Autumn 2014

giving a RATS

GRDC
Grains Research & Development Corporation

YOU WANT RADISH WITH THAT?

No doubt about it, wild radish is shaping up to be one of those weeds we really need to come to grips with sooner or later. I and many others in the industry hope it is sooner. Western Australia now has glyphosate resistant populations along with 2,4-D resistant populations and some that are resistant to various combinations including all three modes of action – B, F and I. Actually most populations in WA are resistant to Group B herbicides. Farmers on the south coast of WA are not immune, with a 2011 survey reported in "Giving a RATS Edition 4" last year showing 2,4-D resistant radish starting its march south.

Not to be outdone, New South Wales has declared it too has 2,4-D resistant radish to bring it into line with South Australia and Victoria. The Editor also has it on good authority that north western Tasmania has 2,4-D + Group B resistant radish. So what to do about it? Test, test, test to know your enemy.

In 2013 surveys of annual ryegrass were conducted over the southern half of Western Australia showing over 40 percent of collections have some level of glyphosate resistance. It is time for farmers to put those management plans into action.

To put glyphosate resistance in perspective, Dave Thornby asked the deep question, "Where does it all come from?" and indicates where we need to be looking in different farming systems.

Some good news includes a case study on an Esperance farmer who is using narrow crop rows and competition to beat his ryegrass problem.

Glyphosate resistant sowthistle that was forewarned in "Giving a RATS" Edition 7 has been confirmed from 7 populations in northern NSW with 30 suspect populations undergoing testing. It looks like more interesting times ahead for northern cropping systems.

A series of Advanced Spray Management workshops have been conducted across the cropping belt. Six conducted in Western Australia have highlighted some issues with getting spray coverage and therefore weed kill over a range of conditions.

The mechanism of glyphosate resistant brome grass has been confirmed by the University of Adelaide team to be gene multiplication, the same mechanism responsible for high levels of resistance in Palmer amaranth (A. palmeri). In the US Palmer amaranth is called Satan weed because of the grief it is causing them.

We also look at a newer member of the team, Greg Brooke and see what his claims to fame are.

Maybe there is a lesson in more interesting news from the south east of the USA with a fertile glyphosate resistant hybrid between *Amaranthus spinosus* and Palmer amaranth making a move into cropping fields.

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> *If you know the enemy and know yourself you need not fear the results of a hundred battles.*
>
> Sun Tzu
>
> Chinese General and philosopher 544-496 BC

Figure 1. High level 2,4-D resistant wild radish Wongan Hills, W.A.

Main Points

- We are running out of herbicide modes of action for wild radish
- Wild radish populations resistant to glyphosate have been found in Western Australia
- Wild radish populations resistant to 2,4-D are becoming widespread across Australia
- Populations resistant to up to three MOAs are increasing
- Farmers need to test, test, test to determine which herbicides still work
- Farmers need to develop robust weed management plans with broader rotations to manage the weed seedbank – herbicides won't solve herbicide resistance.

Western Australia now has three glyphosate resistant populations wild radish *(Raphanus raphanistrum)*, along with numerous 2,4-D resistant populations and some that are resistant to various combinations of up to three modes-of-action – B, F and I. (In fact most populations in WA are resistant to Group B herbicides, yet sulfonylurea (B) herbicides are standard in most tank mixes). One farmer has lost all his herbicides and has to rely on non-herbicide tactics to decimate the radish seed bank. Farmers on the south coast of WA are not immune, with a 2011 survey reported in "Giving a RATS Edition 4" last year showing that 2,4-D resistant radish is popping up in the south.

Not to be outdone, New South Wales has declared in late 2013 that it too has 2,4-D resistant radish bringing it into line with South Australia and Victoria. It also looks like north western Tasmania has 2,4-D + Group B resistant radish. The wild radish tends to 'blow-out' in the poppy crops.

So why is it becoming such a problem?

- Wild radish will germinate any time of year as long as it has sufficient soil moisture.
- It starts flowering early and will continue flowering and setting pods until it runs out of water.
- Fertile seed is formed three weeks after the flower is pollinated.
- It must share pollen with another plant to form fertile seed which allows the sharing of resistant genes.
- Radish sheds many pods before harvest, leading to dense clumps in the paddock. This makes getting good spray coverage on all individual plants difficult.
- Seed from pods that don't go through a header won't germinate for two years if left on the surface and longer if buried. An ideal adaptation for the once popular wheat-lupin rotation in WA.
- It has a long lived seedbank, worsened by the hard seed pod which protects the seed.

- ➔ Pods break into cereal grain sized segments and end up with the grain, becoming difficult to grade out. Contamination by green pod segments kills cereal grain.
- ➔ To date there are two levels of 2,4-D resistance – high where plants are rate insensitive and moderate, where 2,4-D rate and crop competition are still effective management tools.

So what work has been done to investigate this troublesome 'beast'?

Glyphosate resistance -
Mike Ashworth AHRI

Mike, a PhD candidate at the University of Western Australia, has been searching for glyphosate resistant wild radish and yes he found three populations in Western Australia with two from winter fallow and one from glyphosate resistant canola. Read the details here.

2,4-D resistance in WA - Mike Walsh, Australian Herbicide Resistance Initiative

In 2008, Mike Walsh and colleagues published a paper showing that wild radish with moderate 2,4-D resistant could be controlled by 2,4-D and wheat crop competition. This demonstrates that if weeds are noticeably affected but not controlled by a herbicide then the additional impact of crop competition can deliver effective weed control.

Grant Thompson - Managing multiple resistant wild radish

Grant conducted several trials on multiple resistant wild radish in the Geraldton district in 2013 to investigate herbicide strategies to minimise the risk of developing resistance to pyrasulfotole (group H) the main active in Velocity® and Precept®. The Geraldton district uses more Velocity® than the combined remainder of Australia.

The trials highlighted the benefits of a two spray strategy – Early post emergent when the radish was 2 leaf followed by a second post emergent treatment at 4 leaf, which gives highest weed control and crop yield. Velocity® followed by Velocity® gave highest level of control, but crop yield wasn't significantly different to bromoxynil or Jaguar® followed by Velocity®.

Bill Campbell, Nufarm – Multiple resistant wild radish – 5-stage approach

Bill has been working on the management of radish for over a decade and has seen an ever worsening problem develop in the northern WA wheat belt. Bill reckons that to control 'later stage' multiple resistant radish the cost is between $60 (2 sprays – crop yield and low weed numbers) to $90 (3 sprays - no seed set) per hectare. Preconceived "dollar spends per hectare" for weed control go out the door.

Nufarm are developing a strategy called WeedLogic® where radish resistance is divided into 5 stages. It is based on the fact that different MOA combinations (at full label rates) can have either additive or multiplicative effects. The higher the number the fewer the MOA combinations are available to the grower. The only way you know where your radish fits is to test each MOA combination separately. Bill has one client where NO herbicides, either alone or in combination, will work. *(Surely this must be stage 6? Ed.)*

Bill's work shows the following are essential to effective control radish:

- ➔ Testing each mode of action separately and in combination to know what herbicide combinations still work in each paddock.
- ➔ Multiple herbicide applications in the one season.
- ➔ All radish seed production must be prevented each season.

Andrew Storrie

Figure 2. Wild radish sprayed at 2 leaf stage with glyphosate at 750 g a.i./ha. M. Ashworth.

Main Points

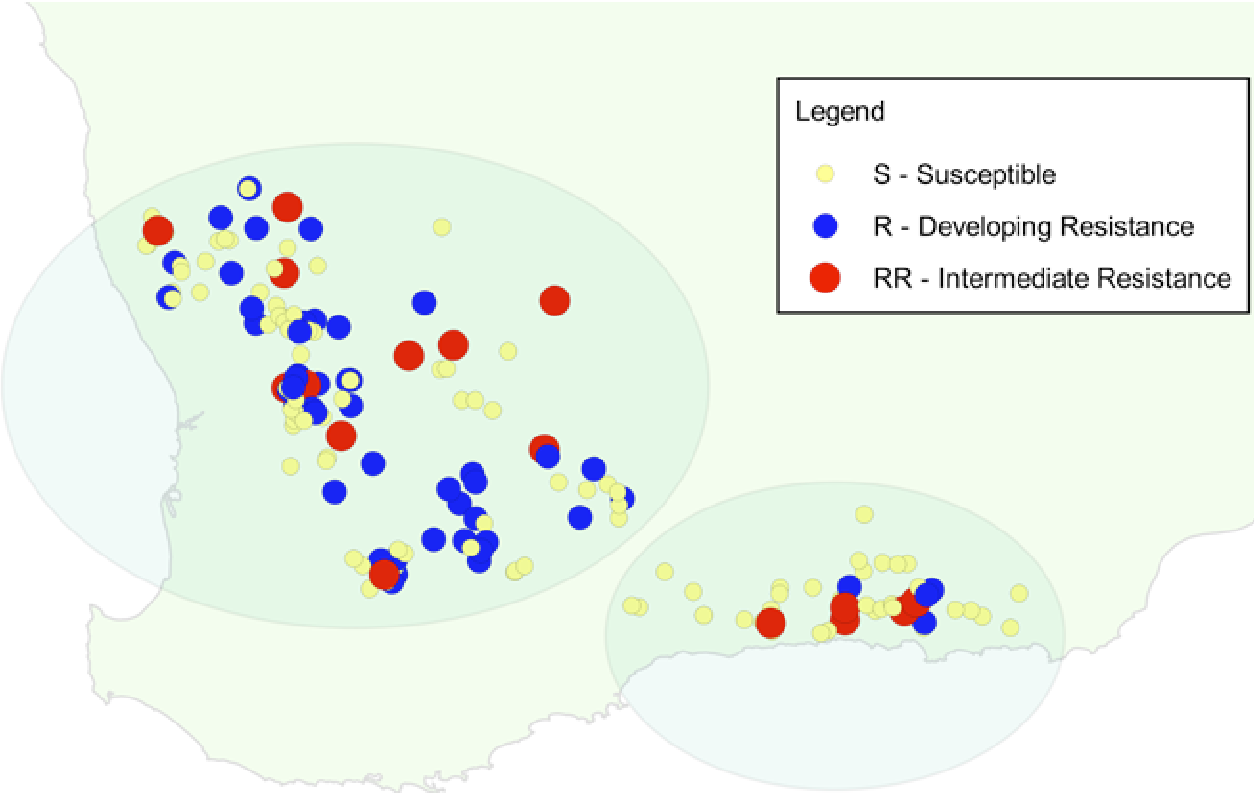

Figure 3. The results so far of the 2013 pre-harvest survey (Seed Test) combined with the earlier Quicktest results.

- ➔ The preliminary results of a recent survey showed over 40 per cent of annual ryegrass samples displayed some level of resistance to glyphosate
- ➔ As the majority of the samples showed only weak resistance, strategies can be devised to prevent resistance from worsening
- ➔ It is now time for growers to develop and implement their own strategies on their farms

As part of a GRDC-funded Glyphosate, Paraquat and 2,4-D resistance project, Dr Sally Peltzer from DAFWA coordinated a survey before the 2013 harvest to raise the awareness of glyphosate resistance in annual ryegrass in WA's wheatbelt and determine how widespread it is. This followed a survey around the Esperance and the south coast earlier in 2013 that found 14 glyphosate resistant populations (adding to the 55 populations already recorded for the region).

The 2013 pre-harvest survey focussed on weedy paddocks, proposed by growers, agronomists and growers groups for seed collection. The seed was then sent to Peter Boutsalis of Plant Science Consulting in Adelaide for testing against 1.5 and 3 L/ha of glyphosate (540g a.i.).

Forty-two percent of the samples tested so far have some glyphosate resistance with 32% weak (or developing) resistance, 8% intermediate resistance to the lower glyphosate testing rate. Ten percent of the samples also showed some resistance to the high rate of glyphosate.

Populations with weak resistance are very difficult to spot in the paddock and many of the growers were surprised by their results. It is likely glyphosate resistance is developing on many properties without the growers being aware. This could be due to low levels of herbicide resistance testing being conducted on farms in general.

Now is the time to act. The best practices to prolong the effectiveness of glyphosate include:

- ➔ Applying full herbicide rates under the best conditions possible.
- ➔ Killing any survivors of the glyphosate application, such as using double knock.
- ➔ Rotating herbicide modes of action (including on fence lines).
- ➔ Using harvest weed seed management.

Later in 2014, three regional Best Practice Guides for preventing and managing glyphosate resistance will be developed in collaboration with WA's leading consultants. Six fenceline trials aimed at preventing glyphosate resistance will also be available for viewing at Field Days and Field walks around the state this spring. **Watch this Space!**

Further information about glyphosate resistance can be found at the WeedSmart http://www.weedsmart.org.au/ and the Australian Glyphosate Resistance Working Group http://glyphosateresistance.org.au/ websites.

Sally Peltzer, DAFWA, Albany

Main Points

- Grains paddocks are actually more likely to develop resistance in situ
- Mixed grains/livestock paddocks are more effective at moving resistance, with grains and cotton paddocks being the least effective resistance transporters.
- Farms that are highly connected to other parts of the landscape (with road frontage, channels, import stock feed, and/or have coal seam gas/power/communications infrastructure) have the highest risk of importing resistance
- Paddocks on one farm are more effective transporters among each other than with other types of landscape units.
- Local roadside weed management (and not other farming types) will be the key source of imported resistance

The 2013 WA glyphosate resistance survey in the previous article raises an interesting question, "Did the resistance develop in my paddock or did I get it from somewhere else?" The SHeRPA model give a good indication of what is the most likely scenario.

New modelling from the national herbicide resistance project (UA00124) is telling us more about how herbicide resistance genes might move from one place to another. It shows what is really important is how 'connected' a farm is to everything else in the landscape.

In 2011, we posed two questions:

- 'What are the herbicide resistance risks to grains farms from non-grains enterprises?' In other words, how likely is it that herbicide resistant populations will be selected in non-grains land uses and transported to grains farms, 'infecting' them with resistance?
- If so, is this a big risk for the grains industry, requiring some effort to manage?

The spread of herbicide resistance is a landscape scale problem covering hundreds of square kilometres. Selection also occurs over decades with herbicides like glyphosate, paraquat and 2,4-D. Due to the huge scale and long time frames the analysis of the problem is best done with modelling. The Spatial Herbicide Resistance Pathways Analyser (SHeRPA) model was developed to deal with this problem.

SHeRPA describes the position of different farms, paddocks and other landscape features, but doesn't include detail on their relative size. Instead, it focuses on how the elements of a landscape are connected. In this way it analyses the pathways by which a resistance trait might be moved around from sites of origin to new, previously 'clean' areas. The model assumes the target herbicide is widely used across all land use types in the landscape, so it is well suited to analysing glyphosate resistance in Australia.

SHeRPA, as used here, contains three types of paddocks:

- dedicated grains paddocks
- irrigated cotton fields
- mixed grains/livestock paddocks

It also contains sections of roadside and irrigation channel that connect groups of paddocks. Any individual paddock may be connected to other similar paddocks, different paddocks, roadside sections or irrigation channels (cotton paddocks only). Each section of the landscape (or 'cell') has an increasing chance each year to host a new, locally-evolved resistant population, unless resistance is already present. The chance for any individual cell in the landscape to evolve new resistance in situ is determined by the year of the simulation and what kind of land use is present in the cell.

In most scenarios, grains paddocks are actually more likely to develop resistance in situ than the average for all the different types of cells in the landscape, despite having the same average rate of evolution as other farm types.

Figure 4. Fleabane ifesting a roadside ready to move into neighboring paddocks.

We also tested the effects of increasing how easily the resistance trait can move across the boundary between cells.

- In all scenarios, roadsides and irrigation channels are more effective transporters of resistance than are paddocks.
- Paddocks on one farm are more effective transporters among each other than with other types of cells.

- Mixed grains/livestock paddocks are more effective at moving resistance, with grains and cotton paddocks being the least effective resistance transporters.

We think that connectivity is more important than the individual characteristics of land use types. Grains paddocks are the least connected cells in the model landscape. Roadsides are connected to all the different land use types, and cotton farms are connected to both roadsides and irrigation channels. It seems that increasing the number of places resistance can come from (or go to, in the case of roadsides) is more of a risk to farming enterprises than how well any individual potential source functions either as a 'creator' of resistant populations or as a transporter of the resistance trait. More work needed to confirm this.

So, what is the practical upshot? Grains enterprises do not appear to be at substantially higher risk of importing resistance from outside than they are at risk of selecting resistance in situ. More importantly, this risk only becomes high in conditions where particular land use types are managed at much higher resistance risk than nearby grains farms. Farms that are highly connected to the rest of the landscape (that have lots of road frontage, irrigation channels, and perhaps exposure to other connections like railways and coal seam gas infrastructure, or who import a lot of weed seeds in stock feed or planting seed, for example) are at highest risk of importing resistance. Highly connected farms should be most concerned with quarantine and farm hygiene. Management on farms that are not highly connected to the rest of the landscape, should be directed towards evolution of resistance in situ.

The importance of roadside management is also highlighted. SHeRPA predicts it is local roadside weed management (and not other farming types) that will be the key source of imported resistance. This too appears to be due to the highly connected nature of roadsides in the landscape. Local governments must be especially vigilant and better-armed with information and options, to help reduce the risk of resistance for whole communities.

For the full article go to: http://agronomo.com.au/storage/herbicide-resistance/SHeRPA_Field_connectivity_and_resistance.pdf

David Thornby, DAFF Queensland

TEAM MEMBER PROFILE ... GREG BROOKE

Greg has been an agronomist with the NSW Department of Primary Industries since 1997.

Greg worked as an extension agronomist for 17 years in the Central west region of NSW developing expertise in weed management and zero till technology.

Last year Greg changed to a research and development role and is based at the Trangie Agricultural Research Station to help deliver services to the broader GRDC Northern grains region.

His time is divided between three GRDC funded projects:- National Herbicide resistance project (UA00124), weed survey work for herbicide resistance, high yielding cereal grains crops, Variety Specific Agronomy Package (VSAP) trials and extension. He is also involved in a recently funded Department of Agriculture, Fisheries & Forestry project with the Conservation and No-till Farming Association and South Australian No-Till Farmers Association to improve precision seeding systems. Greg's hope is by uniformly establishing winter crops in high stubble loads more uniform crop growth and better in-row weed competition will be achieved.

The discovery last year of the first NSW case of group I resistant wild radish in central NSW has shown that no-one is immune to this developing problem. Currently Tony Cook and Greg are working on glasshouse screening of barnyard grass for glyphosate resistance.

Figure 5. Mic Fels with his new 60 ft seeder (being modified for 2014)

Mic and Marie Fels

Farm: 6000 ha, 40 km north-east of Esperance

Main weed: annual ryegrass

Main weed control tactics:

- ➔ Narrow row spacings for competition
- ➔ Harvest weed management – Mic style
- ➔ Stacked rotations
- ➔ Doubleknock
- ➔ Monitoring

Mic and Marnie Fels, farm 6000 ha just north of Esperance on the south coast of WA that they bought in 2002. The property is 100% cropping with no livestock.

Mic is serious about managing annual ryegrass and it dominates most decisions made on the farm. With an annual rainfall of 450 mm and an often mild finish to the season, ryegrass will germinate numerous times over the season and set lots of seed.

Mic realised the major weed potential of ryegrass in 2003, the second year after buying the property. It was a very wet year (600 mm over the growing season) and large parts of the farm became dominated with ryegrass with little or no crop (the property had a long history of pasture). The worst areas were cut and baled but there were also some less affected areas that received no seed set control. Three years later (2007) when Mic was applying a knockdown spray before sowing, he noticed lines of ryegrass germinating 9 inches (23 cm) apart. He had not used 9 inch row spacing since 2003 as he had converted to 12 inch (30 cm) spacings in 2004. These ryegrass seedlings had to come from plants that had dropped and landed in the furrows 3 years earlier. This brought home to him the need for at least two consecutive clean years (break crops) to reduce the seed bank. The traditional one year break was definitely not enough. Following this he has incorporated a series of stacked rotations into his program;

1. Triazine Tolerant (TT) canola
2. Roundup Ready® (RR) canola,
3. two years of wheat
4. two barley years.

Mic estimates he now has less than one plant per 20 square metres across the farm, in most seasons.

Figure 6. In 2012, Mic had a pre-emergent trial on one of his paddocks which produced lots of ryegrass in the patch. In 2013, the air seeder drivers (backpackers) had some blocked runs for two paddocks. The blocked runs across the old trial site produced an excellent row spacing trial – 7.5 (left), 15 (middle) and 30 (right) inch row spacing.

Narrow row spacings - Weed Science's poster boy

Mic rates his most significant tactic on the war against ryegrass as the increased crop competition he gets with narrow row spacings. He changed to 7.5 inch (19 cm) spacings in 2011 after designing his own disk seeder with wavy (or fluted) disks to get improved soil throw for the pre-emergent herbicides, press wheels and robust high quality bearings. Mic thinks most disk seeders have poor quality bearings and become very high maintenance. This system has worked so well that he has set up a new 60 ft (18 m) machine this year.

Mic decided to change to narrow row spacing after trawling DAFWA and GRDC research results and reckons that "trial after trial after trial showed huge yield benefits with narrow rows (1% extra per inch making 5% for a reduction from 12 to 7 inch) and with this yield increase you can pay for the machine in the first season – it was just a no brainer. We were previously doing all these great IWM things but were still on 12 inch row spacing. To me it felt like I was giving the ryegrass a free kick". Another advantage of narrow rows comes at harvest where the ryegrass stands tall making it easier to catch.

He thinks many growers do not want to reduce their row spacings due to the higher costs for the machinery, the perceived difficulties with stubble at seeding and the problems associated with the traditional disk machines. Mic feels that many growers are just not aware of the size of the yield and weed competition benefits from narrow rows.

Mic does not have any extra disease issues with the narrow rows and practices canopy management by managing his nitrogen inputs. He also now has very few issues with non-wetting as the new crop rows are always very close to the old ones (where the moisture band is).

Figure 7. The 'foot wide' chaff lines in March 2014.

Harvest weed management - Mic style

Another innovation Mic uses against ryegrass is a hybrid of two conventional tactics; dropping weed seed on tramlines and narrow windrow production. Mic uses chutes on the back of the headers to drop chaff (about one foot or 30 cm wide) into the middle of the header pass (rather than on the tramlines) and spreads the remaining straw back onto the paddock. Whatever goes into the header goes back to the same spot each year. He does not plan to spray out the weed lines, assuming that all the seeds that do come up will compete with each other, and any that set seed will just go back into the same line where they came from. He also expects the mulch effect of chaff to minimise weed emergence.

The advantages of this system include;

- ➔ One row of chaff instead of two (every 40 feet).
- ➔ Not driving on the chaff row. You plant the seeds by driving on it, and you add an inhibiting layer of mulch by not driving on it
- ➔ No need for fancy or expensive equipment (about $200 for the chute). Doesn't affect harvest efficiency.

ONE FARMING FAMILY'S WAR ON RYEGRASS ... *cont*

- If you want to change the tramlines or if you have collected lots of weeds that year or if they are starting to spread out, you can add the straw onto the chaff line in the canola phase then burn in autumn.

Previously Mic dropped straw windrows (for burning) but found numerous problems with this system. He would swath the barley (1 year in 5) as early as he could and cut low to make windrows for burning in autumn. Like many others, he found it very hard not to burn the whole paddock with barley. He chose not to windrow canola or wheat for burning as:

- canola could not be cut low enough to catch all ryegrass.
- wheat maturity is too late and a lot of the weed seeds have dropped by harvest.

Other weed control tactics

Another tactic Mic uses regularly is the 'doubleknock'. He doubleknocks every paddock if there is time, using paraquat at 1.5 to 2 L/ha as the second knock. As he grows RR canola, he is mindful of the risk of developing glyphosate resistance. Because of this, Mic only uses paraquat as a knockdown in the RR canola, keeping two shots of glyphosate for use during the season. This means that glyphosate is not used more often than in any of the other crops. He desiccates his TT canola prior to harvest with glyphosate.

Mic also monitors his fencelines and uses high water rates and low drift air-induction jets (so he can use paraquat). And of course, annual ryegrass gets special attention if it is found on fencelines.

Sally Peltzer, DAFWA Albany

GLYPHOSATE RESISTANT SOWTHISTLE CONFIRMED IN NORTHERN NSW

Main Points

- Seven populations of sowthistle from northern NSW have now been confirmed resistant to glyphosate with another 30 populations being tested.
- GR sowthistle is likely to be widespread in GRDC's northern Grain Region due to the heavy reliance on glyphosate in summer fallows and the weed having wind-blown seed.
- When rosettes get larger than the top of a drink can, they become much harder to control.
- Using a wide range of different management tactics in the one season is essential to manage this weed.

The world's first cases of glyphosate resistance in the important cropping weed, sowthistle *(Sonchus spp.)* have been confirmed in northern New South Wales. The seven populations come from mixed cropping farms on the Liverpool Plains, the same area that produced the latest glyphosate resistant liverseed grass that was confirmed this January. The first two populations were first highlighted in Edition 6 of "Giving a RATS".

Sowthistle and other surface germinating weeds are becoming bigger problems with the widespread adoption of reduced tillage agriculture and over reliance on glyphosate. The presence of glyphosate resistant populations will make weed management more complicated, especially with each plant being able to produce thousands of wind-blown seeds.

There is also widespread resistance to Group B herbicides such as chlorsulfuron and metsulfuron in the northern cropping zone, so this reduces the number of successful herbicide options. Antagonism between glyphosate and 2,4-D when tank mixed also reduces control of sowthistle.

Figure 8. Glyphosate resistant sowthistle in fallow, Liverpool Plains, NSW. A. Storrie

At stem elongation-early flowering, which is when many growers spray sowthistle, 10 to 20 per cent control of the resistant populations is achieved at 1.3 L/ha glyphosate (540 g/L) while the susceptible population reach 90 per cent control.

Like the barnyard grass and wild radish story, size of plants treated and rate of herbicide applied have a big effect on the level of control. Importantly, the smaller plants are more susceptible to glyphosate despite having some resistance. As yet there is no extremely high level of resistance seen in other species where herbicide rate has no effect. This is good for managing sowthistle. It appears from the research that once a resistant plant grows beyond the rosette stage its ability to survive glyphosate magnifies.

GLYPHOSATE RESISTANT SOWTHISTLE CONFIRMED IN NORTHERN NSW... *cont*

The following points will be critical to successful sowthistle management:

- Spray weeds when rosettes no bigger than the top of a drink can. This means spraying more often.
- Keep herbicide rates on the high side of the label with appropriate application volumes.
- Have spray rig properly calibrated to deliver the maximum amount of the herbicide to the weeds.
- 'Double knock' with another mode-of-action.
- Use other modes of action such as Group L, I, L+QControl large survivors with a Weedseeker® or Weed-it® sprayer.
- Get sowthistle tested for glyphosate and Group B resistance.
- Control sowthistle and other weeds around fences, buildings, roads, irrigation channels.
- Use targeted cultivation where appropriate.
- Stop all seed set.

The second round of glyphosate resistance testing confirmed another five cases of glyphosate resistant sowthistle bringing the current total to 7. These new cases are also from the Liverpool Plains and extend from Quirindi to Mullaley. Another 30 populations will be tested over autumn/winter. Many of these samples were collected from central and northern NSW and Queensland's Darling Downs.

More surveys are planned in coming months as recent soaking rains in most parts of NSW will have triggered good emergence of sowthistle.

If you suspect glyphosate resistant sowthistle on your farm phone Tony Cook at Tamworth on 0447 651 607. Our research team will endeavour to collect seed samples or gratefully accept seed samples send by mail.

Tony Cook, NSW DPI Tamworth

SPRAY PRACTICES IN THE NORTHERN WHEATBELT OF WESTERN AUSTRALIA

During March 2014, five Advanced Spray management workshops were run by Bill Gordon in the Geraldton area and one at York. This is part of a GRDC funded project to improve spraying practices across the cropping zones of Australia. The aim is to improve growers' skills in pesticide application and thus improve weed control while minimising the off-target movement (drift) of pesticides, protecting the environment and our export sales.

Figure 9. Bill Gordon (left) discussing how to improve coverage in wheel tracks with Mingenew farmers.

Figure 10. Bill showing forward angled jets and where they should be used.

The workshops were well attended with growers keen to gain a better understanding and thus improve spraying technique and get value-for-money from their herbicides. Following are some interesting the points raised during the workshops.

- Many growers in the northern wheatbelt continue to use flat fan (XR) and Drift Guard® (DG) nozzles with a few participants using air induction (AI) nozzles. It is interesting to note that Western Australia appears to have the lowest sales of air induction nozzles in Australia.
- Following discussion with the participants the current low adoption of AI's is because they used high pressure AI nozzles when they first came out and didn't/couldn't use high enough pressures (>5 bar). This led to blocking of the air intakes and a collapse of the spray pattern leading to poor coverage.
- Not many growers are using boom height control but those that do love it.
- Most summer sprays are applied with oils. This will increase the median droplet size. While the droplet spectrum needs to be in the upper medium to course range, the speed of the droplets needs to be reduced. High velocity droplets have significant bounce when they hit stubble or the target leading to poor deposition. Using pre-orifice or air induction nozzles will reduce the speed of the droplets and improve deposition.
- Virtually no-one is testing for herbicide resistance.
- It is interesting to note that many of the same trends have been identified in central Queensland.

By maximising the coverage and amount of herbicide getting to the weeds, the less resistance you will have!

For more information on improving spray application go to the GRDC.

Figure 11. Early morning fallow at Morawa, Western Australia. Note the still conditions which are a high drift risk for spraying.

INTEGRATED WEED MANAGEMENT A MUST TO MANAGE GLYPHOSATE RESISTANCE IN GREAT BROME

Figure 12. Great brome

Main points

- Glyphosate resistance in great brome grass is a single dominant gene.
- The mechanism for the resistance is gene amplification, the strongest form of glyphosate resistance.
- This is a first case of gene amplification based resistance in Australia.
- Increasing glyphosate rates will be ineffective in controlling these populations so a well considered integrated management plan is essential.

In the winter 2013 edition of the Giving a RATS newsletter, our University of Adelaide team reported the first cases of glyphosate resistant great brome *(B. diandrus)*. We investigated the inheritance of this resistance and found it to be controlled by a single dominant gene, making the development of glyphosate resistance highly likely. In addition to inheritance, we have been studying the mechanism of resistance.

The genetic basis of glyphosate resistance in many weed species remains unknown, however those studied in detail have shown that resistance can be the result of a number of different mechanisms which include:

- Altered absorption or translocation of glyphosate leading to a reduction in the amount of glyphosate reaching the target site (meristematic tissue).
- A mutation within the target site for glyphosate, the enzyme EPSPS, causing insensitivity. So far this has been the most common resistance mechanisms identified.
- Glyphosate is rapidly pumped into vacuoles, preventing contact of the herbicide with the chloroplast and therefore the target site. This mechanism has been observed in Canadian fleabane *(Conyza canadensis)*.
- EPSPS gene amplification found in glyphosate-resistant Palmer amaranth (Amaranthus palmeri). This increased number of EPSPS genes, leads to increased level of the transcript EPSPS protein and enzymatic activity, resulting in resistance. There appears to be no competitive disadvantage for having this resistance mechanism. For more on gene amplification read here.

The different resistance mechanisms confer different levels of resistance, with target-site mutation giving the weakest level of resistance, altered translocation and vacuolar sequestration an intermediate level, and target gene amplification, the highest level with up to 40-fold resistance.

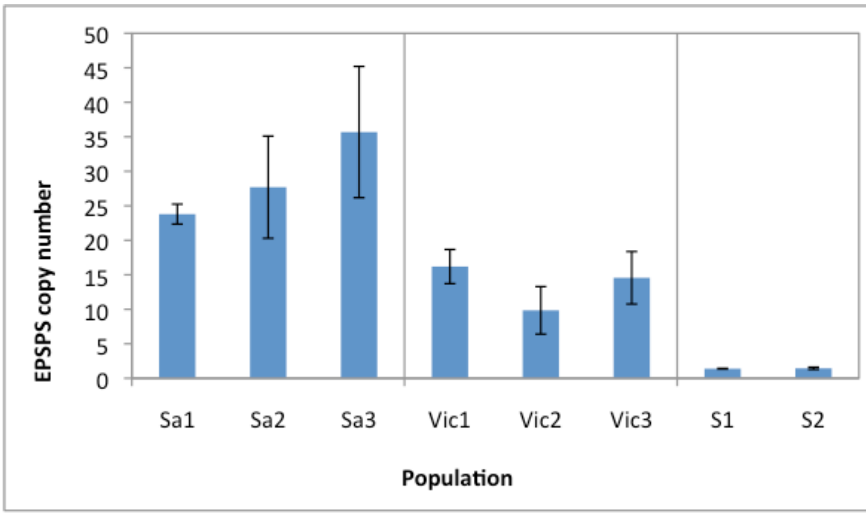

Figure 13. Number of copies of the EPSP gene in resistant brome grass populations (left & centre) compared with susceptible population (right).

Our studies have identified the mechanism of resistance in glyphosate resistant great brome to be EPSPS gene amplification, the first reported case of an Australian weed species having this mechanism of resistance. The resistant population from South Australia had an average of 30 copies of the EPSPS gene and the Victorian population around 15 copies.

The fact that gene amplification confers the highest levels of resistance to glyphosate, together with the inheritance of this resistance being easily selected for, means glyphosate resistant great brome will need to be managed using a diverse range of practices.

Jenna Malone, Peter Boutsalis, Neil Shirley, Sarah Morran and Christopher Preston, University of Adelaide

ANOTHER SPECIES JOINS THE GLYPHOSATE RESISTANCE CONGA LINE IN THE SOUTHERN USA

Figure 14. Needle burr

Jason Bond, Mississippi State University weed researcher along with USDA-ARS researchers Bill Molin and V.K. Nandula have uncovered glyphosate resistant hybrid spiny amaranth (*Amaranthus spinosis)* in a Mississippi cotton field.

Spiny amaranth, or needle burr, was featured in "Giving a RATS" Edition 2, where David Thornby and his team put it at the top of the "most likely" list out of 200 weeds in Australia. *(I hate it when he is correct! Ed)*.

Needle Burr is a weed that is commonly found in pastures in Mississippi, yet it has made the leap into a row crop environment. It has done this through hybridisation with the ubiquitous glyphosate resistant Palmer amaranth found throughout the southern USA.

The mechanism of resistance is through 'gene amplification', the same mechanism endowing glyphosate resistance to Palmer amaranth and brome grass. This has inferred 5 fold resistance in the hybrids.

It is thought that a resistant Palmer female that was pollinated from a spiny amaranth transferring the resistant gene. Amaranthus species are all known to cross with each other and produce copious quantities of pollen. Large numbers of plants in close proximity flowering at the same time will most likely hybridise and transfer resistance genes. The hybrids appear to be mostly fertile.

See here for more information on needle burr in Australia.

Adapted from Delta Farm Press

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