayer with a moving boom, applying a water volume of 77 L ha^{-1} equivalent from a flat fan nozzle at 300 kPa pressure. Adjuvants were added to herbicides as specified by label requirement. A standard susceptible biotype and a known resistant biotype, where available, were included with each cohort of samples, with each herbicide tested in a completely randomised design.

The 137 annual ryegrass samples had been screened in 2008 to herbicides from Groups A ‘fop’, A ‘dim’, B, C, D and M using the herbicide resistance testing protocol from Broster and Pratley (2006). In June and July 2009, 112 wild oat samples had been screened to herbicides from Groups A ‘fop’, A ‘dim’, B, M and Z using the same methodology as the brome grass and barley grass samples.

Table 1. Herbicides and rates used for resistance screening (adjuvants were added as per label instructions).

Herbicide	Group	Rate (g a.i. ha^{-1})
Haloxyfop-R methyl	A (fop)	26
Clethodim	A (dim)	48
Simazine	C	1260
Paraquat + diquat	L	400
Glyphosate	M	572

Herbicide evaluation All samples were assessed 28 days after treatment. Seedlings in post-emergent treatments were counted before and after treatment to enable survival percentages to be calculated. Samples sprayed pre-emergent were rated visually from 0 (no germination) to 10 (no visual difference from susceptible control).

Samples were classified as resistant if the mean survival percentage was greater than 20% for post-emergent herbicides or a visual score of greater than 2 for pre-emergent herbicide. Samples with survival percentages of between 10 and 19% for post-emergent herbicides or a visual score of between 1 and 2 for pre-emergent herbicide were classed as developing resistance.

RESULTS

This survey visited 181 locations finding brome grass and/or barley grass at only 22 of the locations visited compared to 137 annual ryegrass and 112 wild oat samples. All of the 10 brome grass and 13 barley grass populations were found to be susceptible to all five herbicides tested.

Of the 23 brome and barley grass samples, 19 also had annual ryegrass and/or wild oats collected at the same location. Eight of the 10 paddocks from which brome grass samples were collected and 10 of 13 paddocks that provided barley grass also had an annual ryegrass sample collected. Seven of the 10 paddocks and eight of the 13 paddocks that provided brome grass and barley grass samples respectively also provided wild oat samples. Five paddocks provided brome grass, annual ryegrass and wild oat samples, seven provided barley grass, annual ryegrass and wild oat samples and one paddock contained all four species.

Although no brome grass or barley grass samples were found to be resistant, significant levels of resistance were found for the annual ryegrass populations in this survey (Table 2).

The incidence of herbicide resistance in annual ryegrass populations from the locations where brome grass or barley grass were obtained was similar to that recorded overall for the ryegrass populations, for Group A 'fop' and 'dim' herbicides. The incidence of Group B resistance was higher at those locations containing brome grass or barley grass populations (Table 2).

For all wild oat samples resistance was found to two of the tested herbicide groups A 'fops' and Z (Table 3). For the locations where brome grass or barley grass were obtained the incidence of herbicide resistance in wild oats was higher than that recorded overall (Table 3).

For those herbicide groups to which resistance was detected, Groups A 'fop', 'dim' and B in annual ryegrass and Groups A 'fop' and Z in wild oats, the 10 locations from which brome grass samples were collected had a higher incidence of resistance to all but Group Z in wild oats compared with the 13 locations from which barley grass was collected (Table 2 and 3).

Table 2. Percentage of annual ryegrass populations resistant to herbicides at locations from which brome grass or barley grass populations were collected and compared with all ryegrass samples collected.

Herbicide group	All ryegrass	Brome grass sites	Barley grass sites
A (fop)	81	100	70
A (dim)	21	25	10
B	70	100	88
C	0	0	0
M	1	0	0

Table 3. Percentage of wild oat populations resistant to herbicides at locations from which brome grass or barley grass populations were collected and compared with all wild oat samples collected.

Herbicide group	All wild oats	Brome grass sites	Barley grass sites
A (fop)	38	71	50
A (dim)	0	0	0
B	0	0	0
M	0	0	0
Z	10	17	38

DISCUSSION

The results of this survey reveal two important findings. Firstly, no populations of either brome grass or barley grass were found to be resistant and secondly, at the present time these are not the major weeds in the area surveyed.

While not all herbicides used for the control of annual ryegrass or wild oats are also used for brome grass and barley grass (e.g. diclofop-methyl, tralkoxydim and idosulfuron), some of them are (e.g. haloxyfop, fluazifop and clethodim) (Haskins *et al.* 2009). That no brome or barley grass populations were resistant, despite the selection pressure placed on them when targeting annual ryegrass and wild oats, shows that herbicide resistance is much slower to develop in these two species.

This may be due either to these being self pollinating species, compared with a cross pollinating species like annual ryegrass, or that there are fewer populations and plants being treated with herbicides, relative to both annual ryegrass and wild oats, providing lower selection pressure for resistance.

As only a small number of populations of brome and barley grass was collected and screened, these results may not be an accurate representation of the resistance status of the two species. An extensive survey collecting more samples of both of these species would be useful in confirming the results of this initial survey.

While both species were found in fewer than 10% of paddocks in a survey by Lemerle *et al*. (1996), at that time both brome grass and barley grass were perceived by agronomists as being a serious problem for the future. However, this survey collected barley grass samples from 7% of the paddocks visited and brome grass from 6% compared with annual ryegrass from 76% and wild oats from 62% of the paddocks, incidences similar to those of Lemerle *et al*. (1996) who found annual ryegrass, wild oats, brome grass and barley grass to be present 69%, 72%, 9% and 26% respectively. There are some differences between the two surveys. The Lemerle *et al*. (1996) survey was conducted over a smaller area than this survey, and the current survey only recorded those sites with sufficient plants for resistance screening and therefore did not record sites with very low populations of a weed species.

The incidence of both brome grass and barley grass appears not to have increased over this time period. Nevertheless, due to the limited herbicide options for their control in-crop, especially in cereals, the importance of preventing or delaying the development of resistance in these two species is of vital importance. Adoption of non-herbicidal control practices for resistant annual ryegrass may be less effective on brome grass and barley grass thereby enabling these species to become a more serious problem in the future.

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