the northern
# HERBICIDE RESISTANCE Reporter

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

## Herbicide resistance team members scrutinise glyphosate resistant annual ryegrass

The Herbicide Resistance Team inspected glyphosate resistance first hand during a field excursion through the Liverpool Plains in September. For a number of the Queensland team members, this was their first opportunity to observe the problems of glyphosate resistance, as well as seeing first hand the impact that glyphosate resistance has on farming.

During the field tour the group inspected on-farm trials on managing glyphosate resistant ryegrass.

The long term trials demonstrated that planned integrated weed management can significantly reduce the resistance problem. The trials over the past 4 years have focused on overcoming glyphosate resistance by running down the seed bank to a very low level. The strategies targeted both fallow and in-crop situations utilizing both herbicide and non-herbicide control methods. The trial results have considerably expanded the team's knowledge base in relation to glyphosate resistance. The results will be presented early in 2007.

The team also inspected a double knock trial investigating different rates and timing of herbicide application, and a residual herbicide trial that included herbicides from Groups B, C and K.

In summary the field trip was interesting, informative and an opportunity to further build strong links within the team. The exchange of ideas and open discussion continued into the subsequent meeting. The collaborative field research underway in the northern grain region by the NSW DPI and Queensland DPI&F is ensuring that the problem of resistance is kept in hand.

***Paul Moylan***

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***The herbicide resistance team inspects a glyphosate resistant ryegrass trial on a recent field tour***

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# Principles of herbicide resistance

**Herbicide resistance is the inherited ability to survive and reproduce after exposure to a dose of herbicide normally lethal to individuals of that species. Herbicide resistance is not weed escapes from herbicide application, either through poor application or sub-optimal application environment, or species that were never controlled by that herbicide.**

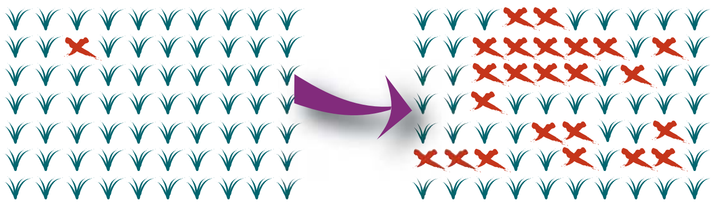
Herbicide resistance is naturally occurring in some weed populations as part of a specie's genetic diversity. It is when this naturally resistant weed is allowed to reproduce and proliferate that the resistance is noticed as a problem. Not allowing weeds to set seed is the only sure way of ensuring that resistance does not proliferate.

**There are several factors which will effect the development of resistance. These are:**

- **Selection pressure**
- **The initial frequency of the resistance gene**
- **Weed density**

Selection pressure works on the basis that the higher the percentage of weeds killed by the herbicide with the same mode of action, the higher the selection pressure for resistance. Higher selection pressure occurs with highly effective herbicide doses and increased number of herbicide hits (Figure 1).

*Figure 1. Selecting for resistance (denoted by a red cross) through using highly effective herbicide treatments*



The initial frequency of a herbicide resistance gene will depend upon the weed species and also the mode of action for which resistance is being selected. The initial frequency of resistance genes can be as high as 1 plant in 10 000 (Group B) and as rare as 1 plant in 100,000,000 for Group M. In general, the risk of resistance is reflected as a continuum in the Mode of Action (MOA) groups with risk highest for Groups A and B.

A greater weed density increases the likelihood that a particular resistance gene is present in a population. As an attendee at a recent workshop suggested, it is the same in a group of humans. In a small group of people, the likelihood that one person has resistance to a certain disease is extremely low. As the size of the crowd increases, so does the likelihood that someone in the crowd has resistance to the disease. It is the same scenario for weeds and herbicide resistance.

Resistance is often first recognised when weeds that were normally controlled by a certain herbicide are no longer controlled. Signs to look out for include, other weed species in the population still being effectively controlled by the herbicide in question and dead plants within a patch of healthy ones (Picture 1).

*Picture 1. A patch of glyphosate resistant annual ryegrass*

There are two mechanisms of herbicide resistance, target site and non-target site resistance.

Target site resistance is when the target site for a herbicide is different in a plant and the herbicide is not able to effectively bind to the target site, disrupt normal plant growth and cause plant death (Figure 2).


*Figure 2. Target site resistance where A) is susceptible and B) is resistant to Glean due to a change in the target site*

Non-target site resistance, also referred to as metabolic resistance, is used to describe mechanisms that enable survival of a herbicide application, other than by changes at the target site. The potential mechanisms include reduced herbicide uptake, reduced translocation, reduced herbicide activation, enhanced herbicide detoxification, changes in intra- or intercellular compartmentalisation, and enhanced repair of herbicide-induced damage.

Some weed populations are able to express resistance to more than one herbicide. This is known as cross resistance. It may arise without the weed population ever being exposed to one of the herbicides.

Cross resistance may be across herbicide sub-groups within a MOA group. One such example of this is resistance to Group A herbicides in wild oat. Group A herbicides are divided into the subgroups of 'fops' and 'dims'. Through continual application of 'fops', some populations have developed resistance to both 'fops' and 'dims', even though a 'dim' herbicide had never been applied. This is usually target site resistance.

Cross resistance may also be across herbicide MOA groups. An example of this is annual ryegrass, which has populations resistant to both Group A and Group B herbicides. This is usually non-target site resistance.

Some weed populations have both target and non-target site resistance which is called multiple resistance. For example, a population of annual ryegrass exhibits resistance to 5 different MOA groups.

If herbicide resistance has not yet taken hold on a paddock, it can be prevented. If herbicide resistance has taken a hold, it can be managed. The issue of prevention vs cure usually comes down to an issue of economics.

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## Editorial

*Welcome to our 8th edition. This issue focuses on research on management options to avoid glyphosate resistance developing in the important summer grasses of our region. There is also an article on the problem weed, fleabane, on testing for glyphosate resistance. The Queensland DPI&F team received very good feedback after they ran five successful grower workshops on important issues relating to glyphosate resistance in central Queensland. More are planned for next year for southern Queensland and northern NSW growers. Dates for these will be published in the next issue, which will also focus on management options to avoid herbicide resistance developing in wild oats.*

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## Consider these 2 scenarios

Scenario 1: Keep using important herbicides that are low cost and highly effective, until they no longer maintain their effectiveness due to herbicide resistance. In this scenario, once a herbicide has 'fallen over', weed management options become more limited and more expensive. These additional weed control costs will be incurred for many years, as resistance is generally a long term problem.

Scenario 2: Preventive actions using integrated weed management are implemented to ensure that important herbicides maintain their usefulness. In this scenario, a variety of different weed management tactics are used to control weeds and stop seed-set on survivors. These additional control tactics will improve weed management in both the short and long-term, and also minimise the risk of herbicide resistance becoming a problem. There will be an additional cost involved with using different and additional weed management tactics. However, these additional costs will not be incurred every year and on every paddock of the property. These additional costs can be viewed like an insurance policy against losing the herbicides that are cheaper and often relied upon for current economic farming.

***Michael Widderick***

***For further information on herbicide resistance, please check out our publications 'Stopping and managing herbicide resistance'. Electronic versions of these brochures can be found on the Weeds CRC website at http://www.weeds.crc.org.au/publications/other_products.html. In addition, check out the Weeds CRC publication on herbicide resistance at http://www.weeds.crc.org.au/documents/iwm_manual_sect2_280806.pdf***.

## KEEP UP TO DATE WITH OUR E-LERT

*Periodically we send out via e-mail the latest information on herbicide resistance in the northern grain region and Australia. The northern herbicide resistance E-lert system is a great way to stay up to date with what is happening in this area and, by doing so, you can be more prepared for what may be ahead. If you would like receive the E-lert, please forward your e-mail address to Michael Widderick (michael.widderick@dpi.qld.gov.au).*

# Predicting the potential for glyphosate resistance development in Roundup Ready® cotton

Glyphosate tolerant (Roundup Ready®) cotton is now widely used in the cotton industry, and is likely to increase with new Roundup Ready® Flex technology on the horizon. There are currently no glyphosate resistant weeds in cotton systems in Australia, largely because of a diversity of herbicide inputs, and other control methods such as cultivation and hand chipping of weeds. However, the increased use of glyphosate associated with glyphosate tolerant cotton may increase the risk of resistance development.

My recently completed PhD study examined the population dynamics of two grass weed species, barnyard grass *(Echinochloa crus-galli)* and liverseed grass *(Urochloa panicoides)*, under a range of weed management strategies. These consisted of an IWM approach with the Roundup Ready® technology (RR + IWM), a reduced residual program with the Roundup Ready® technology (RR + Res), Roundup with a grass herbicide (RR + Grass), and utilizing the Roundup Ready® technology only (RR Only). Experiments investigating the seed producing capabilities of the two species and their response to glyphosate were also undertaken. Data from these experiments were used to develop a population dynamics model in which resistance characteristics were overlaid.

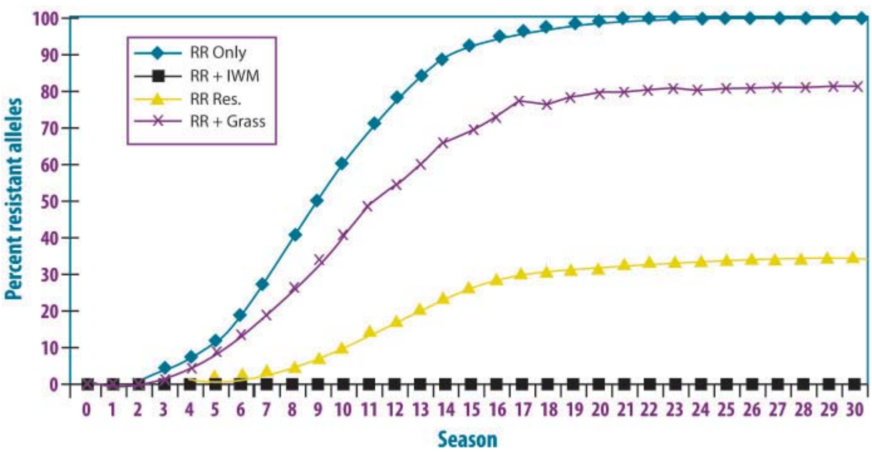


***Figure 1. The accumulation of resistance alleles in a barnyard grass population simulated under a range of weed management strategies. RR = Roundup Ready herbicide, IWM = range of Integrated Weed Management tactics, Res = Residual herbicide, Grass = Grass selective herbicide***

Outputs from the model showed that, if a glyphosate only approach to weed control is taken, resistance is highly likely to occur (Figure 1). Timeframes for possible resistance development, which is are dependant on a number of factors, could be within the vicinity of 12-17 years. However, the largest factor effecting resistance development was management. When a fully integrated approach to weed management was used, resistance did not develop over the 30 year period of the simulation. As IWM practices were reduced, the potential for glyphosate resistance development increased and potential time-frame for resistance to develop decreased.

These simulations show that strategies to prolong the use of glyphosate and reap the advantages of glyphosate tolerant cotton must incorporate a range of weed management options including a variety of herbicides with different modes of action. These resistance management strategies are incorporated into the current Roundup Ready® crop management plan, therefore aiding in the prevention of glyphosate resistance development. It is essential that the industry practices pro-active resistance management and that these issues are revisited as other new herbicide tolerance traits become available.

***Jeff Werth, formerly a PhD student with Cotton Catchment Communities CRC and University of Adelaide, now Research Scientist with Qld DPI&F***

# Plan now for better summer grass management

Summer grasses including liverseed, barnyard and sweet summer grass are at high risk of developing resistance to Group M (glyphosate) herbicides. The risk is high in these weeds as Group M herbicides are heavily relied upon for their control. A series of field trials have evaluated the efficacy of alternative herbicides for each of these weeds, the details of which are included below.

## Liverseed grass

A common rule of thumb in weed science is to spray small weeds for better control. A classic example of this is the control of liverseed grass *(Urochloa panicoides)*. Liverseed grass and most summer weeds have extremely rapid growth rates if ample moisture is available, making early spraying more challenging. If spraying is delayed up to a week, liverseed grass can change from a two leaf seedling to a tillered plant (Photo 1). Glyphosate isn't effective on tillering liverseed particularly at lower rates, so timing of application is critical (Table 1).

***Table 1. Percent control (%) of liverseed grass as affected by various glyphosate (450g/L) rates and plant growth stages***

| Glyphosate rate (L) | Weed size at spraying | | |
|---|---|---|---|
| | 2-3 leaf | mid tillering | late tillering/early panicle emergence |
| 0.6 | 42 | 27 | 7 |
| 0.8 | 83 | 40 | 18 |
| 1.0 | 97 | 77 | 22 |
| 1.2 | 96 | 86 | 40 |
| 1.8 | 98 | 97 | 76 |

Moree, NSW DPI
Note: BS-1000 was added to the glyphosate at 100mL/100L water.
Plants were actively growing for all application times.

***Photo 1. a)The optimal growth stage for the treatment of liverseed grass with herbicides. b) After only a week, liverseed grass become more difficult to control because of their size***

As demonstrated in Table 1, there was a clear glyphosate rate response with the higher rates of application achieving more control. Another major effect was that control of liverseed grass declined for later applications at the same rate. Consequently, later applications will generally result in less effective control or significantly higher rates are required to get the same level of control. For example, 0.8L/ha applied to 2-3 leaf was more effective than 1.8L/ha to large liverseed grass.

Other techniques can be utilised to further enhance the levels of control with glyphosate. One such technique is the use of adjuvants. The addition of ammonium sulphate (various trade names) to glyphosate has been found to significantly increased levels of control. For example, applying 0.6L/ha of glyphosate 450 with ammonium sulphate gave between 91 and 100% control, whereas levels of control with other adjuvants ranged from 26 to 73%.

Most growers use glyphosate-based products to control liverseed grass. However, there are alternative herbicides that control this weed. These alternative herbicides should be applied to prevent liverseed grass resistance to glyphosate. Table 2 highlights the efficacy of some alternative herbicides on liverseed grass.

***Table 2. Percent control (%) of liverseed grass after applications of various herbicides. Application growth stage ranged from 1 leaf to early tillering plants***

| Treatment | Rate/ha | % control |
|---|---|---|
| paraquat 250 g/L | 1.6L | 90 |
| glyphosate 450 g/L | 0.8L | 53 |
| amitrole | 2.5L | 0 |
| 2,2-DPA | 2.5kg | 24 |
| flupropanate | 1L | 0 |

Moree,NSW DPI.All herbicide treatments had BS-1000 added at 100mL/100L of water

In this experiment, glyphosate at the rate it was applied was not the best option. With the increasing threat of glyphosate resistance in this species it is recommended to use an occasional application of paraquat, being sure to target small weeds. Herbicide rotation should be viewed like an insurance policy against resistance.

## Barnyard grass

Barnyard grass *(Echinochloa spp.)* is a common burden in summer fallow and crops. Effective control can be achieved with glyphosate products and this is the herbicide of choice for the vast majority of growers.

To better manage this weed while reducing the risk of resistance to Group M herbicides, alternative herbicide options may need to be applied. A recent study in southern Queensland investigated the efficacy of alternative herbicides and herbicide mixtures registered for fallow control of barnyard grass (Table 3 - opposite page).

The treatments were applied to a population of barnyard grass that were at different maturities; 18plants/m² pre-tillering, 22 plants/m² advanced tillering (Photo 2).

***Photo 2. Barnyard grass at different growth rates were treated***

Barnyard grass can be effectively controlled with Group M alternatives including paraquat (Group L), but there are timing constraints which need to be taken into account. In using paraquat, the herbicide should ideally be applied to pre-tillering plants. This principle also stands for glyphosate, although this herbicide at higher rates is more reliable on barnyard grass than paraquat.

Later flushes following rain in plots with added Flame® (0.2 L/ha) were up to 34% less than plots without Flame®.

The most effective and most reliable treatment for barnyard grass is the application of paraquat after glyphosate as a double knock tactic. This treatment reduces the risk of escapes, the risk that plants will set seed and ultimately the risk of Group M resistance.

## Sweet summer grass

Sweet summer grass *(Brachiaria eruciformis)* is a common summer grass weed in central Queensland, particularly on the Central Highlands where zero tillage is practiced.

Over the past 3 years, the weed agronomy group in Emerald have examined methods of improving sweet summer grass control while reducing the risks for the development of herbicide resistance. Some work has focussed on improving the efficacy of atrazine, while other work has concentrated on alternatives to Group M including the double knock tactic.

Local research has shown that atrazine can be very effective, particularly if applied pre-plant before the sowing rains with applications of 4 L/ha (50% ai product). Applications closest to the day of planting were more effective than those applied earlier in the fallow. When applications were made immediately after planting but prior to sorghum crop emergence, efficacy was improved with either (a) light mechanical incorporation, or (b) addition of Dual Gold® to form a tank mix, even when no follow-up rain was received and the weeds emerged on the residual sowing moisture. When the weed density was greater, higher atrazine rates were more effective than lower rates.

Trial work looking at alternatives to glyphosate showed that products like Flame® (imazapic) were effective provided weed densities were not too high. Double knock tactics using an initial glyphosate application followed by a Gramoxone® application 7 or 14 days later were as effective as using glyphosate alone. A complementary trial to determine how low we can go with Gramoxone® rates showed that rates of this product, when applied alone as an alternative to group M, need to be kept above 1 L/ha (Photo 3) and this was demonstrated on fairly lush actively growing grass weeds at the pre-tillering stage. We suspect, and this will be confirmed this summer, that when the grasses are stressed, higher Gramoxone® rates will be necessary.

***Table 3. Percent control (%) of barnyard grass reduction of early and double-knock treatments. E = early applied treatments, L = late applied treatments when all plants were advanced tillering***

| Treatment (L/ha) | Timing | Pre-tillering | Advance tillering |
|---|---|---|---|
| Glyphosate CT 0.8 | E | 99 | 97 |
| Glyphosate CT 1.2 | E | 99 | 97 |
| Glyphosate CT 1.6 | E | 99 | 98 |
| Paraquat 1.2 | E | 99 | 95 |
| Paraquat 1.6 | E | 99 | 97 |
| Paraquat 2.0 | E | 100 | 95 |
| Flame® 0.2 + glyphosate 1.6 | E | 99 | 99 |
| Flame® 0.2 + paraquat 2.0 | E | 100 | 98 |
| Glyphosate 0.8 + paraquat 1.2 (+7 days) | E | 100 | 100 |
| Glyphosate 1.2 + paraquat 1.6 (+ 7 days) | E | 100 | 100 |
| Glyphosate 1.6 + paraquat 2.0 (+ 7 days) | E | 100 | 100 |
| Glyphosate CT 0.8 | L | | 94 |
| Glyphosate CT 1.2 | L | | 97 |
| Glyphosate CT 1.6 | L | | 92 |
| Paraquat 1.2 | L | | 15 |
| Paraquat 1.6 | L | | 23 |
| Paraquat 2.0 | L | | 25 |

All glyphosate treatments were applied using IPA salt 450g/L.
The first 2 treatments had BS-1000 added at 100mL/100L of water

***Photo 3. Unsprayed sweet summer grass vs. Gramoxone at 1 L/ha, both at 21 days after treatment***

Avoiding and managing herbicide resistance requires forward planning. Now is a good time to evaluate your options in terms of managing these high risk weeds.

***Tony Cook, Michael Widderick, Vikki Osten***

RESISTANCE is FUTILE

# Testing fleabane for glyphosate resistance

***Flaxleaf fleabane has become one of the most difficult-to-control weeds in the Northern Region, particularly in zero tilled farming systems. In many cases, the weed is not controlled well with glyphosate. This may be due to the species having natural tolerance and/or populations have developed resistance to glyphosate.***

*In recent years, a large number of Canadian fleabane populations have developed glyphosate resistance in United States of America, and a few populations of flaxleaf fleabane have developed resistance in Spain and South Africa.*

*We are currently investigating the response of Australian fleabane populations to glyphosate in the glasshouse in Toowoomba, with funding provided by the CRC for Australian Weed Management.*

*We collected seed from 81 populations; 36 from southern Queensland, 35 from northern NSW, 6 from South Australia and 4 from Western Australia. Sixty-eight percent of these were from situations that were highly likely to have had a history of glyphosate exposure, such as from cropping and fallow paddocks. The others were from roadsides, pastures, native vegetation and dam edges, where it would be unlikely to have much if any exposure to glyphosate spraying. Most of the populations were identified as flaxleaf fleabane but seven were identified as tall fleabane.*

*These populations are currently being tested*

***Overview of some of the thousand pots of fleabane being tested***

*for any levels of glyphosate resistance by spraying seedlings growing in pots with a range of glyphosate rates from 0 to 12L/ha. Half the populations were treated in August, and the others will be sprayed in November.*

*Visual observations of the weeds after spraying indicate that there were differences between the species and populations within species in their responses to the different glyphosate rates. At the time of writing this article, the data had not been compiled or analysed, but a report on response of all these populations to glyphosate will be presented in the next newsletter.*

***Steve Walker***

***Response to glyphosate for 3 populations with the top row untreated and the bottom row after treatment with the highest glyphosate rate***

# Mechanisms of glyphosate resistance in weeds: a review

Stephen Powles and Christopher Preston recently wrote a paper 'Evolved glyphosate resistance in plants: biochemical and genetic basis of resistance' in the journal Weed Science (Vol 20, pp. 282-289). The following is a brief summary of this well written paper.

No weeds evolved glyphosate resistance in the first 20 years of the extensive use of this herbicide. However, glyphosate resistance has developed in 8 weeds in many countries since the late 1990's (Table 1).

***Table 1. Glyphosate resistant weed populations***

| Weed | Scientific name | Country |
|---|---|---|
| *Annual ragweed* | *Ambrosia artemisiifolia* | *United States of America* |
| *Flaxleaf fleabane* | *Conyza bonariensis* | *South Africa* |
| | | *Spain* |
| *Canadian fleabane* | *Conyza canadensis* | *United States of America* |
| *Crowsfoot grass* | *Eleusine indica* | *Malaysia* |
| *Italian ryegrass* | *Lolium multiflorum* | *Brazil* |
| | | *Chile* |
| | | *United States of America* |
| *Annual ryegrass* | *Lolium ridigum* | *Australia* |
| | | *United States of America* |
| | | *South Africa* |
| *Common plantain* | *Plantago lanceolata* | *South Africa* |

The two resistance mechanisms identified so far are a weak target site mutation and a reduced glyphosate translocation mechanism.

## Target site resistance

For most herbicides, they are toxic to susceptible plant species because they inhibit enzyme functions essential to plant survival. The specific plant enzyme inhibited by a particular herbicide is defined as the herbicide target site. Target site resistance is where resistance is provided by gene mutation conferring a change to the target site enzyme such that the herbicide no longer effectively inhibits the normal enzyme function. The resistance problem arises following increases in the number of individual plants with the mutation in the weed population.

Glyphosate works by inhibiting the chloroplastic enzyme EPSPS, resulting in the plant starving from lack of essential amino acids.

The first known target site glyphosate resistance was identified in Malaysian populations of crowsfoot grass (known there as goosegrass). Researchers have identified that there are atleast two different mutations

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of the EPSPS gene in different crowsfoot grass populations. Inheritance of these target site resistance mutations is due to a single, mostly dominant gene.

These mutations, which have also been found in Australian and Chilean glyphosate resistant ryegrass populations, confer only moderate levels of resistance.

Insufficient research has been done to establish whether the mutation of the EPSPS gene has any other adverse effects on the plants, that is, whether there are any fitness costs. Some other herbicide resistant weeds are known to be less vigorous than susceptible plants of the same species. When there is a fitness penalty, the ability of the resistant weed to compete with other plants and set seed may be reduced. As a result, development of resistance may be slower where there is a significant fitness penalty associated with the resistance mechanism.

## Non-target site resistance

One of the important features of glyphosate is its considerable mobility within plants, which is essential for achieving herbicide efficacy. Thus, changes on patterns of translocation within plants could endow resistance.

Research on a number of Australian glyphosate resistant ryegrass has shown that glyphosate accumulated in the tips of treated leaves with little movement to the leaf growing points or to the roots. In contrast, glyphosate did accumulate in the lower plant parts and roots in the susceptible plants. Inheritance of the reduced translocation mechanism in ryegrass is likely to involve a single gene. There appears to be some fitness penalty in some of these resistant ryegrass populations, although the agronomic and ecological importance of this trait has yet to be investigated fully.

Similarly, studies have shown that a very similar glyphosate resistance mechanism, involving reduced translocation, is apparent in a number of resistant Canadian fleabane populations. There has been no research to determine whether there is any fitness penalty associated with this resistance mechanism in fleabane.

From these studies, it is probable that reduced translocation in a common mechanism endowing glyphosate resistance in weeds.

## Conclusions

The limited studies have shown that at least two very different mechanisms can endow glyphosate resistance. Target site resistance is due to mutations in the EPSPS gene with two variations of this mutation. Non-target resistance is due to reduction in translocation of glyphosate to the meristematic regions of resistant plants. In cross-pollinated species, both mechanisms could occur in individual plants of populations. It is likely that other mechanisms of resistance will be documented in the future.

***Compiled by Steve Walker with kind permission from Steve Powles and Chris Preston***

# CQ action learning workshops – most growers indicate practice change will happen

**At the recent action learning workshops on herbicide resistance and integrated weed management (IWM) held in central Queensland, regional growers indicated they would consider changing some of their current weed management practices, not only to avoid resistance but to improve overall weed management.**

Sharing of knowledge at the start of the workshops revealed that most grower participants were well aware of the strategies required to avoid a herbicide resistance problem developing on their farm. When asked to indicate, at the end of the workshops, the likely on-farm changes they would implement, the majority favoured a move to different chemical groups in order to maintain benefits of zero-till systems. There were also participants who indicated that no changes will be made, either due to higher costs involved in changing or the belief that their current practices were sufficient to stave off resistance development.

### Some of the proposed changes were:

- Use a broader range of chemicals
- Monitor my glyphosate use and efficacy and change chemicals where necessary
- Look at using alternative products like Flame® and SpraySeed®
- Look to rotate my crops so I can rotate to different groups of herbicides
- Going to use double-knock tactics
- Use barley instead of wheat (for competition) in my weedy paddocks
- Going back to narrow rows in sorghum
- Use tillage on the more difficult and costly weeds to control
- Strategic tillage
- Going to control my weeds a lot earlier

In April/May next year, the project team intends to contact all grower participants to ascertain whether or not changes were implemented, whether they were successful and whether any problems were encountered.

***The CQ action learning workshops combined hands on activities, group participation and visual presentations***

The workshop participants were also asked to identify further activities (research / development / extension) that might assist with their weed management.

### Suggestions included:

- Demonstration field trials showing efficacy of different herbicides and rates, and herbicide mixes (on-farm and Research Stations)
- Field days showing "economic" herbicides and rates
- Follow-up workshops and field visits
- Local field trials focusing on local weeds – not just in Emerald
- Need more understanding/knowledge about our local problem weeds
- Need more knowledge and understanding of different herbicides
- More efficacy and application data on non-glyphosate weed control options
- More trials on use of low rate residual herbicides
- Weed identification workshops

During this coming summer the project team will be conducting field walks across research and demonstration trials located on departmental research stations and on-farm. These will showcase non-glyphosate herbicides (knock-down and residuals), tillage and double-knock tactics with a focus on the summer grasses. Growers will be advised via the "E-lert" e-mail initiative of this project, and through local print news media.

Similar workshop are planned for southern Queensland in July 2007 and northern NSW in August 2007.

***Vikki Osten and Michael Widderick***

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