the northern
HERBICIDE RESISTANCE Reporter

A Newsletter keeping you up to date with research and development in herbicide resistance in the Northern Region

New GRDC project to de-mystify northern herbicide resistance

GRDC has recognised the importance of herbicide resistance in the northern region by agreeing to fund a new $600,000 joint project between NSW DPI and Queensland DPI&F over the next three years.

The project aims to build on existing knowledge of herbicide/weed/farming system complexes that are at risk of developing herbicide resistance by using data from previous trials and surveys to develop management strategies to minimise the adverse impact of existing Group A and glyphosate resistant weeds and reduce the risk of further development.

Staff will conduct herbicide and non-herbicide weed management trials to develop and demonstrate practical integrated weed management techniques. These short term trials looking at the targeted weeds will be conducted across the northern region, while 2 long-term trials from the previous northern region herbicide resistance project will continue at Spring Ridge and Coonamble in northern NSW.

The team will collaborate with other herbicide resistance research groups regionally and nationally to ensure that existing knowledge, including herbicide resistance models, is captured and incorporated, where appropriate, into herbicide resistance management strategies for the region.

Grower awareness and understanding of the risk and management of herbicide resistance will be increased through effective extension activities including publications, field days, farm adviser updates and field demonstrations. We plan to produce a quarterly e-mail newsletter, along similar lines to the "Northern Resistance Reporter" to keep everyone up-to-date with the latest developments in herbicide resistance management.

Most of the same familiar faces growers and agronomists have been dealing with over the past 3 years will continue on this project with Andrew Storrie, Paul Moylan and Tony Cook in NSW, and Michael Widderick, Vikki Osten, Steve Walker, Glen Wright and Geoff Robinson in Queensland.

Andrew Storrie

In this issue ...

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Editorial

Welcome to the final newsletter from the DAQ527 project

This GRDC project, which concludes in June 2005, was funded primarily to raise awareness of, and provide information to, crop farmers regarding weed control strategies to help delay or prevent the impact of herbicide resistance.

The project team has been concerned with herbicide resistance, as it impacts northern (summer and winter) cropping regions of Queensland and New South Wales. The project has been pro-active in identifying weeds of farming systems, and the systems that might be at risk from herbicide resistance. Integrated weed management strategies have been developed for the key weeds at risk particularly for glyphosate resistance.

Throughout this project raising awareness has been through on-farm trials, surveys, farmer meetings, workshops and publicity/media channels.

A comprehensive brochure is being produced specific for each of the 3 cropping zones and will outline

- *General herbicide resistance information*
- *Spread of herbicide resistance*
- *What to look for*
- *Strategies to prevent herbicide resistance for the target weeds for each cropping zone.*

The brochures will be available mid-year.

Finally the GRDC has recently announced the funding of new projects. See article on front page. As mentioned, the new project will be producing an electronic version of a newsletter which is similar to our Northern Resistance Reporter. If you are interested in continuing to receive the latest research information on herbicide resistance and its management, could you please fill in and return the insert in this newsletter.

Kathryn Galea

Research paper summary

A paper has been written by the project team (Vikki Osten, Steve Walker, Andrew Storrie, Michael Widderick, Paul Moylan, Geoff Robinson and Kathryn Galea) titled 'Weed diversity and management in relation to cropping practices in the north-eastern grain region of Australia'. We are hoping it will be published in an Australian journal in the near future.

The following is the summary of the paper.

The main weeds and weed management practices undertaken in broad acre dryland cropping areas of north-eastern Australia have been identified. The information was collected in a comprehensive postal survey of both growers and agronomists from Dubbo in New South Wales (NSW) through to Clermont in central Queensland, where 237 surveys were returned. A very diverse weed flora of 105 weeds from 91 genera was identified for the three cropping zones within the region (central Queensland, southern Queensland and northern NSW). Twenty-three weeds were common to all cropping zones. The major common weeds included 2 broadleaves (the non-seasonal Sonchus oleraceus and the winter growing Rapistrum rugosum) and 2 summer grasses (Echinochloa spp. and Urochloa panicoides). The main weeds were identified for both summer and winter fallows, sorghum, wheat and chickpea crops for each of the zones. Some commonality as well as floral uniqueness was recorded. More genera were recorded in the fallows than in crops, and those in summer fallows exceeded the number in winter. Across the region, weed management relied heavily on herbicides. In fallows, glyphosate and mixes with glyphosate were very common. The importance of the glyphosate mix partner differed between the cropping zones. Use and importance of pre-emergence herbicides in-crop varied considerably between the zones. In wheat, more graminicides were used in northern NSW than in southern Queensland, and virtually none was used in central Queensland, reflecting the differences in winter grass weed flora across the region. Atrazine was the major herbicide used in sorghum, although metolachlor was also used predominantly in northern NSW. Fallow and inter-row cultivation were used more often in the southern areas of the region. Grazing of fallows was more prominent in northern NSW. High crop seeding rates were not commonly recorded indicating growers are not using crop competition as a tool for weed management. While a diversity of management practices was recorded, herbicide resistance has been and continues to be an issue for the region. The implications of floral diversity and management practices for herbicide resistance have been discussed. Successful weed management in the north-eastern grain region hinges on the vigilant monitoring of weed control efficacy and the ability to modify management practices in response to changes in weed dynamics and threats of herbicide resistance.

Alternatives to glyphosate for barnyard grass control

The threat of glyphosate resistant weeds is real. Already there are over 20 populations of annual ryegrass that are resistant in the northern grain belt. Continual reliance on glyphosate as the main source of fallow weed control will lead to further outbreaks.

Barnyard grass is at high risk of developing glyphosate resistance. Depending on frequency of rainfall over warmer months, a summer fallow paddock could be sprayed 5 times with glyphosate. Although rarely employed, other tactics that can be used to control barnyard grass include grazing, cultivation or other herbicides such as desiccants (Group L – paraquat, Spray.seed®) or residual herbicides (Group B – Flame®).

An experiment commenced in early 2004 in northern NSW to investigate the alternative chemical options for fallow barnyard grass control. Barnyard grass populations were dense, between 10 to 200 plants per square metre. There were no limiting environmental factors to herbicide performance, eg. moisture stress. Since some of the herbicides to be tested were classed as desiccants (Spray.seed® and paraquat) and some residual (Flame®), the weeds needed to be very small. Two application timings were made; the first (T1) when barnyard grass was 2 to 3 ½ leaf stage and the second 5 days later (T2) when the weed was 3 ½ leaf to early tillering.

Barnyard grass treated with Glyphosate 450 at 1.2L + Flame 200mL– two months after treatment

Glyphosate is very effective and can be used without too much consideration of weed growth stage. This is typified by **Figure 1,** which shows the high level of weed control with glyphosate CT for rates at or above 1.2L/ha for both application times. The addition of Flame® at 200mL/ha to glyphosate (1.2L/ha) improved barnyard grass control and more importantly gave very good residual control (see picture). Addition of Flame® may reduce the reliance on glyphosate since its residual ability may prevent up to three glyphosate applications.

Desiccant herbicides paraquat and Spray.seed® can also be applied successfully, but unlike glyphosate, application timing is critical. For best results treat small weeds (no greater than 3 leaf). In this experiment, a five day delay in spraying caused barnyard grass to grow from 3 leaf to the early tillering stages resulting in poor control. **Figure 2,** also demonstrates that paraquat was more effective than Spray.seed® at the same rate of product.

Flame® is not commonly used due to its high price and concerns that the residual activity is too restrictive on rotations. The 4-month plant back period for wheat, barley and chickpeas is not restrictive if applied before the end of December.

The adoption of paraquat or Spray.seed® is very poor for two reasons; greater cost compared to glyphosate and the greater perceived toxicity risks for operator. If safety instructions are obeyed, these desiccant herbicides are very safe to use.

Apart from preventing glyphosate resistance, the use of desiccant herbicides could greatly reduce the frequency of glyphosate-tolerant species such as cowvine/ peachvine, tarvine, caustic creeper, black bindweed, fleabane and sowthistle. Furthermore, these herbicides could be used in conjunction with glyphosate as a double knock-down technique, which was investigated this summer for barnyard grass.

Results highlight the robustness of glyphosate, but also demonstrate the excellent levels of control from the alternatives when used correctly.

These alternatives need to be incorporated in barnyard grass fallow management so that prevention or delay of glyphosate resistance is maintained; otherwise glyphosate resistance similar to that experienced with annual ryegrass will be here soon.

Tony Cook

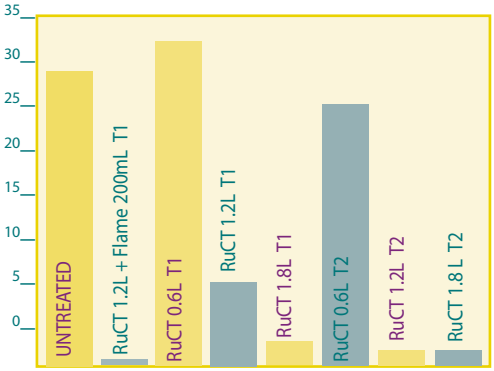


Figure 1: Effect of glyphosate application timings, rates and the addition of Flame® on barnyard grass control, as measured by percent groundcover (RuCT = RoundupCT)

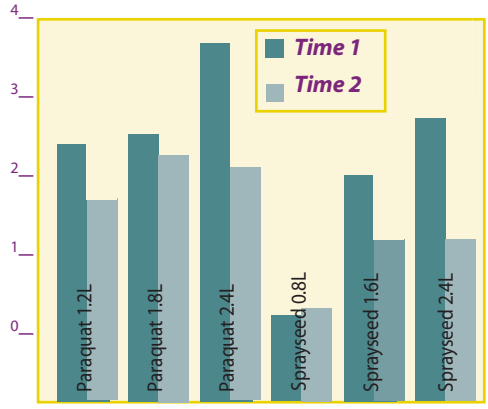
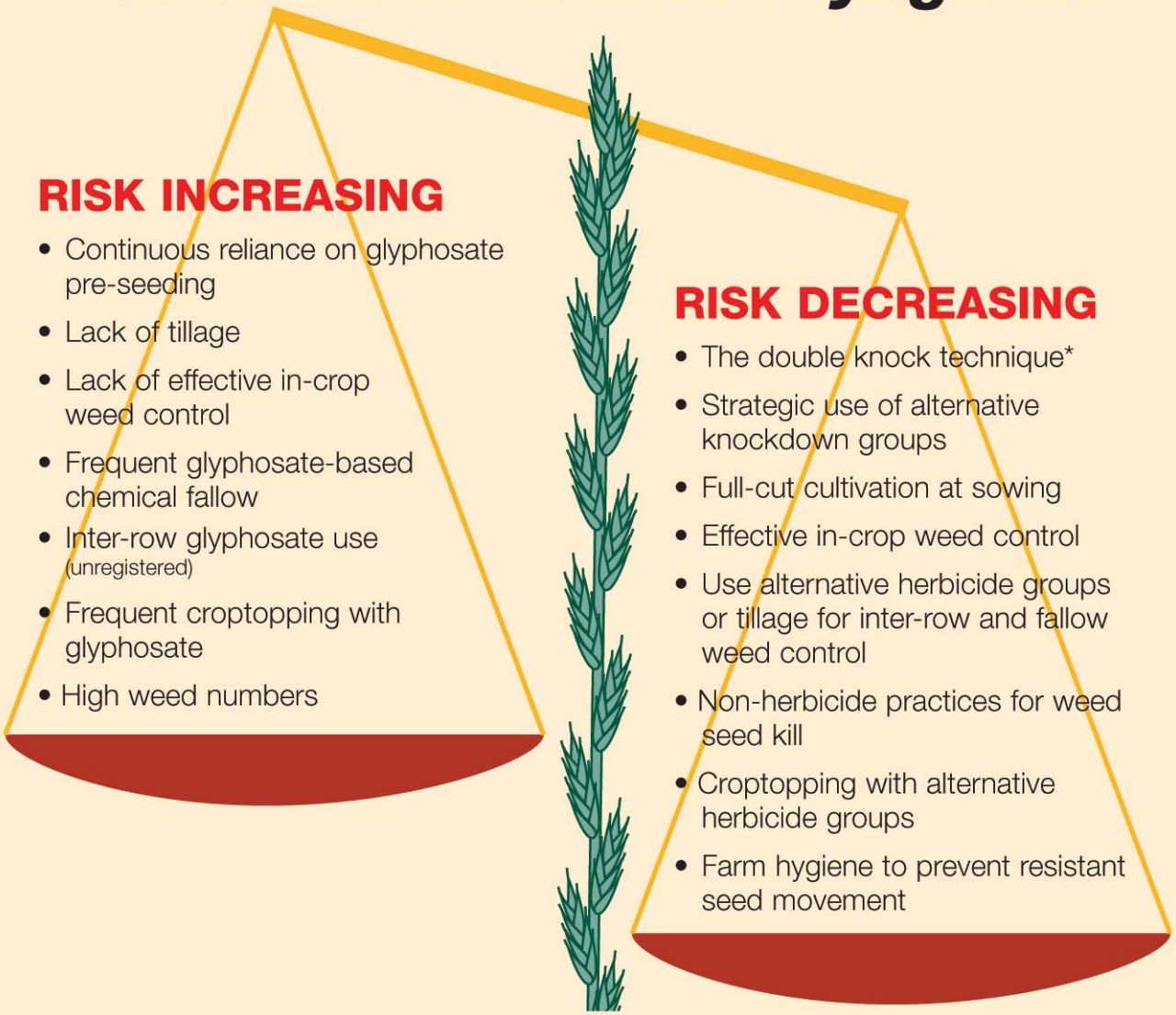


Figure 2: Effect of timing and desiccant herbicide on barnyard grass, as measure by control score using rating of 0-5, with 0 = no control and 5 = 100% control

Keeping glyphosate resistance rare in Australian cropping

Tip the scales in your favour to minimise the risk of glyphosate resistance in annual ryegrass



RISK INCREASING

- Continuous reliance on glyphosate pre-seeding
- Lack of tillage
- Lack of effective in-crop weed control
- Frequent glyphosate-based chemical fallow
- Inter-row glyphosate use (unregistered)
- Frequent croptopping with glyphosate
- High weed numbers

RISK DECREASING

- The double knock technique*
- Strategic use of alternative knockdown groups
- Full-cut cultivation at sowing
- Effective in-crop weed control
- Use alternative herbicide groups or tillage for inter-row and fallow weed control
- Non-herbicide practices for weed seed kill
- Croptopping with alternative herbicide groups
- Farm hygiene to prevent resistant seed movement

All Group M herbicides are glyphosate herbicides

This guide has been produced by the National Glyphosate Sustainability Working Group, a collaborative initiative aimed at promoting the sustainable use of glyphosate in Australian agriculture, involving the CRC Australian Weed Management, Monsanto, Syngenta, Nufarm, WA Herbicide Resistance Initiative (University of WA), University of Adelaide, Charles Sturt University, University of Melbourne, Queensland DPI&F, Department of Agriculture WA, NSW DPI, CRT/Town &Country, AVCARE and the GRDC. 2005.

For more information see: **http://www.weeds.crc.org.au/glyphosate** or e-mail: **Rick.Llewellyn@uwa.edu.au**

*The double knock technique is defined as using a full cut cultivation OR the full label rate of a paraquat-based product **(Herbicide Group L)** following the glyphosate **(Herbicide Group M)** knockdown application.

Diagram based on original concept for minimising glyphosate resistance in annual ryegrass in southern Australian grain growing by Paul Neve, WAHRI, University of WA.

Optimal management techniques for other weed species may differ.

National Glyphosate Sustainability Working Group acknowledges the financial support of AVCARE, the CRC for Australian Weed Management and the GRDC.

Research highlights on the long-term trial at Edgeroi

The aim of this trial was to develop and test on-farm strategies to minimize risk of herbicide resistance developing in the main weeds at the site.

There are number of measures to delay the onset of herbicide resistance.

A simple and effective cropping weed management system based on a sorghum – wheat rotation utilising a range of options including best herbicide technology and non-herbicide methods was tested at Owens' family property 'Old Edgeroi', Edgeroi from December 2002 until December 2004. The key management strategy was to keep weed numbers low, reduce the selection pressure on target weeds, control any weeds that escaped initial control and have a flexible approach.

Target weeds included barnyard grass, liverseed grass, annual ryegrass, wild oat, black bindweed, annual phalaris, turnip weed and sowthistle. These weeds were also deemed to have the highest potential to develop herbicide resistance.

Did we achieve our aim? Yes. What were the key points?

- Maintain very low weed numbers
- Minimising herbicide selection pressure
- Controlling escapees or late germinating weeds
- Maintain a flexible integrated management plan
- Low numbers – always have low weed numbers and keep them low by preventing seed set. Herbicide resistant weeds are more likely to develop in paddocks with a high weed population, because the frequency of resistant genes within that population is greater. 'Old Edgeroi' had very low weed population at commencement of the trials as a result of excellent weed management.
- Selection pressure - management decisions were based on rotating herbicide groups throughout the rotation. This reduces the speed at which selections occurs.

Use of the same herbicide group was avoided by replacing glyphosate for one application per season of Gramoxone®. Flame® proved very effective in fallow reducing the dependence on knockdowns and reducing the risk of barnyard grass developing resistance. It also provided effective residual control of many broadleaf weeds. Good control on broadleaf weeds was achieved by simply adding 2,4-D i.p.a. to glyphosate.

- Controlling weeds – weeds that escaped the initial treatment or late germinating weeds were controlled by both chemical and non-chemical methods. This was an important part of the low numbers strategy. Post-emergent herbicides were used in some treatments to control escapes from the pre-emergent herbicide.

In the sorghum phase, post emergent application of glyphosate using inter-row shield sprayer reduced the number of barnyard grass plants. Inter-row cultivation was also used successfully.

In the wheat phase, Affinity® + MCPA and Mataven® gave high levels of control of broadleaf weeds and wild oat. Affinity® is a group G herbicide, expanding the herbicide spectrum and was the highest yielding treatment at 5.0 t/ha. Metsulfuron + Starane® and Mataven® also gave excellent weed control but yield was reduced by 14%. Mataven® provided excellent control of wild oats and reduced the reliance on group A.

- Flexible management – a plan was devised that had a range of options and was adjusted as required. It used best herbicide technology in combination with herbicide group rotation plus non-chemical options such as strategic cultivation during the fallow phase.

Other options included delayed planting of winter crop so the initial flush of weeds was controlled by glyphosate. A higher fertiliser regime was used to produce a more competitive crop. Seeding rates and row spacing were in accordance with normal farmer practice.

Using these strategies in wheat - sorghum rotation **(Table 1)**, a simple and effective cropping weed management system can delay and reduce the risk of herbicide resistance developing.

Table 1. Effect of different weed management strategies on crop yield and weed control in a sorghum – wheat rotation during Dec 2002 to Dec 2004

Treatments in sourgham	Sorghum yield (t/ha)	Fallow	Treatments in wheat	Wheat yield (t/ha)	Gross Margin ($/ha)	Weeds Dec 04 (no/m2)
Atrazine pre Atrazine post + Starane®	6.67	glyphosate x 4 glyphosate + 2,4-D i.p.a. x 2 cultivation x 1	metsulfuron + Starane® Mataven®	4.29	1803	0
Atrazine pre Inter-row cultivation	7.03	glyphosate x 6 glyphosate + 2,4-D i.p.a. x 2	Chlorsulfuron Achieve®	4.45	1955	0
Atrazine pre	6.63	glyphosate x 1 glyphosate + 2,4-D i.p.a. x 2 Flame® x1 Gramaxone® x 1	Affinity® + MCPA Mataven®	5.0	1977	0
Atrazine pre	7.9	glyphosate x 4 glyphosate + 2,4-D i.p.a. x 2 cultivation x1	trifluralin + Avadex® Trodon® 242	4.49	2161	< 1
Atrazine pre	7.19	glyphosate x 4 glyphosate + 2,4-D i.p.a. x 2	2, 4-D amine	4.53	2049	< 1
Atrazine pre glysophate post by inter-row sheilded sprayer	6.5	glyphosate x 4 glyphosate + 2,4-D i.p.a. x 2	Hussar®	4.94	1938	0

Paul Moylan

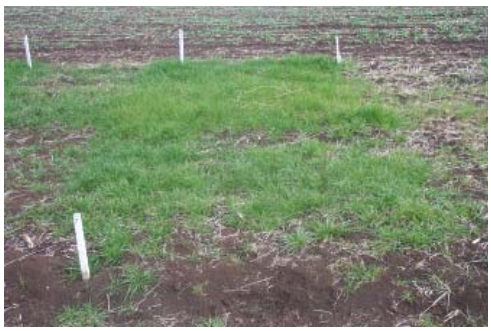
Double knockdown works on glyphosate resistant ryegrass!!

Recent findings have indicated that the number of glyphosate (Group M herbicide) resistant annual ryegrass populations in Australia has increased to 40. The majority of these populations can be found on the Liverpool plains. The level of resistance in these plants is high. An application of glyphosate at 9L per hectare resulted in only 53% control.

One option for slowing the spread of such populations is the use of the double knockdown technique, where the herbicide paraquat is applied after glyphosate (7 to 10 days later) to control glyphosate resistant individuals.

Until recently, this technique had not been tested on glyphosate resistant plants. Research by Tony Cook from NSW DPI, investigated the double knockdown technique on such highly resistant plants.

Mr Cook stated that computer models have predicted that the double knockdown technique can significantly reduce the likelihood of developing herbicide resistance, but no predictions were made regarding population growth once glyphosate resistance has developed. "Basically we are trying to determine if this technique has some practical relevance for people with Group M resistant ryegrass", said Mr Cook.



Glyphosate at 1.2L/ha

Double knockdown treatment

The results are impressive, with high levels of control obtained from the standard double knockdown application. "We are consistently achieving excellent control, at least 95% control and sometimes as high as 100%", Mr Cook explained.

As the table below shows, the level of resistance was high, with 62% of ryegrass plants killed after one application of glyphosate (1.2L/ha). However, with the introduction of another herbicide such paraquat or Spray.seed® (Group L), the level of control was elevated dramatically.

"Farmers need to know more about the specifics when applying Group L herbicides. It is important that they are applied to small weeds. Weed growth stage at the time of application is the key", stressed Mr Cook. "Once plants are larger than the early 2 to 3 leaf stage the effect of paraquat declines very rapidly", he said.

It seems another key to success is spraying first with glyphosate and waiting up to 14 days to apply the paraquat or Spray.seed®. Reversing the order of application results in lower levels of control and will most likely allow glyphosate resistant plants to survive and set seed for next year.

Mr Cook commented that the knockout blow from the double knockdown technique comes from the second treatment (the Group L herbicide). "It appears that the first application of glyphosate checks the resistant ryegrass plants long enough for effective follow-up applications of paraquat or Spray.seed®", he said.

Although the repeated applications of either paraquat or Spray.seed® gave impressive control, it is not recommended as this demonstrates total reliance on one herbicide group. "If this alternative technique is used frequently, it won't be long before we are dealing with Group L resistant plants", warned Mr Cook.

More experimental work is expected next year on ryegrass and barnyard grass, to fine-tune the technique.

For more information: Tony Cook, NSW DPI Tamworth Phone: (02) 6763 1250

Results from the double knockdown experiment

Application Time 1 1.6.2004	Application Time 2 9.6.2004	Application Time 3 15.6.2004	% control of annual ryegrass
Rygrass @ 1 1/2 leaf stage	Ryegrass @ 3 to 4 leaf stage (very early tillering)	Ryegrass @ 4 leaf stage (early tillering)	
Gly		Para	100
Para		Gly	98
Gly		SS	98
SS		Gly	96
Para	Para		100
SS	SS		100
Para			62

Where Gly = glyphosate 450 at 1.2L/ha
Para = Paraquat 250 at 1.5L/ha
SS = Spray.seed 250 at 1.5L/ha

National Glysophate Sustainable Working Group

The National Glyphosate Sustainable Working Group (GSWG) was established in October 2004 to minimize the development of glyphosate resistance weeds. The long-term aim of the group is to promote sustainable management of glyphosate.

The working group is a collaboration of people from the following areas of research, industry and extension.

- *CRC for Australian Weed Management*
- *Nufarm*
- *Syngenta*
- *Monsanto*
- *Avcare*
- *University of Western Australia, WA Herbicide Resistance Initiative*
- *New South Wales Department of Primary Industries*
- *Queensland Department of Primary Industries and Forestry*
- *University of Adelaide*
- *Charles Sturt University*
- *University of Melbourne*
- *CRT Town and Country*
- *Grains Research Development Corporation*

The development of this group is timely, as the level of awareness of herbicide resistance has risen markedly, particularly in Queensland in the last four years. The approach of the group is to develop strategies, which enable farmers to continue to use glyphosate and keep the risk of resistance low.

The goals of the group are to:

1. ***Increase the sustainability of glyphosate usage through the development and delivery of clear consistent information, based on industry incentives***
2. ***Increase collaborations and consistency among the glyphosate research and extension activities of key research, extension and industry groups.***
3. ***Contribute to the development of research, development and extension initiatives aimed at improving the management of glyphosate***

In the last 6 months, the group has produced:

- ***A register of all identified glyphosate resistant weed populations in Australia***
- ***A list of frequently asked questions, such as:***
  - What does glyphosate resistance look like?
  -What is the mechanism of glyphosate resistance?
  -Will glyphosate resistance spread?
- ***Information on what to do if you suspect you have glyphosate resistance***
- ***A fact sheet on the risk factors that lead to development of glyphosate resistance.***

All of this is now available on the Weeds CRC website at www.weeds.crc.org.au

GRDC project UQ138 discovers molecular basis of group A resistance in wild oat.

Through the GRDC-funded project UQ138 'Detection, monitoring and management of herbicide resistance – northern region', the project's molecular biologists, Dr Dion Harrison and PhD student, Ms Wenjie Liu have discovered 5 new mutations in the ACCase gene of wild oat *(Avena sterilis L. ssp. Ludoviciana)* that can confer resistance to Group A herbicides.

On commencement of the project, only one mutation was known to confer resistance to Group A herbicides and little was known about the resistance mechanisms in weeds of the northern region. Initial research on suspected Group-A resistant wild oat populations supplied by farmers in the northern region through the HeRTS (herbicide resistance testing service) scheme quickly showed that the only mutation known at the time was not present in these populations. Through further molecular research on the different populations the additional mutations were identified.

These results suggest that resistance can evolve independently in farming systems of close geographical proximity. Interestingly, all of the mutations appear to confer resistance to Group A 'fops' but not necessarily group A 'dims'. Recently, similar mutations have since been reported for other weed species in Australia and overseas including annual ryegrass *(Lolium rigidum)* and black grass *(Alopecurus myosuroides)*.

Additional outcomes of the UQ138 project include a suite of simple molecular diagnostic tests that can be used to rapidly detect and help monitor the various mutations in wild oat populations suspected of being resistant to Group A herbicides. An advantage of molecular tests is that they can detect resistance mutations when present in populations at very low gene frequencies. However, only the known mutations can be assayed for. Further investigations are likely to reveal more mutations conferring resistance to Group A herbicides. Future research will assess whether the different mutations confer different levels of resistance.

Dion Harrison

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CRC Weed management

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