giving a RATS

Newsletter of :

GRDC Project UA00124 Understanding and management of resistance to Group M, Group L and Group I herbicides.

What's in a name??

Welcome to the first edition of the official newsletter for GRDC National Project UA00124 - *"Understanding and management of resistance to Group M, Group L and Group I herbicides".*

Yes it is a bit of a mouthful, so from now on we will call it the *'national glyphosate resistance project'* or ***"Giving a RATS"*** for short.

So where does the name come from? The only way you will prevent and manage resistance if you start looking at the bigger weed management picture. That is what integrated weed management is all about - we need to focus on all the following points:

Resistance – what types of resistance do you have? Have you tested to determine what MOA's still work? We will cover the latest research and extension developments on resistance to glyphosate, paraquat and 2,4-D.

Application – are you getting a lethal dose of herbicide to the intended target?

We need to discuss issues affecting herbicide effectiveness such as the boom set up, meteorological conditions and the use of robust rates of herbicide.

Tactics – We just can't rely on herbicides, so what non-herbicide tactics are you using? This is where integrated weed management really comes in. Is there anything new that might be useful in your situation you haven't tried yet?

Systems – Every grower has different skills, knowledge, attitudes and aspirations so every farm system will be different – there are no prescriptive solutions. We will have interviews with 'Farm Adviser Learning Groups' and growers to see how they are dealing with these tough problems.

INDEX FOR THIS ISSUE

Who is in the team?

In each edition we will have more specific information on two team members.

Dr. Christopher Preston,
Associate Professor, University of Adelaide and Project Leader;

Dr. Jenna Malone,
Postdoctoral fellow, University of Adelaide;

Mr Tony Cook,
Technical Specialist Weeds NSW DPI Tamworth;

Mr Russel Carty,
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Andrew Storrie,
AGRONOMO and Adjunct Research Fellow, UWA, Albany Western Australia.

GLYPHOSATE, PARAQUAT AND 2,4-D RESISTANCE - THE STARTING POINT....

Glyphosate

Around the world there are now 22 species with populations resistant to glyphosate, with the USA have over double the number of species found in Australia. This does not include all the weeds that have now become a problem because they were never controlled by glyphosate. Tropical spiderwort (*Commelina benghalensis*) was a minor weed of cotton but now is a major weed of glyphosate resistant cotton in southern USA.

Table.1 Number of weed species in each country with glyphosate resistant populations (Source: http://www.weedscience.org/In.asp)

Country	Number Species	Country	Number Species
Canada	1	Italy	1
USA	13	Czech Republic	1
Brazil	5	Israel	1
Argentina	3	South Africa	3
Chile	1	China	1
Spain	5	Malaysia	1
France	1	Australia	6

Table.2 Number of glyphosate resistant weed populations by Australian state as at February, 2012.

Weed species	No. cases per state (@ Feb 2012)				
	Qld	NSW	Vic	SA	WA
Annual ryegrass (*L. rigidum*)	-	92	42	132	43
Barnyard grass (*E. colonum*)	10	10	-	-	1
Fleabane (*C. bonariensis*)	13	30	-	6	-
Liverseed grass (*U. panicoides*)	-	2	-	-	-
Windmill grass (*C. truncata*)	-	2	-	-	-
Brome grass (*B. diandrus*)	-	-	-	1	-

Paraquat

Outside of Australia there are 19 species with confirmed populations resistant to paraquat. These include 3 grass and 16 broadleaf species. Paraquat is widely used in tree crops and plantations around the world. The use of paraquat in no-till farming due has increased markedly in recent years due to the development weeds with resistance to glyphosate in these systems.

In Australia six species have populations resistant to paraquat. The most concerning cases are the populations of annual ryegrass found in South Australia in 2010.

Table.3 Weed species found to have populations resistant to paraquat in Australia as at February 2012.

Common Name	Year confirmed	State	Crop	Resistance to other Modes-of-action
Capeweed (*A. calendula*)	1984	Victoria	lucerne	diquat (L)
Northern Barley grass (*H. glaucum*)	1983	Victoria	lucerne	diquat (L)
Barley grass (*H. leporinum*)	1988	Victoria	lucerne	diquat (L)
Annual ryegrass (*L. rigidum*)	2010	South Australia	pasture seed	A
Annual ryegrass (*L. rigidum*)	2010	South Australia	pasture seed	M
Small square weed (*M. hirtus*)	2007	Queensland	mangoes	diquat (L)
Silvergrass (*V. bromoides*)	1990	Victoria	lucerne	diquat (L)

2,4-D

There are now 29 species of weeds with populations resistant to phenoxy herbicides (Group I) such as 2,4-D and MCPA. Australia currently has two species, wild radish (*Raphanus raphanistrum*) and Indian hedge mustard (*Sisymbrium orientale*).

Wild radish resistant to Group I herbicides is widespread in WA and present in South Australia as one population that is also resistant to MOA Groups B and F.

Indian hedge mustard is found at about 10 sites in SA and these populations are also resistant to Group B herbicides.

Andrew Storrie

BE VIGILANT AS BROME GRASS FOUND TO BE RESISTANT TO GLYPHOSATE.

Key Messages

- brome grass from South Australia has been confirmed resistant to glyphosate
- the resistant brome grass developed along an old fence line where glyphosate had been the only control
- weed management on fence lines needs a range of tactics which will depend on the soil type, slope of the land and prevailing conditions.

A population of great brome grass (*Bromus diandrus*) from South Australia has been confirmed resistant to the world's most important herbicide glyphosate. This is the first time that this highly competitive annual grass weed of crops and pastures has evolved resistance to glyphosate and is the third Australian weed species confirmed as resistant to glyphosate in the past 18 months. This highlights the need for growers to be on-the-lookout for any weeds that should be controlled by glyphosate but which survive.

The resistant brome grass was found surviving in a paddock where an old fence had been removed and cropped over and a pre-sowing application of glyphosate had been applied.

The fence line had previously been sprayed with glyphosate for many years with no other weed control tactics used.

This is a huge concern to Australian grain growers because this highly competitive weed has been becoming a major problem in reduced-tillage farming.

Glyphosate resistant brome grass (L) and susceptible (R) following 1.0 L/ha glyphosate (540 g/L).

Currently the number of glyphosate-resistant ryegrass populations evolving along fence lines is exploding. That and this new discovery is a real 'wake-up call' and shows that any weed might develop glyphosate resistance and growers need to be vigilant.

Brome grass is a major weed of crop and pasture on lighter textured soils from across the southern and western Australian cereal belts. In wheat - there are few effective in-crop herbicide options for this species, and it can reduce yields by 30 to 40%. It also emerges after crop establishment enabling it to compete strongly with the crop and produce large amounts of seed. Brome grass is also a host to a range of cereal crop diseases including take-all and barley net-blotch, while the mature seeds can injure stock. Populations of brome grass are already resistant to grass selective Group A and Group B herbicides in Victoria and Group B and Group C herbicides in Western Australia.

Managing brome grass and other weeds along fence lines requires a diverse approach. Herbicides with different modes-of-action to glyphosate need to be included. On erosion-prone sites ground cover needs to be maintained so control along fences and firebreaks should take place late winter to early spring. The older tactic of sowing crops to the fence line then baling and spraying an area along the edge of the crop for a firebreak is a valuable way of stopping weeds moving into the crop while protecting the soil.

The management of brome grass in winter cereals is complex and requires many different tactics to get weed numbers down and lessen the risk of developing herbicide resistance. Which tactics are used will be determined by location, farming system and the farmer's aspirations.

Farmers need to use a rotation that enables a sufficient range of tactics to be used so that the weed seedbank can be driven down and kept low. Tactics such as spray-topping, brown or green manuring, hay, crop competition and windrow burning are useful to take selection pressure for resistance off the herbicides.

Andrew Storrie

FARM ADVISOR LEARNING GROUPS – WA NORTHERN GROUP

Some of the WA Northern Group members after a breakfast meeting held at the Perth Advisor Updates in February, 2012; (from left) Peter Newman, Richard Quinlan, Peter Bostock, Helen Lethlean, David Cameron, Chris Wilkins, Erin Cahill and Abul Hashem. Behind the camera Sally Peltzer.

Key Messages

- Six Farm Advisor Learning Groups are being established across the cropping belt
- Groups are run by farm advisers who decide on research and extension questions relevant to Group M, L and I resistance in their area
- The Northern WA group are deeply concerned about managing glyphosate resistance in a range of species and 2,4-D resistance in wild radish.

Part of the new GRDC-funded Resistance Project is the establishment of six Farm Advisor Learning Groups. These groups consist of farm advisors (and some growers) who meet to discuss all things related to the onset of resistance to Group I, M and L herbicides.

In Western Australia, there are 2 groups, one in the northern cropping region (between Perth and Geraldton) and one near Esperance on the far south coast. Groups in other states are located at Horsham, Victoria, Moree, Tycannah Creek and Dubbo, NSW .

2,4-D resistant wild radish.

The Northern Group consists of 7 farm advisors (David Cameron, David Cahill, Helen Lethlean, Peter Bostock, Chris Wilkins, Geoff Fosbery and David Peake), John Even from the GRDC Western panel, Richard Quinlan from GRDC Regional Cropping Solutions - Northern Ag Region (where herbicide resistance has been set as a priority) and Peter Newman and Sally Peltzer from DAFWA.

The northern cropping region of WA has two major weed species, annual ryegrass and wild radish, although brome grass and barley grass and occasionally wild oats can also be a problem. The growers from this area of the wheatbelt are mainly continuous croppers (wheat, canola, lupins and barley) with few livestock. Herbicide resistance is a major drawback and annual ryegrass has resistance to 5 herbicide Mode-of-Action Groups (MOA's) (A, B, C, D and M) while wild radish to 4 MOA's (B, C, F and I).

This group has met twice so far and their priorities for 2012 and beyond are:

- Glyphosate resistance testing to determine the extent of glyphosate resistance in the area and to ground truth what it actually looks like.
- Two long-term fence-line trials - to reduce the reliance upon glyphosate as the main herbicide and reduce resistance development.
- A crop-topping trial for wild radish control - to revisit some older chemistry and try and find something suitable for late seed-set control.
- Some economics for glyphosate resistance – to determine what widespread resistance will actually cost.
- Case studies on continuing to farm despite widespread resistance.

Sally Peltzer

CONTROL OF GLYPHOSATE RESISTANT ANNUAL RYEGRASS ON FENCE LINES

Key Messages

- Glyphosate resistant annual ryegrass occurs on fence lines in South Australia as a result of the intensive use of glyphosate in these areas
- There are other herbicides and herbicide mixtures that can control glyphosate-resistant annual ryegrass in these areas
- Glyphosate resistant annual ryegrass must be controlled on fence lines, as it can move at least 50 m into the crop if not controlled

Weeds growing freely on fence lines can move into cropping fields and contaminate the harvest. They can also serve as alternative hosts to various pests. As a result grain growers prefer to control weeds and other vegetation on their fence lines. Many farmers use glyphosate to control weeds on fence lines because it is easy to use and is a relatively low cost option. A consequence of continuous glyphosate use has been the evolution of glyphosate resistant annual ryegrass on many fence lines. The 2011 survey (see 'Glyphosate resistance in non-cropping areas of Australia) found 53 out of the documented 189 sites with glyphosate resistant annual ryegrass was from fence lines.

It is important to manage glyphosate resistant weeds on fence lines to prevent the resistant plants moving into cropping fields. To identify alternative herbicide controls for growers the University of Adelaide conducted two field trials in South Australia to assess the effectiveness of glyphosate and other herbicide mixtures in controlling glyphosate resistant annual ryegrass on fence lines. Weed mapping was also conducted determined how far these resistant ryegrass had moved into cropping fields from the fence lines.

Fence line trials were conducted at two sites; Ungarra on the Eyre Peninsula and Hilltown, near Clare. Ungarra had a larger population of annual ryegrass,

however both sites had a history of intensive glyphosate use for over 12 years. Control was assessed by counting the number of seed heads per square metre.

The annual ryegrass plants were larger and more resistant to glyphosate at Hilltown compared with Ungarra. Mixtures containing Roundup PowerMAX® did not fully control annual ryegrass on the at either site.

Mixtures containing Spray.Seed®, Alliance® (paraquat + amitrole) or Basta® (glufosinate) were most effective, with less than 10 seed heads m^{-2} recorded at Ungarra. Spray.Seed® was more effective where the annual ryegrass was smaller and at a lower density at Ungarra compared with that at Hilltown. The double knock application of two treatments of Spray. Seed® 14 days apart was the most effective of the currently registered options. This would also be true for consecutive applications of paraquat.

To determine how far resistant weeds had dispersed into fields, actively growing annual ryegrass were collected at distances of 0, 15, 30 and 50 metres from the fence. They were then tested for resistance to glyphosate. At both sites, resistant ryegrass plants were found at each distance, including the furthest distance of 50 metres into the crop. This shows that it is essential to control glyphosate-resistant annual ryegrass on fence lines to prevent its movement into the paddock.

Table.4 Control of glyphosate-resistant annual ryegrass with alternative herbicides at the Hilltown and Ungarra sites.

Treatment	Ryegrass heads per square metre	
	Hilltown	Ungarra
Untreated	1111	271
Roundup PowerMAX® (1L/ha)	1002	78
Roundup PowerMAX® (2L/ha)	919	61
Roundup PowerMAX® (1L/ha) + Amitrole® T (6L/ha)	367	86
Spray.Seed® (3.2 L/ha)	172	3
Alliance® (4L/ha)	76	3
Basta® (6L/ha) + Amitrole® T (6L/ha)	138	1
Spray.Seed® (3.2 L/ha) followed-by Spray. Seed® (3.2 L/ha)	27	3

NOTE: herbicide + herbicide denotes a tank-mix whereas herbicide followed-by herbicide denotes two consecutive applications.

Fence line trial showing different herbicide treatment plots with varying levels of control.

Patricia Adu-Yeboah, Peter Boutsalis, Gurgeet Gill, Jenna Malone and Christoper Preston.

TEAM MEMBER PROFILE

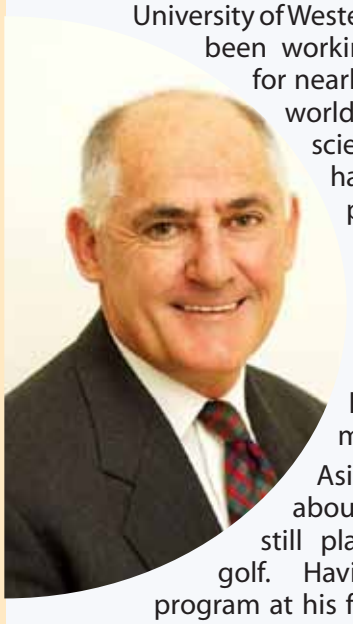
GET TO KNOW THE TEAM...

Chris Preston

Chris Preston is an Associate Professor of Weed Management at the University of Adelaide. He chairs the Australian Glyphosate Sustainability Working Group. Chris co-ordinates the GRDC research project on 'Understanding and management of weeds resistant to glyphosate, Group I herbicides and paraquat'. Chris also co-ordinates research projects on 'Glyphosate resistance in non-agricultural areas', 'Paraquat resistance in the pasture seed industry', 'Integrated weed management in the Southern Region, and 'New pre-emergent herbicides to manage trifluralin resistance'. Chris teaches weed management to both undergraduate and postgraduate students. He also frequently discusses weed management issues with farmers and farm advisors.

In Chris' spare time he has invented a new sport – extreme dog walking.

Stephen Powles



Stephen Powles is Director of the Australian Herbicide Resistance Initiative and a Winthrop Professor at the University of Western Australia. Prof Powles has been working on herbicide resistance for nearly 30 years and is one of the world's most highly cited plant scientists. He and colleagues have published 180 research papers on herbicide resistance and two books. Powles has recently been elected to the Australian Academy of Science for his research contributions to herbicide resistance and its management.

Aside from always thinking about herbicide resistance Steve still plays hockey (Veterans) and golf. Having a 1500 acre cropping program at his farm at Quairading, WA, also provides plenty of thinking time on how to control the weeds without over-relying on glyphosate!

KNOW WHAT HERBICIDES STILL WORK!!!

We are getting closer to time for planting winter crops so we need to get our brains around herbicide resistance and figure out what herbicides are still worth using.

Unfortunately only a small percentage of growers test for herbicide resistance, usually as a reaction to a herbicide failure, and an even smaller percentage use resistance testing as a part of their overall weed management program.

Start with your high risk paddocks

High risk paddocks are those where there is a long history of herbicide use and no conscious management to prevent herbicide survivors from setting seed and often have high weed numbers.

The table below gives a rule-of-thumb for the number of years before a problem is likely to develop for the major herbicide groups. Remember these do not need to be consecutive applications.

Table.5 Number of years of herbicide use before herbicide resistance is likely to be a problem.

Herbicide group	Years of application
B	4
A 'fop'	6
A 'dim'	8
C	10–15
D	10–15
F	10
I	>20
L	>15
M	>12

High risk paddocks with high weed numbers should be put back to a crop or pasture where a range of non-herbicide tactics can be used to control weed numbers. Tactics such as manuring, silage, hay or pasture should be considered for problem paddocks.

Double knocking before delayed sowing of a competitive crop using an effective pre-emergent herbicide is a good start.

Use post emergent herbicides from a MOA you haven't used before. This is likely to be more expensive than your normal brew.

Monitor, Monitor, monitor!!

After the herbicides are applied make sure you, or your advisor, has a close look at these high risk paddocks for surviving weeds. If plants that would have been present at the time of spraying are alive you need to figure out if they were spray failures (poor application) or are resistant. Weeds in obvious patches are a fair indicator of resistance.

Spraying these plants again is a high risk (of losing $$$) option, as you cannot be certain they are susceptible the herbicide you wish to use. Get them tested!

You could wait till the end of the year and collect seed for testing, but unless you act this season you are on the way to a weed blowout that may take 4-6 years to get back to manageable levels.

The other option is to collect plants from these patches and send them off for the "Quick-test". You will then have enough information to make a well-informed management decision before the weeds set seed.

Andrew Storrie

HOW TO SAMPLE PLANTS FOR THE QUICK-TEST

What is the Quick-Test

The Quick-test is a simple method by which plants (mainly grasses) growing in your paddock can be tested for herbicide resistance. The test takes 4 weeks to complete.

How old can the plants be?

The Quick-test will work on plants from seedlings to advanced tillering as long as the plants are green and healthy.

Plants are trimmed and planted into pots to allow new leaves to regenerate for a week.

The recovery of new leaves ensures that the herbicide response is similar to when young plants are sprayed in the paddock.

The plants with new leaves are then sprayed in a cabinet sprayer.

When can plants be sampled?

Plants can be sampled either before a herbicide application (eg. break of season) or after herbicides have been applied and poor control is noticed.

Sampling for Quick-Test

It is important to provide accurate details where the plants were collected from during registration.

- Collect 50 to 100 plants per paddock.
- Collect plants suspected of being resistant i.e. from the patches if collected after a herbicide application.
- Carefully pull out plants (loosen soil with a shovel) and wash roots.
- Wrap in a couple of sheets of paper towelling.
- Too much paper towel can dry small plants out
- DO NOT add any more water.
- Place the wrapped plants in a waterproof plastic bag such as a zip-lok™ bag.
- Keep in fridge until ready to post.
- Mail to testing company. Avoid sending specimens over a long weekend.

Plants sent in mid-March prior to the application of a selective herbicide. Note the paper towel is only slightly damp.

For more information:

Dr Peter Boutsalis, Plant Science Consulting (www.plantscienceconsulting.com.au)

GLYPHOSATE RESISTANCE IN NON-CROPPING AREAS OF AUSTRALIA

Key Messages

- A survey of non-agricultural areas in 2011 has found a large number of glyphosate resistant annual ryegrass, fleabane and windmill grass populations.
- Most resistant populations came from roadsides where spraying with glyphosate was the dominant weed control practice.
- Management strategies for herbicide resistance in non-agricultural areas must be developed and implemented to stop spread of glyphosate resistant weeds and contain management cost.

Glyphosate is the most widely used herbicide for weed control in Australia, in both agricultural and non-agricultural situations. While glyphosate resistance has occurred at numerous sites in agricultural systems in Australia, it has also begun to appear in a number of non-agricultural land-uses including road sides, railway rights-of-way and irrigation channels. Glyphosate resistance in these non-crop areas has the ability to spread into other areas causing new weed management. Non-agricultural situations are a new growth area for herbicide resistance so little is known about the risks of herbicide resistance in these areas.

A physical survey of areas likely to be of high risk of glyphosate resistance was conducted across Australia in 2011 with the aim of gaining a better understanding of the extent of resistance in non-cropping areas. Surveys were conducted by four Australian weed management research groups and covered Western Australia, South Australia, Victoria, New South Wales, and Queensland. The surveys were conducted in non-cropping areas considered at risk of developing glyphosate resistance. This involved driving along major roads and highways and stopping randomly every 3 to 5 kilometres and collecting any weed species present on the roadsides, around railways, buildings or irrigation channels.

Four different weed species were collected from the non-cropping areas surveyed and included annual ryegrass (*Lolium rigidum*), flaxleaf fleabane (*Conyza bonariensis*), windmill grass (*Chloris truncata*), and awnless barnyard grass (*Echinochloa colona*).

A total of 186 samples of annual ryegrass were collected as whole plants from SA, NSW and WA and subsequently tested for resistance to glyphosate following pruning and re-growth. Of these populations, 50% were found to contain high numbers of resistant individuals, and resistance was found in all three states.

For fleabane, 84 samples were collected as seed from all five states surveyed. When tested with glyphosate, 44 populations were found to contain resistance. Resistance was only found in populations from QLD, NSW and SA.

Fleabane populations sprayed with 1500 g a.i/ha Touchdown® Hi Tech, clearly showing susceptible and resistant populations.

A total of 146 windmill grass samples were collected from all states except Queensland. Due to poor germination, not all populations have been tested for resistance, however so far, 8 populations from Victoria, Western Australia and NSW appear to contain resistance to glyphosate.

Nine barnyard grass populations were collected from Queensland and NSW. One Queensland population and 2 populations from NSW were found to contain resistance to glyphosate.

Glyphosate resistance was found to occur on roadsides, in irrigation channels, on railway rights of way and around buildings. The survey has determined there is a large amount of resistance in non-cropping areas that has the potential to spread into nearby crops, and highlights the need to focus on management of these areas before they cause management problems elsewhere.

Table.6 Summary of the location and number of populations collected, and number of qlyphosate resistant populations for each species collected from the 2011 non-cropping area survey.

Species	Total number collected	Total % resistant for each species	State	Number resistant / Number collected
Ryegrass	186	50%	NSW SA WA	37/75 41/54 15/57
Fleabane	84	52%	QLD NSW VIC SA WA	7/9 31/41 0/14 6/12 0/8
Barnyard grass	9	33%	QLD NSW	1/1 2/8
Windmill grass	146	6% *	VIC WA SA NSW	5/64 2/22 6 1/54

*of populations tested so far

Jenna Malone, Tony Cook, Hanwen Wu, Abul Hashem, Peter Boutsalis and Christopher Preston

BARNYARD RESISTANCE!

BIG JUMP IN BARNYARD GRASS RESISTANT TO GLYPHOSATE

Glyphosate has been a very reliable herbicide for many years. Its effectiveness, low cost, lower toxicity and ease of use are key to maintaining no or minimum till cropping systems. Therefore maintaining the effectiveness of glyphosate is crucial to the success of current farming systems.

As a consequence, GRDC have made this issue a high priority within a new 5 year project – Improving Integrated Weed Management practices in the northern region. NSW DPI, along with the Northern Grower Alliance, University of Queensland and DAFF QLD teamed together to conduct a targeted survey of summer fallows.

This survey has shown a big jump in the number of glyphosate resistant awnless barnyard grass (GR BYG) (*Echinochloa colona*) populations going from 20 to 60 in the Northern Grain Region.

A request was sent to a network of approximately 40 agronomists for samples from paddocks that have a history of poor BYG control following glyphosate. 84 samples came from northern NSW and south-east QLD, but were fewer than anticipated because of wet weather and growers double knocking suspect fields.

Testing involves the quick-test where live plant samples were sent to the research team at Tamworth Agricultural Institute and grown-out in pots to be sprayed under standard conditions.

Results

Eighty four samples were received with 64 fully tested and 8 samples yet to be tested. Eleven sample died on the operating table due to poor preparation or were susceptible to glyphosate and were sprayed before collection.

Of the 64 fully tested 40 (62%) were resistant, 19 (30%) were susceptible and 5 (13%) were deemed marginally resistant.

It is important to remember that this was a targeted survey, however it is still a huge wake-up call to realise that the number of confirmed awnless barnyard grass populations resistant to glyphosate in the Northern Grain Region has trebled!!!

Growers must increase their levels of monitoring for spray-survivors and kill any plants before they can set seed. Double knocking in fallows by following glyphosate with paraquat is needed in high risk paddocks. The inclusion of a residual herbicide with the second knock should also be considered early in the fallow.

Modifying the rotation to include competitive short-season broadleaf crops over summer such as mung beans should also be included. This will allow use of other herbicide modes-of-action in conjunction with crop competition and an early harvest.

Growing sorghum in these high risk paddocks should be delayed until weed numbers have been dramatically reduced as barnyard grass numbers are likely to increase if pre-emergent herbicides are compromised by dry weather during crop establishment.

Some samples will be kept and tested next year to determine the level of resistance by applying various rates of glyphosate. Currently the level of resistance for most cases is classed as low to moderate with some populations having 5 to 7 fold resistance.

Tony Cook

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