Herbicide resistance in focus paddocks of WA champion farmers

Roberto Busi and Hugh Beckie, Australian Herbicide Resistance Initiative, School of Agriculture and Environment, University of Western Australia

Key messages

Weed seed samples were collected from farms implementing harvest weed seed control.

PRE herbicides allow effective ryegrass control, POST herbicide efficacy is compromised by resistance.

PRE and POST herbicide mixtures increase herbicide efficacy, suppress weed populations numbers and minimize herbicide resistance risk.

Aims

In Australia herbicide resistance has increased in a number of weed species and the number of herbicides affected. New cases of herbicide-resistant weeds continue to be reported due to the overreliance on herbicides to manage very large farm operations. Grain growers have responded to the escalating herbicide resistance challenge by adopting harvest weed seed control and new pre-emergence herbicides to control multiple herbicide resistant weeds.

As grain growers demand simplicity in their large programs to achieve effective weed control we envisage that there is an increasing need, with particular focus on the GRDC Western Region, to test and better understand herbicide resistance in weeds by targeting a number of problematic “focus paddocks”.

Method

In 2018 a proof-of-concept study was conducted to assess herbicide resistance in annual ryegrass seed samples collected from focus paddocks across nine different farms located in the Kwinana West Port Zone. A total of 19 seed samples were obtained from champion farmers’ farms where harvest weed seed control has been practiced. Plants were grown outdoors at UWA during the autumn/winter season. Herbicide resistance status was determined by treating germinating seeds or two-leaf seedlings with a range of herbicide modes of action. Well characterized herbicide-resistant and herbicide-susceptible weed populations maintained by Australian Herbicide Resistance Initiative (AHRI) were used as controls. A total of seventeen samples of ryegrass were prepared and examined (i.e. two samples has extremely low seed viability and were not tested). . Herbicide treatments, MoA and dosages are shown in Table 1. Plant survival 0 - 5% indicates an herbicide ‘susceptible’ sample, 6 - 19% survival identifies ‘developing resistance’ and survival ≥ 20% is interpreted as herbicide ‘resistance’.

Results

Plant survival across all samples to POST herbicides was 25% denoting substantial herbicide resistance across weed samples, whereas survival to tested PRE herbicides was 1% which reflects the current effective ryegrass control in the field when PRE herbicide area adopted.

POST EMERGENCE

GROUP A

Diclofop-mehtyl

As expected and reported in several random herbicide resistance surveys focused on annual ryegrass in WA, resistance to diclofop-methyl was high in frequency (94% samples tested) with >70% plant survival observed in those 16 herbicide-resistant samples (Table 1). Plants surviving diclofop-methyl were subsequently treated with a full label dose of clethodim (250ml of commercial product) with 14% survival observed (Table 2).

Butroxydim

In 17 samples tested, there were three samples found “developing” resistance (18% of samples tested) to butroxydim and one only sample herbicide-resistant with 38% plant survival (sample # 19). The overall survival to butroxydim was < 5% (Table 1).

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Clethodim

Six samples were clethodim resistant, three were developing resistance and eight susceptible to clethodim. The overall plant survival to clethodim (250 ml) across 17 populations was 21% and a greater clethodim dosage (500 ml) re-sprayed on survivors resulted in moderately lower survival (Table 1). In one sample (sample #19) we observed 78% survival, but the increase of clethodim dosage proved to be ineffective with only a minor decrease in survival ~74%.Thus, an increase in clethodim dosage - an easy-to-adopt strategy – is likely to result in a moderate increase of herbicide efficacy. Most likely the effect of an increase in clethodim dosage will be negligible when the level of clethodim resistance is high.

Clethodim + Butroxydim

No sample exhibited resistance to the mixture clethodim + butroxydim (250 ml + 180 g commercial product). The sample with highest clethodim and butroxydim resistance (sample #19) exhibited 5% survival and therefore it was categorized as susceptible.

GROUP B

Sulfometuron

The majority of samples (94 %) were resistant to the sulfonylurea sulfometuron with one sample categorized as "developing" resistance. Survival ranged from 9% to 100%. Six samples were -resistant to sulfometuron and clethodim (38% samples tested). Sulfometuron and clethodim resistant populations exhibited a mean survival of 75% and 40%, respectively. Clethodim survival of sulfometuron survivors was on average 20% across all tested samples (Table 1).

Imazamox + Imazapyr

Similarly to sulfometuron the frequency of resistance to imazamox + imazapyr was high (88%). As expected, the overall survival to a full dose of imazamox + imazapyr was slightly lower than sulfometuron with 45% versus 69%, respectively. There was a high frequency of multiple resistance (multiple IMI + clethodim resistance found in 44% tested samples). Across all samples clethodim survival of imazamox + imazapyr survivors was 20% (Table 1).

GROUP L

Paraquat

There was no resistance found to paraquat. Only approximately 5% of plants survived the treatment with 1 L paraquat ha^{-1} (Table 1, see notes). Survivors were re-sprayed with 1 L paraquat ha^{-1} further reducing plant survival to 1%. Only two samples returned to 'develop' a minor level paraquat resistance with plants highly suppressed (Table 1).

GROUP M

Glyphosate

No resistance was observed at the dose of 2 L ha^{-1}. However, it is concerning the at the lowest recommended dose of 1 L there were four samples (24%) assessed as resistant, 65% as 'developing' resistance and 11% as susceptible. On average there was 16% survival across all tested samples after treatment with 1 L glyphosate ha^{-1} (Table 1, see notes). Progeny tests will be conducted to confirm field resistance to glyphosate. Similarly, growers should carefully monitor plant survival after glyphosate treatments.

PRE-EMERGENCE

GROUP C

Atrazine

There was no resistance detected to atrazine.

GROUP D

Trifluralin

There was low level resistance to trifluralin with three samples categorized as 'developing resistance'. In one sample (sample #3) the low "developing" resistance frequency was maintained at a high rate of 2L trifluralin ha^{-1} suggesting strong target-site resistance at relatively low frequency (data not shown). The overall survival to 1L trifluralin ha^{-1} was 1% (Table 1).

Propyzamide

There was no resistance found in ryegrass populations to propyzamide confirming its important role for herbicide rotation. The maximum survival observed was 2% in sample #14.

GROUP J

Prosulfocarb

The majority of samples were found to be susceptible to prosulfocarb. Five samples (approx. 30%) were classified as 'developing' resistance. Careful monitoring is required to early-detect possible shift towards resistance to prosulfocarb which remains effective with mean survival < 5% across all tested samples.

Prosulfocarb + Trifluralin

All samples were susceptible to the mixture trifluralin + prosulfocarb. The maximum level of plant survival to this mixture was 4%.

GROUP K

Pyroxasulfone

All samples were susceptible to pyroxasulfone. Two samples were categorized as 'developing' resistance with a maximum level of plant survival of 15% and 10%, respectively. However, such a level of survival was not confirmed in a subsequent repeated experiment when the herbicide was applied directly on 'naked' seeds. In 2019 we will assess the seed progeny of these few samples to carefully monitor the evolution of resistance to pyroxasulfone in WA fields.

Pyroxasulfone + Trifluralin

All samples were susceptible to the mixture trifluralin + pyroxasulfone.

Conclusion

AHRI has conducted major surveys in Western Australia to assess the level of herbicide resistance in major agricultural weeds including ryegrass and wild radish in 1998, 2003 and 2010 [1-4].

This focus paddocks study shows high levels of resistance to POST herbicides [Group A FOP and Group B (Sus + IMIs)] and confirms the results of previous large random surveys in WA. There are significant levels of clethodim resistance in contrast to moderate level of resistance to butroxydim. The mixture clethodim + butroxydim is highly effective in mitigating herbicide resistance – in the most clethodim- and butroxydim-resistant ryegrass sample, plant survival to the clethodim + butroxydim mixture was below 5%. High level resistance to POST herbicides has been the driving factor for widespread adoption of PRE herbicides and harvest weed seed control to achieve effective ryegrass control.

Resistance to PRE herbicides remains low. Herbicide mixtures of PRE herbicides (Group D, J and K) are effective in controlling resistant ryegrass and should be adopted to reduce population size and risk of herbicide resistance. Annual ryegrass can easily evolve multiple resistance to D, J and K herbicides. A few field populations have been identified to be multiple-resistant to trifluralin, prosulfocarb, triallate and pyroxasulfone [5-8].

High level adoption of harvest weed seed control should not decrease to achieve diversity of selection pressures on weeds, keep weed numbers low and complement effective control achieved with PRE herbicides. AHRI will continue to encourage herbicide stewardship and develop new herbicide solutions with particular focus on annual ryegrass and wild radish infesting WA farms. As part of doing this, AHRI will continue to provide proactive herbicide resistance testing (rapid agar test and 'traditional' pot tests) to as many WA 'focused' growers as possible during 2018-2020.

Key words

Herbicide resistance, IWM, Mixtures, Selection diversity, Weed control

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GRDC Project Numbers: UWA1803 - Focus farms fighting weed foes in the Kwinana West Port Zone. UWA1807 - A simple and innovative test for real-time detection of resistance in weeds.

Table 1. Herbicide products, formulations, mixtures and dosages used to assess resistance levels in 17 populations of annual ryegrass (*Lolium rigidum*) collected in Western Australia in 2018 from cropped fields. Plant survival is the mean value - percentage - observed across 17 seed samples tested (with standard deviation of the mean).

Herbicide	Product #	Group	Applied	Dose product	% survival (std dev)	% Cletho500 (std dev) ##	% A+B MR (std dev) ###
Butroxydim	Factor (24%)	A	POST	180 g	4.3 (8)		
Clethodim	Sequence (24%)	A	POST	250ml	19 (23)	7 (17)	
Clethodim + Butroxydim	Sequence + Factor	A	POST	250ml + 180g	0.7 (2)		
Diclofop	Diclofop (50%)	A	POST	0.75 L	67 (28)		14 (18)
Imazamox + Imazapyr	Intervix (3.3% + 1.5%)	B	POST	750ml	43 (21)		20 (23)
Sulfometuron	Oust (75%)	B	POST	20 g	68 (22)		20 (20)
Paraquat	Gramoxone (25%)	L	POST	1 L fb 1L	1.3 (3) **		
Glyphosate	Round Up PowerMax (54%)	M	POST	2 L	1.6 (4) **		
Atrazine	Nutrazine (90%)	C	PRE	1.1 Kg	2.6 (3)		
Propyzamide	Dargo (50%)	D	PRE	1 L	0.1 (0)		
Prosulfocarb	Arcade (80%)	J	PRE	2.5 L	4.8 (3)		
Prosulfocarb + trifluralin	Arcade + Treflan	J + D	PRE	2.5 L + 1 L	0.4 (1)		
Pyroxasulfone	Sakura (85%)	K	PRE	118 g	0.5 (1)		
Pyroxasulfone + trifluralin	Sakura + Treflur X	K + D	PRE	118 g + 1 L	0.0 (0)		
Trifluralin	Treflur X (48%)	D	PRE	1 L	1.4 (3)		

 # Commercial brand names are provided however authors do not accept any responsibility for herbicide efficacy reported on *L. rigidum* plants and also emphasize there is no endorsement / conflict of interest for any particular commercial herbicide product listed here.

A higher dose of clethodim (500 ml) was applied on surviving plants to 250 ml clethodim ha^{-1}

Survival to 250 ml clethodim ha^{-1} applied on plants surviving diclofop-methyl, imazamox+imazapyr (A+ B multiple resistance) or sulfometuron (A+ B multiple resistance)

** Survival (%) observed at 1L glyphosate ha^{-1} was 16% (14 SD). Survival to the first paraquat treatment of 1L paraquat ha^{-1} was 5.3% (7 SD).

References

1. Owen MJ, Martinez NJ and Powles SB, Multiple herbicide-resistant *Lolium rigidum* (annual ryegrass) now dominates across the Western Australian grain belt. *Weed Res*; **54**(3): 314-324 (2014).
2. Owen MJ, Martinez NJ and Powles SB, Multiple herbicide-resistant wild radish (Raphanus raphanistrum) populations dominate Western Australian cropping fields. *Crop and Pasture Science*; **66**(10): 1079-1085 (2015).
3. Owen MJ and Powles SB, Glyphosate-resistant rigid ryegrass (Lolium rigidum) populations in the Western Australian grain belt. *Weed Technology*; **24**(1): 44-49 (2010).
4. Owen MJ, Walsh MJ, Llewellyn RS and Powles SB, Widespread occurrence of multiple herbicide resistance in Western Australian annual ryegrass (Lolium rigidum) populations. *Crop and Pasture Science*; **58**(7): 711-718 r (2007).
5. Busi R, Gaines TA, Walsh MJ and Powles SB, Understanding the potential for resistance evolution to the new herbicide pyroxasulfone: field selection at high doses versus recurrent selection at low doses. *Weed Res*; **52**(6): 489-499 (2012).
6. Busi R and Powles SB, Cross-resistance to prosulfocarb and triallate in pyroxasulfone-resistant *Lolium rigidum*. *Pest Manag Sci*; **69**(12): 1379-1384 DOI Electronic Resource Number (2013).
7. Busi R and Powles SB, Cross-resistance to prosulfocarb+ S-metolachlor and pyroxasulfone selected by either herbicide in Lolium rigidum. *Pest Manag Sci*; **72**(9): 1664-1672 (2016).
8. Brunton DJ, Boutsalis P, Gill G and Preston C, Resistance to Multiple PRE Herbicides in a Field-evolved Rigid Ryegrass (Lolium rigidum) Population. *Weed Sci*: 1-5 r (2018).

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