

Roundup Ready® Flex cotton

Weed Resistance Management Plan



1. Objective

The Roundup Ready Flex cotton Weed Resistance Management Plan details strategies that can be implemented to minimise the risk of glyphosate resistance developing in weeds on-farm. It complements the training which growers received before growing Roundup Ready Flex cotton, and the Roundup Ready Flex cotton technical manual. Roundup Ready Flex cotton offers superior and effective weed control to growers, with a wide glyphosate application window, outstanding crop safety, broad spectrum weed control and the ability to control weeds where they appear. The flexibility of an Integrated Weed Management (IWM) strategy including Roundup Ready Flex cotton offers management efficiencies as well as a variety of in-crop weed control options. Prudent management of Roundup Ready Flex technology and mitigation of resistance risks will ensure these options for weed control are available to Australian cotton growers well into the future.

2. Growing Roundup Ready Flex cotton

There are several requirements and audits which form a part of the Technology User Agreement (TUA) for Roundup Ready Flex cotton and the product label for Roundup Ready Herbicide with PLANTSHIELD® by Monsanto for growers and chemical users. In summary these are:

- Attendance at an accreditation course before a grower plants Roundup Ready Flex cotton for the first time, and signs their first TUA
- Allowing Monsanto staff or representatives to conduct audits on fields planted to Roundup Ready Flex cotton
- Reporting of any suspected resistance of weeds in a Roundup Ready Flex cotton crop
- Implementing an IWM strategy



These requirements are a part of Monsanto's stewardship program, aimed at protecting the Roundup Ready Flex technology to ensure its effectiveness into the future. It is critical that all growers read and understand the terms and conditions of the TUA and the product label for Roundup Ready Herbicide with PLANTSHIELD prior to using the products.

3. Protecting an important tool – glyphosate

Herbicide resistant weeds have been a reality for decades in Australia – no herbicide is immune, including glyphosate. While the problem is significant, it is also manageable and effective mitigation strategies can reduce the risk and delay its development. In Australia, glyphosate resistant populations of several weed species have been found, including some throughout the cotton growing regions. Glyphosate is a critically important part of any IWM program on cotton farms, and growers want to make sure that the benefits it delivers are preserved and maintained. Where glyphosate resistance has occurred, it can be effectively managed through good agronomic practices. There are actions that every grower can take to prevent or manage glyphosate resistance on their property. By acting now we can ensure the long term sustainable use of glyphosate herbicides in cotton crops, by minimising the risk of glyphosate resistance developing.

Naturally occurring populations of some weeds may possess biotypes with resistance to glyphosate. Growers should be aware of this prior to using glyphosate and should aim to decrease the development and spread of resistant populations. If you suspect resistant biotypes are present, they should be sampled and tested. Contact the local Monsanto Regional Business Manager for assistance with this process.

The Weed Resistance Management Plan aims to reduce the likelihood of glyphosate resistance developing, it does not, however, guarantee that there will be no resistance.

4. Understanding your glyphosate resistance risk

Each field planted to Roundup Ready Flex cotton has its own unique risk of glyphosate resistance developing, based on its usage history, the weeds present and their density and other historical rotations and agronomic management strategies employed.

As a part of any sound IWM plan, growers are encouraged to assess their resistance risk prior to planting Roundup Ready Flex cotton, and when making decisions about weed management strategies. Queensland DPI have developed a “Risk Assessment Tool” which can be accessed at <http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/weed-management-in-field-crops/herbicide-resistance/glyphosate-resistance-toolkit>. This tool can be used to help make decisions about what strategies could be used to reduce the specific risk areas on each farm, and in each field.

5. On farm factors that change resistance risks

The Australian Glyphosate Sustainability Working Group has developed a guide for sustainable use in northern Australian grain and cotton which describes practices that affect the development of resistance.

Factors that decrease resistance risk

- Monitoring and preventing weed control escapes from setting seed
- Planning and implementing an IWM strategy to reduce the weed seed-bank
- Strategic use of alternative knockdown herbicides and tillage in fallows prior to sowing
- Use of alternate herbicide modes of action including residual herbicides in crops and fallows
- Use of a double-knock glyphosate followed by tillage or paraquat (Group L) based products at effective rates
- Applying stewardship plans when growing glyphosate tolerant crops
- Farm hygiene to prevent importing and moving resistant seeds

Factors that increase resistance risk

- Frequent glyphosate-based chemical fallows
- Continuous reliance on glyphosate as a knockdown prior to sowing
- Inter-row use of glyphosate in grain crops (unregistered)
- Lack of tillage
- Lack of use of alternative herbicide modes of action in fallows and crops
- Allowing survivors of glyphosate applications to set seed
- High weed numbers

- Lack of crop competition on weeds
- Over-reliance on glyphosate tolerant crops as a weed control mechanism

6. Resistance management principles for Roundup Ready Flex cotton

As outlined on the Roundup Ready Herbicide with PLANTSHIELD by Monsanto label, there are some guidelines for designing a successful IWM strategy. The implementation of these principals should result in the reduction in the weed population entering the Roundup Ready Flex cotton cropping phase, and maximise the control of weeds that may be resistant to glyphosate. These are;

- a. Aim to enter the Roundup Ready Flex cropping phase of your rotation with a low weed burden
- b. Integrate as many different weed control options as possible through all phases of the crop rotation
- c. Make every herbicide application count – use registered rates at the correct application growth stage and always assess its effectiveness
- d. Rotate herbicides with different modes of action throughout the crop rotation
- e. Regularly monitor the effectiveness of resistance management practices
- f. Test weed populations for herbicide resistance status as a part of ongoing IWM
- g. If planting into a paddock with suspected glyphosate resistance growers must have a plan to manage such weeds

The simplest and most effective way to minimise the risk of resistance developing in a Roundup Ready Flex cotton crop is to rotate away from glyphosate immediately following the Roundup Ready Flex cotton crop. Preventing seed set from any weeds surviving glyphosate application is critical to preventing resistance development and spread – never use the same technique twice on the same weed, or weeds growing from seed produced by a surviving weed.

The following table outlines some key principles for weed control at different stages through the cotton season. For more information about any of these recommendations, see the Roundup Ready Flex cotton technical manual.

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| Pre-plant knockdown | <ul style="list-style-type: none"> • Always start clean by planting into a weed-free field using either tillage or an herbicide application. • Know your field history in order to identify whether any volunteer cotton present is Roundup Ready Flex. • Consider using tank mixes with Roundup Ready Herbicide with PLANTSHIELD by Monsanto or other registered products as part of an IWM strategy. |
| Residual herbicides | <ul style="list-style-type: none"> • Residual herbicides should be used where appropriate in a Roundup Ready Flex weed control system. • Consider using residual herbicides where weeds not controlled by Roundup Ready Herbicide with PLANTSHIELD by Monsanto are present. • The residual herbicide can be applied as a pre-emergence application (either a pre-plant incorporated application, or at planting application). • Use the recommended labelled rate and timing of the residual herbicide. |
| In-crop weed control | <ul style="list-style-type: none"> • Only apply Roundup Ready Herbicide with PLANTSHIELD by Monsanto according to the registered application window <ul style="list-style-type: none"> – 0–22 nodes – 4 OTT applications (max 1.5 kg/ha per application) – 60% open to harvest – 1 OTT application (max 1.5 kg/ha per application) • Use a maximum of 4 applications and no more than a total of 6.0 kg/ha of Roundup Ready Herbicide with PLANTSHIELD by Monsanto per crop. • Target the first application of Roundup Ready Herbicide with PLANTSHIELD by Monsanto on young cotton with weeds less than 6cm in size. • Sequential applications of Roundup Ready Herbicide with PLANTSHIELD by Monsanto may be required to control new and subsequent germinations of weeds. • Select the timing of sprays based on the most difficult to control weed species in each field. • Post directed sprays should be used to achieve more thorough coverage on weeds. • Refer to the 'Weeds Controlled' table in the Roundup Ready Herbicide with PLANTSHIELD by Monsanto label for rate recommendations on specific weeds. • Be aware of any potential contamination of spray application equipment (including mixing stations). • Ensure all equipment is thoroughly cleaned and free of residues. • Do not tank mix any product with Roundup Ready Herbicide with PLANTSHIELD by Monsanto. • Ensure all applications are made according to label guidelines on water volume, droplet size and environmental conditions. • Be aware of off-target drift to susceptible crops and fields with both aerial and ground applications. |
| Lay-by applications | <ul style="list-style-type: none"> • If you currently use lay-by herbicides, then consider maintaining this program. • A robust lay-by program can provide residual control of weeds not controlled by Roundup Ready Herbicide with PLANTSHIELD by Monsanto. • Use the recommended labelled rate and timing of the residual herbicide. |
| Pre-harvest application | <ul style="list-style-type: none"> • OTT application of 1.0 kg/ha is available if required before harvest and after cotton reaches 60% open bolls. • This application can be used to control late season weeds and improve harvest efficiency. • Compatible with commonly used defoliant (see Roundup Ready Herbicide with PLANTSHIELD by Monsanto label). • Do not use on crops intended for seed production. |

Monsanto strongly recommends that growers consult an agronomist when designing an IWM strategy for their property. For some more resources and information see www.glyphosateresistance.org.au and www.weedsmart.org.au.

7. Monitoring herbicide efficacy

All growers or agronomists should inspect fields between 14 and 28 days after spraying with glyphosate to monitor the effectiveness of the herbicide application. During an inspection, any surviving weeds that are normally susceptible to glyphosate should be identified. The outcomes of any inspection and any remedial application used should be recorded. Any case of suspected resistance should be reported immediately to Monsanto for further investigation.

The Post Spray Survey (PSS) is a random audit carried out by Monsanto to monitor the effectiveness of glyphosate in Roundup Ready Flex cotton crops, and each year 10% of growers will be audited to identify which weeds have survived a glyphosate application. It is recommended that these inspections should be carried out regardless of whether an audit takes place or not, as a part of any IWM strategy.

8. What to do if you suspect resistance

If any spray failure of Roundup Ready Herbicide with PLANTSHIELD by Monsanto occurs, it is essential to determine the reason. Possible reasons for spray failures may be:

- Resistant weeds
- Poor spray application
- Emergence after a spray application

Any weeds which are suspected to be resistant to glyphosate should be tested to confirm this. Monsanto will provide support for any Roundup Ready Flex cotton growers with testing suspected resistant weeds in a Roundup Ready Flex cotton field. Contact your Technology Service Provider or Monsanto Regional Business Manager for more information. Their contact details can be found at www.cottonchoices.com.au.

9. WeedSmart

WeedSmart is an initiative that promotes the long term sustainability of glyphosate and other herbicide use in Australian agriculture. The program centres on providing farmers and agronomists with the latest tools and resources to manage herbicide resistance. Commitment to the WeedSmart initiative has come from research and development organizations, advisors and agronomists, chemical companies, agribusiness and grower representative bodies who share a common goal to safeguard the industry's future.

Central to the initiative is the campaign hub located at www.weedsmart.org.au.



10. Management of resistant or hard to control weeds

In order to maximise the effectiveness of in-crop applications of Roundup Ready Herbicide with PLANTSHIELD by Monsanto, growers should base the timing of these applications on the growth stage of the most difficult to control weed species present in each field. The "Weeds Controlled" table on the Roundup Ready Herbicide with PLANTSHIELD by Monsanto label lists the weeds which glyphosate will control and rate recommendations on specific weeds. Some "hard to control" weeds will not be controlled by glyphosate, and are not listed on the Roundup Ready Herbicide with PLANTSHIELD by Monsanto label. Examples of these are Fleabane (*Conyza bonariensis*) and Feathertop Rhodes Grass (*Chloris virgata* Sw.). These weeds, where present should be controlled by other means. For information and guidance on their control see the cotton pest management guide (http://crdc.com.au/?post_type=publication&p=3175), consult your agronomist or guidelines produced by QDAFF or NSW DPI.

Currently in the Australian cotton growing regions there are several weeds confirmed as glyphosate resistant, and others at high risk of developing resistance. In addition to the "hard to control" weeds, an IWM strategy should take these weeds into account and special care should be taken to control these weeds and prevent them setting seed. Not every population of these weeds will be resistant, but resistance development in another part of the country places them at high risk of resistance development elsewhere.

a. Glyphosate resistant grass species

There are currently six grass species which have developed glyphosate resistance in Australia.
These are:

Annual ryegrass (*Lolium rigidum*)



Awnless barnyard grass (*Echinochloa colona*)



Liverseed grass (*Urochloa panicoides*)



Windmill grass (*Chloris truncata*)



Great brome grass (*Bromus diandrus*)



Sweet summer grass (*Brachiaria eruciformis*.
(Sm.) Griseb.)



b. Glyphosate resistant broadleaf species

There are currently three broadleaf species which have developed glyphosate resistance in Australia. These are:

Fleabane (*Conyza bonariensis*)



Sowthistle (*Sonchus oleraceus*)



Prickly lettuce (*Lactuca serriola*)



See the Australian Glyphosate Sustainability Working Group website for up to date details of which weeds have been found to be resistant to glyphosate, and where they are located (glyphosateresistance.org.au). If any of these species are present in a Roundup Ready Flex cotton field or in non-cropping areas they should be monitored and controlled using the principles described in this document.



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