Current levels of herbicide resistance in key weed species in the WA grain belt

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Key messages

- High levels of resistance to Group A and B herbicides in ryegrass and wild radish
- Resistance levels vary within cropping regions for all species and herbicides
- Despite high levels of herbicides resistance, farmers are able to keep their ryegrass numbers low

Aims

To identify the frequency and distribution of herbicide resistance in key weed species in cropping paddocks.

Background

In Australia, broadacre cropping programs invest heavily in continuous cropping and no-till systems which rely on herbicides for weed control (Llewellyn *et al.* 2012). Consequently, the evolution of herbicide resistant weed populations are now widespread in Australia for major crop weeds, including *Lolium rigidum* (annual ryegrass), *Raphanus raphanistrum* (wild radish), *Avena* spp. (wild oat), *Bromus* spp. (brome grass) and *Hordeum* spp. (barley grass) (Llewellyn and Powles 2001; Broster and Pratley 2006; Owen *et al.* 2007; Walsh *et al.* 2007; Owen and Powles 2009; Broster *et al.* 2011; Boutsalis *et al.* 2012; Owen *et al.* 2014). The GRDC-funded random surveys conducted in Australia reveal that herbicide resistant weeds species are common. However, the incidence of resistance varies significantly for weed species in cropping regions both within a cropping zone and across Australia.

Method

Seed collection

Seed material was collected during October and November 2015 as part of a broad scale survey evaluating herbicide resistance in key weed species. Farmers provided farm maps which were used to locate properties at the time of seed collection. The whole western region was surveyed for target weed species including annual ryegrass, wild oat, wild radish, brome grass and barley grass. During the collection, emerging weed species including *Arctotheca calendula* (capeweed) and *Emex australis* (double gee) were also collected.

In total, 509 crop fields were visited just prior to grain harvest. Crop fields were chosen at random and weed seed collected by two people walking in an inverted 'W" pattern across each field. During sampling, weed density ratings were recorded and mature seed heads were collected from a large number of plants (50-100 plants, bulked at collection). After collection, seed heads were rubbed and chaff was removed by aspiration (wild radish seed pods were milled to release the seeds and chaff material was then separated by aspiration). Seed samples were stored in a warm, dry glasshouse with a daily average temperature of 30 C over the summer months (December to April) to relieve any seed dormancy.

Seed Germination

Wild radish seeds were sown directly into trays of moist potting mix in the autumn and winter of 2016. Annual ryegrass was germinated on agar at 20° for 5 days and then transplanted into trays of potting mix during May to October 2016. In the 2017 growing season, brome grass and barley grass seeds were pre-germinated on agar for 10-14 d at 4°C, then transplanted into potting mix. In the 2018 growing season, wild oat seeds will be scarified by nicking in order to relieve physical dormancy, and germinated using the same techniques as brome and barley grass. Wild oat seedlings will then be transplanted into potting mix. For screening with pre-emergent herbicides, seedlings were transplanted after 3 d, when the radicle is just visible.

Herbicide Resistance Screening

When wild radish and grass seedlings had reached the appropriate growth stage, they were sprayed with the highest recommended field rate of the herbicides commonly used for the control of each species using a dedicated cabinet sprayer and protocols optimised in previous surveys (Owen et al 2007). Seedlings were then grown outdoors for another 21 d with regular

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watering and fertilisation. Depending on seed numbers, each population was screened once or twice, with 50 seedlings per treatment. Plant mortality was assessed 21 days after treatment by determining whether the growing point was chlorotic or new growth was visible, as well as comparing with well-characterised susceptible and resistant (where available) control populations. Populations have been classified based on the number of individual plants surviving each herbicide treatment. Susceptible populations were classified as those having 0% plant survival. Resistant populations were classified into two groups: those having 1 - 19% plant survival (hereafter denoted as <20%) and those having ≥20%. To clarify, these categories of lower and higher resistance define the proportion of plants surviving herbicide application, not the level of resistance of an individual plant. Populations in the lower category can still contain highly resistant individuals capable of surviving higher than the recommended rates and going on to produce (resistant) seed.

Results

A total of 509 cropping paddocks were visited just prior to harvest in the Western Australian wheat belt. A total of 348 annual ryegrass, 65 wild radish, 128 wild oat, 97 brome grass, 42 barley grass, 47 capeweed, 5 double gee, and 1 silver grass populations were collected from crop fields.

Annual Ryegrass

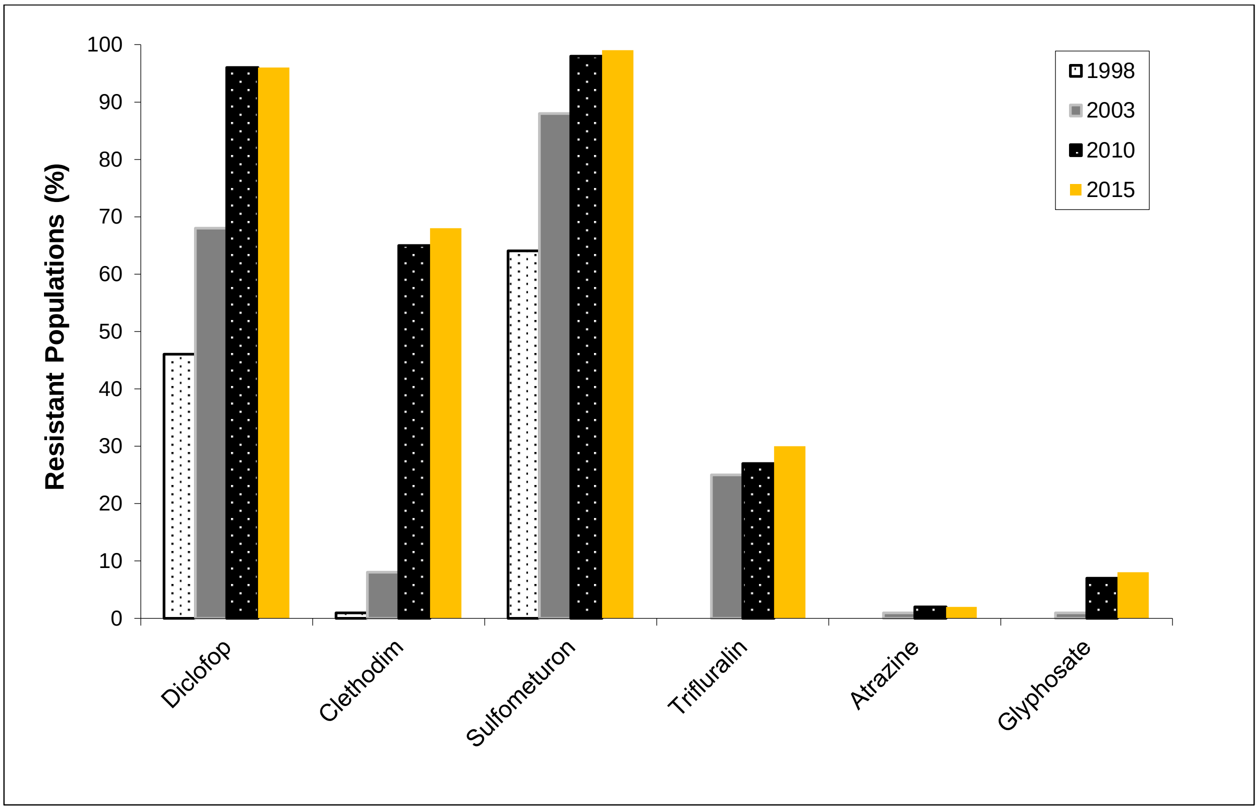
During 2016, annual ryegrass populations were treated with a number of herbicides to determine their resistance spectrum. Of the 338 populations treated with the ACCase-inhibiting herbicide diclofop, 96% of populations contained resistant plants, while 83% of populations also had resistance to sethoxydim. Only 44% of populations had resistance to clethodim at the higher rate (Table 1). For the ALS-inhibiting herbicides, 99% of populations had sulfometuron-resistant plants, while 97% contained plants resistant to imazamox + imazapyr. Only 2% of populations had plants resistant to atrazine. The knockdown herbicides glyphosate and paraquat (photosystem I inhibitor) provided good control of most ryegrass populations. No populations had resistance to paraquat, while some populations displayed resistance to glyphosate (Table 1). Resistance to the pre-emergence herbicide trifluralin (microtubule disruptor) showed a small increase, with 30% of populations showing some level of resistance (Figure 1). Resistance was detected to the newer pre-emergence herbicide Boxer Gold® (prosulfocarb+S-metolachlor: lipid synthesis inhibitor) though this is still being evaluated.

Table 1. Annual ryegrass resistance levels from 2015 survey

Herbicide	Susceptible (100% control)	Developing Resistance (1-19% survival)	Resistant (>20% survival)
Diclofop	4	17	79
Sethoxydim	17	10	73
Clethodim 60g	32	44	24
Clethodim 120g	56	30	14
Sulfometuron	1	7	92
Imazamox + imazapyr	3	23	74
Trifluralin	70	29	1
Atrazine	98	2	0
Glyphosate	92	7	1
Paraquat	100	0	0
Prosulfocarb+S-metolachlor:	89	11	0
Pyroxasulfone	100	0	0

Preliminary data suggests that resistance in ryegrass has not increased dramatically since 2010 for commonly used herbicides (Figure 1), though there have been small changes in resistance frequencies. Although there was only a small increase in the number of glyphosate-resistant populations, resistance is no longer confined to the higher rainfall zones on the south coast (Owen *et al.* 2014).

Figure 1. Change in ryegrass resistance levels in Western Australia over the last 15 years



Wild Radish

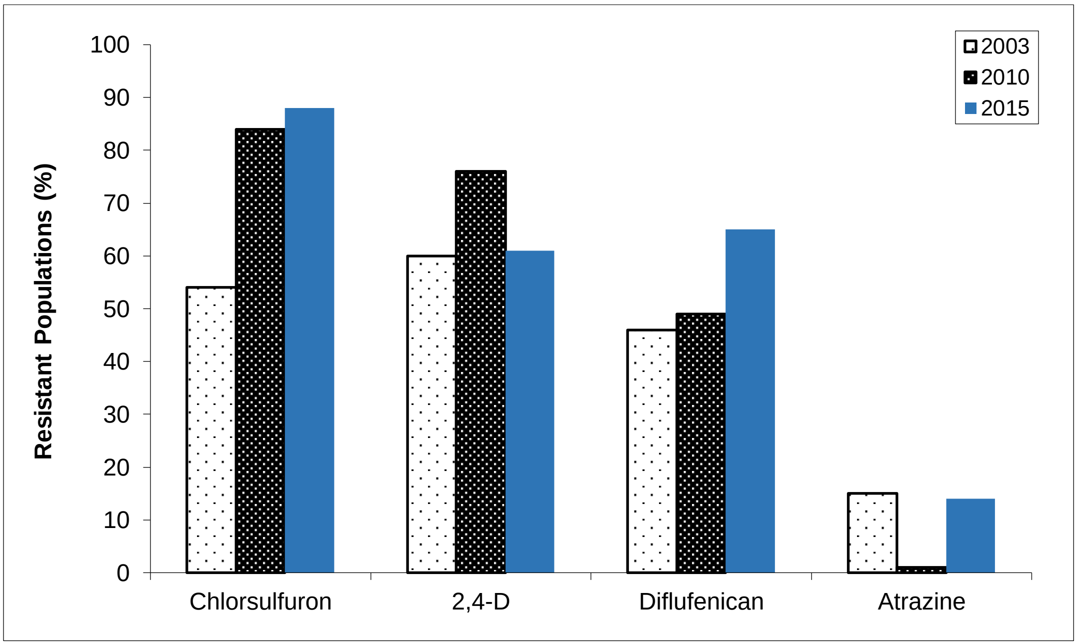
During the 2016 growing season, collected wild radish populations were treated with a range of herbicides. Of the 65 populations sprayed with the ALS-inhibiting herbicide chlorsulfuron, 88% of populations had resistant plants. Also 70% of populations had cross resistance to the ALS herbicide mixture imazamox + imazapyr (Table 2). For the synthetic auxin 2,4-D, 61% of populations contained resistant plants, while no populations exhibited resistance to the knockdown herbicide glyphosate (EPSPS inhibitor). Screening with atrazine (photosystem II inhibitor) and diflufenican (PDS inhibitor) indicates there are some populations displaying resistance to these herbicides, although resistance levels have not changed significantly over the past 5 years (Figure 2).

Table 2. Wild radish resistance levels from 2015 survey

Herbicide	Susceptible (100% control)	Developing Resistance (1-19% survival)	Resistant (>20% survival)
Diflufenican	35	47	18
2,4-D	39	22	39
Chlorsulfuron	12	14	74
Imazamox + imazapyr	30	43	27
Atrazine	86	8	6
Pyrasulfotole + bromoxynil	100	0	0
Glyphosate	100	0	0

There were fewer wild radish populations collected in 2015 than in other surveys, with the major reduction coming from the northern agricultural region where wild radish is most prolific. Wild radish numbers in other regions of the wheat belt were similar to previous years.

Figure 2. Changes in wild radish resistance levels since 2003



Brome and Barley Grass

During the 2017 growing season, brome and barley grass seedlings were treated with herbicides to determine their resistance profile. So far, no populations have shown resistance to fluazifop, clethodim, glyphosate or paraquat. Some brome populations have displayed resistance to the sulfonylurea-type ALS-inhibiting herbicides sulfosulfuron and sulfometuron, while barley grass populations are yet to be treated with these. Screening will be completed in 2018.

Conclusion

High levels of resistance to the Group A and B herbicides in annual ryegrass is evident across all areas of the WA grain belt, while other herbicides such as glyphosate, trifluralin and atrazine generally provide good control for most populations dependent on the location. Herbicide resistant wild radish populations are common, particularly in the northern agricultural region, while some group B resistance is evident in brome grass populations in the northern region. Therefore, it is important to know the resistance status for an individual field, as resistance patterns vary between fields and location. In WA, even though resistance is widespread for ryegrass, plant density in most fields was around 1 plant/m^2, indicating that farmers are still able to keep weed numbers relatively small by employing a range of weed control methods including harvest weed seed management techniques which prevent seeds from re-entering the seed bank. The challenge is to use a wide range of integrated weed management options that help achieve herbicide sustainability and thus productivity of cropping systems.

Key words

Resistance evolution, random survey, emerging weeds

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