Herbicide resistance in Australian cotton farming systems

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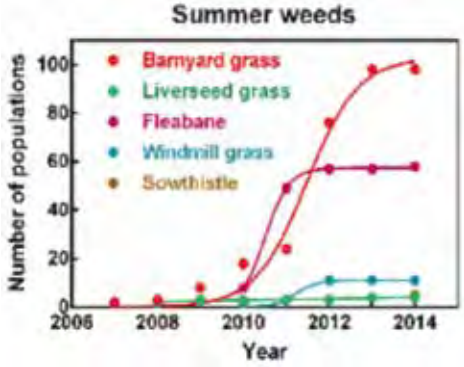
Introduction

Weed populations are naturally genetically diverse. Due to this diversity it is likely that a small number of individuals may exist that are able to survive exposure to a particular herbicide mode of action (MOA). When a herbicide from this MOA is used upon the population, individuals that have this gene present may survive and set seed, whereas the majority of plants without the gene (susceptible plants) are killed. While it might only be one or two individuals surviving at first, continued use of the same MOA herbicide will result in an ever-increasing proportion of the population being able to survive those herbicide applications. In Australia, herbicides have been grouped according to their mode of action (the way they work) which is represented by a letter code on the label and are ranked according to their resistance risk. Research has shown that weeds can develop resistance to any single control tactic used alone, not only herbicidal ones. For example, annual ryegrass has developed a more prostrate growth habit which allows it to set seed below the level that weed seed harvesters can reach.

FIGURE 1: Number of confirmed cases of winter and summer weeds has increased.

The increase in confirmed cases of glyphosate-resistance in winter weeds beween 1996 and 2014 is:

The increase in confirmed cases of glyphosate-resistance in summer weeds beween 2007 and 2014 is:



Source: Preston, C. The Australian Glyphosate Sustainability Working Group. Online. Internet. Wednesday 10 Sep 2014 Available http://www.glyphosateresistance.org.au/

Throughout the world, there are currently 238 herbicide resistant weed species and resistance has been documented in 22 of the 25 known herbicidal modes of action. Costs of weed control in cotton in the US have increased from $150 to $400 per acre due to the evolution of resistance to glyphosate. While historically the Australian cotton industry has had a strong integrated weed management system, the extensive use of herbicide tolerant (HT) cotton varieties since 2006 has meant that glyphosate now accounts for more than 80% of all herbicide used within cotton. Herbicide resistance is a reality in the Australian cotton industry with 10 weed species now confirmed as glyphosate resistant, 7 of which occur widely in cotton farming systems.

Why the need for an industry wide strategy

Experience with conventional insecticide resistance has encouraged a proactive culture to resistance issues in the Australian cotton industry. The increased use of glyphosate and escalating incidence of resistance (Figure 1) has brought about the need for an industry wide Herbicide Resistance Management Strategy. While there are significant resources available for control of specific weeds and a plethora of information is available on integrated weed management, a need to develop an industry wide strategy in conjunction with industry stakeholders was identified. This strategy would draw the available information together enabling growers to understand and manage the risks of herbicide resistance in Australian cotton farming systems.

How was the HRMS strategy developed?

The herbicide resistance management strategy was developed by the TIMS herbicide technical panel to help the Australian cotton industry manage the risk of herbicide resistance, and in particular to manage the risks associated with glyphosate. The strategy indicates how different combinations of weed control tactics affect the timeframe to resistance development as well as their impact on the weed seed bank. The draft strategy was circulated widely to industry and modified based on industry feedback, prior to its ratification by the TIMS committee.

The modeling used as the foundation of the HRMS is based on barnyard grass control in glyphosate tolerant cotton where three over the top (OTT) glyphosate applications are made in any one season. The time to resistance development and effect on the weed seed bank was predicted using combinations of weed control tactics used in crop and in the summer fallow phase for both irrigated and dryland cropping systems. The models indicate that in irrigated cotton, crop competition provides higher weed control than in dryland systems. The model demonstrates that the weed control tactics used in the summer fallow phase have the greatest impact on the time to glyphosate resistance development.

Will the HRMS change in the future?

It is expected that the HRMS will go through a similar process of annual reviews for continuous improvement like the Insecticide Resistance Management Strategy (IRMS). The IRMS started from a basic position and has matured overtime with the benefit of stakeholder feedback. It is anticipated that HRMS will be expanded to include more scenarios, tactics, and combinations of tactics as well as mature to be relevant in a multi-herbicide-trait cotton system.

Why does the HRMS only focus on glyphosate?

Glyphosate resistance has been confirmed in 10 weed species in Australia (Table A); 7 grass species and 3 broadleaf species; 4 winter-growing and 6 summer-growing weed species. The latter have been selected mainly in chemical fallows. The strong reliance on glyphosate in the current farming system and the increasing number of cases of glyphosate resistance (Figure 1) has meant that for the first HRMS, glyphosate is the key focus.

It is important to note that the principles behind the strategy, particularly the use of a diverse range of tactics and the control of survivors are applicable to other groups as well as group M (glyphosate). There is concern that glyphosate resistance may result in reliance on other herbicidal groups, leading to multiple resistance, for example, reliance on the repeated use of Group A grass selective herbicides can quickly lead to development of Group A resistance. The intent is to expand the HRMS to incorporate other modes of action and multi-trait HR cotton varieties.

TABLE A: Confirmed glyphosate weeds

Weed species	Year first documented	Number of confirmed populations May 2014
Annual ryegrass (*Lolium rigidum*)	1996	574
Barnyard grass (*Echinochloa colona*)	2007	98
Liverseed grass (*Urochloa panicoides*)	2008	4
Fleabane (*Conyza bonariensis*)	2010	58
Windmill grass (*Chloris truncata*)	2010	11
Great brome (*Bromus diandrus*)	2011	5
Wild radish (*Raphanus raphanistrum*)	2013	2
Sowthistle (*Sonchus oleraceus*)	2014	4
Red brome (*Bromus rubens*)	2014	1
Sweet Summer grass (*Brachiaria eruciformis*)	2014	1*

Preston, C. The Australian Glyphosate Sustainability Working Group. Online. Internet. Wednesday 10 Sep 2014 Available http://www.glyphosateresistance.org.au/
* Modfied to include August 2014 confirmation of glyphosate resistant sweet summer grass (*Brachiaria eruciformis*) in central Queensland

How to use the HRMS

Given that glyphosate resistance takes around 18 years to develop when used alone in an irrigated cotton cropping system and 14 years in dryland, it is important to identify the likelihood of resistance development in your own operation. The HRMS table (page 90–91) enables you to determine which other weed control tactics can be incorporated into your management system by providing guidance as to how much extra time they will give you until resistance develops, and demonstrating the effect they will have on the weed seed bank, which is critical to effectively managing resistance.

How do non-cropping areas relate to the HRMS?

Areas adjacent to cotton fields such as irrigation channels, head ditches, tail drains, roadways, fence lines and areas next to stock routes can be a significant entry source for resistant weed seeds. Where possible, use a range of tactics to manage weeds in these non-crop areas, and do NOT rely on glyphosate to manage weeds in these non-crop areas. Prevent survivors of herbicide application from setting seed.

Why does the strategy include weed seed bank as well as herbicide resistance risk?

The key to good weed management is having low weed seed bank levels. Not only does this reduce impact on the crop, but it also reduces herbicide resistance risk. The more weed seeds present, the more likely that an individual containing herbicide resistance genes will be present and hence likely to become a problem.

Do I have to adhere to the HRMS?

The HRMS is not intended to be prescriptive, and is aimed to be an industry mechanism for communicating the herbicide resistance risks from different tactics. It has been designed to present the risk related to a range of tactic combinations, to allow growers and consultants to make their own, informed decisions.

Assessing your own risk

For a more detailed assessment of the resistance risks for individual paddocks, use QDAFF's Online Glyphosate Resistance Toolkit, available via www.mybmp.com.au. This tool allows you to check what your current level of risk is for developing glyphosate-resistant weed populations on your farm. You can use it more than once, to rate different paddocks on your farm or to try out different scenarios. The tool allows you to enter information on your current practices (including crop rotation, crop density, and weed control tactics) and to identify which weed species you usually have to control. The tool will then calculate a glyphosate resistance risk score for the paddock, and a level of risk for each weed identified. The risk assessment tool can show you the areas of greatest risk in your crop

A patch of glyphosate resistant awnless barnyard grass, likely to have started near a road. Consider whole of farm use of herbicides. (Photo: T.Cook NSW DPI)

Glyphosate resistant barnyard grass was confirmed in 2007. This infestation had a 'blow-out' as the previous summer period was extremely wet and prevented access to the paddock and hence no effective treatment at an early growth stage. (Photo: T.Cook NSW DPI)

Surviving glyphosate resistant awnless barnyard grass plants amongst dead susceptible plants and dead plants of other species.

rotation and herbicide use, and whether there are any weed species you need to treat carefully. Use these suggestions to get the best results from any changes you make.

The Glyphosate Resistance Toolkit is available online through www.mybmp.com.au or DAFF Qld website. The toolkit also contains a herbicide resistance quiz which explains the important drivers in herbicide resistance development.

What does herbicide resistance look like?

Resistance can begin with the survival of one plant and the seed that it produces. Early in the development of a resistant population, resistant plants are likely to occur only in isolated patches. These are often surrounded by dead 'susceptible' plants of the same species, or other species usually controlled by the herbicide applied. This is the critical time to identify the problem. Many of the symptoms of herbicide resistance can also be explained by other causes of spray failure. Evaluate the likelihood of other possible causes of herbicide failure. Resistant weed seeds can also be transported in to a management unit through irrigation channels, vehicle tyres or blow in on the wind in the case of species such as fleabane.

How can I confirm if my weeds are resistant?

Testing a plant population for the presence of herbicide resistant individuals involves growing large numbers of plants in 'ideal' conditions, then at particular growth stages applying the herbicide at a range of rates and observing the responses. Generally, seed is collected from the suspect plants and is sent for testing. However, the dormancy mechanism in some species, such as barnyard grass, creates problems with this process. It is difficult to get sufficient quantities of seed to germinate uniformly in short time frames. An alternative sampling method is to collect actual plants out of the field for the 'Quick test'. This process is limited to seedling/small plants as large numbers need to be collected and posted. Upon arrival they are potted up and once re-established, herbicide treatments are applied. In mid-summer conditions plants are less likely to survive the trip than if collected in cooler times of the year. It is recommended to take seed samples from the surviving plants in summer and mark these sites to enable seedling collections in the following autumn or spring if they are needed. The timeline for obtaining results from sending seed samples can be several months. Results are usually available by the end of April when samples are received before January. When plants are sent for Quick tests, results are usually available within 4–8 weeks.

Collecting seed samples:

- Collect 2000–3000 seeds from plants you suspect are resistant. Barnyard grass = 1 cup full.
- If testing >3 modes of action, collect additional seed.
- Avoid collecting large amounts of seed from just a few large plants.
- Follow a 'W' shaped pattern stopping every ~20 m if survivors are widespread. If survivors are localised, collect from within this area.
- Shake seed heads into a bucket to ensure only ripe seed is collected.
- Store samples in a paper bag at room temperature, away from sunlight, moisture and heat. Post as soon as possible.

Collecting plant samples for the Quick Test:

- For each mode of action to be tested: collect 50 plants/field from areas where you suspect resistance.
- Gently pull out plants and wash roots.
- Wrap in moistened paper towel.
- Place in waterproof plastic bag.
- Keep in fridge and Express Post on the next Monday.

Sending samples to resistance testing services

Follow the instructions above and send samples together with contact details, field and weed management history and testing required to either of the testing services below.

Dr Peter Boutsalis (seed or Quick Test)
Plant Science Consulting
22 Linley Avenue,
Prospect SA 5082
Phone: 0400 664 460
Email: info@plantscience consulting.com
Website: www.plantscienceconsulting.com

John Broster (seed test only)
Charles Sturt University
Herbicide Resistance Testing Service,
PO Box 588
Wagga Wagga NSW 2678
Phone: (02) 6933 4001
Email: jbroster@csu.edu.au

How do I manage glyphosate resistant weeds?

The strategy to **manage** glyphosate resistant weeds is similar to the strategy to **prevent** glyphosate resistance – integrate a range of different tactics throughout the weed lifecycle to rapidly deplete the soil weed seed bank, and prevent further seed set/recruitment. This means that the HRMS is just as relevant to managing resistance weeds as it is preventing them. If detected early, managing known patches of herbicide resistant weeds by applying an intensive program of different tactics and ensuring weeds do not set seed, may be effective in preventing the problem spreading.

Refer to Weed Management in Australian Cotton (page 92).

For more information on herbicide resistance visit www.weedsmart.org.au

Contact David Thornby on 0421 957629 or david@innokasintellectual.com.au

Herbicide Resistance Management Strategy

Explanatory notes: 2014-15

The Herbicide Resistance Management Strategy (HRMS) is designed as a tool for weed management in irrigated and dryland farming systems incorporating herbicide tolerant (HT) cotton, to delay glyphosate resistance.

This strategy predicts the increased number of years of sustainable glyphosate use that can be achieved using glyphosate plus other tactics both in crop and in summer fallow compared to a glyphosate alone system. It also predicts the effects these tactics will have on the weed seed bank.

The strategy has been developed in response to the escalating problem of group M herbicide resistance. This first version of the HRMS focuses on a glyphosate tolerant cotton system; however the current availability of other HT and future availability of multi-trait herbicide tolerant varieties have also been considered in the design of the strategy, and may require a more sophisticated strategy to follow into the future.

The formula to manage/delay glyphosate resistance:
Extensive modelling of potential glyphosate resistance development has found that irrespective of whether a farm is irrigated or dryland, or the weed species present, or the amount of glyphosate used, the most effective way to delay resistance is to use:

2 non-glyphosate tactics targeting both grasses and broadleaf weeds during the cotton crop
+
2 non-glyphosate tactics in summer fallow targeting both grasses and broadleaf weeds
+
0 survivors, control survivors of glyphosate applications and do not allow them to set seed.

If a tactic is selected that only targets grass weeds, then an additional tactic that targets broadleaf weeds will need to be included.

How to use the industry HRMS:
This strategy has been designed to help the Australian cotton industry manage the risk of herbicide resistance by indicating how different combinations of weed control tactics affect the timeframe to resistance development as well as their impact on the weed seed bank.
Seed bank control is modelled on barnyard grass; however tactics are applicable to all weeds. The same practices apply to managing situations where resistant populations are already present.

Given the diversity of the Australian cotton farming system, the HRMS is not intended to be prescriptive, and is aimed to be an industry mechanism for communicating the herbicide resistance risks from different tactics.

Increased time to resistance:
Modelling has been used to predict the increased time to resistance as compared to a glyphosate only system, as the key determinant of risk. Identify where your cotton system already sits on the timeline to glyphosate resistance.

Research indicates glyphosate resistance develops in grass weeds in 13 years (dryland) and 19 years (irrigated) in a glyphosate only system. Resistance in broadleaf weeds is slower to develop and takes around 18 years in both irrigated and dryland systems with a summer fallow. Glyphosate resistance is delayed by 4-6 years if residual + double knock is already used in summer fallow.

Cropping System:
The HRMS models two systems:
- Continuous back to back irrigated glyphosate tolerant cotton with no summer fallow, and
- Dryland glyphosate tolerant cotton grown every second year, alternating with long summer fallows.

Determine the system that is most similar to your own. If you grow irrigated cotton but at a reduced frequency whether it is broken up by summer fallows or rotation cropping, it is more appropriate to use the dryland scenario. This will be somewhat conservative, as irrigated cotton is able to provide more crop competition.

In a dryland scenario, rotation cropping should be considered similar to a fallow, and 2 non-glyphosate tactics should be applied. Dryland or irrigated rotation crops provide an important opportunity to incorporate other tactics, rotate herbicide groups, vary the time of year crop competition suppresses weeds and produce stubble loads that reduce subsequent weed germinations.

In Crop Tactics:
- Each model assumes that three over the top (OTT) glyphosate applications are made. Reducing the number of glyphosate applications in crop does not impact the time to resistance substantially. The control of survivors and use of non-glyphosate tactics is much more significant.
- The model assumes that the first weed flush of the season is the largest emergence. Start early in the season for weed seed bank control.

- A key principle of herbicide usage in an IWM system is to rotate herbicide groups.
- Residual herbicides need back up, such as tillage, chipping and non-glyphosate knockdowns. When using residuals, consider plant back periods.
- Aim for 100% control of glyphosate survivors after glyphosate application. In terms of survivor control, high efficacy with an alternative tactic is good, but high frequency control is better than reliance on efficacy. Cultivation after glyphosate application is predicted to achieve 80% survivor control, whereas cultivation plus chipping is predicted to achieve 99.9% survivor control. Other tactics for survivor control could be equally effective, such as shielded or spot-spraying with an effective knockdown herbicide.
- The *Monsanto Roundup Ready Flex Cotton Weed Management Guide* can be referenced for in crop tactic options.

Summer Fallow tactics:
- The dryland model compares glyphosate-only summer fallows with fallows that include 2 non-glyphosate tactics (residual herbicide followed by double knock).
- Summer fallows may include any two non-glyphosate tactics such as residual or knockdown herbicides or tillage that are effective on the weed species.
- See page 88 for comments on rotation crops.

Seed Bank Control:
A high weed burden contributes to herbicide resistance risk, as the more weeds that are present, the more likely that a resistant individual will be present and hence multiplies. Strategies are best aimed at driving down the seed bank and preventing seed bank replenishment.
Seed bank Control Key:

Very high = <10 seeds/m2
High = 10-100 seeds/m2
Med =100-500 seeds/m2
Low = 500-1500 seeds/m2
Very low =>1500 seeds/m2

Other management recommendations:
- Control weeds in adjacent areas (channels, tail drains, fencelines and roadsides) to minimise the seed bank and eliminate unknown weed seed sources. Do NOT rely on glyphosate to manage weeds in non-crop areas. Manage adjacent areas as fallows and rotate non-glyphosate tactics including residual herbicide and chipping of weeds.
- Be aware of weed seed contamination sources (eg waterways, vehicle/machinery, and farm inputs). Establish and maintain COME CLEAN. GO CLEAN to prevent introduction and transport of resistant seeds. Monitor high risk areas around machinery sheds and where vehicles enter and exit the farm.
- Monitor and follow up to ensure weeds that survive glyphosate applications are controlled using a non-glyphosate tactic before they are able to set seed
- Get suspect weed survivors tested for resistance – refer page 87.
- Patch control - control weeds in isolated patches
- Use IWM best practice when employing tactics
- Regular scouting and correct weed identification
- Good record keeping
- Timely implementation of tactics
- Rotate herbicide mode of action groups
- Always follow label recommendations
- Consider other aspects of crop agronomy.

Assessing your own risk:
For a more detailed assessment of the resistance risks for individual paddocks, use the Department of Agriculture's *Online Glyphosate Resistance Toolkit*, available via www.mybmp.com.au.

Australia glyphosate sustainability working group findings so far:
All of the glyphosate resistant weed populations (confirmed) have occurred in situations where there has been intense use of glyphosate, often over 15 years or more, few or no other effective herbicides used and few other weed control practices used.

This suggests the following are the main risk factors for the evolution of glyphosate resistance:
- Intensive use of glyphosate - every year or multiple times a year for 15 years or more
- Heavy reliance on glyphosate for weed control
- No other weed control measures

Preston, C. The Australian Glyphosate Sustainability Working Group. www.glyphosateresistance.org.au.

Key findings for delaying resistance development:
Using specific, well-timed, non-glyphosate tactics to control glyphosate survivors after every glyphosate application is the best-performing option & should be the first action.
- Actions taken to control glyphosate survivors should be made to every weed flush in a given year, where possible. Modelling shows that inter-row cultivation is a useful tactic for survivor control, and is further enhanced when followed up with chipping.
- Irrigated systems present greater opportunity to delay glyphosate resistance through more timely herbicide applications to even weed flushes and through enhanced crop competition compared to dryland systems.
- Summer fallows where glyphosate only is used pose the greatest risk of glyphosate resistance development; taking two non-glyphosate actions in every summer fallow is predicted to be of substantial benefit for seed bank control and in many cases to extend the lifespan of glyphosate (especially on barnyard grass) if even a single non-glyphosate action is also taken in-crop.
- Using two non-glyphosate actions in every summer fallow is predicted in many cases to extend the lifespan of glyphosate (especially on barnyard grass) in conjunction with a single non-glyphosate action in-crop.
- In almost all cases, strategies that work best to slow or prevent resistance are the same as the best strategies for controlling resistant seed banks in the long term.
- Resistance can be imported through machinery or other methods regardless of glyphosate use history.

Cotton HRMS:

Irrigated back to back cotton

Decreasing - Non-glyphosate tactics and survivor control - increasing

Increased time to 100% resistance	In crop tactics 3 x OTT glyphosate applications PLUS	Seed bank control	Comments
>20 years	Very high survivor control after **each** OTT glyphosate	Very high	Aim to avoid controlling last in-crop flush with glyphosate alone
	Moderate survivor control after **each** OTT glyphosate	Very high	Control survivors of OTT applications
	2 x strategic in crop cultivations	Very high	Time the second cultivation to control last weed flush and escapes prior to row closure
10-20 years	Pre-plant residual plus residual layby	Very high	Consider plantback period restrictions
5-10 years	Very high survivor control after **first** OTT glyphosate	Very high	Control survivors from first flush which has highest weed germination
	Cultivation + grass selective herbicide (note: repeated use of Group A grass selective herbicide can lead to development of Group A resistance)	Effects on seed bank not yet modelled	
<5 years	Moderate survivor control after **first** OTT	Low	Control survivors from the first flush which has the highest weed germination
nil	Glyphosate only	Very low	Test survivors for glyphosate resistance

Simulation data provided by D. Thornby

Model Assumptions:

- Glyphosate tolerant cotton grown every summer with a short winter fallow. 3 in crop glyphosate applications are made + 1 in fallow.
- Cultivation occurs in winter for crop destruction, pupae busting, stubble management and seedbed preparation but not specifically for weed control.
- The first weed flush of the season is the largest emergence.
- Pre-plant residual + layby assumes a maximum of 90% efficacy and an average of 70% to 85% efficacy over 30 years.
- Seed bank control is modelled on barnyard grass
- Survivor control:
  Very high survivor control = 99.9%. This can be achieved through cultivation then chipping or spot spraying with an alternative mode of action.
  Moderate survivor control = 80%. This can be achieved through cultivation.

Notes:

- Do NOT rely on glyphosate to manage weeds in non-crop areas (channels, tail drains, head ditches). Manage adjacent areas as fallows and rotate with non-glyphosate tactics to control weeds and cotton volunteers.
- COME CLEAN. GO CLEAN to prevent introduction and transport of resistant seeds. Monitor high risk entry areas and patch manage introduced weed seeds.
- Monitor and follow up to ensure survivors are controlled by another tactic before they are able to set seed. Have suspect weed survivors tested for resistance
- Conduct regular scouting and correct weed identification.
- Keep good records.
- Ensure timely implementation of tactics
- Rotate herbicide mode of action groups.
- Always follow label recommendations.
- Refer to *page 92* for additional tips on IWM and use of tactics.

Cotton HRMS:

Dryland cotton every second summer

Decreasing - Non-glyphosate tactics and survivor control - increasing

Increased time to 100% resistance	Summer fallow tactics	In crop tactics 3 x OTT glyphosate applications PLUS	Seed bank control	Comments
>20 years	2 non-glyphosate tactics	Very high survivor control after **each** OTT glyphosate	Very high	The most effective scenario for delaying glyphosate resistance
10-20 years	Glyphosate only fallow	Very high survivor control after **each** OTT glyphosate	Very high	Very high frequency & efficacy of survivor control is required if in-crop only tactics are used.
	2 non-glyphosate tactics	Moderate survivor control after **each** OTT glyphosate	High	Lower intensity in-crop tactics can give excellent results if backed up in summer fallows. Specific, frequent, well-timed control of glyphosate survivors provides long-term resistance delay/ management
5-10 years	Glyphosate only fallow	Two strategic cultivations	Low	Time last cultivation to control late flushes and escapes
<5 years	Glyphosate only fallow	Pre-plant residual + layby	Very Low	These tactics give limited increased time to resistance and poor seed bank control
	Glyphosate only fallow	Moderate survivor control after **each** OTT	Very Low	
	2 non-glyphosate tactics	Glyphosate only	Very Low	
nil	Glyphosate only fallow	Glyphosate only	Very Low	

Simulation data provided by D. Thornby

Model Assumptions:

- Glyphosate tolerant cotton grown every second summer, alternating with long summer fallows.
- 2 non- glyphosate tactics in summer fallow – model uses residual herbicide followed by double knock.
- Model assumes pre-plant residual + layby has a maximum of 90% efficacy, averages 70% to 85% efficacy.
- Seed bank control modelled on barnyard grass
- Survivor control:
  Very high survivor control = 99.9%. This can be achieved through cultivation then chipping or spot spraying with an alternative mode of action.
  Moderate survivor control = 80%. This can be achieved through cultivation.

Notes:

- Do NOT rely on glyphosate to manage weeds in adjacent non-crop areas (roadways, fencelines). Manage adjacent areas as fallows and rotate with non-glyphosate tactics to control weeds and cotton volunteers.
- COME CLEAN. GO CLEAN to prevent introduction and transport of resistant seeds. Monitor high risk entry areas control weeds in isolated patches
- Monitor and follow up to ensure that survivors of glyphosate applications are controlled using another tactic before they set seed. Have suspect weed survivors tested for resistance
- Conduct regular scouting and correct weed identification.
- Keep good records.
- Ensure timely implementation of tactics
- Rotate herbicide mode of action groups
- Always follow label recommendations
- Refer to *page 92* for additional tips on IWM and use of tactics.

This document is part of a larger publication -
The Cotton Pest Management Guide for Cotton 2014 - 15

The complete document can be found on the CRDC or myBMP web sites during the 2014-15 Australian cotton season
www.crdc.com.au
or
www.mybmp.com.au

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