HERBICIDE RESISTANCE SURVEY: FIGHTING WEEDS IN THE KWINANA WEST ZONE

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Photo: Evan Collis

MORE INFORMATION

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Introduction

Weeds are costing Australian grain growers an estimated $3.3 billion a year or $146/ha in lost revenue and control costs[i].

According to experts, weeds will continue to be one of the industry's biggest challenges with estimates that resistant weeds are costing the industry an additional $187 million each year, equating to an average of more than $8/hectare[ii].

Annual ryegrass is the most prolific and damaging weed to Australia's grains industry, with eight million hectares infected by the weed, costing growers an estimated $93 million in lost revenue annually[iii].

The Australian Herbicide Resistance Initiative (AHRI), with investment from the Grains Research and Development Corporation (GRDC), is researching and developing new ways for growers to tackle this costly yield constraint to improve the profitability of Australian grain growers.

Herbicide resistance in annual ryegrass to Group A and Group B post-emergent chemicals is widespread and a recent analysis of a limited focus paddock survey shows that resistance to pre-emergent herbicides is increasing.

Take-home messages

- In the WA wheatbelt Group A and Group B post-emergent herbicides are now widely accepted as ineffective on a large proportion of annual ryegrass populations.
- Low levels of resistance were observed in the annual ryegrass samples controlled with pre-emergent herbicides; however, pre-emergent herbicides remain the most effective tool to control annual ryegrass field populations.
- No resistance was found to mixtures of pre-emergent herbicides or double-knock treatments.
- Testing for herbicide resistance, including herbicide mixtures and new herbicides coming onto the Australian market, is critical for accurately assessing resistance levels on a paddock-by-paddock basis to ensure use of highly effective herbicide solutions.

Paddock studies

A series of studies undertaken by AHRI since 1998 has demonstrated the steady increase in the rate of resistance to post-emergent herbicides, particularly in annual ryegrass populations.

The latest in this series of GRDC-invested paddock surveys, compiled by Dr Roberto Busi from AHRI in 2018, shows 95 per cent of focus paddocks (for example, those paddocks chosen by growers as somewhat more problematic) had annual ryegrass resistance to post-emergent Group A and Group B herbicides.

Resistance levels to pre-emergent chemistry, while not yet at concerning levels, also continues to increase as growers rely more on these control strategies to combat weeds.

AHRI is continuing to collect paddock seed samples to closely monitor the evolution of annual ryegrass resistance to herbicides.

AHRI researcher Roberto Busi undertaking trials into herbicide resistance in annual ryegrass at the University of Western Australia. PHOTO: MELISSA WILLIAMS

The research

Annual ryegrass seed samples were taken from random paddocks across nine different properties located in the Kwinana West Port Zone. Harvest weed seed control strategies are practised on all surveyed farms.

Weed seeds were collected in March and April 2018 from narrow windrows (not yet burned), chaff-lines, chaff tramlines or plant heads still present in the paddock.

These seed samples were grown outdoors at the University of Western Australia during the autumn–winter season (reflecting in-paddock conditions) and resistance levels were determined by treating all seedings, either at germination stage or two-leaf seedling stage, using most modes of actions available including herbicides from Groups A, B, C, D, J, K, L, M and mixtures/double-knocks.

Well-characterised herbicide-resistant and herbicide-susceptible weed populations were used as controls.

[i, ii & iii] Llewellyn RS, Ronning D, Ouzman J, Walker S, Mayfield A and Clarke M (2016) Impact of Weeds on Australian Grain Production: the cost of weeds to Australian grain growers and the adoption of weed management and tillage practices. Report for GRDC. CSIRO, Australia. https://grdc.com.au/__data/assets/pdf_file/0027/75843/grdc_weeds_review_r8.pdf.pdf.

The findings

The outcomes from this 2018 study reinforced the findings from previous random paddocks surveys of the WA wheatbelt undertaken in 1998, 2005, 2010 and 2015, with high percentages of the seed samples demonstrating some level of resistance to Group A and Group B post-emergent herbicides.

The study also showed some developing resistance issues in pre-emergent herbicides, particularly trifluralin, prosulfocarb and pyroxasulfone. However, pre-emergent herbicides remain an important strategy to tackle annual ryegrass.

Table 1 shows the post-emergent and pre-emergent herbicide resistance results for annual ryegrass sampled in the focus farms project. The herbicide resistance status of the 17 populations of annual ryegrass sampled was divided by percentage into:

- herbicide susceptible (survival less than five per cent);
- developing resistance (survival between six and 19 per cent); and
- highly resistant (survival greater than 20 per cent).

Table 2 (see page 7) provides detailed descriptions of the herbicide resistance results for each of the chemical groups.

TABLE 1 Herbicide resistance status of the 17 populations of annual ryegrass (*Lolium rigidum*) collected in WA in 2018.

Herbicide	Product	Group	Herbicide susceptible (% samples)	Developing resistance (% samples)	Highly resistant (% samples)
Butroxydim	Factor® (24%)	A	82	18	0
Clethodim	SeQuence® (24%)	A	47	18	35
Clethodim + butroxydim	SeQuence® + Factor®	A	100	0	0
Diclofop	Diclofop (50%)	A	0	6	94
Imazamox + imazapyr	Intervix® (3.3% + 1.5%)	B	6	12	82
Sulfometuron	Oust® (75%)	B	0	6	94
Paraquat	Gramoxone® (25%)	L	94	6	0
Glyphosate	Roundup® PowerMAX (54%)	M	88	12	0
Atrazine	Nu-Trazine® (90%)	C	100	0	0
Propyzamide	Dargo® (50%)	D	100	0	0
Prosulfocarb	Arcade® (80%)	J	71	29	0
Prosulfocarb + trifluralin	Arcade® + Treflan™	J + D	100	0	0
Pyroxasulfone	Sakura® (85%)	K	88	12	0
Pyroxasulfone + trifluralin	Sakura® + TrifluX®	K + D	100	0	0
Trifluralin	TrifluX® (48%)	D	82	18	0

SOURCE: AHRI

Post-emergent herbicides

Group A

DICLOFOP METHYL

Ninety-four per cent of samples (16 samples) had some level of resistance to diclofop methyl, with more than 70 per cent plant survival observed in those 16 herbicide-resistant samples. These plants surviving diclofop-methyl were subsequently treated with a full label dose of clethodim (250ml of commercial product, 60g clethodim ha^{-1} as active ingredient) with a further 14 per cent surviving that treatment.

BUTROXYDIM

In 17 samples tested, there were three samples found that were developing resistance (18 per cent of samples tested) to butroxydim and one sample herbicide-resistant. The overall survival to butroxydim was less than five per cent.

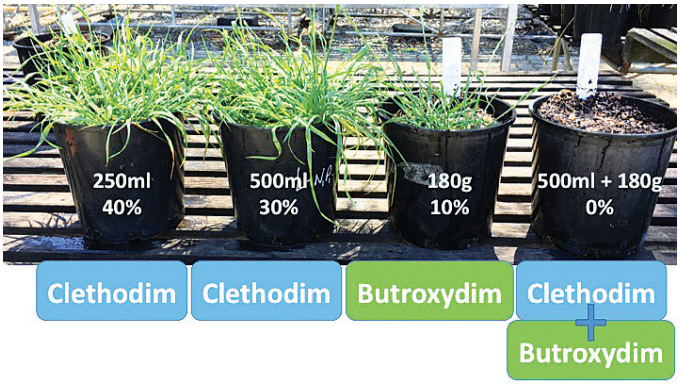
CLETHODIM

Of the 17 samples, six samples were clethodim-resistant and three were developing resistance. Even after a greater clethodim dosage (500ml, equivalent to 120g clethodim ha^{-1}) was resprayed on survivors, this proved to be ineffective with only a minor decrease in survival. Therefore, increasing the clethodim dosage in already clethodim-resistant populations – while an easy-to-adopt strategy – may have a small impact.

Clethodim (Group A) herbicide affecting ryegrass plants. PHOTO: CHRIS PRESTON

CLETHODIM + BUTROXYDIM

No sample exhibited resistance to the mixture of clethodim + butroxydim [250ml clethodim (60g ai/ha) + 180g butroxydim (45g ai/ha)]. In one sample resistance to clethodim was greatly reduced by using this mixture. This herbicide option appears to be not sufficiently safe in canola crops.



Testing resistance to Group A herbicides. SOURCE: DR ROBERTO BUSI, AHRI

Group B

SULFOMETURON

The majority of samples (94 per cent) were resistant at some level to the sulfonylurea sulfometuron, with one sample categorised as 'developing' resistance. Survival ranged from nine per cent to 100 per cent.

Six samples showed multiple resistance (stacked genes) to sulfometuron and clethodim.

IMAZAMOX + IMAZAPYR

Similar to sulfometuron, the frequency of resistance to imazamox + imazapyr was high (88 per cent). As expected, the overall survival to a full dose of imazamox + imazapyr was slightly lower than sulfometuron, with 45 per cent versus 69 per cent respectively. There was a high frequency of multiple resistance (multiple IMI + clethodim resistance found in 44 per cent of tested samples).

Group L

PARAQUAT

There was no resistance found to paraquat. Only five per cent of plants survived the treatment with paraquat applied at 1L/ha (250g ai). Survivors were resprayed with a further 1L/ha, which reduced survival to one per cent. Only two samples showed a 'developing' minor-level paraquat resistance with most plants being highly suppressed.

Group M

GLYPHOSATE

No resistance was observed at the robust dose of 2L/ha (1080g ai).

However, at the lowest recommended dose of 1L/ha there were four samples assessed as resistant, 65 per cent as 'developing' resistance and 11 per cent as susceptible. On average there was a 16 per cent survival rate across all tested samples after treatment with 1L/h.

Post-emergent herbicide use – guidance for future use

- Do not rely solely on post-emergent Group A or B chemistry to combat annual ryegrass.
- Applying full recommended rates of clethodim to an already-resistant annual ryegrass will have little to no effect.
- Use a mixture of clethodim + butroxydim, according to label recommendations, to achieve greater efficacy on clethodim-resistant annual ryegrass.
- When using glyphosate apply recommended label rates. Double-knock applications will help mitigate resistance to glyphosate.

Pre-emergent herbicides

Group C

ATRAZINE

There was no resistance detected to atrazine.

Group D

TRIFLURALIN

There was low-level resistance to trifluralin, with three samples categorised as 'developing' resistance. In one of these samples, this resistance frequency was maintained even when a high rate of 2L (960g trifluralin/ha) was applied, suggesting a strong trait for resistance was present in that particular field population.

PROPYZAMIDE

There was no resistance to propyzamide, confirming its important role for herbicide rotation to control annual ryegrass. The maximum survival observed was two per cent.

Group J

PROSULFOCARB

Most samples were found to be susceptible to prosulfocarb. Five samples were classified as 'developing' resistance. Careful monitoring is required to detect any early resistance to prosulfocarb.

PROSULFOCARB + TRIFLURALIN

All samples were susceptible to the mixture trifluralin + prosulfocarb.

Group K

PYROXASULFONE

All samples were susceptible to pyroxasulfone. Two samples were initially categorised as 'developing' resistance with an observed plant survival up to 15 per cent. However, no survivors were observed in a subsequent repeated experiment when the herbicide was applied directly onto seeds. Careful monitoring of the evolution of resistance to pyroxasulfone in WA will be critical.

PYROXASULFONE + TRIFLURALIN

All samples were susceptible to the mixture trifluralin + pyroxasulfone.

Pre-emergent herbicide use – guidance for future use

- Beware of developing resistance to trifluralin, even after robust rates are applied.
- Use a mix of chemistry, according to label recommendations, to achieve greater efficacy.

TABLE 2 Herbicide products, formulations, mixtures and dosages used to assess resistance levels in 17 populations of annual ryegrass (*Lolium rigidum*) collected in WA in 2018 from cropped paddocks.

Herbicide	Product #	Group	Applied	Dose product / ha	% survival (std dev)*	No. of resistant / susceptible samples**
Butroxydim	Factor® (250g/kg)	A	POST	180g (45g ai)	4.3 (8)	3 DR, 14 SS
Clethodim	SeQuence® (240g/L %)	A	POST	250ml (60g ai)	19 (23)	6 RR, 3 SR, 8 SS
Clethodim + butroxydim	SeQuence® + Factor®	A	POST	250ml + 180g (60 +45g ai)	0.7 (2)	17 SS
Diclofop	Diclofop (500g/L)	A	POST	0.75L (375g ai)	67 (28)	16 RR, 1 DR
Imazamox + imazapyr	Intervix® (33g/l + 15g/L)	B	POST	750ml (25 + 11g ai)	43 (21)*	14 RR, 2 DR, 1 SS
Sulfometuron	Oust® (750g/kg)	B	POST	20g (15 ai)	68 (22)*	16 RR, 1 DR
Paraquat	Gramoxone® (250g/L)	L	POST	1L fb 1L (250 + 250g ai)	1.3 (3)	1 DR, 16 SS
Glyphosate	Roundup® PowerMAX (540g/L)	M	POST	2L (1080g ai)	1.6 (4)	2 DR, 15 SS
Atrazine	Nu-Trazine® (900g/kg)	C	PRE	1.1kg (1000g ai)	2.6 (3)	17 SS
Propyzamide	Dargo® (500g/L %)	D	PRE	1L (500g ai)	0.1 (0)	17 SS
Prosulfocarb	Arcade® (800g/L %)	J	PRE	2.5L (2000 ai)	4.8 (3)	5 DR, 12 SS
Prosulfocarb + trifluralin	Arcade® + TrifluX®	J + D	PRE	2.5L + 1 L (2000 + 480g ai)	0.4 (1)	17 SS
Pyroxasulfone	Sakura® (850g/kg)	K	PRE	118g (100g ai)	0.5 (1)	2 DR, 15 SS
Pyroxasulfone + trifluralin	Sakura® + TrifluX®	K + D	PRE	118g + 1 L (100 + 480g ai)	0.0 (0)	17 SS
Trifluralin	TrifluX® (480g/L)	D	PRE	1L (480g ai)	1.4 (3)	3 DR, 14 SS

*__Plant survival is the mean value – percentage__ observed across 17 seed samples tested (with standard deviation of the mean). A proportion of samples (20 per cent) were found to have multiple resistance to clethodim.

**__No. of resistant samples:__

- **RR** denotes herbicide resistance (number of samples with survival more than 20 per cent)
- **DR** denotes 'developing' resistance (number of samples with survival more than six per cent)
- **SS** denotes herbicide susceptible, for example no resistance (number of samples with survival less than five per cent)

NOTE: Commercial brand names are provided; however, AHRI and GRDC do not accept any responsibility for herbicide efficacy reported on *L. rigidum* plants. The authors also emphasise there is no endorsement/conflict of interest for any commercial herbicide product listed here.

SOURCE: AHRI

Case study

Derek and Rhonda Young

Derek and Rhonda Young, pictured with their corgi Lotti, have changed the seeding strategy for their cereal crops to allow the use of the pre-emergent herbicide trifluralin to control annual ryegrass. PHOTO: MIKAYLA YOUNG

SNAPSHOT

GROWERS: Derek and Rhonda Young

LOCATION: Kulin

FARM SIZE: 2903ha

CROPPING SYSTEM: cereals and break crops (wheat, canola, barley, lupins)

ANNUAL RAINFALL: 330mm

HARVEST WEED SEED CONTROL: iHSD (integrated Harrington Seed Destructor) from 2018

Kulin growers Derek and Rhonda Young knew something in their cropping strategy had to change to improve their attack on weeds across their south-eastern wheatbelt property.

Derek says while the weed burden may not have been increasing, their zero-till disc seeding approach was limiting their herbicide options.

“We didn’t feel like we were winning,” Derek says.

“We needed to look at other options to allow us to get on top of the weed burden.”

Since 2003, Derek and Rhonda have used a zero-tillage system, with full stubble retention and disc seeder.

While this strategy has had numerous long-term agronomic benefits, their options for pre-emergent herbicide applications were limited because of an inability to incorporate certain herbicides into the soil.

Despite the well-known efficacy of trifluralin, particularly on annual ryegrass, this was one herbicide that Derek did not have access to under his zero-till system.

Given their reliance on Group J and Group K herbicides (across 25 per cent of the property), Derek says he suspected some level of resistance was beginning to occur.

Results from the paddock survey study confirmed there was developing resistance to prosulfocarb (Arcade®) plus the possibility of developing resistance to glyphosate applied at the lower rate of 1L/ha. Annual ryegrass also showed resistance to Group B herbicides imazamox and imazapyr (Intervix®).

As a result of these findings, and after 17 years of zero tillage, Derek has trialled full tillage for some of his cereal crops, with stubble incorporation, while continuing to use his disc seeder. This strategy now allows him the flexibility to rotate his modes of action and incorporate trifluralin at the pre-emergent crop stage.

“We trialled small areas using this approach in 2018 and the results were very positive,” Derek says.

“This year, almost a quarter of our cereal program has been put in this way, and so far, we are seeing an excellent response.”

Derek has also included barley in the cereal rotation to increase the in-paddock weed competition.

The Youngs use an iHSD at harvest time plus a WEED-IT spot sprayer for summer weed control.

Case study

Gary and Sue Lang

Wickepin grower Gary Lang says while he has the unusual situation of several paddocks with annual ryegrass still susceptible to diclofop (Hoegrass®), he is aware that a reliance on this post-emergent Group A herbicide will render it almost useless in the future. PHOTO: NATALIE LEE, GRDC

SNAPSHOT

GROWERS: Gary and Sue Lang

LOCATION: Wickepin

FARM SIZE: 4930ha (total); 4200ha (cropped)

CROPPING SYSTEM: cereals, break crops and pastures

ANNUAL RAINFALL: 400mm

HARVEST WEED SEED CONTROL: chaff deck since 2013 and an iHSD for harvest 2019

Despite long-term data demonstrating widespread annual ryegrass resistance to Group A and Group B herbicides, Wickepin grower Gary Lang is one of the lucky few who still has access to diclofop (Hoegrass®), at least in a couple of his paddocks.

Gary participated in the paddock survey and says he was not particularly surprised to see annual ryegrass in his new lease paddock susceptible to diclofop, particularly since the paddock had not been cropped in the previous eight years.

“Before I took on this parcel of land, this paddock had been in pasture for many years and had only been cropped a few times in the last few decades – so essentially we hadn’t messed it up yet by creating resistance issues,” Gary says.

This is one of a couple of paddocks that has annual ryegrass still susceptible to Group A herbicides, which is a major bonus for the business particularly if breaking rains are late in the season and there is limited opportunity for a pre-seeding knockdown.

But Gary says he is very aware of the dangers of relying on a Group A herbicide to control his most prolific weed: annual ryegrass.

“The resistance testing showed there may be some developing resistance so we can’t overuse Hoegrass®,” he says.

“Our entire integrated weed management system must be spot on in an attempt to manage the weed seed bank over time.”

The Langs are trialling a double broadleaf rotation strategy (canola followed by lupins) to attack grasses two years in a row.

Gary says he also intends to keep sheep in the system for the long term.

“If one paddock is particularly problematic, we can take it out of the cropping rotation and put it into fallow for a few years, which gives us the opportunity to clean it up,” he says.

The Langs manage harvest weed seeds by placing their chaff on tramlines and by swath-topping their canola.

This harvest will be their first using an iHSD after the recent purchase of a new header.

“We are hoping the iHSD is now tried and tested enough to be a manageable fit into the business as one more strategy to target our weeds,” Gary says.

Case study

Russell and Rebekah Burges

SNAPSHOT

GROWERS: Russell and Rebekah Burges

LOCATION: Meckering

FARM SIZE: 2500ha, 2100ha cropped

CROPPING SYSTEM: cereals, break crops and pastures

ANNUAL RAINFALL: 350mm

HARVEST WEED SEED CONTROL: narrow windrows burnt for many years and now chaff lines

Meckering grower Russell Burges has a multi-pronged approach to dealing with a developing glyphosate resistance issue.

Developing annual ryegrass resistance to glyphosate has been the impetus for Meckering grower Russell Burges to make changes to his cropping rotation.

While Russell already knew he had some annual ryegrass resistance to post-emergent Group A and B herbicides, the results from the resistance testing came as an unpleasant surprise.

“The testing Roberto did for us has become an important part of our planning process, and has meant we have taken at least one paddock out of Roundup Ready® canola and replaced it with pasture, so we can get on top of the annual ryegrass without using glyphosate,” Russell says.

Russell believes the resistance issues to glyphosate may have begun many years ago when he first introduced Roundup Ready® canola into the system. However, in the past five years the business has moved away from relying on glyphosate in an attempt to avoid developing resistance.

“After seeing this paddock test positive to a developing resistance to glyphosate, I could probably pick other paddocks that may have that issue too – so we will have to plan very carefully how we proceed to avoid exacerbating the problem,” he says.

Weeds are a major challenge for this central wheatbelt mixed cropping and livestock business. Russell is keen to keep sheep in the system to give himself the option of taking a problem paddock out of the cropping rotation and putting it into a fallow or pasture.

This is the third season in a row that he has dry sown most of his crop due to a late break, and so has not had the option of applying a double knockdown on weeds before seeding.

As such, he relies heavily on pre-emergent herbicides and has seen significant success mixing chemistries to attack annual ryegrass.

He is also now doubling his broadleaf crop rotations, such as canola followed by lupins, to give the annual ryegrass two hits before a cereal crop.

Canola, lupins and clovers are desiccated before harvest to stop annual ryegrass seed-set and reduce selection pressure on glyphosate.

During harvest, Russell has moved to a chaff line system where weed seeds may deteriorate over time or are eaten by the sheep.

“Weeds are as big a hurdle for us as frost, but navigating our way around the weed challenge takes a lot more planning and effort,” Russell says.

“What we now know after participating in this survey is the importance of testing for resistance, so our planning is on track.”

Notes

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