



# FINAL REPORT 2015

For Public Release

## *Part 1 - Summary Details*

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

CRDC Project Number: SC1310

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**Project Title:** National Cotton Extension Development & Delivery – stewardship of  
biotechnologies and crop protection

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**Project Commencement Date:** 01/07/2012 **Project Completion Date:** 30/06/2015

**CRDC Research Program:** Farming Systems

## *Part 2 – Contact Details*

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**Signature of Research Provider Representative:** \_\_\_\_\_

**Date Submitted:** \_\_\_\_\_

## **Part 3 – Final Report**

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(The points below are to be used as a guideline when completing your final report.)

### **Background**

#### **1. Outline the background to the project.**

Transgenic cotton was introduced to Australia in 1996 with Ingard® which was replaced by Bollgard II® in 2004/05. Transgenic cotton is now grown by over 95% of Australian cotton growers so is an integral part of the Australian cotton industry, helping enable the industry to dramatically reduce insecticide use by 89% (Australian Grown Cotton Sustainability Report 2014).

The cotton industry has been able to work closely with the commercial companies involved and regulatory bodies in developing resistance management plans and monitoring the performance of the technology primarily through the TIMS committee and research organisations. However the stewardship of the technologies at a grower level has been largely the responsibility of the commercial companies.

An industry need was identified for the delivery and promotion of independent industry research focussed on resistance to GM cotton and the effectiveness of commercial stewardship programs to ensure the protection of the technology for future industry use.

### **Objectives**

#### **2. List the project objectives and the extent to which these have been achieved, with reference to the Milestones and Performance indicators.**

The project was based on the following four objectives:

1. Promotion of stewardship of biotechnologies and crop protection products in the cotton industry to protect the performance of current and new GM technologies and selective insecticides.
2. Prepare industry for possible resistance issues
3. Coordination of TIMS technical panels to ensure industry resistance plans and review processes are working effectively
4. Improve communication between TIMS, CottonInfo Team and wider industry

In order to achieve these objectives, the following milestones were used:

**Objective 1: Promotion of stewardship of biotechnologies and crop protection products in the cotton industry to protect the performance of current and new GM technologies and selective insecticides.**

**Milestone 1.1: Coordination of an extension plan for resistance management so that growers have an understanding of the importance of resistance management in transgenic cotton and conventional insecticides in protecting the future of the industry.**

**Achieved** through developing an annual extension and communication plan that included:

- promotion and increasing awareness of the Insecticide Resistance Management Strategy (IRMS),
- communication to industry of the latest research resistance results (toward both the toxins contained in Bt cotton and conventional insecticides),
- promotion of best practice in managing *Helicoverpa* in Bt cotton,
- annual updates to both the Cotton Pest management Guide and Cotton Production Manual in the areas related to stewardship,
- promotion to the wider industry of the ‘intent’ of the BGII Resistance Management Plan (RMP) as a way of protecting the Bt technology in the future, not just as a compliance document and
- promotion of the Bollgard 3 RMP

**Milestone 1.2: Work with Regional Development Officers in the CottonInfo Team to develop, where appropriate, an extension plan specific to regional requirements to help address milestone 1.1.**

Achieved through regular involvement and communication with the CottonInfo team.

**Milestone 1.3: Ensure resistance management information in myBMP is kept up to date and relevant to latest research outcomes**

**Achieved** through annual updates to the myBMP biotechnology module, inclusion of updated resources including fact sheet and latest RMP documents.

**Objective 2: Prepare industry for possible resistance issues.**

**Milestone 2.1: In conjunction with relevant CottonInfo Technical Specialists, facilitate the development and review of contingency plans by the TIMS Technical Panels and commercial stakeholders.**

**Partially achieved.** The contingency plan has been discussed at length by the TIMS Bt Technical Panel and Monsanto (commercial stakeholder). It was agreed that the contingency plan would form part of the Conditions of Registration for Bollgard 3. These conditions are currently in draft form and should be finalised by the end of 2015 with input from TIMS, the Bt Technical Panel and Monsanto.

**Objective 3: Coordination of TIMS technical panels to ensure industry resistance plans and review processes are working effectively.**

**Milestone 3.1: IRMS annually updated with endorsement from CropLife Australia and the cotton industry prior to each season.**

**Achieved.** The TIMS Insecticide Tech Panel met annually face to face to report on resistance research results and discuss changes needed to the IRMS for the following season. Once a draft was agreed upon by the panel it was then circulated to CropLife Australia, TIMS Committee, CottonInfo Team and Crop Consultants Australia for feedback prior to the TIMS Insecticide Panel agreeing on the final version and requesting endorsement from the TIMS Committee. This was achieved each season prior to the printing deadline of the Cotton Pest Management Guide and prior to the start of the next cotton season.

**Milestone 3.2: Annually facilitate communication between the TIMS Bt Technical Panel and Monsanto to review the Bollgard II RMP in developing the Bollgard 3 RMP.**

**Achieved.** Mark-ups or variation requests to the Bollgard II RMP were reviewed by the TIMS Bt Technical Panel before submission to the TIMS Committee. This has included a number of regionally specific Bollgard II planting window variation requests, Bollgard II planting window permits for either allowing a longer planting window in dry conditions to take advantage of rainfall or to investigate the impact of a wider planting window in preparation for developing the Bollgard 3 RMP. A number of research permits were also included in this.

The draft Bollgard 3 RMP was submitted to the TIMS Committee along with supporting documentation from the Bt Technical Panel, outlining in detail the specific points the panel supported and didn't support, with justification for each. The proposed Bollgard 3 RMP is currently being reviewed by the APVMA.

**Milestone 3.3: Annually facilitate the exchange of research results between all parties involved in research relating to the current and future deployment of Bt cotton – developing RMPs, Helicoverpa genetics, Helicoverpa ecology and evaluating the efficacy of the current RMP.**

**Achieved.** REFCOM has been held annually (August 2012, August 2013, September 2014 and August 2015). The agenda for each REFCOM has been developed through consultation with main stakeholders (CRDC, Cotton Australia, TIMS Bt Technical Panel and relevant commercial companies). REFCOM has been a forum for all members of the resistance research community and interested stakeholders to review and discuss research in the area of Bt resistance management. Presenters have included PhD students, consultants, established researchers and international guests. Topics have included:

- the performance and value of unsprayed refuges,

- the future of sprayed refuges,
- adaptive area wide resistance management
- development of Bollgard 3 RMP
- as well as discussing performance and compliance of current Bt products

**Milestone 3.4: Provide feedback to CRDC on ways to improve current engagement with TIMS technical panels.**

**Achieved.** Feedback has been provided formally through the CRDC 6 monthly reporting system as well as via informal conversations with CRDC management.

**Milestone 3.5: Facilitate communication between TIMS, relevant commercial companies and APVMA to develop a process to ensure all RMPs (current and potential) are developed and updated together so as to be practically managed by growers.**

**Partially achieved.** All stakeholders are aware of the industry commitment to ensure all RMPs are as consistent as possible in their implementation, auditing and updating to ensure they can be practically managed on farm and by industry. The process of how this will work is still in draft form. The industry is currently looking at another potential entrant to the Bt market in Australian cotton (Bayer CropSciences) and in the process of assessing this product and developing an RMP a process will be developed to meet this milestone.

**Objective 4: Improve communication between TIMS, CottonInfo and wider industry.**

**Milestone 4.1: Establish a regular communication protocol between TIMS Committee and the CottonInfo Team.**

**Achieved.** The role of the Stewardship Technical Specialist was intended to be the communication link between TIMS, CottonInfo and wider industry. Regular updates to the CottonInfo team have been provided via the CottonInfo teleconference and team face to face meetings. The tech specialist role has attended TIMS meetings as a representative of CottonInfo, and as the Bt and Insecticide Technical Panels Coordinator. Where appropriate, communication has been provided to the wider industry on the outcomes of TIMS meetings.

**Methods**

**3. Detail the methodology and justify the methodology used. Include any discoveries in methods that may benefit other related research.**

The methodologies for this project have been in the area of communication and extension.

Methodologies used:

1. **Print media.** This project has produced 20 articles for Spotlight Magazine and 6 articles for The Australian Cottongrower. The use of print media in industry publications has been a key way for the project to communicate stewardship research to the industry. This methodology has been particularly useful for complex stewardship topics such as the series of articles that were developed looking at the ‘intent’ of the RMP and explained in detail the science behind resistance management tactics such as planting windows, refuges and pupae destruction.
2. **E news.** The project has used both the CottonInfo Enews and the CCA e-newsletter to communicate messages to the industry. This has been used for short messages such as the release of the new IRMS each season, or for emerging issues that require immediate information, such as the management of *Helicoverpa* spp. survivors in Bt crops.
3. **Presentations.** The project has been involved in 8 separate presentations to industry (details in publications section) including presenting at CCA Forums and the 17<sup>th</sup> Australian Cotton Conference. Topics have covered the development of the Bollgard 3 RMP, resistance management in Bt cotton and the IRMS.
4. **Industry publications.** Annual updates to the Cotton Production Manual and the Cotton Production Guide have been provided. A new Stewardship chapter was produced for the Cotton Production Manual for the 2014 edition.
5. **Web Resources: myBMP/Fact Sheets/Case Studies.** The content of the myBMP biotechnologies module was updated annually. The project produced two CottonInfo fact sheet resources on Bt resistance: crop destruction and pupae busting and Management

Guidelines for Helicoverpa in Bt Cotton. Assistance was also provided to the production of a CottonInfo Case Study on refuge management. A stewardship stage was developed for the CottonInfo website.

6. **Facilitation:** Facilitation of the TIMS Bt Technical Panel and Insecticide Technical Panel was an important component of this project. Effective facilitation included coordination of meeting times and agendas, facilitation of meetings/teleconferences, distribution of background information, minute taking and distribution of minutes. Facilitation was used to ensure the panels worked towards specific outcomes and was also used to develop communication pieces (articles etc.) for wider distribution.

## **Results**

### **4. Detail and discuss the results for each objective including the statistical analysis of results.**

#### **Objective 1: Promotion of stewardship of biotechnologies and crop protection products in the cotton industry to protect the performance of current and new GM technologies and selective insecticides.**

Promotion of stewardship of crop protection products has occurred through:

- Promotion of IRMS each season via articles in Spotlight and circulation through the CCA networks. This promoted the IRMS, along with the Impact on Beneficials table, as the key resources for management decisions when pests require control in cotton crops.
- The Southern NSW RDO identified a need to deliver IPM information to new cotton growers in the region. A presentation was given at the Southern Cotton Expo 2013 looking primarily at early season IPM and using the IRMS for management decisions.
- The Macquarie Valley RDO identified a need to address Silverleaf Whitefly management in the valley. A SLW workshop was organised, attended by key consultants in the region with Lewis Wilson to discuss in detail management scenarios for SLW in the region, with a key focus on early season IPM as a management tool. A Spotlight article was also produced from this workshop as a way to inform the wider industry.
- Any changes in resistance frequencies in pests to crop production products has been communicated to industry through:
  - changes in the IRMS, such as the reduction in recommended number of synthetic pyrethroids to 1 per season in 2014/15,
  - and through media articles, such as the increasing levels of Abamectin resistance in mites seen in 2015 resistance monitoring results.

Promotion of stewardship of biotechnologies has occurred through:

- A total of 17 articles have been produced during the project (details listed in Section 9) looking at various aspects of the Bollgard II RMP. Although each article related to a specific aspect of Bollgard II management, the overall message that was common throughout was that of promoting good stewardship of biotechnologies to ensure they remain an effective tool for the industry into the future. The aim was to independently promote the Bollgard II RMP from a research perspective as a positive tool for growers in managing Bt resistance, rather than as a set of onerous tasks that growers are obliged to meet.
- The cotton industry will be transitioning to third generation Bt technology starting from 2015/16, so an important component of the project was to inform and prepare the industry for this transition. This occurred through 3 specific articles relating to Bollgard 3 (details in section 9) as well as incorporating Bollgard 3 knowledge into other stewardship articles as appropriate. A series of Bollgard 3 face to face updates were also presented in each cotton growing valley throughout 2014, as a joint initiative between CRDC, Cotton Australia and Monsanto. The aim of these articles and presentations has been to prepare industry for the release of Bollgard 3 by:
  - Demonstrating the industry need for a third generation technology
  - Informing of the components of Bollgard 3, the addition of Vip3a on to the already existing toxins in Bollgard 3. Of importance was the message of

- maintaining susceptibility to current technology, as this is the platform on which Bollgard 3 is based on.
- Discussing expected efficacy and field performance of the product, in reference to crop management.

#### Production manual updates

Updates to the Cotton Production Manual have been produced as required. In 2014, a new chapter on stewardship was written for the manual. This was then updated for 2015.

#### Cotton Pest Management Guide updates

Updates for the CPMG have been coordinated each season for the IRMS, Preamble to the RMP and Unsprayed pigeon pea agronomy chapters. This has been done in consultation with key researchers in each of these areas.

#### myBMP updates

Each year, updates have been supplied for the biotechnology module in myBMP ensuring the information remains up to date and the latest fact sheets etc. are available through the myBMP website.

#### **Objective 2: Prepare industry for possible resistance issues.**

While having an effective and practical RMP is key to the industry managing resistance in biotechnologies, it is also important to have a plan if something goes wrong. There is potential for resistance to increase slowly through natural evolution, or rapidly (such as through a biosecurity incursion). The industry needs to be prepared with a response (or contingency plan) if either of these scenarios occurs. Through the industry and Monsanto resistance monitoring programs, any changes in resistance frequencies should be able to be identified, however the important questions that need to be addressed in developing a contingency plan are:

- What constitutes a significant ‘change’ in resistance frequencies?
- If a change is identified, what mitigation strategies should be put in place to manage the potential risk?

Industry, through the TIMS Bt Technical Panel, start working on a contingency plan prior to the start of this project and were engaging with Monsanto in this process as the key commercial stakeholder. The process was halted in 2013/14 primarily because the tech panel and Monsanto could not agree on the first question – what constitutes a change? The two stakeholders were attempting to agree on an increase figure in resistance frequencies that would act as a ‘trigger point’ to flow on to the next question as how to manage any potential risk. There were also issues around ownership of the contingency plan, as it was not clear as to whether the plan was owned by industry or by Monsanto.

With the introduction of Bollgard 3, industry has been working on developing a new contingency plan. As part of the Bollgard 3 condition of registration that have been submitted to the APVMA, the registrant (Monsanto) is required to conduct an annual review each season with industry (TIMS Committee) and report the results back to the APVMA. Industry has seen this as an opportunity to build the contingency plan into the annual review. The annual review charter is currently in draft form, however the main points that industry would like to include to cover the issue of preparedness are:

- Results of resistance monitoring programs, compliance data and other relevant information are presented each year at a joint meeting of Monsanto and the TIMS Bt tech panel
- Both parties report back independently to TIMS with the primary aim of informing TIMS how effectively the Bollgard 3 RMP is working, and if there are any changes in resistance frequencies or compliance data that are cause for concern.
- TIMS Committee review the reports and make a decision as to whether there is a cause for concern, and if so, whether any action needs to be taken.
- TIMS Committee can then work with the Bt tech panel and/or Monsanto, as required, to look at any possible changes that may be required to manage resistance risk.

The main benefits of this proposed method are:

- There is no requirement for Bt Tech Panel and Monsanto agreement; both parties can freely express their own recommendations to TIMS.

- Ownership of managing resistance risk resides with industry, through the TIMS Committee. The Bt Tech Panel is there to offer scientific advice as required by TIMS.

A second commercial company (Bayer CropScience) is developing a 3-gene product for the Australian market. The TIMS Committee and Bt Tech Panel are currently working with Bayer to ensure:

- The product is equivalent in efficacy and resistance characteristics to Bollgard 3 so that the same RMP can be used for both Bt products. This ensures an RMP that can be practically managed on farm.
- The annual review process currently being put forward by Monsanto can be replicated by other companies, such as Bayer, to ensure the industry has a consistent review and contingency plan in place that applies to all Bt products.

**Objective 3: Coordination of TIMS technical panels to ensure industry resistance plans and review processes are working effectively.**

Coordination of the TIMS technical panels (Insecticides and Bt) has been a key component for this project. Coordination has included:

- Annual meeting of the Insecticide tech panel to review key insect pest resistance data and review the IRMS. The IRMS has been updated annually following this process, in consultation with key industry stakeholders (TIMS, CCA, Croplife). Annual update has ensured IRMS remains relevant in an industry that is dominated by Bt crops. Ensures IRMS reflects the latest resistance results and all available chemistry.
- Any changes to the current Bollgard II RMP that are submitted to the APVMA require industry support from TIMS. TIMS seeks technical advice on these changes from the Bt tech panel. During the project, there have been a number of changes requested including Planting Window variation, research permits and pupae busting date variations. The project has been responsible for coordinating a response from the Bt tech panel on these requests.
- The development of the Bollgard 3 RMP has been a critical part of the Bt Tech Panel activities over the past 3 years. Appendix 1 outlines the communication between TIMS, the Bt Tech Panel and Monsanto during this process. The role of this project was to coordinate the tech panel involvement in the RMP development process, including meeting agendas and minutes.
- The project has been responsible for coordinating all TIMS panel meetings (both face to face and teleconferences), email correspondence, development of meeting agendas, facilitation of meetings, meeting notes and production of meeting minutes.
- The annual exchange of resistance research information occurs through REFCOM. This is an industry forum, open to all researchers, growers, consultants and commercial companies with an interest in resistance management. The project role was to coordinate this event each year, including developing topic areas, coordinating speakers and developing agenda. REFCOM has occurred each year in various locations, Toowoomba, Narrabri, and the Gold Coast attracting around 30-50 participants each year. Major topics for discussion have included resistance monitoring results, compliance updates, refuge management, international resistance implications, resistance management on a landscape scale, Helicoverpa ecology and Bollgard 3. REFCOM is an opportunity for both established researchers and students to present their work and for the research community to be informed of the different types of research occurring, identify research gaps and potential areas for collaboration. The agendas for each REFCOM during the project period are attached in Appendix 2.
- Feedback to CRDC on ways to improve current engagement with TIMS tech panel was provided informally with CRDC managers and formally through the reporting system. The main changes that have occurred as a result for this feedback are:
  - Increased panel representation by TIMS. In addition to the TIMS Chair, both the Bt and Insecticide Technical panels now have a specific representative from TIMS whose role it is to offer a practical viewpoint to the technical panels and give feedback to TIMS from the panels. This is to ensure the TIMS Committee

are more fully aware of reasoning behind tech panel recommendations and to improve communication in general between the panels and TIMS.

- Development of the annual review charter to ensure responsibility for any management changes in the Bollgard 3 RMP lies with the TIMS Committee. The Bt technical panel role is to give scientific advice on any of these proposed changes, or if a change is required.
- Update to the TIMS Charter to more clearly outline the roles and responsibilities of the technical panels (in development stage).

**Objective 4: Improve communication between TIMS, CottonInfo and wider industry.**

Regular communication has occurred via:

- Regular updates to the CottonInfo team at teleconferences and team meetings on stewardship issues. Correspondence sent out to CottonInfo Team, such as the IRMS or any variations to the current RMP.
- Representation and participation on behalf of the CottonInfo team to TIMS meetings
- Communication of outcomes of TIMS meetings as appropriate to the wider industry via industry publications/media. Examples of this are an article produced “Industry engagement in resistance management decision making” (Ceeney, Leven, Kauter, Spotlight Magazine Autumn 2014), outlining TIMS involvement in the Bollgard 3 RMP development process.
- Communication between the Insecticide tech panel and CropLife Australia on insecticide resistance issues, particularly cross industry resistance issues.
- Communication has begun with the Insecticide tech panel and the National Insecticide Resistance Management (NIRM) group. NIRM is a GRDC organisation tasked with developing resistance management strategies to key insect pests in grains. Representatives from each group have attended each organisations meetings with the intent to identify learning opportunities and opportunities for collaboration between the groups. This cross industry collaboration provides an opportunity to improve resistance management in products that are used in a number of different crops.
- Pulse Australia now has a representative on the TIMS Insecticide Tech Panel, again providing an opportunity to improve cross industry resistance management.

***Outcomes***

**5. Describe how the project’s outputs will contribute to the planned outcomes identified in the project application. Describe the planned outcomes achieved to date.**

From the project application, 2 main outcomes were identified:

1. *Growers gain knowledge in the importance of stewardship of BT and crop protection technologies. Uptake of best practice in these areas is increased.*
2. *Industry better prepared to manage potential future resistance issues to ensure the impact on productivity and sustainability of the industry is reduced.*

The following outcomes have contributed to outcome 1:

- Grower knowledge has been improved by the publication of various articles outlining the importance of stewardship and crop protection technologies (outlined in section 9). The annual update of the CPMG, Cotton Production Manual, myBMP website and IRMS has also contributed to this.
- Grower knowledge is benefitted by the communication of the project with the CottonInfo team. The CottonInfo team has been regularly updated and informed of issues arising in stewardship. As a result, the CottonInfo team are able to also promote the message of Bt stewardship and crop protection in their individual networks.
- Grower knowledge and ability to practice effective stewardship will be enhanced by cross industry collaboration between cotton, grains and pulse industry. This cross industry collaboration has the potential to develop more effective resistance management strategies for pests at a wider than crop specific level.

The following outcomes have contributed to objective 2:

- The Bollgard 3 RMP has been developed with significant input from industry (through both the Bt tech panel and TIMS Committee). This has resulted in an RMP that is both robust and practicably manageable. This will enhance growers ability to manage potential future resistance issues to ensure the impact on productivity and sustainability of the industry is reduced.
- The addition of the BG 3 RMP conditions of registration are an important step in managing future potential resistance issues. The proposed conditions of registration will ensure the BG3 RMP is formally reviewed annually and the industry has the capacity to make changes to the RMP in a timelier manner to respond to any arising issues. The development of the annual review process is currently underway, but not finalised. In addition to the proposed conditions of registration Monsanto has made a number of general commitments in reference to improving mandatory refuges:
  - *promoting better agronomy for refuges (Refuge Management Guide, Monsanto stewardship documents for growers, training for TSPs, new ranking guides, supporting extension initiatives for CottonInfo)*
  - *supporting selection and production of foundation seed of appropriate pigeon pea varieties*
  - *work with industry to improve QA standards for pigeon peas and*
  - *review mechanisms to audit refuge quality (timing, technologies etc)*

The TIMS Committee and Bt tech panel are currently working with Monsanto to better develop the general commitments into achievable milestones for the industry.

- A number of Bollgard II RMP permits and variations have been approved by the TIMS Committee, following consultation with the Bt tech panel, during the project timeframe. The majority of these variations have been for planting window changes for particular regions. A permit was approved for the 2014/15 and 2015/16 seasons to extend the planting window for 15 days in NSW and Sthn Qld and by 2 weeks for Central Qld. The intent of this was to investigate the impact a wider planting window would have on end of season crop management to inform the industry in developing the BG3 RMP.
- Bayer Crop Sciences are currently working with the TIMS Committee and Bt Tech Panel to develop an RMP for a 3 gene Bt product they are intending on releasing into the Australian market. The industry has made a commitment that any new Bt products released onto the market must at least equivalent product efficacy to products currently on the market (Bollgard 3 in this case) and all products must have RMPs that can be practically concurrently managed on farm, and concurrently updated each year (if required) with industry support. To achieve this, Bayer are working on showing product equivalency to Bollgard 3 so that an equivalent RMP can be used for both products. This will greatly enhance the industry's capacity to manage 2 RMPs and ensure the potential impact on sustainability and productivity is reduced.
- Communication between the TIMS Committee, tech panels and industry has been improved by:
  - TIMS Committee representatives being appointed to both the Bt and Insecticide tech panels (in addition to the chair). The representatives' role is to provide practical advice to the tech panels and report back to TIMS Committee on tech panel activities.
  - Communication of tech panel activities and role to the wider industry, including the CottonInfo Team and general growing community.
  - Review of the current TIMS Committee charter, including review and better definition of the roles of the technical panels.

Improving industry communication and better definition of panel roles ensures the industry process of how potential resistance issues are managed is well understood and works efficiently, allowing the industry to react in a timely manner if these issues arise.

## 6. Please describe any:-

- a) technical advances achieved (eg commercially significant developments, patents applied for or granted licenses, etc.);**
- b) other information developed from research (eg discoveries in methodology, equipment design, etc.); and**
- c) required changes to the Intellectual Property register.**

## **Conclusion**

### **7. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. What are the take home messages?**

The submission of the BG3 RMP to the APVMA accompanied with a letter of support from industry via the Cotton Australia TIMS Committee in October 2014 is a major highlight of this project. The TIMS Bt Technical Panel has been responsible for advising on the scientific plausibility of proposed resistance management tactics and the associated resistance risks of these tactics to the TIMS Committee. After a lengthy process, the Bt tech panel was able to reach a group consensus on their recommendation to the TIMS Committee. Despite varying views within the panel, the importance of finding a consensus so that the cotton industry had the best possible result was seen as a priority. On the whole, the TIMS Committee fully considered the advice provided by the tech panel and supported them in most instances, in others (most notably the reduction in refuge size and pupae busting dates) the TIMS Committee reached a compromise between what was proposed in the BG3 RMP and the advice given by the tech panel.

Overall, feedback suggests that all stakeholders are satisfied that the RMP that has been submitted is both scientifically robust and practically manageable. The addition of the conditions of registration will give the industry more flexibility to make changes to the BG3 RMP as required in a timely manner. The conditions will allow the industry to respond quickly to any resistance issues that may arise, and conversely also allows room to make the RMP less restrictive if evidence is available to support this.

The consultative process that was adopted between industry and the technology provider in developing the BG3 RMP has provided not only a robust and practical RMP, but sets a precedent in developing RMPs for other biotech products coming into the Australian market. The proposed conditions of registration also sets a benchmark which can be applicable across a number of Bt products, allowing the industry to be able to practically manage multiple RMPs in the future.

The overall aim of the project has been to increase grower awareness of stewardship not as a 'must do' but a 'should do' to protect the industry's access to biotechnologies and insecticides in the future. Monsanto compliance data for Bollgard II shows that non-compliance cases are still heavily influenced by environmental factors outside of the control of the grower. This is evidence that there are very few cases of intentional non-compliance. The industry has been growing Bollgard II for 9 years, and Ingard for 10 years prior to that. Despite this long history, resistance monitoring data from both CSIRO and Monsanto in 2014/15 show that resistance to Cry1Ac remains relatively rare for both *H. punctigera* and *H. armigera*. Resistance to Cry2Ab is higher in both species, but there is no evidence for a significant increase in resistance frequencies since 2007/08. This indicates that our current resistance management strategy is working, especially when the evidence that Australia is one of the few countries in the world that grow Bt crops where resistance has not increased is considered.

The continued review of the industry IRMS each season ensures that it remains relevant and useful in a Bt dominant industry. The management of pests other than *Helicoverpa* has become an important part of crop management, and the IRMS is a key tool for an effective IPM strategy. Survey data from the annual Crop Consultants Australia in 2013/14 show that 94% of consultants follow the IRMS when selecting insecticides and 93% consider preserving beneficials in their decision-making. The industry use of IPM is also highlighted by the well documented 80% reduction in insecticide use since the introduction of Bollgard II. Continuing this high adherence to the IRMS and IPM principles has been an important focus of the project. However, it must be acknowledged that most cotton growers also grow a number of other crops. Resistance management in pests is not something that can be managed solely within an industry as many key pests are found in a number of crops, and insecticide chemistry is also used in a range of crops. Collaboration between the cotton industry, grains and pulse industries has begun to look at resistance management above individual crop types, which has the potential to benefit insecticide resistance management on a much wider scale.

## *Extension Opportunities*

### **8. Detail a plan for the activities or other steps that may be taken:**

- (a) to further develop or to exploit the project technology.**
- (b) for the future presentation and dissemination of the project outcomes.**
- (c) for future research.**

This project is an extension project, so (b) has been achieved throughout the entire project.

### **9. A. List the publications arising from the research project and/or a publication plan. (NB: Where possible, please provide a copy of any publication/s)**

- “New Look IRMS for 2012/13; the first place to go when selecting a spray” Spotlight Magazine Spring 2012 ed. and CCA newsletter October 2012.
- Ceeney, S., Downes, S., Leven, T., & Maas, S. (2012). Planting Windows. Investing in Cotton’s Future. The Australian Cottongrower Oct-Nov 2012. Spotlight Magazine Summer ed. 2012.
- Ceeney, S. Baker, G., Whitehouse, M. Gregg, P., Tann, C., Leven, T., Downes, S. & Wilson, L. (2012). Refuge Crops – Investing in Cotton’s Future. Australian Cottongrower Dec-Jan 2012 and Spotlight Magazine summer ed. 2012.
- Downes, S., Mahon, R., Walsh, T., James, B. and Ceeney, S. (2012). Vip3A resistance genes exist in *Helicoverpa* before release of Bollgard III. The Australian Cottongrower Dec-Jan 2012.
- Early season aphid management package. Produced by D&D Team, primary author Susan Maas.
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### **Presentations**

- CCA Cropping Solutions Seminar May 2013: “Draft 2014 Insecticide Resistance Management Strategy”
- Southern Cotton Expo, Griffith, July 2013: “Integrated Pest Management”
- REFCOM, July 2013: “Industry communication of Bt stewardship R&D”.
- CCA Seminar, Moree, May 2014: “Evaluating the performance of resistance management tactics in BGII and the implications for developing and RMP for BG3” with Tracey Leven (CRDC) and Kristen Knight (Monsanto)
- TIMS Committee, Goondiwindi, May 2014: “Bollgard 3 RMP Development”
- TIMS Committee, Goondiwindi, May 2014: “IRMS Development for 2014/15”
- “Bollgard 3 Information Sessions” with G. Kauter, K. Knight & T. Leven. Grower groups at Goondiwindi, Moree, Narrabri, Warren and Griffith July 2014.
- 17<sup>th</sup> Australian Cotton Conference 5-7 August 2014. “Designing Tactics to Mitigate Resistance Risk”.

### **B. Have you developed any online resources and what is the website address?**

## ***Part 4 – Final Report Executive Summary***

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Provide a one page Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web. Explain the main outcomes of the research and provide contact details for more information. It is important that the Executive Summary highlights concisely the key outputs from the project and, when they are adopted, what this will mean to the cotton industry.

The main objectives of the project were:

1. Promote stewardship of biotechnologies and crop protection products in the cotton industry to protect the performance of current and new Bt technologies and selective insecticides.
2. Prepare industry for possible resistance issues
3. Coordination of TIMS technical panels to ensure industry resistance plans and review processes are working effectively
4. Work with TIMS, the CottonInfo Team and wider industry to ensure good communication between all parties

These were achieved through the following:

The submission of the BG3 RMP to the APVMA accompanied with a letter of support from industry via the Cotton Australia TIMS Committee in October 2014 is a major highlight of this project. The

TIMS Bt Technical Panel has been responsible for advising on the scientific plausibility of proposed resistance management tactics and the associated resistance risks of these tactics to the TIMS Committee. After a lengthy process, the Bt tech panel was able to reach a group consensus on their recommendation to the TIMS Committee. Despite varying views within the panel, the importance of finding a consensus so that the cotton industry had the best possible result was seen as a priority. On the whole, the TIMS Committee fully considered the advice provided by the tech panel and supported them in most instances, in others (most notably the reduction in refuge size and pupae busting dates) the TIMS Committee reached a compromise between what was proposed in the BG3 RMP and the advice given by the tech panel.

Overall, feedback suggests that all stakeholders are satisfied that the RMP that has been submitted is both scientifically robust and practically manageable. The addition of the conditions of registration will give the industry more flexibility to make changes to the BG3 RMP as required in a timely manner. The conditions will allow the industry to respond quickly to any resistance issues that may arise, and conversely also allows room to make the RMP less restrictive if evidence is available to support this.

The consultative process that was adopted between industry and the technology provider in developing the BG3 RMP has provided not only a robust and practical RMP, but sets a precedent in developing RMPs for other biotech products coming into the Australian market. The proposed conditions of registration also sets a benchmark which can be applicable across a number of Bt products, allowing the industry to be able to practically manage multiple RMPs in the future.

The overall aim of the project has been to increase grower awareness of stewardship not as a 'must do' but a 'should do' to protect the industry's access to biotechnologies and insecticides in the future. Monsanto compliance data for Bollgard II shows that non-compliance cases are still heavily influenced by environmental factors outside of the control of the grower. This is evidence that there are very few cases of intentional non-compliance. The industry has been growing Bollgard II for 9 years, and Ingard for 10 years prior to that. Despite this long history, resistance monitoring data from both CSIRO and Monsanto in 2014/15 show that resistance to Cry1Ac remains relatively rare for both *H. punctigera* and *H. armigera*. Resistance to Cry2Ab is higher in both species, but there is no evidence for a significant increase in resistance frequencies since 2007/08. This indicates that our current resistance management strategy is working, especially when the evidence that Australia is one of the few countries in the world that grow Bt crops where resistance has not increased is considered.

The continued review of the industry IRMS each season ensures that it remains relevant and useful in a Bt dominant industry. The management of pests other than *Helicoverpa* has become an important part of crop management, and the IRMS is a key tool for an effective IPM strategy. Survey data from the annual Crop Consultants Australia in 2013/14 show that 94% of consultants follow the IRMS when selecting insecticides and 93% consider preserving beneficials in their decision-making. The industry use of IPM is also highlighted by the well documented 80% reduction in insecticide use since the introduction of Bollgard II. Continuing this high adherence to the IRMS and IPM principles has been an important focus of the project. However, it must be acknowledged that most cotton growers also grow a number of other crops. Resistance management in pests is not something that can be managed solely within an industry as many key pests are found in a number of crops, and insecticide chemistry is also used in a range of crops. Collaboration between the cotton industry, grains and pulse industries has begun to look at resistance management above individual crop types, which has the potential to benefit insecticide resistance management on a much wider scale.

**Appendix 1:  
Bollgard 3 TIMS communication information journal**

<b>Date</b>	<b>Form/Activity</b>	<b>To</b>	<b>From</b>	<b>Subject</b>	<b>Comments</b>
2013.05.08	Meeting, CA Mascot	A.Parkes, G.Kauter, A.Kay, T.May & K.McLean		Regulatory timeline & proposed RMP development.	MON PPT slide on regulatory timeline. Discussed: Predictive modelling, Refuge trials.
2013.06.19	Email	K.McLean	G.Kauter	Written regulatory proposal requirement. Research Data table update (for 2013)	Requested written BG3 regulatory timeline proposal and advised R&D table - 2013 data population (asap)
	Phone call	A.Parkes	T.May		
2013.06.18	Phone call	T.Leven	T.May		
2013.06.26	Phone call	G.Kauter	T.May	Preparation of information documents for BG3 reg. timeline.	Also possible confidentiality undertaking re: VIP3A (Syngenta)
2013.07.01	Teleconference meeting	Bt Technical Panel: P.Grundy, M.Whitehouse, N.Schellhorn, T.Walsh, S.Downes, G.Kauter, T. Leven, L.Wilson, S.Ceeney, P.Gregg Monsanto: T. May, K. Knight		Discussion of BG3 R&D table. Update BG3 reg. timeline.	Gaps in BGIII R&D table identified. Discussion of 2 <sup>nd</sup> BG3 table development on mitigation tactics to address gaps. See meeting notes.
2013.07.23	Teleconference meeting	TIMS Committee			
2013.08.28-29	Meeting	TIMS Committee			
2014.02.28	Meeting	TIMS Bt Technical Panel: G. Kauter, T. Leven, S. Ceeney, G.Baker, S. Downes, M. Whitehouse, T. Walsh, N.Schellhorn, P. Gregg, L. Bird, P. Grundy, R. Roush. Monsanto: T. May, K. Knight		Key topic: End of season tactics. Presentation & discussion of pupae busting, alternative tactics, planting windows	See meeting notes
2014.03.14	Teleconference meeting	S Ceeney, G Kauter, T Leven, T. May, K. Knight		Formulate agenda for next Bt tech panel meeting	
2014.04.03-	Meeting	TIMS Bt Tech Panel:		Key topics/discussion	See meeting

04		T. Leven, S. Ceeney, G. Baker, S. Downes, C. Tann, M. Whitehouse, T. Walsh, N. Schellhorn, P. Gregg, P. Grundy, R. Roush Monsanto: T. May, K. Knight	of draft RMP statements: end of season tactics, planting windows. Refuges: Location, time of planting & crop destruction, agronomic management	notes
2014.05.02	Teleconference meeting	S. Ceeney, T. Leven, K. Knight, T. May	Discussion of joint presentation by CRDC and Monsanto to industry at Crop Consultants Aus seminar	
2014.05.10	Industry presentation - Emerald	G. Kauter, ?	TIMS/Monsanto/CRDC BG3 information session to industry	
2014.05.14	Industry presentation	T. Leven, K. Knight, S. Ceeney	Joint CRDC / Monsanto presentation to industry at CCA to update industry on BG3 RMP development process	
2014.05.19	Industry presentation - Theodore	G. Kauter, ?	TIMS/Monsanto/CRDC BG3 information session to industry	
2014.05.27-28	Meeting	TIMS Committee		
2014.06.24	Teleconference meeting	S. Ceeney, G. Kauter, K. Knight, S. Maas	Formulate agenda for next Bt tech panel meeting	
2014.07.14	Industry presentation - Goondiwindi	S. Ceeney, G. Kauter, K. Knight	TIMS/Monsanto/CRDC BG3 information session to industry	
2014.07.15	Industry presentation - Moree	S. Ceeney, G. Kauter, K. Knight	TIMS/Monsanto/CRDC BG3 information session to industry	
2014.07.15	Industry presentation - Narrabri	S. Ceeney, G. Kauter, K. Knight	TIMS/Monsanto/CRDC BG3 information session to industry	
2014.07.23	Industry presentation - Griffith	S. Ceeney, G. Kauter, K. Knight	TIMS/Monsanto/CRDC BG3 information session to industry	
2014.07.24	Industry presentation - Warren	S. Ceeney, K. Knight	TIMS/Monsanto/CRDC BG3 information session to industry	
2014.07.29-30	Meeting	TIMS Bt Technical Panel: G. Kauter, S. Ceeney, G. Baker, S. Downes, N. Schellhorn, C. Tann, M. Whitehouse, L. Wilson, L. Bird, P. Gregg, P. Grundy, R. Roush. Monsanto: Tony May, Kristen Knight, Graham Head, Allen Willse Other: T. Ives (Uni		See meeting notes

		Wisconsin – Madison via Skype)		
2014.08.06	Meeting	G. Kauter, T. May, K. Knight, CQ growers & Consultants	Discussion of Bollgard 3 RMP specific to CQ region	
2014.08.20	Teleconference	TIMS Bt Tech panel: S. Ceeney, S. Maas, L. Wilson, G. Baker, P. Grundy, N. Schellhorn, C. Tann, M. Whitehouse	Preparation of advice to TIMS Committee regarding BG3 RMP	

## Appendix 2: REFCOM Agendas

### **2013 REFCOM: *Resistance Management for Third Generation Bt Cotton* Crossing Theatre, Narrabri, Monday 5<sup>th</sup> August Agenda**

9:30 am        Tea & coffee on arrival

**10:00 am        Welcome**  
Andrew Parkes, TIMS Committee Chairman and Greg Kauter, Cotton Australia

10:15 am        **Industry communication of Bt stewardship R&D**  
Sally Ceeney, Development & Delivery Team

#### **Session 1 – The performance and value of unsprayed refuges**

10:30 am        **Long term evaluation of unsprayed pigeon pea and conventional cotton refuges**  
Geoff Baker & Colin Tann, CSIRO

11:00 am        **Factors effecting refuge attractiveness and productivity**  
Mary Whitehouse, CSIRO

**11:30 am        Morning Tea**

Noon            Discussion time- what will the relative role of pigeon pea and unsprayed conventional cotton refuges be in a Bollgard III system?

#### **Session 2 – Towards Bollgard III**

12:20 pm        Monsanto update  
TBA

1:00 pm        R&D Investment supporting Bt stewardship  
Tracey Leven, CRDC

**1:15 pm        Lunch**

#### **Session 3 – The future of sprayed cotton refuges**

1:45 pm        Long term changes in Helicoverpa population dynamics and the implications for a Bt dominant system  
Peter Gregg, UNE

2:15 pm        Long term changes in insecticide use pattern, implications for resistance conventional insecticides  
Lisa Bird, NSW DPI

## 2:45pm Afternoon Tea

- 3:15 pm A consultant perspective on the value and management of sprayed refuges  
Rob Holmes, HMAg
- 3:45 pm Landscape impacts of *Helicoverpa* population dynamics and the implications for future refuge management  
Nancy Schellhorn, CSIRO
- 4:15 pm Discussion time - what will the role of sprayed cotton refuges be in the future?  
Is there an opportunity to look at a reduced % requirement in a BGIII RMP?
- 5:00 pm **Meeting Close**
- 7:00 pm **Dinner, Crossroads Hotel, 170 Maitland St, Narrabri**

## REFCOM 2014 Agenda 17<sup>th</sup> – 18<sup>th</sup> September, O’Shea’s Royal Hotel - Goondiwindi QLD

### Day 1

10:30am	Morning tea on arrival	
<b>SESSION 1</b> 11:00am	<b>BGII Update</b> <ul style="list-style-type: none"> <li>Resistance monitoring: <i>Sharon Downes (CSIRO) &amp; Kristen Knight (Monsanto)</i></li> <li>BGII Compliance Report: <i>Kate Lang (Monsanto)</i></li> </ul>	Chair: Sally Ceeney (CottonInfo)
11:30am		
12:00pm	Lunch	
<b>SESSION 2</b> 1:00pm	<b>Understanding <i>Helicoverpa</i> ecology and moth movement (20 min talks)</b> <ul style="list-style-type: none"> <li>Population mixing from different plant host origins within landscapes of differing habitat complexity: <i>Colin Tann (CSIRO)</i></li> <li>Ecology &amp; overwintering of <i>Punctigera</i>: <i>Matt Binns (UNE)</i></li> <li>Using <i>Gossypol</i> to track moth movement: <i>Kristen Knight (Monsanto)</i></li> <li>Moth behavior in response to landscape structure: <i>Nancy Schellhorn (CSIRO)</i></li> <li>Using satellite imagery for refuge management: <i>Mary Whitehouse (CSIRO)</i></li> </ul>	Chair: Hamish McIntyre (Chair TIMS Committee) Discussion: Identifying research gaps and priorities
3:00pm	Afternoon Tea	
<b>SESSION 3</b> 3:30pm	<b>Future tactics &amp; research tools for resistance management (20 min talks)</b> <ul style="list-style-type: none"> <li><i>Helicoverpa</i> flight capacity and implications for resistance management: <i>Jason Callander (UQ)</i></li> <li>Moth busting: <i>Alice del Socorro (UNE)</i></li> <li>Role of other crop types as unmandated refuge: <i>Tony May (Monsanto)</i></li> <li>Mapping the <i>Helicoverpa</i> genome: what implications could this have for resistance management? <i>Tom Walsh (CSIRO)</i></li> <li>Adaptive Resistance Management: <i>Tony Ives (Uni Wisconsin-Madison)</i></li> </ul>	Chair: Susan Maas (CRDC) Discussion: Identifying research gaps & priorities
5:30	Meeting adjourned	

### Dinner 6:30pm O’Shea’s Royal Hotel

## Day 2

<b>SESSION 4</b> 8:30am	<b>Monitoring &amp; Adaptive Resistance Management:</b> <i>Tony Ives (Uni Wisc.)</i> Introduction (Background, model assumptions)	Chair: Sally Ceeney (CottonInfo)
<b>SESSION 5</b> 9:15am	<b>Monitoring &amp; Adaptive Resistance Management WORKSHOP:</b> <i>Tony Ives (Uni Wisc.)</i> Workshop style session aimed at exploring questions around future resistance management Example questions: 1. How much does variation matter? <ul style="list-style-type: none"> <li>• Refuge – temporal variation in proportion (structured/ unstructured) and total habitat (within seasons and among years)? What to do about it in terms of the RMP?</li> <li>• Pupae destruction – does it matter if the % area pupae ‘busted’ and/or % effectiveness of the operation varies among years?</li> </ul> 2. What is impact of growing period? <ul style="list-style-type: none"> <li>• Planting windows in CQ</li> <li>• Year round cotton - volunteers/ratoons</li> <li>• In CQ – how does the winter unstructured refuges (non-cotton hosts) contribute?</li> </ul>	Chair: Sharon Downes (CSIRO)
10:30am	Morning tea	
<b>SESSION 5 cont.</b> 11:00am	Example questions: 3. Difference between population size and proportion of population being selected  4. Contingency plans, how to identify a trigger/s that indicate increases in resistant alleles, and what and how to think about mitigation strategies?	
<b>SESSION 6</b> 11:45am	<b>The Role of Adaptive Management in Future RMPs</b> <b>Discussion session:</b> How might it work? What would it look like? Grower perspective? What are the research gaps?	Chair: Susan Maas (CRDC)
1:00pm	Meeting close	

**2015 REFCOM AGENDA**  
**Crossing Theatre, Narrabri, Thursday 6<sup>th</sup> August**

8:30am	Tea and coffee on arrival
8:50am	Welcome, Hamish McIntyre, TIMS Committee Chairman
<b>SESSION 1</b>	<b>Bt Resistance Management: The Local Story</b>
9:00am	<ul style="list-style-type: none"> <li>Resistance Monitoring Results: <i>Sharon Downes, CSIRO</i></li> </ul>
9:10am	<ul style="list-style-type: none"> <li>Resistance Monitoring Results: <i>Kristen Knight, Monsanto</i></li> </ul>
9:20am	<ul style="list-style-type: none"> <li>Bollgard II Compliance Report: <i>Kate Lang, Monsanto</i></li> </ul>
9:30am	<ul style="list-style-type: none"> <li>Bollgard 3 update: <i>Kate Lang/Kristen Knight, Monsanto</i></li> </ul>
9:45am	<ul style="list-style-type: none"> <li>Moth Busting and the potential implications on Helicoverpa populations in refuge crops: <i>Peter Gregg, UNE</i></li> </ul>
10:05am	<ul style="list-style-type: none"> <li>The response of Helicoverpa to Bt toxins and refuges: the role of tolerance and the loss of efficacy: <i>Mary Whitehouse, CSIRO and Sharna Holman.</i></li> </ul>
10:30am	Morning tea
<b>SESSION 2</b>	<b>Bt Resistance Management: A Landscape View</b>
11:00am	<ul style="list-style-type: none"> <li>Area-wide pest suppression in transgenic landscapes: implications for resistance management: <i>Tony Ives, University Wisconsin - Madison and Nancy Schellhorn, CSIRO</i></li> </ul>
11:40am	<ul style="list-style-type: none"> <li>Do moth populations reflect local landscape complexity? <i>Geoff Baker, CSIRO</i></li> </ul>
12:00pm	<ul style="list-style-type: none"> <li><i>H. punctigera</i> ecology in inland Australia: <i>Kris le Mottee, UNE</i></li> </ul>
12:20pm	Lunch
<b>SESSION 3</b>	<b>Bt Resistance Management: International Impacts</b>
1:30pm	<ul style="list-style-type: none"> <li>Helicoverpa armigera in Brazil: <i>Tom Walsh, CSIRO</i></li> </ul>
1:50pm	<ul style="list-style-type: none"> <li>Lessons from international cases of Bt resistance: <i>Kristen Knight, Monsanto</i></li> </ul>
2:10pm	<ul style="list-style-type: none"> <li>International R&amp;D in Bt resistance management: <i>Ian Taylor, CRDC</i></li> </ul>

<b>SESSION 4</b>	<b>Wrap up</b>
2:30pm	Identifying gaps and opportunities in resistance research: <i>Facilitated by Ian Taylor, CRDC</i>
3:00pm	Meeting close