Australian Government
Cotton Research and Development Corporation

FINAL REPORT 2014

Confidential

Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC Project Number: **CRDC1411**

Project Title: Developing and industry agreed strategy for managing herbicide resistance in cotton

Project Commencement Date: 15 Nov 2013 **Project Completion Date:** 31 Aug 2014

CRDC Program: 2 Industry

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Part 3 – Final Report

Background

The introduction of glyphosate-tolerant cotton has significantly changed weed management in cotton to a glyphosate-dominated system, particularly in crop. Approximately 98% of cotton grown in Australia is glyphosate tolerant. With the adoption of this technology, cotton growers have increasingly opted to use glyphosate instead of other weed control tactics such as residual herbicides, cultivation (both between crops and in-crop) and chipping. Cotton growers are enjoying a weed management system that brings with it water and labour efficiencies.

Cotton growers are not currently facing yield losses as the consequence of unmanageable herbicide resistant weeds. They are, however, facing the threats from a changing spectrum of target weed species. Glyphosate tolerant and glyphosate resistant weeds are now a reality in the cotton system with 10 species now confirmed as glyphosate resistant, 8 of which are found in cotton farming systems.

There are significant resources available to cotton growers and their consultants about management options for specific weeds, efficient ways to utilise alternative control tactics such as cultivation or double knocks and impacts herbicides can have on cotton. The aim of the project was to develop a framework which ranked the various weed control tactics and their effect on glyphosate resistance development so growers have a tool to identify which are of greatest value for their individual situations. The framework incorporated the principles underpinning sustainable integrated weed management.

Objectives

1. Draft Herbicide Resistance Management Strategy for cotton

Milestones

1.1 Engage TIMS Herbicide Technical Panel to define the HRMS underpinning principles.

A TIMS technical panel (herbicide) meeting was held at University of Qld St Lucia on 26 Nov 2013. The framework for a herbicide resistance management strategy (HRMS) was discussed and it was identified that glyphosate resistance in HT cotton was the highest priority issue to address. Dave Thornby (QDAFF, Innokas) and Jeff Werth (QDAFF) presented model data on timeframes for glyphosate resistance development in barnyard grass using various weed control tactics, and the effect of these tactics on the weed seed bank. A framework based on best practice principles, integrated weed management tactics (chemical and mechanical) in crop and in summer fallow, time to glyphosate resistance development and effect on the weed seed bank was drafted (Appendix 1). Weed control in adjacent areas to cotton fields was included. This framework became the draft HRMS. In the subsequent weeks, the HRMS was developed to address an irrigated and a dryland cotton weed management system. The tactics and components included in the draft HRMS were reviewed and further developed in regular consultation with David Thornby and Tracey Leven (CRDC). The draft HRMS was then reviewed by the TIMS technical panel (herbicides) in March.

1.2 Engage commercial and farming systems stakeholders in drafting an HRMS for cotton.

A meeting with the regional development officers (RDO's) in Narrabri on Dec 6th 2013 as part of their team meeting was instigated. The background of the project to develop a framework for herbicide resistance management was explained and the concept of the draft herbicide resistance management strategy (HRMS) introduced. It was asked that the cotton grower associations be introduced to the concept of the draft HRMS at the regional meetings and for any feedback to be provided to the project coordinator.

A weeds management meeting was held at Cotton Australia on 19 Dec 2013 at which the WeedSmart herbicide resistance management system was presented by Keryn McLean from Monsanto. At this point it was discussed how the HRMS might fit with the WeedSmart system which was launched in WA in February 2013. WeedSmart was being reviewed and adapted for use in northern cropping systems. The outcome of this meeting was that the HRMS, once developed, would fit well with the WeedSmart system, as a cross industry approach i.e. with grains, was identified as being high priority in tackling the herbicide resistance issue.

A series of workshops for advisors titled "Driving Down Problem weeds Seeds Banks was held by ICAN as part of a GRDC funded initiative. The project coordinator attended the Moree workshop the concept of the HRMS was introduced to those in attendance (23 participants). A discussion which identified the weed control tactics and crop rotations that were highest priority for inclusion in the HRMS evolved. The highest priority scenarios to be modelled identified were:

Irrigated systems

1. Cotton* 2 years in 3 (i.e. cotton, cotton, summer fallow) which accounts for 75% of fields grown in normal water availability seasons. Glyphosate resistance development under this scenario was modelled by David Thornby (Appendix 2). This scenario was presented to the TIMS committee who elected not to include it in first edition of the HRMS as the tactics modelled relied highly on cultivation which produced limited time to glyphosate resistance development (5 years or less)

2. Cotton 1 year in 2 (i.e. cotton, summer fallow) identified as second priority. Time to glyphosate resistance development in this scenario has not yet been modelled

3. Southern regions have identified a summer rotation with maize as a priority system

*Cotton in these scenarios assumes HT cotton (glyphosate tolerant)

Dryland systems

1. Cotton 1 year in 2,
   (cotton 1 year in 2 is the dryland scenario currently included in the HRMS)

2. Cotton 1 year in 3 and 1 year in 5. Winter cereals (wheat and barley) and pulses (chickpeas and to a lesser extent, fababeans) were identified as the most commonly used winter rotation crops. Sorghum in the northern areas and maize in the southern areas were identified as the most commonly grown summer rotation crops. These summer crops provide good opportunities for non glyphosate tactics for example, residual herbicide, to be used in the summer phase.

*Cotton in these scenarios assumes HT cotton (glyphosate tolerant)

The crop rotation table attached in Appendix 3 addresses some other rotations that have already been modelled.

A PowerPoint presentation was developed outlining glyphosate and other herbicide use in the cotton industry, the threat of herbicide resistance, the status of herbicide resistant species and other background information. The draft HRMS and background to the project was presented at the CCA seminar in Moree on the 14th May 2014. Feedback from this presentation was primarily positive towards the HRMS concept. Feedback from a Goondiwindi consultant indicated that the tactics modelled for the irrigated cropping scenario relied heavily on cultivation and that many growers were not currently set up for this. The presentation was again made to the TIMS committee meeting in Goondiwindi on 28th May 2014. Feedback from this group was that a wider combination of weed control tactics needed to be incorporated into the HRMS. This is identified as an area of further development of the HRMS that has not been addressed in the available timeframe. Some combinations of tactics that were suggested were:

Irrigated scenario:

- Residual herbicides plus cultivation
- Cultivation plus group A herbicide effect on the weed seed bank
- A tactic including spot spraying for survivor control

Dryland scenario:

- Control given by alternative knockdown herbicides to glyphosate
- Knockdown herbicide followed by cultivation
- Cultivation followed by residual herbicide

The HRMS is currently modelled on barnyard grass and data produced for resistance development in sowthistle has indicated that broadleaf species behave differently to grasses.

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1.3 Draft HRMS available for industry consultation

The revised draft HRMS was circulated to the TIMS technical panel (herbicides) in early June 2014 and approved for industry stakeholder consultation. The draft HRMS was open for industry consultation from the 4th June until 11th July 2014.

2. Industry consultation on draft HRMS

Milestones

2.1 Communication with all regional CGAs, CCA and CropLife about proposed HRMS.

A letter was drafted in conjunction with Tracey Leven and Susan Maas (Appendix 4). The letters presenting the draft HRMS were addressed to industry stakeholders which consisted of grains industry – Northern Grower Alliance (NGA), Grains Orana Alliance (GOA), manufacturers (CropLife, Nufarm, Monsanto) Crop Consultants Australia (CCA), Independent Consultants Agricultural Network (ICAN) and all regional cotton grower associations (CGA's) (15 in total). A total of 22 letters were sent in mid June 2014. The consultation period closed on the 11th July 2014.

Feedback was received from 5 organisations (CCA, Gwydir Valley CGA, CropLife, NGA and Nufarm) and 3 individual growers (see Appendix 5). A meeting was instigated by the CCA executive prior to the Cropping Solutions Seminar in Goondiwindi in July. Key concerns from this meeting concerning the draft HRMS were:

- That the HRMS would become a mandatory compliance document and they were against this.

- Chemical manufacturers would refer to the HRMS as part of their product labels making it off label (illegal) to not adhere to the HRMS. For example, growers did not want to cultivate after every glyphosate application.

Letters raising concerns with the draft HRMS were received from the Crop Consultant's Association and the Gwydir Valley Cotton Growers Association. See Appendix 6 and 7

2.2 CottonInfo RDOs have high awareness of the HRMS concept and are engaged in the regional consultation process.

The CottonInfo team were informed of development of the HRMS subsequent to the initial draft in December 2013. This was done by introducing the background of the project and the general concept at their meeting in December in Narrabri.

Regional Development Officers also attended the CCA cropping solutions seminar in Moree where the project was presented, and the cropping solutions seminar in Goondiwindi in July where the HRMS draft was available for discussion.

A meeting was organised by the manager of the Cotton Info Team after the project was presented at the Australian Cotton Conference in early August to clarify any questions that arose from the ratified strategy. It was identified from this meeting that the some of the newer Regional Development Officer's were not familiar with the background and concepts of the project and this needs to be addressed by their manager.

3. Finalisation of HRMS

Milestones

3.1 Tech Panel refines HRMS in response to industry feedback and proposes annual review process.

The industry stakeholder feedback (see Milestone 1.2) was reviewed by the TIMS technical panel via phone hook up on the 28th July 2014. Supporting text was created detailing how to use the strategy and the principles underlying it. The draft HRMS was circulated to the TIMS technical panel via email for final comments and review prior to ratification and release to the TIMS committee.

It is proposed that the HRMS be reviewed by the TIMS committee on an annual basis as per the insecticide resistance management strategy (IRMS). It is intended that the HRMS will be expanded as part of the annual review process. The expansion required is to include other herbicidal groups (than group M), other HT cotton varieties (glyphosate + glufosinate stacks and glyphosate + glufosinate + dicamba stacks) as they become commercially available and other combinations of weed control tactics, for example, incorporating more residual herbicide and spot spraying .

3.2 TIMS Committee ratifies HRMS for cotton.

The draft HRMS was ratified by the TIMS technical panel (herbicides) and the TIMS committee on the 6 Aug 2014 in time for presentation at the Australian cotton conference (Appendix 8).

4. Review existing weed management resources for cotton and make recommendations to CRDC on future resources needed to support the implementation of the HRMS by the cotton industry.

Cotton Pest Management Guide - The weeds section was reviewed and the section discussing herbicide resistance updated for the 2014-2015 edition. The HRMS has been included in the 2014-15 edition with supporting text on how the framework for the HRMS has been developed and guidelines for its use as a weed management tool.

WeedPak – The Herbicide Resistance and the Crop Management Plan Section of WeedPak was reviewed. The HRMS with the supporting text on the principles underlying the strategy and the information on how to use the HRMS complement the herbicide resistance section well. The HRMS could be inserted between sections C3.3 "Selection in a glyphosate based system" and section C3.4 "The importance of the crop management plan."

Roundup Ready Flex cotton Weed Resistance Management Plan (Monsanto) – This document was reviewed and it is recommended that the HRMS be referred to in Section 4 "Understanding your glyphosate resistance risk" in the same way that a link to the risk assessment tool is provided in this section. As part of the annual review of the HRMS by TIMS, a request could be made to Monsanto for reference to the HRMS to be included in this document.

The HRMS may benefit in being regionalised as the IRMS is. This takes into account different weed management practices used in different regions. For example, in southern New South Wales, which is rapidly increasing its percentage of the crop grown, double knock (glyphosate followed by paraquat) is not common practice as in the northern areas. Maize is also commonly used as a summer rotation crop which is less common practice in northern farming systems.

Milestones

4.1 Gather feedback from researchers, commercial stakeholders, farming systems stakeholders, cotton growers and cotton consultants about the resources that are required to facilitate/support implementation of the HRMS.

Implementation of the HRMS has been initiated through the CottonInfo team. This group has identified various methods to introduce and promote implementation of the strategy

- Articles in the CSD Seeds For Thought publication and local regional newspaper publications

- The cotton Info newsletter – Liase with Ruth Redfern CRDC when timely weeds management messages come out in the CottonInfo newsletter

Researcher feedback on resources required to support implementation of the HRMS

- Make updating the HRMS a weeds researcher's project objective
- Liaison with Monsanto and other glyphosate manufacturers to included the HRMS as part of their Crop Management Plans and other weeds management publications
- Inclusion of the HRMS in the cotton industry education material such as UNE graduate certificate cotton course and as part of weeds resistance training packages eg those run by SMARTtrain (NSW DPI) and Chemcert

Grower feedback on resources required to support implementation of the HRMS

- Introduce HRMS as part of a combined IWM approach with other tools
- A strong extension program with facilitation in field i.e. trials, would introduce the HRMS as part of IWM with area wide management. This could include weed control trials where various combinations of tactics within the strategy have been used over multiple seasons to control either grasses or resistant weeds.
- Demonstrations on weed control in adjacent areas with residual herbicides – roads, head ditches, channels and tail drains

Results

An industry agreed strategy for managing herbicide resistance in cotton (HRMS) has been developed and ratified and is in the process of being introduced to growers. Supporting resources are under development.

Outcomes

The HRMS currently provides a basic weed management framework for managing weeds for delaying the onset of herbicide resistance.

Conclusion

The cotton industry now has a framework for herbicide resistance management, initially for managing glyphosate resistance in HT cotton. Future development of the HRMS should include more weed control tactics, for example residual herbicides and spot spraying, extend the herbicide groups included and cover multi herbicide tolerant cotton varieties as they become commercially available.

The HRMS would benefit from expansion to include model data for other cropping scenarios, for example, irrigated cotton one year in two and two years in three (this scenario already modelled, see Appendix 2). For dryland systems cotton one year in three and one year in five to include winter and summer rotation crops (see Appendix 3) are high priorities.

Weeds develop resistance to any singular control method used repeatedly. A diverse range of weed control tactics are required to avoid or delay herbicide resistance. There is definitely a requirement for some mechanical weed control such as cultivation in the system.

In the northern cotton growing regions, a unique scenario exists as there are both summer and winter active weeds in the system and rotations incorporate both summer and winter crops.

The whole cropping system needs to be considered with regards to weed management, not just the cotton phase of the rotation. Model data indicates that the weed control tactics used in the summer fallow phase have the greatest impact on delaying the onset of glyphosate resistance and that it is more likely to develop in dryland systems incorporating cotton than in irrigated systems where crops provide more competition.

Extension Opportunities

Cross industry weeds management needs to be consistent. The HRMS fits well promoted in conjunction with integrated weeds management (IWM) tactics in cotton.

Field walks on technology in weeds management provide a good opportunity for introduction and discussion of the HRMS. For example, Ben Dawson from B & W Rural in Moree is hosting 1 or more field days in the Gwydir Valley in 2014/15 showcasing how drone technology can be used in weeds monitoring.

Engage the regional development officers to organise growers who participated in the 2014 US weeds tour to relay their experiences at CGA meetings with regards to attitudes towards weeds management and experiences with herbicide resistance. Combine this with some Australian growers who currently are dealing with or have dealt with herbicide resistance to speak regarding their experiences, for example, Tom Murphy from North Star.

Demonstrations in field of the combinations of weed control tactics used in the HRMS and their effects on the weed seed banks over a period of multiple seasons.

List the publications arising from the research project and/or a publication plan.

Spotlight Magazine 2014 autumn issue – article titled "CRDC working to Develop New Herbicide Resistance Management Strategy"

CCA Cropping Solutions Seminar: May 2014 Seminars and Papers – Special feature Responding to Herbicide Resistance in the Cotton Industry

The Australian Cotton Grower October-November 2014 issue - Herbicide Resistance Management Strategy for Australian Cotton.

Part 4 – Final Report Executive Summary

Developing an industry agreed strategy for managing herbicide resistance in cotton

There are significant resources available to cotton growers and their consultants about management options for specific weeds, efficient ways to utilise alternative control tactics such as cultivation or double knocks and impacts herbicides can have on cotton. The aim of this project was to develop a framework which ranked the various weed control tactics and their effect on glyphosate resistance development so growers have a tool to identify which are of greatest value for their individual situations.

The framework is presented as a herbicide resistance management strategy (HRMS) which incorporates individual or combinations of weed control tactics in cotton farming systems. The objective of the HRMS was that it was based on the principles underpinning sustainable integrated weed management. The draft HRMS was developed based on the 2 + 2 + 0 (2 non-glyphosate tactics in crop plus 2 non glyphosate tactics in fallow + survivor control) current best practice weed control tactics promoted in cotton.

The strategy addresses weed management in both the in crop and in summer fallow phases of the cropping system. The initial HRMS is developed on glyphosate resistance in barnyard grass in herbicide (glyphosate) tolerant cotton which was identified as the highest priority issue currently facing growers. The scenarios modelled include both irrigated and dryland cotton farming systems. The major differences between these systems are the regularity of the summer fallow phase and the extra crop competition effect provided by cotton grown in an irrigated system.

The HRMS was drafted initially by the TIMS technical panel (herbicides) and then opened for a period of consultation to industry stakeholders. Feedback from the stakeholders was addressed and incorporated into the strategy which was then ratified by TIMS. The strategy was presented at the 2014 Australian Cotton Conference.

The strategy will be communicated to industry via inclusion in the Cotton Pest Management Guide 2014, the cotton information team through the various cotton grower organisations and articles in publications including Spotlight and the Australian Cottongrower Magazine.

Resources that would aid adoption of the HRMS include articles in regional media, in field demonstration trials incorporating various weed control tactic combinations and promoting the HRMS as an Integrated Weed Management Tool

The HRMS will be reviewed by TIMS on an annual basis in a similar fashion to the insecticide resistance management strategy which has been in place for many years. It is intended that the strategy will be expanded to include more weed control tactics, modes of action and herbicide tolerant cotton varieties as they become commercially available. The HRMS is a voluntary weed management tool that provides a framework for managing the increasing problem of herbicide resistant weeds.