Australian Government
Cotton Research and Development Corporation

FINAL REPORT 2017

For Public Release

Part 1 - Summary Details

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

CRDC Project Number: DAQ1502

Project Title: Crop Protection Development Specialist

Project Commencement Date: 1 July 2014 **Project Completion Date:** 30 June 2017

CRDC Research Program: 1 Farmers

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Signature of Research Provider Representative: _____

Date Submitted: _____

Part 3 – Final Report

Background

1. Outline the background to the project.

Volunteer, ratoon and feral cotton plants represent a significant challenge to the delivery of sustainable crop protection systems for the Australian cotton industry. The presence of these plants can raise difficulties for crop managers by allowing the on farm survival of various pest and disease species between seasons. This can result in earlier pest reinfestation, increased incidence of disease such as Cotton bunchy top or the carry-over of pests with resistant alleles. Volunteer cotton can also pose biosecurity risks as these plants can aid the establishment and spread of new exotic pests should they enter Australia's cotton cropping regions.

The primary aim of this project was to provide crop protection extension leadership for the Australian cotton industry. In particular, it sought to improve the industry's awareness of the need to control volunteer cotton and provide new registered tactics enabling growers to achieve effective control.

This project aimed to achieve this by:

- Providing linkages between the cotton industry and the RD&E sector for biosecurity and crop protection issues; by seeking to extend and where necessary assist in the validation of control tactics for volunteer cotton management.
- Quantifying the costs involved in current control methods, as well as actual and potential impacts of the costs incurred when control of volunteers is not implemented.
- Working with private and public weed and herbicide development researchers to develop better control tactics for cotton volunteer management.
- Leading an extension program that seeks to better communicate the issues associated with volunteer cotton control that include practical advice as to how control might be best achieved.

It is anticipated that measurable improvements in the control of volunteer cotton across the industry will be enabled by the tactics developed by this project and that these improvements over time will be detected in data collected by other researchers who survey the incidence of pests, weeds and diseases on farm.

This project also had key involvement providing support to two industry funded projects (Paul Grundy's DAQ1401 *Strengthening the Central Highlands Cotton Production System* and Richard Sequeira's DAQ1204 *Management of mirids, stinkbugs and Solenopsis Mealybug*) that had research components conducted in the Central Highlands. This was achieved through the provision of a technical officer and extension support.

Objectives

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

The primary objective of the project was to provide crop protection extension leadership to industry. In particular, the project sought to increase the control of volunteer cotton plants through improved levels of farm hygiene. Table 1 summarises the objectives, milestones and performance indicators from the research proposal.

Table 1. Summary of DAQ1502 Crop Protection Specialist objectives, milestones and performance indicators.

Objective	Milestone	Performance Indicator
1. Professional development.	Coordinate and deliver activity between researchers, specialists and interested growers and consultants.	Organisation and involvement in relevant workshops and meetings
2. Undertake field activities/experiments to test suppression of cotton volunteers from a range of farming practices.	Investigate control tactics in conjunction with specialists and researchers with view to validate techniques and develop control options for cotton volunteers.	Field validation exercises conducted with data developed that may assist with the deployment of new volunteer control products or techniques.
3. Provide technical support for projects based in Central Queensland with the aim of understanding the drivers of volunteer establishment and identifying practices that may have volunteer suppression as a co-benefit.	Provision of guidance and technical assistance to regional projects.	Planning of Central Queensland based project activities undertaken and reviewed each season.
4. Develop communication products from research for industry audiences.	Contribute to the review of industry publications, articles and presentation of information at relevant industry forums.	Assistance and authorship is provided to industry publications.
5. Work with the CottonInfo team to respond to seasonal issues.	CottonInfo team collaboration.	Participate in CottonInfo team meetings and conduct activities which complement CottonInfo campaign topics.
6. Evaluate industry performance in volunteer management over time.	Conduct targeted surveys to assess volunteer control success.	Surveys conducted either specifically or as part of other researcher surveys.
7. Complete Final Project Report.	Final report completed and submitted on time.	Report completed and submitted on time.

1. Professional Development - Increase knowledge and awareness of relevant Crop Protection, farming systems and volunteer cotton R&D (current and past).

During the project, Crop Protection Specialists Ngaire Roughley (July 2014 – August 2015) and Sharna Holman (January 2016 – June 2017) increased their knowledge and awareness of relevant crop protection, farming systems and volunteer R&D via participation and involvement in a number of industry events and activities. These events over the past three years included FUSCOM, REFCOM, Australian Cotton Conferences, Central Highlands Cotton Growers & Irrigators Association meetings, Dawson Valley Cotton Growers Association meetings, CottonInfo research tours, soil pit field days, crop agronomy field walks and specific cotton workshops. Attendance at these events and meetings assisted with

further developing relationships with local cotton growers and consultants as well as key pathologists and industry members involved with farm hygiene and cotton volunteers.

Sharna Holman also co-ordinated and organised activities which brought together researchers and interested growers and consultants through a CottonInfo Crop Protection R&D Update for the Central Highlands and Dawson Valley regions in October 2016. This meeting was held to review and give an update on local crop protection research projects happening in Central Queensland including the annual disease and virus disease surveys, reniform nematode trials and mealybug management trials.

Sharna was also involved in co-ordinating and chairing the Cotton Industry Biosecurity Reference Group annual meeting in 2016. This group and the annual meetings are maintained to assist in identifying biosecurity research and preparedness gaps and opportunities, and provide oversight of industry implementation and adoption of biosecurity strategies.

2. Undertake field activities/experiments to test the suppression of cotton volunteers from a range of farm practices

This project undertook different field activities and experiments to test the suppression of cotton volunteers from a range of farm practices through a volunteer cotton management practices survey and explored potential herbicide chemical options available for controlling large volunteer and ratoon cotton plants.

Ngaire Roughley developed a volunteer cotton management practices survey which was delivered to 50 – 60 growers in collaboration with plant pathology teams from DAF and NSW DPI during the 2014 – 2015 season. 27 growers participated in the survey which aimed to identify common control practices, tangible management costs and grower attitudes towards volunteer cotton and on farm hygiene. Furthermore fields were surveyed for in-crop volunteer prevalence early in the growing season to determine the relative frequency of volunteer cotton in fields across Queensland and northern NSW.

Throughout the project, a number of herbicide products were tested as potential options for the control of large volunteer cotton plants when applied through an optical spray boom in collaboration with Paul Grundy (DAF) and Frank Taylor (Nufarm).

These experiments and further large scale trials identified three potential herbicide control tactics that enable the control of large volunteer cotton. These treatments were:

1. Comet® (fluroxypyr) applied at 1L/ha twice with a treatment interval of 7-10 days.
2. Comet® applied at 1L/ha and then followed with Nuquat (paraquat) at 3.2L/ha approximately 7-10 days after first application.
3. Comet® at 1L/ha mixed with Amicide 700 (2,4D) at 1L/ha as a single pass application.

These potential rates and use patterns were already registered for use against other weeds using optical booms. The work completed has enabled a data package that Nufarm is utilising to pursue product label registrations to include large volunteer cotton as a target species with optical boom sprayers. In the interim period Cotton Australia have applied for a permit to use these herbicide options on volunteer cotton prior to registration.

3. Provide technical support to project activities based in CQ: investigating Solenopsis Mealybug and the strengthening CQ farming systems

The Crop Protection Specialist provided technical assistance for Paul Grundy's (DAQ1401 *Strengthening the Central Highlands Cotton Production System*) and Richard Sequeira's (DAQ1204 *Management of mirids, stinkbugs and Solenopsis Mealybug*) project work in the Central Highlands region.

The Crop Protection Specialist and Technical Officer Gail Spargo also collaborated with researchers from different organisations to provide assistance for satellite trial sites for

projects which were of regional or industry interest. These trials include Mary Whitehouse's *Helicoverpa* moth productivity (CSE1601 M*anaging Bt resistance and induced tolerance in Bollgard 3 using refuge crops*), Lisa Bird's insecticide resistance monitoring (DAN1506 *Conventional insecticide resistance in Helicoverpa*), Simone Heimoana's investigating cotton colour grades trial (CSP1703 *Investigating the relative contributions of weathering insect honeydew and fungal agents to cotton colour grade changes and discounts*) and assisting the Queensland Department of Agriculture and Fisheries cotton pathology group with the annual industry disease survey in Central Queensland (RRDP1724 *Improving the management of cotton diseases in Australian cotton farming systems*).

The collaboration with researchers to assist in further data collecting from the Central Highlands region has resulted in significant outcomes for the industry and local growers including:

- For Paul Grundy's project (DAQ1401 *Strengthening the Central Highlands Cotton Production System*) this collaboration resulted in 3 large scale field experiments examining crop and climate interactions along with commercial crop benchmarking of fields planted in August and December.
- The technical and extension assistance provided to Richard Sequeira's project (DAQ1204 *Management of mirids, stinkbugs and Solenopsis Mealybug*) helped find control options through chemical and beneficial insect trials, with minor use permits being developed based on the data collated during this project. Richard provided updates on the project and mealybug information to growers and consultants through events organised by the Crop Protection Specialist such as the Crop Protection R&D Update for Central Highlands and Dawson Valley region in October 2016.
- The organisation and management of satellite sites which were included in Mary Whitehouse's *Helicoverpa* moth productivity project (CSE1601 M*anaging Bt resistance and induced tolerance in Bollgard 3 using refuge crops*) has allowed for information on the Central Highland cotton system to be collected with Bt resistance and induced tolerance monitored.
- The technical assistance and management of satellite sites which were included in Simone Heimoana's investigating cotton colour grades trial (CSP1703 *Investigating the relative contributions of weathering insect honeydew and fungal agents to cotton colour grade changes and discounts*) involved applying artificial honeydew to treatments and collecting cotton lint samples after weather events over a period of time, and transportation to Narrabri for colour grade and quality testing.
- For Lisa Bird's project (DAN1506 *Conventional insecticide resistance in Helicoverpa*) this collaboration resulted in the collection of moths from a grid of traps, processing and transportation to Narrabri for conventional insecticide resistance testing.

4. Develop communication products from research for industry audiences

Throughout the project communication products from research were developed for industry audiences. Annually the project team conducted reviews of relevant chapters and chemical tables in the Cotton Pest Management Guide and Cotton Production Manual. The project team also contributed Central Queensland district reports and annual Central Highlands season summaries for the Australian Cottongrower Magazine.

Authorship was provided to articles and factsheets for the Spotlight Magazine and CottonInfo e-newsletters covering aspects of cotton volunteer control, farm hygiene and cotton diseases.

The project team also resumed writing regional newsletters 'CQ Cotton Update' for local growers and industry to stay abreast of the latest news, information and research from Central Queensland. Topics covered in the 'CQ Cotton Update' included final irrigations, diseases surveys, post-harvest management, management considerations for early sown crops and compaction.

All newsletters and Spotlight articles are included in Table 2 and 3 on Page 15.

5. Work with the CottonInfo team to respond to seasonal issues

The Crop Protection Specialist had regular dialogue with relevant CottonInfo team members to coordinate extension activities and respond to seasonal issues.

Out workings from these meetings include – weekly teleconferences, organising biosecurity training for CottonInfo members and other industry members, Cotton Pest Management Guide updates, Australian Cotton Production Manual updates etc.

6. Evaluate industry performance in volunteer management over time

Industry performance in volunteer management over time is measured through different surveys. These surveys include Ngaire Roughley's volunteer cotton management practices survey which was delivered to 50 – 60 growers in collaboration with plant pathology teams from DAF and NSW DPI during the 2014 – 2015 season, as well as trends indicated through Crop Consultants Qualitative Survey which captures a large proportion of the Australian cotton industry and the practices implemented on-ground.

These surveys found that cotton growers with the best farm hygiene (no volunteer cotton plants in-crop) were utilising a combined control strategy for volunteer management – that is pre-planting herbicide application and multiple inter-row cultivations.

7. Complete Final Project Report.

Five bi-annual reports and Final Project Report completed and submitted.

Methods

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

The Crop Protection Specialist extension component of this project developed publications to support best practice adoption with a focus on volunteer cotton, farm hygiene practices and disease management. The extension strategy for the project concentrated on raising awareness amongst growers and agronomists about farm hygiene issues and the need to implement volunteer and ratoon control. The strategy also involved collaborating with researchers to communicate research outcomes and trial results e.g. the 'Vert update: the latest in vert research' and 'Verticillium wilt: the IDM fast facts series' factsheets which were developed in collaboration with Linda Smith (DAF), Karen Kirkby (NSW DPI), Hannah Hartnett (CSD), Susan Maas (CRDC) and Ruth Redfern (CRDC/CottonInfo) to disseminate the latest findings in Verticillium wilt research.

Discussions with Paul Grundy (DAF) and Frank Taylor (Nufarm) enabled herbicide products and usage tactics to be identified that may be able to control large volunteer and ratoon cotton plants. These herbicide products were then tested through small plot trials with successful herbicide products then tested in large commercial trials. These large commercial trials involved further validating usage tactics and collection of data to support updating chemical label registrations.

With the assistance of Technical Officer, Gail Spargo, the Crop Protection Specialist also supported and provided technical assistance for Paul Grundy's (DAQ1401 *Strengthening the Central Highlands Cotton Production System*). For this project this assistance entailed generating crop biomass, light interception and yield data as well as conducting routine trial site maintenance. Furthermore commercial crops were benchmarked according to specific protocols and relationships were developed and maintained with key collaborators, consultants and the researcher to ensure that the trial program was effectively deployed. Extension support was provided to workshops and agronomic field walks.

Technical and extension assistance was also provided to Richard Sequeira's (DAQ1204 *Management of mirids, stinkbugs and Solenopsis Mealybug*) project work in Emerald through

assisting Gail Spargo collect data from chemical product and beneficial insect trials. Extension support was provided through organising project review meetings with consultants, key growers and CottonInfo regional extension officers, and Crop Protection R&D Update for Central Queensland cotton growing valleys.

Furthermore the project team collaborated with researchers from other organisations to provide assistance to satellite trial sites for projects which were of regional or industry interest including Mary Whitehouse's *Helicoverpa* moth productivity (CSE1601 M*anaging Bt resistance and induced tolerance in Bollgard 3 using refuge crops*), Lisa Bird's insecticide resistance monitoring (DAN1506 *Conventional insecticide resistance in Helicoverpa*), Simone Heimoana's investigating cotton colour grades trial (CSP1703 *Investigating the relative contributions of weathering insect honeydew and fungal agents to cotton colour grade changes and discounts*) and assisting the Queensland Department of Agriculture and Fisheries cotton pathology group with the annual industry disease survey in Central Queensland (RRDP1724 *Improving the management of cotton diseases in Australian cotton farming systems*).

Results

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

Professional Development - Increase knowledge and awareness of relevant Crop Protection, farming systems and volunteer cotton R&D (current and past).

During the project, Crop Protection Specialists Ngaire Roughley (July 2014 – August 2015) and Sharna Holman (January 2016 – June 2017) increased their knowledge and awareness of relevant crop protection, farming systems and volunteer R&D via participation and involvement in a number of industry events and activities. These events and meetings allowed the Crop Protection Specialist the opportunity to build capacity and networks with growers, agronomists, researchers and stakeholders.

Undertake field activities/experiments to test suppression of cotton volunteers from a range of farming practices

This project undertook different field activities and experiments to test the suppression of volunteer cotton plants from a range of farm practices through a volunteer cotton management practices survey and exploring potential herbicide chemical options available for controlling volunteer and ratoon cotton plants.

Early season volunteer cotton survey and effectiveness of control practices

Crop Protection Specialist Ngaire Roughley undertook an industry survey of volunteer cotton plants across Queensland and Northern New South Wales over the 2014 – 2015 season to assess the distribution and abundance of early season volunteer cotton plants as well as effectiveness of control practices of the prevalence of volunteer cotton plants.

She found that volunteer cotton plants were not exclusive to one region and that it is an industry wide problem (Fig. 1) which requires a multi-faceted and targeted approach to management. Ngaire surveyed a range fields with a variety of rotation systems and found that crop history was a major factor contributing to the presence of volunteer cotton plants (Fig. 2). A vast majority of cotton volunteer populations were detected in fields grown in a back to back cotton system; with only a small number present in fallow or grain rotations.

Figure 1. The percentage of fields with volunteer cotton plants.

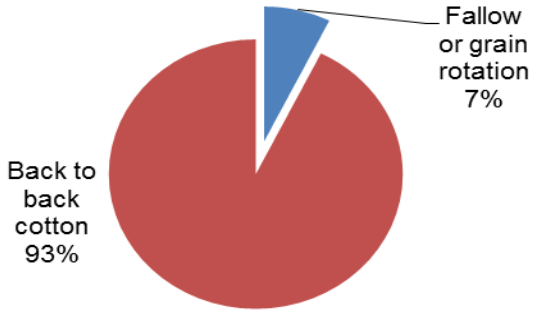

Figure 2. Field cropping history where volunteer cotton plants were found.

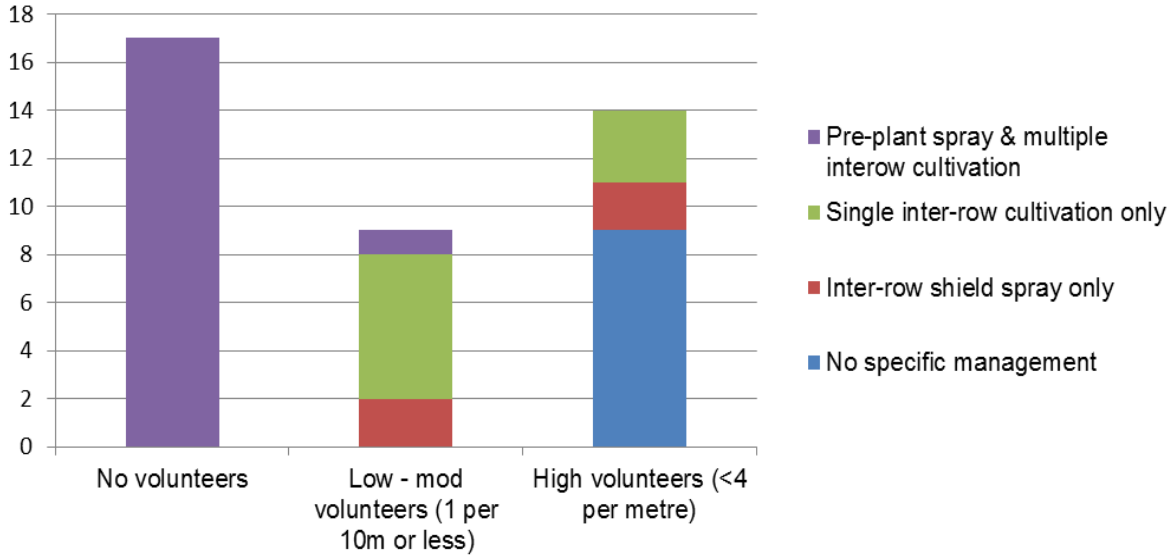

Figure 3. The effect of different control strategies on volunteer incidence in fields.

The survey also evaluated the success of various control strategies. Back to back cotton fields with no volunteer cotton plants were shown to be the result of a combined control strategy – that is pre-planting herbicide application and multiple inter-row cultivations. While back to back fields with low to moderate volunteer cotton plant populations (1 per 10m or less) generally used a singular control tactic – either a shielded spray application or single inter-row cultivation. Fields with a high volunteer cotton plant population (>4 plants per metre) were shown to be the result of either a single control tactic or where the grower had no specific management practices that targeted volunteer cotton plants (Fig 3).

Volunteer and ratoon herbicide control options

There were no registered herbicide options available for use on medium to large volunteer and ratoon cotton plants at the commencement of this project. To address this issue Paul Grundy (DAF) and Frank Taylor (Nufarm) reviewed previous work that had been done by Nufarm along with the range of existing weed herbicide registrations that might have applicability for cotton control. From existing registrations a number of potential options for use with optical boom technology were chosen for efficacy testing against large volunteer and ratoon cotton plants. The advantage of the optical boom registrations is that much higher concentrations of herbicides can be used compared to conventional boom broad acre registrations. The initial list of potential options included.

Some of the initial herbicide treatments tested were:

1) Comet® at 1 L/ha
2) Comet® at 1 L/ha followed up with Nuquat® at 3.2 L/ha 7 days later
3) Comet® at 1 L/ha and Amitrole at 5.6 L/ha
4) Comet® at 1 L/ha and Valour at 90 g/ha
5) Comet® at 1 L/ha and Amicide 700® 1 L/ha
6) Comet® at 1 L/ha and Bromicide® 1.5 L/ha
7) Comet® at 0.5 L ha 'double hit' 7 days apart
8) Control (nothing applied)

Several small plot experiments were conducted in the first season to evaluate these treatments against large volunteer cotton plants. To evaluate the success of these herbicide treatments visual ratings (percent control) were conducted on a whole plot basis as well as individual plant basis at 30, 70 and 110 days after the second application to assess volunteer/ratoon cotton control. Plants were rated as either complete mortality or deemed to have survived due to the evidence of regrowth. All plants were recorded within each plot. Plants were categorised into three size groups (<10 nodes, 10 – 20 nodes and >20 nodes) with results then averaged and converted to a percentage mortality of the plants present. An analysis of variance (ANOVA) was conducted on the data using GENSTAT statistical analysis package.

After these initial experiments a smaller set of treatments were identified for further testing. These experiments and further large plots trials identified three potential herbicide options for the control of large volunteer cotton plants. These treatments were:

1. Comet® (fluroxypyr) applied at 1L/ha twice with a treatment interval of 7 or more days.
2. Comet® applied at 1L/ha and then followed with Nuquat (paraquat) at 3.2L/ha 7 or more days after first application.
3. Comet® at 1L/ha mixed with Amicide 700 (2,4D) at 1L/ha as a single application.

These potential rates and usage patterns are already registered for use against other weeds using optical booms. The work completed developed a data package that Nufarm have utilised to pursue label changes to include large volunteer cotton plants on each product label. This process was commenced in August 2017 and is now with the APVMA for consideration. In the interim period Cotton Australia have applied for a permit for the usage of these products for the control of large volunteer cotton as a minor use permit (10,000 hectares).

Provide technical support to project activities based in CQ: investigating Solenopsis Mealybug and the strengthening CQ farming systems

The Crop Protection Specialist provided technical assistance for Paul Grundy's (DAQ1401 *Strengthening the Central Highlands Cotton Production System*) and Richard Sequeira's (DAQ1204 *Management of mirids, stinkbugs and Solenopsis Mealybug*) project work in Emerald. For Paul Grundy's project (DAQ1401 *Strengthening the Central Highlands Cotton Production System*) this technical assistance resulted in 3 large scale field experiments

examining crop and climate interactions along with commercial crop benchmarking of fields planted in August and December. While the technical and extension assistance provided to Richard Sequeira's project (DAQ1204 *Management of mirids, stinkbugs and Solenopsis Mealybug*) helped find control options through chemical and beneficial insect trials, with minor use permits available through the data collated during this project. Richard provided updates on the project and mealybug information to growers and consultants through events organised by the Crop Protection Specialist such as the Crop Protection R&D Update for Central Highlands and Dawson Valley cotton growing regions.

The Crop Protection Specialist and Technical Officer Gail Spargo also collaborated with researchers from different organisations and regions to provide assistance to satellite trials sites for projects which are of regional or industry interest. These trials include Mary Whitehouse's *Helicoverpa* moth productivity (CSE1601 M*anaging Bt resistance and induced tolerance in Bollgard 3 using refuge crops*), Lisa Bird's insecticide resistance monitoring (DAN1506 *Conventional insecticide resistance in Helicoverpa*), Simone Heimoana's investigating cotton colour grades trial (CSP1703 *Investigating the relative contributions of weathering insect honeydew and fungal agents to cotton colour grade changes and discounts*) and assisting the Queensland Department of Agriculture and Fisheries cotton pathology group with the annual industry disease survey in Central Queensland (RRDP1724 *Improving the management of cotton diseases in Australian cotton farming systems*)

The collaboration with researchers to assist in further data collecting from the Central Highlands region has resulted in research outcomes for the industry and local growers including:

- The organisation and management of satellite sites which were included in Mary Whitehouse's *Helicoverpa* moth productivity project (CSE1601 M*anaging Bt resistance and induced tolerance in Bollgard 3 using refuge crops*) has allowed for information on Central Queensland cotton system to be collected with Bt resistance and induced tolerance monitored.
- The technical assistance and management of satellite sites which were included in Simone Heimoana's investigating cotton colour grades trial (CSP1703 *Investigating the relative contributions of weathering insect honeydew and fungal agents to cotton colour grade changes and discounts*) involved applying artificial honeydew to treatments and collecting cotton lint samples after weather events over a period of time, and transporting the samples to Narrabri for colour grade and quality testing.
- For Lisa Bird's project (DAN1506 *Conventional insecticide resistance in Helicoverpa*) this collaboration resulted in the collection of moths from a grid of traps, processing and transportation to Narrabri for conventional insecticide resistance testing.

Develop communication products from research for industry audiences

Throughout the project communication products arising from concurrent research were developed for industry audiences. Annually the project team conducted reviews of relevant chapters and chemical tables in the Cotton Pest Management Guide and Cotton Production Manual. The project team also contributed Central Queensland district reports and annual Central Highlands season summaries for the Australian Cottongrower Magazine.

Authorship was provided to articles and factsheets for the Spotlight Magazine and CottonInfo e-newsletters covering aspects of cotton volunteer control, farm hygiene and cotton diseases (Table 2).

The project team also resumed writing regional newsletters 'CQ Cotton Update' for local growers and industry to stay abreast of the latest news, information and research from Central Queensland (Table 3).

Table 2. Articles contributed to for Spotlight magazine and CQ Cotton Update Newsletters.

Articles related to hygiene, volunteer and disease management
Enlisting overseas experience for nematode management' (Summer 2014)
'Come Clean Go Clean is the only way to keep your farm clean' (Autumn 2015)
'Post-harvest management for all the right reasons' (Winter 2015)
'Survey tells volunteer story' (Winter 2015)
'Keep the rogues under control' (Winter 2015)
'Keep soil free of disease, pests and weeds (Autumn 2016)
'Refuge health vital' (Spring 2016)
Other Spotlight article contributions:
'Industry support creates careers' (Autumn 2016)
'Supporting our next champions' (Autumn 2017)

Table 3. CQ Update Newsletters

2015	2016	2017
CQ Cotton Update – No. 1 (22/1/2015)	Central Highlands Cotton Update 'Considerations for growing cotton crops out' (16/2/2016)	CQ Cotton Update – No. 5 'Picking and Fibre Quality' (1/2/2017)
CQ Cotton Update – No. 2 (13/2/2015)	CQ Cotton Update – No. 1 'Getting ready for the season' (17/8/2016)	CQ Cotton Update – No. 6 'Importance of good crop destruction' (30/3/2017)
CQ Cotton Update – No. 3 (6/3/2015)	CQ Cotton Update – No. 2 'Management considerations for early sown crops' (23/9/2016)	CQ Cotton Update – No. 1 'Planting in August?' (26/6/2017)
CQ Cotton Update – No. 4 (29/5/2015)	CQ Cotton Update – No. 3 'Pests and Diseases' (9/11/2016)	
	CQ Cotton Update – No. 4 'Pests and Diseases continued' (1/12/2016)	

Sharna Holman was also involved with using other forms of media to deliver effective crop protection messages. These include:

- Collaborating with Paul Grundy (DAF), Tonia Grundy (DAF) and Oliver Knox (UNE) to develop the 'Lone Stranger and Pronto' farm hygiene parody videos which provided a fresh perspective and delivery of farm hygiene messages including Come Clean Go Clean, volunteer cotton management and the reporting of exotic pests. This video series, available to view on the CottonInfo YouTube channel, has been very successful with over 1300 views (on the 24th August 2017).
- Sharna was involved with the 'Mealybugs in Cotton – the what, where and why' webinar, presenting information on the importance of farm hygiene, Come Clean Go Clean and volunteer cotton management in relation to mealybug (23rd of March 2017). This webinar is also available on the CottonInfo YouTube channel.

Work with the CottonInfo team to respond to seasonal issues
The Crop Protection Specialist had regular dialogue with relevant CottonInfo team members to coordinate extension activities and respond to seasonal issues. These included:

- During the spread of mealybug in the Darling Downs and Borders River regions, Sharna Holman distributed guidelines for good farm biosecurity practices when organising and running field walks and field days to CottonInfo Regional Extension Officers and other cotton industry members (including Cotton Australia Regional Managers and Cotton Seed Distributors Extension and Development team)
- Developed disease information packs for CottonInfo Regional Extension Officers to discuss and provide growers who were interested in sending samples away for proper diagnostics. These packs included a postal bag, an information sheet on how to collect and send samples and the pathology diagnostic form.

Evaluate industry performance in volunteer management over time
Majority of growers and consultants recognise the threat that volunteer and ratoon cotton plants pose to the industry. In both the 2010 and 2011 Crop Consultants Qualitative Survey, volunteer and ratoon cotton plants were identified as the weed having the greatest impact on client's profitability. However in the most recent 2016 Crop Consultants Survey, volunteer and ratoon cotton plants had reduced prominence with regard to impacting profitability (budgeted or non-budgeted costs, or yield loss) with respondents noting weeds such as Bellvine, Peachvine, Pigweed and Polymeria Puscilla as more problematic than volunteer cotton plants within the irrigated farming system. In this survey 35% of consultants thought that volunteer/ratoon cotton plants posed no cost to their clients, 23% noted <$10/ha and $11 - $50/ha respectively and 5% noted that volunteer and ratoon cotton would cost their clients $51- $100/ha.

This project followed on from another related CRDC and DAF jointly funded project (CRC1212 *National Extension Development and Delivery – Crop Protection: 2011 - 2014*), with the primary target of the project being the adoption of volunteer and ratoon cotton best management practices. Grower and consultant awareness of volunteer and ratoon cotton issues and associated best management practices was raised through both these projects over a number of years. In the 2013 – 2014 Crop Consultant Qualitative Survey, 92% of consultants had recalled reading or hearing about the industry's zero tolerance of volunteer and ratoon cotton, and this awareness in the past few years would appear to have translated to greater levels of growers adopting improved volunteer and ratoon cotton best management practices. The most recent 2016 Crop Consultants Qualitative Survey indicated that majority of consultants' clients are successfully managing volunteers and ratoon cotton plants (95% and 81% of clients' respectively).

Complete Final Project Report
Five bi-annual reports and Final Project Report completed and submitted on time.

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.

Objective	Output
1. Professional Development - Increase knowledge and awareness of relevant Crop Protection, farming systems and volunteer cotton R&D (current and past).	The Crop Protection Specialist was involved in relevant workshops and industry meetings which assisted with professional development and building networks.
Outcomes The Crop Protection Specialist Ngaire Roughley and Sharna Holman increased their knowledge and awareness of relevant crop protection R&D. The success of the cotton industry is driven by the development of its workforce and ability to stay connected and utilise networks.	
2. Undertake field activities/experiments to test the suppression of cotton volunteers from a range of farm practices.	Field validation exercises for volunteer cotton control conducted, with data developed that may assist with the deployment of new volunteer control products or techniques.
Outcomes A farm practices and volunteer cotton survey confirmed that the most successful strategy for controlling volunteer cotton within cotton fields utilises 2 or more tactics in unison. Data was also developed during this project to support label changes for 3 herbicides that will enable growers to control large volunteer cotton plants using weed seeker boom technology. This will be particularly useful where large volunteers occur in subsequent grain crop stubble. The improved control of volunteer and ratoon cotton plants will assist in preventing exotic disease incursions, lower the risk of existing disease outbreaks (such as Cotton Bunchy Top), and reduce the opportunity for outbreaks of silverleaf whitefly, aphids and Solenopsis mealybug.	
3. Provide technical support to project activities based in CQ: investigating Solenopsis Mealybug and the strengthening CQ farming systems.	Assistance provided to project activities based in Central Queensland. Further assistance was provided for the running of satellite trials for other projects which were of regional or industry interest.
Outcomes Key Central Queensland cotton farming system issues have been addressed with information extended.	
4. Develop communication products from research for industry audiences.	Effective communication at various times of the year and information on control tactics packaged in a way that growers can readily access and adopt.
Outcomes Growers and agronomists are aware of the significant threat volunteer and ratoon cotton plants are to the sustainability of crop protection systems for the Australian cotton industry. This awareness through relevant communication products has translated to practice change with the most recent 2016 Crop Consultants Qualitative Survey indicating that majority of consultants' clients are successfully managing volunteer and ratoon cotton plants (95% and 81% of clients' respectively). The survey also revealed that only a few of these clients (8% of irrigated and dryland hectares captured in the survey) are using solely Glyphosphate as a tactic for volunteer control with many growers using Glyphosphate + 2 or more other tactics (68% of irrigated hectares and 58% of dryland hectares captured in the survey).	

5. Work with the CottonInfo team to respond to seasonal issues.	CottonInfo team members are engaged in regular dialogue around crop protection and volunteer management issues via teleconferences and meetings.
Outcomes CottonInfo Regional Extension Officers (REO's) are aware of the progress of the project and the latest crop protection information. REO's are another avenue for information to be delivered to growers and consultants in different regions to assist with growers adopting recommended farm hygiene and volunteer cotton control practices.	
6. Evaluate industry performance in volunteer management over time.	Review of existing practices and awareness of volunteer and ratoon cotton issues through growers and consultant surveys (CCA, CRDC Grower Surveys etc) and industry performance in volunteer management evaluated over time.
Outcomes A measure of the project's success will be recognisable improvement on rate of growers' adoption of best practice and the comparison of changes over time.	
7. Complete Final Project Report.	Report completed and submitted.
Outcomes Project information and outputs available online for interested parties' to access.	

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

Through the project three herbicide options for the control of large volunteer cotton were identified with data packages developed to pursue label changes.

These treatments were:

1. Comet® (fluroxypyr) applied at 1L/ha twice with a treatment interval of 7 or more days.
2. Comet® applied at 1L/ha and then followed with Nuquat (paraquat) at 3.2L/ha approximately 7 or more days after first application.
3. Comet® at 1L/ha mixed with Amicide 700 (2,4D) at 1L/ha as a single application.

These potential rates and usage patterns are already registered for use against other weeds using optical booms. The data package developed by this project is being used by Nufarm to pursue label changes to include large volunteer cotton plants on each product label. This process was commenced in August 2017 and is now with the APVMA for consideration. In the interim period Cotton Australia have applied for a permit for the usage of these products for the control of large volunteer cotton as a minor use permit (10,000 hectares).

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?

- There are no silver bullets for cotton volunteer management. The highest rate of success is likely to be achieved where growers utilise multiple tactics (e.g. cultivation and herbicide) make a continual effort to eliminate volunteer cotton plants from the farming system.

- Herbicide products and usage patterns which controlled large volunteer cotton plants were identified with data packages developed that are being used to make registration label changes. These treatments are: Comet® (fluroxypyr) applied at 1L/ha twice with a treatment interval of 7 or more days; Comet® applied at 1L/ha and then followed with Nuquat (paraquat) at 3.2L/ha approximately 7 or more days after first application; and Comet® at 1L/ha mixed with Amicide 700 (2,4D) at 1L/ha as a single application. In the interim period Cotton Australia have applied for a permit for the usage of these products for the control of large volunteer cotton as a minor use permit (10,000 hectares). This will be particularly useful where large volunteers occur in subsequent grain crop stubble. The ability to control large cotton plants with herbicides will be useful for many growers particularly where cotton fields are rotated out to other grain crops for a period of time.

- The improved understanding of volunteer and ratoon cotton management issues and ability to control volunteer and ratoon cotton in the field will assist in preventing exotic disease incursions, lower the risk of existing disease outbreaks and reduce the opportunity for outbreaks of silverleaf whitefly, aphids and Solenopsis mealybug.

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.

Industry publications have been used to raise awareness of the prevalence of volunteer cotton plants as a significant threat for biosecurity and crop protection reasons. These risks have been well integrated into various pest, disease and weed messages. These messages have been well received by growers and consultants, with this awareness being translated to the adoption of best practice.

(b) for the future presentation and dissemination of the project outcomes.

When Cotton Australia receive the minor use permit (10,000 hectares) for the three herbicide products trialled controlling large volunteer cotton, information regarding these options for volunteer control will be disseminated through industry publications such as Spotlight or the CottonInfo E-newsletters, as well as through the Crop Consultants Australia network.

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)

Publications

Spotlight articles:

- 'Enlisting overseas experience for nematode management' – Summer 2014 – 2015
- 'Come Clean. Go Clean is the only way to keep your farm clean' – Autumn 2015
- 'Post-harvest management: for all the right reasons' – Winter 2015
- 'Survey tells volunteer story' – Winter 2015
- 'Keep the rogues under control' – Winter 2015
- 'Keep soil free of disease, pests and weeds' – Autumn 2016
- Contributed to 'Refuge health vial' – Spring 2016

The Australian Cottongrower magazine:

- Bi-monthly district reports – 2014, 2015, 2016 and 2017
- Annual season reviews – 2014, 2015, 2016

CottonInfo factsheets/e-newsletters:

- 'Integrated Disease Management' factsheets for Seedling disease, Reniform nematodes, Fusarium, Cotton bunchy top and boll rot in collaboration with Linda Smith (DAF), Karen Kirkby (NSW DPI) and Stephen Allen (CSD)– August 2015
- 'Vert Alert' CottonInfo factsheet and newsletter developed in collaboration with Linda Smith (DAF), Karen Kirkby (NSW DPI), Stephen Allen (CSD), Susan Maas (CRDC) & Ruth Redfern (CRDC/CottonInfo) – April 2015
- 'Controlling volunteers' factsheet – July 2015
- 'Biosecurity: Come Clean Go Clean' factsheet – April 2015
- 'Vert update: the latest in vert research' and Verticillium wilt: the IDM fast facts series' factsheets and e-newsletter developed in collaboration with Linda Smith (DAF), Karen Kirkby (NSW DPI), Hannah Hartnett (CSD), Susan Maas (CRDC) and Ruth Redfern (CRDC/CottonInfo) – September 2016
- 'Black root rot: the research roundup' and Black root rot: the IDM fast facts series' factsheets and e-newsletter developed in collaboration with Linda Smith (DAF), Karen Kirkby (NSW DPI), Lily Pereg (UNE), Christopher Anderson (formerly Biosecurity Queensland), Susan Maas (CRDC) and Ruth Redfern (CRDC/CottonInfo) – October 2016
- Contributed to the 'Picker clean down and inspection checklist' factsheet – March 2017

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

Over the three years, the project team assisted with annually updating relevant CottonInfo webpages and BMP modules to reflect the latest information, research and legislation associated with crop protection.

http://www.cottoninfo.com.au/

https://mybmp.com.au/

CottonInfo YouTube channel:

Sharna Holman was involved with the development of the Lone Stranger and Pronto farm hygiene and biosecurity parody videos:

- Lone Stranger adventures. Part 1: Come Clean. Go Clean - https://www.youtube.com/watch?v=-a0N8sm0dwU&t=24s
- Lone Stranger adventures. Part 2: Farm biosecurity - https://www.youtube.com/watch?v=ZgWEWR_VSgY
- Lone Stranger adventures. Part 3: Cotton volunteers - https://www.youtube.com/watch?v=625yP3mvYps&t=126s

These videos have been collectively watched over 1300 times.

Sharna was involved with the 'Mealybugs in Cotton – the what, where and why' webinar, presenting information on the importance of farm hygiene, Come Clean Go Clean and volunteer cotton management in relation to mealybug (23rd of March 2017). This webinar is also available on the CottonInfo YouTube channel.
https://www.youtube.com/watch?v=cvbp5wCHBms

Part 4 – Final Report Executive Summary

The project focused on aspects of farm hygiene as it relates to crop protection within cotton farming systems, while also providing regional extension support in Central Queensland. Specifically this project addressed volunteer cotton management, farm hygiene practices and disease management.

Key outcomes of project include:

- A farm practices and volunteer cotton survey that confirmed the most successful strategy for controlling volunteer cotton within cotton fields was to utilise 2 or more tactics in unison.
- Data developed during the project from herbicide trials was used to support label changes for 3 herbicides that will enable growers to control large volunteer cotton plants using the weed seeker boom technology.
  The products being registered for use on large volunteer cotton are:
  1. Comet® (fluroxypyr) applied at 1L/ha twice with a treatment interval of 7 or more days.
  2. Comet® applied at 1L/ha and then followed with Nuquat (paraquat) at 3.2L/ha approximately 7 or more days after first application.
  3. Comet® at 1L/ha mixed with Amicide 700 (2,4D) at 1L/ha as a single application.
- A variety of communication products that raised awareness of volunteer cotton as a significant threat to biosecurity and crop protection.

The improved understanding of volunteer and ratoon cotton management issues and ability to control volunteer and ratoon cotton in the field will assist in preventing exotic disease incursions, lower the risk of existing disease outbreaks and reduce the opportunity for outbreaks of silverleaf whitefly, aphids and Solenopsis mealybug.

Furthermore technical and extension assistance was provided to Central Queensland projects including Paul Grundy's (DAQ1401 *Strengthening the Central Highlands Cotton Production System*) and Richard Sequeira's (DAQ1204 *Management of mirids, stinkbugs and Solenopsis Mealybug*) project work as well as other CRDC funded projects which were of regional or industry interest.