



# FINAL REPORT 2018

For Public Release

## Part 1 - Summary Details

---

CRDC ID: CSP1504

Project Title: 'Science into best practice' linking research with CottonInfo

Project Start Date: 01/07/2014

Project Completion Date: 30/06/2018

Research Program: 1 Farmers

## Part 2 – Contact Details

---

**Administrator:** Ms Jo Cain

**Organisation:** CSIRO

**Postal Address:** Locked Bag 59, Narrabri, NSW, 2390

**Ph:** 02 6799 1513 **Fax:** 02 6793 1186 **E-mail:** [jo.cain@csiro.au](mailto:jo.cain@csiro.au)

**Principal Researcher:** Mrs Sandra Williams – Team Leader

**Organisation:** CSIRO

**Postal Address:** Locked Bag 59, Narrabri, NSW, 2390

**Ph:** 02 6799 1585 **Fax:** 02 6793 1186 **E-mail:** [Sandra.williams@csiro.au](mailto:Sandra.williams@csiro.au)

**Supervisor:** Dr Michael Bange – Group Leader/Research Scientist

**Organisation:** CSIRO

**Postal Address:** Locked Bag 59, Narrabri, NSW, 2390

**Ph:** 02 6799 1540 **Fax:** 02 6793 1186 **E-mail:** [Michael.bange@csiro.au](mailto:Michael.bange@csiro.au)

**Signature of Research Provider Representative:**

\_\_\_\_\_

**Date Submitted:**

\_\_\_\_\_

## **Part 3 – Final Report**

---

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

### **Background**

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

CSIRO is strategically committed to extension of research and to development of tools and techniques to support a more productive and profitable cotton farming system which also has an improved environmental performance. To ensure a high level of industry impact, CSIRO research outcomes need to be linked with campaigns that are implemented through the CottonInfo team and supported by myBMP.

The CottonInfo team provides a mechanism to capture, develop, package and deliver research outcomes and foster their uptake by industry. This project made use of the strong links between the CottonInfo team and research community. It involved integrating new research appropriately to help develop a range of extension support such as publications, online decision support, extension activities and the resources behind myBMP.

This project applied the industry knowledge and experience, research awareness, familiarity with development and delivery formats to lead numerous initiatives. Some of the key activities from this project included;

1. Leading extension campaigns to help the industry recognise the importance of IPM.
2. Ensuring that myBMP is linked and updated with the latest best practice messages from research results.
3. Validating best practice guidelines using field experiments. E.g. Pix experiments.
4. Supporting CottASSIST users.
5. Helping with the development of key industry publications. E.g. Australian Cotton Production Manual, Cotton Pest Management Guide.
6. Coordinating the Cotton Pest Management Short Course (2017/18) to train the next generation of crop consultants and farm managers in IPM practices and principles.

### **Objectives**

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

All agreed objectives in the project contract were based on ongoing initiatives, roles, responsibilities and achievements.

##### **Objective 1. Provide leadership in supporting and coordinating key CottonInfo initiatives.**

Objective 1 encompassed Sandra's role with maintaining linkages between the CottonInfo team and the research community. Activities to achieve this objective were based on effective communication, genuine collaboration and actively supporting the CottonInfo team.

Opportunities for communication, collaboration and support with researchers and the CottonInfo team was uninhibited throughout the life of this project. Sandra proactively engaged with members of the CottonInfo team and researchers when leading various extension initiatives.

**Objective 2. Undertake the role as technical specialist in the areas of integrated pest and disease management when called upon.**

The majority of industry impact from this project is derived from objective 2.

Working in a part time role, Sandra has been applying her industry knowledge and experience, research awareness, and familiarity with development and delivery formats to lead many key extension initiatives.

Sandra's role of technical specialist developed throughout the life of this project. It evolved from supporting the CottonInfo REO's with information, material, research connections as they led the relevant campaign, to designing and leading the campaign with the support of the CottonInfo REO's. Between May and November 2014, the CottonInfo team employed a technical specialist in the area of disease management, which gave Sandra the opportunity to concentrate her efforts in Integrated Pest (insect) Management (IPM).

**Objective 3. Ensure that practices in the myBMP system continue to align with research outputs and outcomes**

Objective 3 encompassed Sandra's role with reviewing the BMP's with the relevant researchers and conducting research to refine BMP's for cotton growth management.

Reviewing BMP's (annually) involved seeking feedback from relevant researchers to ensure that the practices, and levels in myBMP for the practice remained relevant, achievable and scientifically valid. Sandra collaborated with Dr. Robert Mensah and Dr. Lewis Wilson to review the Integrated Insect and mite management practices annually. The supporting resources for this key area in myBMP are primarily the Cotton Pest Management Guide and the Pest and Beneficials in Australian Cotton Landscapes, both of which Sandra has played a major role in their development and delivery.

**Objective 4. Support any existing decision tools/mobile apps and explore opportunities for the development of new tools/apps.**

Achievements for objective 4 can be broken into two main areas, the ongoing user support for the CottASSIST web tools and the development of new or existing web tools (until May 2016).

*Ongoing user support* - With well over 1000 registered users, CottASSIST remains a popular extension tool to assist with many farming decisions. Supporting the large user base has been ongoing task for Sandra, and a fundamental part of developing useful tools. As it was through this user interaction and feedback that many of the new initiatives were generated.

Since May 2016, when development funding ceased, Sandra has concentrated her efforts on the existing CottASSIST basic functions and tools. Most of the support that Sandra provides is either through user emails or phone calls. These enquiries are based on both registration troubleshooting and CottASSIST tool use.

**Objective 5. Provide leadership as the industry lead in IPM**

**Objective 6. Be responsible for the IPM technical area extension activities**

**Objective 7. Review industry pest practice for IPM**

Objectives 5, 6 and 7 covered Sandra's role as the IPM technical lead for the 2017/18 season. These new objectives were a variation to the original proposal in order to continue the project for an additional year.

With the extreme pest pressure in all regions during the 2016/17 season, the ever-changing pest dynamics in our new Bt cotton system, incidences of resistance to key insecticides and management concerns with Silverleaf Whitefly, the need to continue promoting a systems approach to pest management (Integrated Pest Management) was vital. The increasing importance on using integrated pest management tactics to manage pests such as Silverleaf Whitefly, created an urgency to continue to proactively deliver messages about IPM to spark practice change.

As the CottonInfo technical lead for IPM, Sandra continued to;

- be the industry's go-to IPM specialist
- lead the CottonInfo team's extension effort in IPM
- provide a regular review of the industry's best practices in insect and mite management

Sandra's overarching objectives were to;

- prevent over reliance on pesticides and ensure longevity of pesticides,
- ensure industry sustainability and reputation and
- maximise productivity and profitability.

## **Methods**

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

Each objective and activities within this project have been guided by various methodologies. The main methods used can be separated into two areas, extension and research.

#### Key extension methods

Activities and proactive initiatives that successfully met the milestones for a number of objectives were based on extension methods to build productive collaborations with members of the CottonInfo team, researchers and the cotton farming community. Building networks and maintaining professional and social relationships is fundamental to successful extension campaigns.

Two significant extension areas that Sandra has played an active role in is developing extension material/resources and coordinating training or workshops.

Methodologies Sandra has used to develop extension material/resources, include;

*Maintaining relevance of the subject* – it is important to deliver relevant messages at the right time of the year on the right topic. For example, in planning the delivery of the Pest Management Short course, it was essential that the theory component be delivered before the season commenced (Aug 17). It was also necessary for the practical workshops, which involved in-field sampling techniques, to be rolled-out at the start of the season when there was cotton to sample, but before pest management decisions needed to be made.



*Component two of the cotton pest management short course at Warren (Dec 2017). This workshop gave participants a chance to practice their insect sampling skills and learn about plant measurements such as fruit retention.*

*Keep in mind learning styles* – for an increase the likelihood of a positive change arising from the extension of information it is important to provide a range of reference material and activities to accommodate many learning styles. For example, when developing some written resources, Sandra ensured that where appropriate, an image is used, along with a useful caption to provide a better learning opportunity for the more visual learners. When planning the cotton pest management short course, Sandra made sure that the course included written, verbal and practical components as well as group and solitary activities.

Another example of providing a variety of learning methods is the development and delivery of the CottASSIST web tools. Providing useful decision tools has been a major component of Sandra’s work and has been indisputably an effective method used by the industry to learn about cotton management. From learning about cotton growth using the ‘Crop Development Tool’ to learning about yield reductions from the two-spotted spider mite using the ‘Mite Yield Loss Estimator’. In addition to CottASSIST, the myBMP system with best practice checklist items linked to appropriate and specific reference sources is a convenient way to access information from the one website. Ensuring up-to-date referencing and best practices for myBMP has been an objective for Sandra throughout this project.

Research methods

As mentioned before, experiments conducted during this project were to validate growth regulator (Mepiquat Chloride (MC)) management in Bt Cotton.

Five experiments were based at the Australian Cotton Research Institute (including 1 glasshouse and 4 small plot experiments) and one large scale experiment was conducted on “Bellvue” near Narrabri. They were conducted during the 2014/15, 2015/16 and 2016/17 seasons (refer to table 1).

*Table 1. Experiment summary*

<b>Season</b>	<b>Experiment</b>	<b>Key Focus</b>
2014/15	“Bellvue” MC	Comparing management using VGR and grower management
2014/15	ACRI B2 MC – high VGR	Comparing rates of early single MC applications / high and low rate cutout MC – on high VGR cotton
2014/15	ACRI B2 MC – low VGR	Comparing rates of early single MC applications / high and low rate cutout MC – on low VGR cotton
2015/16	ACRI A3 MC	Comparing very high and normal rates of early single MC applications on high and low VGR cotton / cutout MC

2015/16	ACRI glasshouse MC	Measuring the effect of MC rates on root growth
2016/17	ACRI D2 MC	Measuring the effect of MC on Low VGR and high VGR cotton / cutout Pix

These methods will focus on the small plot experiments.

We established two different crop types; one with vigorous growth (High VGR) and the other with normal plant growth habits (Low VGR). To grow these two crop types (using cultivar Sicot 74BRF) we used two planting dates. The low VGR crop was planted mid-October (normal planting time) and the high VGR crop was planted late (early December). The high VGR crop also received an extra side dress application of 200kg/ha of urea in late December.

#### *Treatments*

Early season treatments compared rates of a single application of MC at first flower. Later season cut-out treatments compared a low and high rate of MC. Cut-out treatments were applied to the low VGR plots a little over 3 weeks before the Last Effective Flower date (27<sup>th</sup> February) estimated for Wee Waa by using the CottASSIST Last effective flower tool ([www.cottassist.com.au](http://www.cottassist.com.au)).

#### *Design*

All experiments used a randomised complete block design with four replications. Plots were 12m long by 4m (4 rows) wide. MC was applied using a calibrated hand held spray boom (width 4m).



*Applying Mepiquat Chloride with hand boom early season (multiple application treatment at squaring). Photo: M. Bange*

#### *Measurements*

VGR was monitored weekly from first square (where 50% of plants have squares) to two weeks post flowering. The measurement of height was taken from the plant cotyledon to the top of plant terminal, along with counting of the number of nodes starting above the plant cotyledon to the top of the plant terminal where the last subtending leaf is fully unfurled and about the size of a ten cent piece. VGR was calculated using the following equation:

$$VGR(cm / node) = \frac{\text{This weeks height (cm)} - \text{Last weeks height (cm)}}{\text{This weeks node number} - \text{Last weeks node number}}$$

The number of Nodes Above White Flower (NAWF) was also monitored weekly at the time of the cut-out MC applications and up until the treatments had all reached 4 NAWF.

Maturity assessments (number of days from planting to 60% open) were conducted weekly after 20% open bolls, and conducted until all the cotton in the sampled metre had been removed.

After defoliation, full plant maps were conducted. Measurements included: Final plant height, total nodes, number of fruiting branches, number of vegetative branches, number of vegetative fruit, total fruit and % fruit retention ((all fruit retained/all fruit positions)\*100)

Cotton lint was harvested using a specialised cotton picker used for small plot experiments.

## **Results**

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

#### **Objective 1. Provide leadership in supporting and coordinating key CottonInfo initiatives.**

Opportunities for communication, collaboration and support with researchers and the CottonInfo team was uninhibited throughout the life of this project. Sandra proactively engaged with members of the CottonInfo team and researchers when leading various extension initiatives. Examples of the more structured communication activities where Sandra participated include;

- Fortnightly CottonInfo teleconferences.
- Biannual CottonInfo team planning meetings.
- Working with local REO to organise annual researcher tour – a non-formal day to connect local growers with researchers.
- Attending, presenting or chairing at various seminars and conferences. The main three included the Australian Cotton Conference, the Australian Cotton Research Conference and the CCA seminars.



*2016 Researcher tour to "Windy Station" - organised by Sandra and local REO Geoff Hunter. This tour is a networking opportunity for researchers and growers and a chance to discuss local issues/concerns.*

#### **Objective 2. Undertake the role as technical specialist in the areas of integrated pest and disease management when called upon.**

Sandra has been applying her industry knowledge and experience, research awareness, and familiarity with development and delivery formats to lead many key extension initiatives.

Sandra's role of technical specialist developed throughout the life of this project. It evolved from supporting the CottonInfo REO's with information, material, research connections as they led the relevant campaign, to designing and leading the campaign with the support of the CottonInfo REO's. Between May and November 2014, the CottonInfo team employed a technical specialist in the area of disease management, which gave Sandra the opportunity to concentrate her efforts in Integrated Pest (insect) Management (IPM).

Achievements within this objective can be grouped into two main areas, support and major campaigns.

*Support* – Sandra's achievements listed below in the area of support include extension material developed or reviewed and various activities that have serviced the CottonInfo team as they achieve their goals in fostering a productive and profitable cotton farming system.



- Updated Cotton Pest Management Guide (annually) – Coordinated the review of all insect pest related information involving the relevant researchers.
- Updated Australian Cotton Production Manual (annually) – Coordinated the review of numerous chapters with relevant researchers as well as updating my own chapters ('Managing crop growth' and 'The cotton plant').
- Coordinated insect identification clinics (annually) at ACRI and compiled insect identification information folders to support participants.
- Wrote CottonInfo e-newsletters and e-alerts (ongoing) – eg. 'Are spider mites snacking on your cotton?', 'Is your crop ready to defoliate?', '5 tips for early season pest management', 'Avoid a sticky situation...'. e-alert – 'Don't risk sticky cotton'.
- Presented for CottonInfo YouTube videos (ongoing) – eg. 'Timing cotton defoliation', 'Vegetative growth rate (VGR) in cotton'.
- Presented numerous times to grower groups/ CCA/ students (ongoing) to deliver positive messages around achieving high yields with IPM.
- Supported CottonInfo Education Technical Specialist (ongoing). Sandra has coordinated a number of interactive science lessons for primary students and has coordinated a number of ACRI tours for high school and college students.
- Compiled a 'plant measurement' protocol (Jan 15) to assist CottonInfo REO's with their demonstration trials.
- Wrote other articles - CRDC spotlight (2015, 2017) 'Matrix helps simplify SLW Spray Decision', 'Early season insect sampling', 'Changes to the SLW Matrix'. Narrabri Courier 'science in the shire' articles.
- Re-designed cotton insect checking cards printed by CSD (Dec 16).
- Coordinated and chaired an IPM information webinar (July 17)
- Key author of the Silverleaf Whitefly Management Booklet (last updated Nov 17).

*Major campaigns* - Achievements listed below in the area of major campaigns include the larger activities that Sandra has led that have been primarily proactive with the aim to boost industry best practice in IPM.

- Coordinated IPM workshops across five cotton growing valleys with over 130 growers and consultants participating (Nov/Dec 2016). Sandra worked closely with CottonInfo REO's and researchers to deliver positive messages around achieving high yields with IPM.



*IPM workshop at Boggabilla Dec 2016. Experienced industry researchers' Dr Lewis Wilson, Dr Mike Bange, Dr Robert Mensah, Dr Paul Grundy, Dr Jamie Hopkinson and Dr Sandra McDougall were among those who presented at the workshops, which took place at Warren, Griffith, Cecil Plains, Boggabilla and Boggabri.*

*The workshops had two clear messages for growers and consultants: IPM plays an essential role in helping to avoid insecticide resistance, and you can achieve high yielding cotton using IPM.*



- Led and coordinated the new and revised cotton pest management short course. This is a joint venture with Tocal Agricultural College providing the formal accreditation with funding from the NSW Government's AgSkilled™ program for cotton and grains.

After months of planning and developing the course materials in collaboration with Tocal, Sandra rolled out the new and revised cotton pest management short course for the 2017/18 cotton season. The first theory component (a two day workshop) was successfully conducted in each of the four NSW regions with over 70 young consultants and farm managers participating. The second part to the course involved an in-field practical on insect and plant monitoring in each of the four NSW regions.

Sandra applied her experience, skills and knowledge of cotton physiology and IPM as the key presenter at both components of the course.

With continued support from the NSW Government's AgSkilled™ program, Tocal is once again providing the short course for the 2018/19 season.

- Coordinated and prepared detailed caged mirid experiment protocol for the CottonInfo REO's (Nov 17). In addition to this, coordinated the transport of the cages to all regions and sourced green mirids for 4 out of the 6 experiments (2017/18 cotton season).

### **Objective 3. Ensure that practices in the myBMP system continue to align with research outputs and outcomes**

During this project, Sandra provided support to Rachel Holloway as she conducted a major independent review of myBMP. A key action as a result of the review was the need to decrease the number of practices for all modules. Sandra helped re-write and reduce the number of practices in the key area of Integrated Insect and mite management practices.

#### *Exploring best practices for growth regulator management in Bt Cotton*

Considerable effort was given to conducting research to refine BMP's for cotton growth management. During this project, Sandra conducted 6 experiments (Table 1) to validate growth regulator (MC) management in Bt Cotton and assess if using measurements of Vegetative Growth Rate (VGR) is still applicable in Bt Cotton.

#### *Key findings*

- From the 2013/14 experiment, Sandra measured no significant difference in lint yield between early single and multiple MC applications.
- Results from the 2014/15, 2015/16 and 2016/17 measuring the effects of MC in high VGR situations, has shown that a positive yield response can be achieved although this is less positive in Bt Cotton. We also measured the effects of MC applications in low VGR situations, and these experiments showed that the risk of a negative yield response is greater in Bt Cotton. See Figure 1 below.
- All experiments included various cutout treatments which did not generate any significant lint yield differences.
- Measuring weekly height and nodes to calculate VGR is still the best practice to assist with decisions relating to cotton growth management.

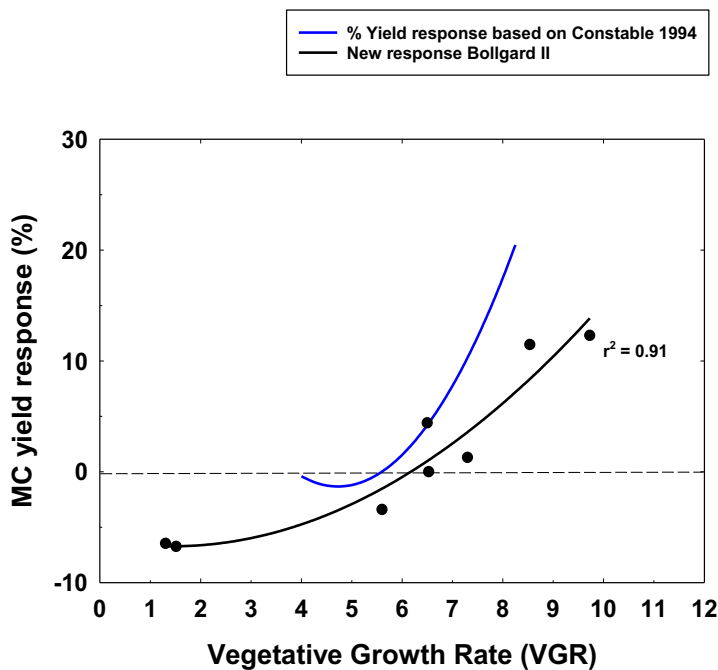


Figure 1. VGR (at flowering) and the corresponding yield response % when Mepiquat Chloride (MC) was applied. Note: Conventional cotton (blue line) and Bt cotton (black line)

**Objective 4. Support any existing decision tools/mobile apps and explore opportunities for the development of new tools/apps.**

*Ongoing user support* - With well over 1000 registered users, CottASSIST remains a popular extension tool to assist with many farming decisions. Supporting the large user base has been ongoing task for Sandra, and a fundamental part of developing useful tools. As it was through this user interaction and feedback that many of the new initiatives were generated.

Since May 2016, when development funding ceased, Sandra has concentrated her efforts on the existing CottASSIST basic functions and tools. Most of the support that Sandra provides is either through user emails or phone calls. These enquiries are based on both registration troubleshooting and CottASSIST tool use.

**Objective 5. Provide leadership as the industry lead in IPM**

**Objective 6. Be responsible for the IPM technical area extension activities**

**Objective 7. Review industry pest practice for IPM**

With the extreme pest pressure in all regions during the 2016/17 season, the ever-changing pest dynamics in our new Bt cotton system, incidences of resistance to key insecticides and management concerns with Silverleaf Whitefly, the need to continue promoting a systems approach to pest management (Integrated Pest Management) was vital. The increasing importance on using integrated pest management tactics to manage pests such as Silverleaf Whitefly, created an urgency to continue to proactively deliver messages about IPM to spark practice change.

As the CottonInfo technical lead for IPM, Sandra continued to;

- be the industry's go-to IPM specialist
- lead the CottonInfo team's extension effort in IPM
- provide a regular review of the industry's best practices in insect and mite management

Sandra's overarching objectives were to;

- prevent over reliance on pesticides and ensure longevity of pesticides,
- ensure industry sustainability and reputation and
- maximise productivity and profitability.

Key achievements as the IPM technical lead during the 2017/18 season were;

- The coordination and delivery of the new cotton pest management short course, rolled out in the 2017/18 season (as outlined on page 4 of this report).
- Delivering an updated Silverleaf Whitefly Management Booklet (Nov 17)
- Coordinated and prepared detailed caged mirid experiment protocol for the CottonInfo REO's (Nov 17).



Observations made in the 2016/17 season was that some cotton managers were spraying early season pests with the aim to hold as much early fruit as possible. But did this early spraying really make a difference to early fruit retention?

The regional cage experiments aimed to find out whether high pest (Green Mirid) pressure during early squaring (Nov, Dec) really makes a difference to final fruit retention / yield?

- Coordinated the review of all pest related information for the 2018/19 Cotton Pest Management Guide. This year, acting upon feedback from the Crop Consultants Australia, Sandra also re-designed all pest control tables to include a colour coded column to indicate the impact on beneficial insects as well as the insecticide group (see example below).

**TABLE 6: Control of mirids**

Active ingredient	Concentration and formulation	Application rate of product	Comments
Mirids (Green mirid <i>Ceratostyles dilutis</i> and Yellow mirid or Apple dimpling bug <i>Campyomma heliobeschi</i> )			
Acetamiprid	200 g/L SL	0.06-0.1 L/ha	Apply as drenching bag (Ceratostyles spp. biocontrol). Apply with 0.2% Insect penetrant. Target nymphs and/or adults. On above threshold or increasing populations, suppression only may be observed. Use higher rate under sustained heavy aphid pressure.
Alpha-cypermethrin	100 g/L EC	0.3 or 0.4 L/ha	Apply at recommended threshold levels as indicated by field checks. Use the higher rate when pest pressure is high and increased residual protection is required. #
Bifenthrin	100 g/L EC	0.6-0.8 L/ha	Apply at recommended threshold levels as indicated by field checks. Use the higher rate for increased pest pressure and longer residual control. #
Chlorantraniliprole/Thiamethoxam	200 g/kg/200 g/kg WG	0.250 kg + non ionic or organo-silicon surfactant	If pest pressure remains high additional control measures may be required from 7 days after application. Do not use as first foliar if neonicotinoid seed treatment used. #
Ciflutrin	400 g/L EC	2 L/ha	Apply as indicated by field checks and pest pressure. Ensure good coverage. Maximum 5 applications per season. Treatment effects may not be seen for 3 or more days. A repeat application may be required at 14-20 days if conditions favour pest development.
Clothianidin	200 g/L SC	0.125-0.25 L/ha + Pulse Penetrant	Apply when numbers reach threshold levels requiring treatment. Do not apply more than 2 sprays per season. #
Deltamethrin	27.5 g/L EC	0.18 L/ha	Suppression only. #
Dinotefuran	200 g/kg WG	90 g/ha	When mirids and SLW are present always use SLW rate. Performance can be reduced in stressed crops or when senescing late season. #
Dimethoate	400 g/L EC	0.34-0.5 L/ha	Apply when pests appear. Use higher rate for heavy infestations. #
Emamectin benzoate	17 g/L SC	0.55 or 0.7 L/ha	For suppression only. Apply to developing populations that are predominantly nymphs. Use non-ionic surfactant at label rate. Maximum effect may take 5 to 7 days. #
Emamectin benzoate/benflupropyl	32.5 g/L/218 g/L	0.3-0.35 L/ha	Apply at or just prior to hatching. Use non-ionic surfactant as per label. #
Imidacloprid	200 g/L SC	0.0625-0.125 L/ha	Apply spray to achieve thorough coverage. Use higher rate under sustained heavy pressure, 3-4 days to reach full effectiveness. Long residual impact on bees. #
Phosalone	200 g/L WG	1.5-2.0 L/ha	Thorough spray coverage is essential.
Gamma-cyhalothrin	150 g/L SC	0.06 L/ha	Apply at recommended threshold levels as indicated by field check. #
Imidacloprid	200 g/L SC	0.2-0.3 L/ha + Pulse Penetrant at 0.2% v/v	Do not use as first foliar if neonicotinoid seed treatment used. #
		0.145 L/ha + organosilicone adjuvant at recommended rate	
Indoxacarb	150 g/L EC	0.55 L/ha or 0.65 L/ha	Under high populations suppression only may be observed. #
Indoxacarb + salt	150 g/L EC	0.3 or 0.4 L/ha + Insect Gyl	For controlling green mirid ONLY. Use the higher rate on infestations exceeding economic spray threshold levels and/or large canopy crops. #
Lambda-cyhalothrin	250 g/L SL	0.06 L/ha	Apply at recommended threshold levels as indicated by field checks. #
Dimethoate	400 g/L SL	0.14-0.28 L/ha	Use high rate where population exceeds 1m row. #
Paraffinic oil	718 g/L SC and 792 g/L SL	2-5 L/ha or 2-5 L/100L of water	Apply fine rate for suppression of fewer than 0.5 mirids/m. Apply high rate if population reaches threshold of 0.5 mirids/m or apply 2 successive low rate sprays not more than 7 days apart.
		1-2% or 1-2L/100L of water	Suppression only. Include canopy in tank-mix when applying any other insecticide by ground rig.
Phorate	240 g/L G	50 g/100 m row or 5 k/ha	OLD and NEW only. Suppression only. Apply into seed furrow at planting or incorporate into the soil side dressing deep enough to avoid disturbance by future cultivations.
Sulfoxacar	500 g/kg WG	0.2-0.3 L/ha	Use lower rate when infestation is predominantly nymphs. #

#Vitality in cotton crops is not allowed after 1 December 2017. #See label for instructions to minimise impact on bees.

This example shows the 2017/18 Mirid control table (left) compared to the new 2018/19 table (right).

**TABLE 7: Control of mirids (Green mirid *Ceratostyles dilutis* and Yellow mirid or Apple dimpling bug *Campyomma heliobeschi*)**

Active ingredient	Insecticide group	Overall Impact on beneficials*	Comments**
Paraffinic oil	No group	Very low	Apply low rate for suppression of fewer than 0.5 mirids/m. Apply high rate if population reaches threshold of 0.5 mirids/m or apply 2 successive low rate sprays not more than 7 days apart.
Ciflutrin	No group	Low	Apply as indicated by field checks and pest pressure. Ensure good coverage. Maximum 5 applications per season. Treatment effects may not be seen for 3 or more days. A repeat application may be required at 14-20 days if conditions favour pest development.
Indoxacarb	Group 22A	Low	Under high populations suppression only may be observed. Maximum 3 applications per season.
Indoxacarb + salt	Group 22A	Low	For controlling green mirid ONLY. Use the higher rate on infestations exceeding economic spray threshold levels and/or large canopy crops. Maximum 3 applications per season.
Chlorantraniliprole/Thiamethoxam	Group 28/4A	Moderate	If pest pressure remains high additional control measures may be required from 7 days after application. Do not use as first foliar if neonicotinoid seed treatment used. Maximum 2 applications per season.
Sulfoxacar	Group 4C	Moderate	Use lower rate when infestation is predominantly nymphs. Maximum 1 application per season.
Pipronil (high rate)	Group 2B	Moderate	Apply spray to achieve thorough coverage. Use higher rate under sustained heavy pressure. 3-4 days to reach full effectiveness. Long residual impact on bees. Avoid repeated use of this insecticide group.
Flonicamid	Group 29	Moderate	Thorough spray coverage is essential. Maximum 2 applications per season.
Emamectin benzoate	Group 6	Moderate	For suppression only. Apply to developing populations that are predominantly nymphs. Use non-ionic surfactant at label rate. Maximum effect may take 5 to 7 days. Maximum 2 applications per season.
Emamectin benzoate/benflupropyl	Group 6/4A	Moderate	Apply at or just prior to hatching. Use non-ionic surfactant as per label. Maximum 2 applications per season.
Acetamiprid	Group 4A	Moderate	Apply with 0.2% insect penetrant. Target nymphs and/or adults. On above threshold or increasing populations, suppression only may be observed. Use higher rate under sustained heavy aphid pressure. Maximum 2 applications per season.
Clothianidin	Group 4A	Moderate	Apply when numbers reach threshold levels requiring treatment. Maximum 2 applications per season.
Imidacloprid	Group 4A	Moderate	Do not use as first foliar if neonicotinoid seed treatment used. Maximum 2 applications per season.
Dinotefuran	Group 4A	Moderate	When mirids and SLW are present always use SLW rate. Performance can be reduced in stressed crops or when senescing late season. Maximum 2 applications per season.
Phorate	Group 1B	High	OLD and NEW only. Suppression only. Apply into seed furrow at planting or incorporate into the soil as side dressing deep enough to avoid disturbance by future cultivations. Maximum 1 application per season.
Dimethoate (high rate)	Group 1B	High	Do not use when resistant strains are present. Do not harvest for 14 days after application. Do not graze or cut for stockfeed for 14 days after application. Maximum 2 applications per season.
Gamma-cyhalothrin	Group 3A	Very High	Apply at recommended threshold levels as indicated by field check. Maximum 1 application per season.
Lambda-cyhalothrin	Group 3A	Very High	Apply at recommended threshold levels as indicated by field checks. Maximum 1 application per season.
Alpha-cypermethrin	Group 3A	Very High	Apply at recommended threshold levels as indicated by field checks. Use the higher rate when pest pressure is high and increased residual protection is required. Maximum 1 application per season.
Bifenthrin	Group 3A	Very High	Apply at recommended threshold levels as indicated by field checks. Use the higher rate for increased pest pressure and longer residual control. Maximum 1 application per season.
Deltamethrin	Group 3A	Very High	Suppression only. Maximum 1 application per season.

\*For all control options (AGRI) refer to the table for information on to minimise impact on bees.  
\*\*For more details about impact on beneficial insects, refer to table 3 in this guide.

## Outcomes

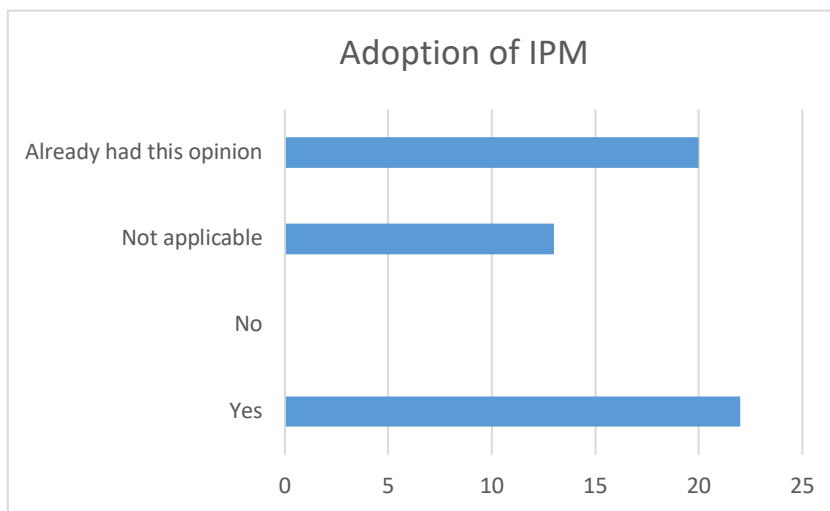
### 5. Describe how the project's outputs will contribute to the planned outcomes identified in the project application. Describe the planned outcomes achieved to date.

The major outcomes originally planned for this project was that better information is available for informed decisions optimising yield and fibre quality with inputs and environmental impacts minimised. Similarly, information, decision tools, linked with CottonInfo campaigns, the new cotton

pest management short course and the myBMP system has an influence on improved cotton crop management practices.

Outputs from this project have contributed to achieving these outcomes with a variety of updated and relevant information delivered to the industry. Two significant delivery platforms that Sandra coordinated was the Nov/Dec 2016 IPM workshops and the new cotton pest management short course that commenced in Aug 2017.

The IPM workshops were rolled out across five valleys. Over 120 growers and consultants participated in the hands-on workshops that encouraged valuable and open discussion based on growing high yielding cotton using an IPM approach. Evaluation sheets from these workshops were very positive and indicated that as a result of attending, participants felt increasingly confident to either understand or adopt an IPM approach.



**Figure 2. Results from evaluation sheets – As a result of the IPM workshop, are you more likely to adopt IPM in your business?**

Over seventy young agronomists and farm managers enrolled in the first round (2017/18 season) of the new Cotton Pest Management short course. The course provided future crop managers with the latest information, a network of resources and the practical skills to confidently manage pests using an IPM approach. Student comments after completing the course were very positive and in fact over 60 students have enrolled in the Cotton Pest Management short course for the 2018/19 season. This number is considerably high when taking into account the reduced area of cotton planted for 2018/19.

Another significant outcome from this project came from the results of the growth regulator experiments. These results yielded some key messages for the industry that have assisted with managing cotton crop growth. Results confirmed that measuring weekly height and nodes to calculate VGR is still the best practice to assist with decisions relating to cotton growth management. We also established that a positive yield response can be achieved through managing excessive crop growth, although this is less positive in Bt Cotton. In addition to this, we showed that the risk of a negative yield response is greater in Bt Cotton when managing crop growth that is not excessive.

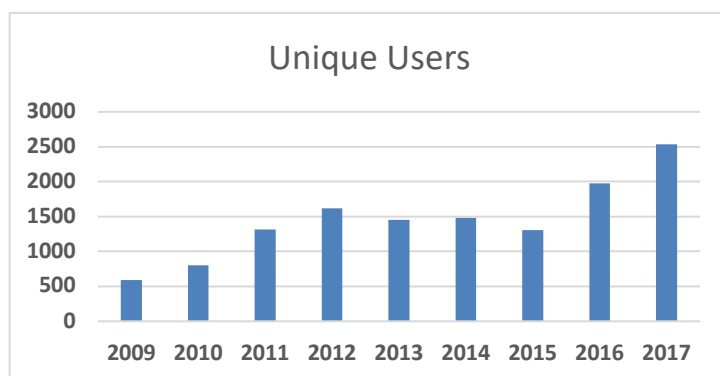
## **Conclusion**

### **6. 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?**

Extension material developed or updated during this project will undoubtedly have varying levels of impact which are difficult to estimate. From the annually updated major industry publications such as the Cotton Pest Management Guide to the one-off management booklet, e-newsletter or YouTube video. The key to a successful extension campaign is to provide a range of resources and training to

cater for various learning styles. This project has developed a wide range of extension resources from supporting online web-tools, to developing written material and coordinating workshops and training. This project has played some significant roles in important extension campaigns that has generated impact. This impact ranges from helping a young farm manager to develop an understanding of IPM, to changing the way that an experienced grower and/or consultant makes their IPM decisions.

The impact from fostering our existing CottASSIST decision support web-tools is also potentially varied and wide depending on seasonal issues. E.g. In a season where Spider Mites are a concern, CottASSIST's Mite Yield Loss Estimator has a potentially large impact for users. In a cool region where monitoring Nodes Above White Flower (NAWF) is important for cut-out decisions, CottASSIST's Crop Development Tool is an important resource. Figure 3 below indicates the continued and increasing use of the CottASSIST tools, with over 2500 individual users logging on to CottASSIST in the 2017 financial year compared to over 500 users in 2009.



**Figure 3. Annual unique (individual) users of CottASSIST**

In addition, results from the cotton growth management experiments have been used in updated guidelines for cotton growth regulator best management practices. These guidelines have been delivered in the Australian Cotton Production Manual, a major resource for myBMP. The likely impact from these results is an increase in confidence when making a cotton growth management decision.

All of these impacts big and small supports a more productive and profitable cotton farming system with improved environmental performance.

### ***Extension Opportunities***

#### **7. 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.**

The Cottoninfo team, together with Tocal Agricultural College, have already seized the opportunity to continue to provide the Cotton Pest Management short course. It will be important to analyse the course evaluation sheets to incorporate user feedback in future training.

Continuing to update, develop and deliver a range of extension resources is without a doubt a fundamental objective for the cottoninfo team.

To further disseminate the results from the cotton growth management experiments, a draft journal paper is a future priority.

#### **9. A. List the publications arising from the research project and/or a publication plan.**

Williams, S. A. 2014. Why is cotton grown in our Narrabri/Wee Waa district? North West Courier.

Williams, S. A. and Whitehouse, M. 2014. Spiders – friend or foe in cotton? North West Courier.

Williams, S. A. 2014. Silverleaf Whitefly Management – booklet

Williams, S. A. and Bange M. P. 2014. Using Mepiquat Chloride in Bollgard II Cotton. DRAFT Cotton Grower article.

Rochester, I, Williams, S. A and Quinn, J. 2014. Highest yielding crops use N fertiliser efficiently. Cotton Grower article.

Williams, S. A. 2015. Silverleaf Whitefly Management in Australian Cotton – booklet (<http://www.cottoninfo.com.au/publications/managing-silverleaf-whitefly-australian-cotton>)

Williams, S. A. and Bange M. P. 2015. Re-evaluating mepiquat chloride use in Bollgard II. Australian Cotton Grower article February-March 2015 pp 16-21 (<http://www.cottongrower.com.au/images/articles/39f008447caabff0f820e79212f4d82a.pdf>)

Williams, S. A. and Bange M. P. 2015. Re-evaluating mepiquat chloride use in Bollgard II® Cotton. 2015 Australian Agronomy Conference Proceedings, Hobart, TAS.

Williams, S. A. and Bange M. P. 2015. Re-evaluating mepiquat chloride use in Bollgard II® Cotton. 2015 Australian Agronomy Conference Proceedings, Hobart, TAS.

Australian Cotton Production Manual (annually) – Chapter 1, The cotton plant.

Australian Cotton Production Manual (annually) – Chapter 17, Managing crop growth.

Spotlight article to promote revised NutriLOGIC. Spring edition 2014.

Spotlight article autumn 2015 – pp 26. Matrix helps simplify SLW spray decisions.

Spotlight article spring 2015 – pp 26. Early season sampling and ID vital.

Does high mirid pressure at early squaring have an effect on yield across 5 growing regions?  
By Amanda Thomas, Sandra Williams, Mary Whitehouse, Sally Dickinson, Annabel Twine, Janelle Montgomery, Kieran O’Kieffe. (2018)

CottonInfo e-news (Feb 15) ‘Are spider mites snacking on your cotton?’ (<http://www.cottoninfo.com.au/cottoninfo-e-newsletter>)

CottonInfo e-alert (Mar 15) ‘don’t risk sticky cotton’ (<http://www.cottoninfo.com.au/cottoninfo-e-newsletter>)

NUTRIpak re-write – Chapter ‘NutriLOGIC’

## **Presentations**

Williams, S. A. and Staines, T. 2014. Oral Presentation – Tools for ID and efficient Sampling – 17<sup>th</sup> Australian Cotton Conference Aug 2014.

Presentation on Cotton growth – written by Sandra, presented by Kieran O’Keefe.

Williams, S. A. 2014. Oral Presentation. CCA seminar. Goondiwindi July 2014.

Sandra has conducted presentations for two u-tube videos to explain 1. VGR and 2. Assessing crop maturity.

Presented results on the Cotton growth regulator experiments at two field days; the Lower Namoi CSD Bollgard III field walk and at the McIntyre field day, Feb 15.

Presented information on IPM to the cotton short course, Mar 15.

Presented information on sampling pest and beneficial insects in cotton, years 1&2 St. Francis Xavier's Primary School Narrabri, Mar 15.

Presented results on the Cotton growth regulator experiments at the Australian Cotton Research Conference, Toowoomba.

Sandra compiles a presentation on the Cotton growth regulator experiments for the Agronomy conference, Hobart 2015. (Michael Bange was the presenter)

Presented information on science – mixing materials / molecules, years 1&2 St. Francis Xavier's Primary School Narrabri, Sept 15.

Presented information about IPM at the Warren AgnVet training day (Dec 15).

Presented information about IPM at a grower field day at Forbes (Mar 16).

Presented information about plant roots – library science event (Mar 16).

Presented information regarding the Cotton growth regulator experiments at the CSIRO Monday talk.

Presented information about IPM and cotton physiology for the cotton pest management short course – Total Agricultural Collage and CottonInfo (2017/18)

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

No new tool development in this space, but rather enhancing existing tools and supporting users with cottassist.com.au

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

---

Tools and techniques to support a more productive and profitable cotton farming system with an improved environmental performance need to be based on the latest research, linked with campaigns that are implemented through the CottonInfo team and supported by myBMP.

The CottonInfo team provides a mechanism to capture, develop, package and deliver research outcomes and foster their uptake by industry. This project made use of the strong links between the CottonInfo team and research community. It involved integrating new research appropriately to help develop a range of extension support such as publications, online decision support, workshops and training. Working in a part time role, Sandra has applied her industry knowledge and experience, research awareness, and familiarity with development and delivery formats to lead many key extension initiatives.

This project supported the role of the IPM technical specialist as it changed and evolved throughout the life of this project. It evolved from supporting the CottonInfo REO's with information, material, research connections as they led the relevant campaign, to designing and leading the campaign with the support of the CottonInfo regional extension officers.

With changing insect pest dynamics in our new Bt cotton system, the need to continue promoting a systems approach to pest management (Integrated Pest Management) is vital. The 2016/17 season saw extreme pest pressure in all regions, cases of resistance to key insecticides and management concerns with Silverleaf Whitefly. This created an urgency to continue to proactively deliver messages about IPM to spark practice change. As the CottonInfo technical lead for IPM, this project continued to be the industry's go-to for IPM support and lead the CottonInfo team's extension effort in IPM.



Major extension efforts in IPM lead by this project included regional IPM workshops (2016/17 season) and delivering a new cotton pest management short course (2017/18 season).

Over 120 growers and consultants participated in the regional IPM workshops that encouraged valuable and open discussion based on growing high yielding cotton using an IPM approach. As indicated by workshop evaluation sheets participants felt increasingly confident to either understand or adopt an IPM approach.

Over seventy young agronomists and farm managers enrolled in the first round (2017/18 season) of the new cotton pest management short course. The course provided future crop managers with the skills to confidently manage pests using an IPM approach. The CottonInfo team, together with Tocal Agricultural College, have already seized the opportunity to continue to provide the Cotton Pest Management short course. In fact over 60 students have enrolled in the Cotton Pest Management short course for the 2018/19 season. This number is considerably high when taking into account the reduced area of cotton planted for 2018/19.

The project also supported our industry's best management practices through validating cotton growth best management. Results from six experiments over three seasons confirmed that measuring weekly height and nodes to calculate Vegetative Growth Rate (VGR) is still the best practice to assist with decisions relating to cotton growth management. We also established that a positive yield response can be achieved through managing excessive crop growth, although this is less positive in Bt Cotton. In addition to this, we showed that the risk of a negative yield response is greater in Bt Cotton when managing crop growth that is not excessive. These guidelines have been delivered in the Australian Cotton Production Manual, a major resource for myBMP.