

# Spotlight

ON COTTON R&D

**SUMMER 2020-21**

Cotton and  
Country Road  
team up

Protecting the  
rivers' inhabitants

New IPM tools  
ready for the  
paddock





Ian Taylor

# In the Spotlight

Welcome to the Summer edition of *Spotlight*.

As 2020 comes to a close, CRDC is looking to the future.

The future of the Australian cotton industry is dependent on many factors, but ultimately, the industry must be sustainable.

Sustainability isn't just about how we approach factors like natural resource management; it's also about aspects such as the health and wellbeing of our people, the health of our soil and the impact we have on people, the planet and our paddocks. Since the launch of the Australian Cotton Sustainability Report earlier this year, the industry has been working on setting sustainability targets to guide the industry's success into the future under the *PLANET. PEOPLE. PADDOCK.* sustainability framework.

Concurrently, CRDC has been continuing to invest in research to support the industry to improve sustainability, and we feature some of that research in this edition of *Spotlight*. Of significance is CRDC's commitment to RD&E to improve fish health in our rivers, and to give growers information and mitigation strategies to avoid fish entrainment in irrigation systems. It is so pleasing to see growers proactively working towards this in the Macquarie.

CRDC is also involved with a ground-breaking program with Cotton Australia and clothing brand Country Road to improve the health of river red gums and riparian zones in the Namoi Valley. Partnerships like these are a valuable tool to work with our customers and users of cotton fibre to improve biodiversity on cotton farms.

This year has seen some big changes in the pest dynamic in Australia with the arrival of fall armyworm – a reminder that our industry is susceptible to biosecurity incursions. This is why CRDC is a partner in the Plant Biosecurity Research Initiative, to harness the RD&E of all plant industries to better understand exotic pests that pose a common threat to these industries. A series of podcasts have been released on fall armyworm, which we encourage readers to listen to.

A new disease has also been found in cotton fields. A form of wilt, named reoccurring wilt, is currently under investigation. Exotic pathogens have been excluded as the cause, and CRDC is supporting pathologists who are working to identify the pathogen. Facilitating a quick response through R&D has been paramount.

Finally, we include with this edition a snapshot of CRDC's 2019-20 Annual Report, which outlines our key investments and impacts during the year. We hope you have a safe Christmas, and we wish everyone across the industry a happy and prosperous new year.

Ian Taylor  
CRDC Executive Director



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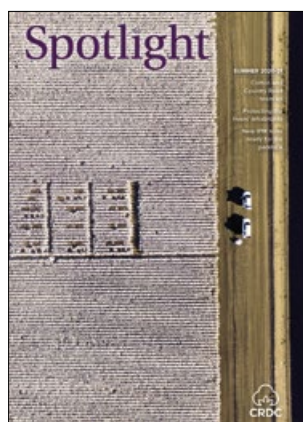
**Our purpose:** Investing in world-leading RD&E to benefit Australia's dynamic cotton industry.  
**Our vision:** CRDC: Powering the success of Australian cotton through world-leading RD&E.

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**ON THE COVER:** Segmenting underway in the Bollgard 3 retention study, which offers new knowledge around mirid management.

## Want to see more of Spotlight?

This edition can be viewed online at: [www.crdc.com.au](http://www.crdc.com.au)

## COTTON NEWS

- 4 Connecting with science, socially
- 4 Building skills in the bush
- 5 CRDC welcomes Director appointments
- 5 RDCs create new innovation investment company
- 6 CRDC hosts Department of Agriculture head
- 8 Ensuring success now and into the future
- 8 Global focus is on sustainability
- 10 Riparian zones support high biodiversity

# Summer 2020-21



## FEATURES

### ON THE COVER

- Protecting biodiversity in cotton landscapes **7**
- Impacts and solutions: Evaluating interactions between irrigation infrastructure and fish **11**
- Keep a closer eye on whitefly with nymph monitoring system **20**

- Taking a proactive approach at Trangie **13**
- Survey identifies current practice and future issues **14**
- Reoccurring wilt: a possible new cotton disease **15**
- Supporting change for resilient regional communities **17**
- Moving forward in the same direction **18**
- Early season mirid management **19**
- Species and resistance status might be different to what you suspect: Why mites continue to be on the research radar **23**
- Podcast project targets fall armyworm **27**
- Preparedness is key in biosecurity plan **28**
- Man's best friend and ag biosecurity defender **28**
- Diversifying smart plant surveillance **29**
- Heat and microbes dictate nitrogen loss **30**
- Fighting verticillium using an unlikely ally **31**

### ANNUAL REPORT REVIEW

- Adapting to change, rising to challenges, investing in innovation **32**

## Connecting with science, socially

THE Association of Australian Cotton Scientists (AACS) has entered the Twitterverse.

“There is so much research, and so many cotton growers and consultants using Twitter so it’s only natural we join in,” AACS social media coordinator Warren Conaty says.

“We will showcase the amazing people and science the Australian cotton research community has produced, putting them on display in the domestic and international cotton research stage.

“We are always looking to build even stronger connections and links between researchers and users of the research: the growers and consultants, and it’s also a great way for other scientists to stay up to date with other research.

“COVID-19 created a situation where we postponed our biennial conference to 2022 as not to clash with the Australian Cotton Conference, which will now go ahead next year.

“So, considering it’ll now be a long time between drinks (read: AACS conferences) and largely in the absence of face-to-face catch ups, we also hope that this is just one mechanism to keep a connection between researchers.”

The new Australian Cotton Science Twitter page (@AusCottonSci) is run by the AACS committee. If you’d like to reach out to them about content please contact [AACS.social.media@gmail.com](mailto:AACS.social.media@gmail.com)



## Building skills in the bush

**AFTER** participating in Cotton Australia’s Cotton Gap program in 2017, Matt Clearwater is now a qualified agronomist working in the cotton industry.

Originally from Canberra with no farming background, Matt was working on Sundown Pastoral Company’s ‘Keytah’, west of Moree, NSW during his gap year and is now hooked on cotton.

Since then, Matt has studied a Bachelor of Agriculture at the University of New England and is now working in the Riverina as an agronomist and looking to undertake an Honours degree.

“When I started at ‘Keytah’, I didn’t know where I wanted to go career-wise when I left school, apart from wanting to do something in ag,” he said.

“The thing I enjoyed most about Cotton Gap was the opportunities to upskill throughout the year through informal on-farm lessons and formal certificates, such as those offered through AgSkilled.

“Everyone was friendly, happy to answer questions and offer help when I got stuck. It was also a great way to meet people in the industry and establish connections.

“I was exposed to a range of enterprises and potential career paths.

“When I started, I didn’t know what I wanted to do in agriculture, but the more hands-on experience I got the more determined I was to pursue a career in agronomy.”

Cotton Australia Education Coordinator Jenny Hughes said Cotton Gap engages with the next generation of workers, so the industry can secure a skilled and enthusiastic workforce for seasons to come.

“The closure of international borders due to the COVID-19 pandemic will see thousands of students who had planned to travel overseas for a gap year now looking for alternate experiences here in Australia,” Jenny said.

“We’d like to see some of this cohort coming to work on our cotton farms and pursue a career in the industry.

“I’d encourage cotton growers, scientists, agronomists and anyone else working in the industry – if they know any school leavers who may be interested in participating – to contact us.”

Matt said he would “definitely recommend this program to other school-leavers – you’ve got nothing to lose, it is definitely worth a go.

“It’s a great way to spend a year (or more), and it gives you time to learn new skills or use previously established skills and build a new career in something you may have never considered.”

### For more:

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# CRDC welcomes Director appointments

CRDC has welcomed the appointment of six directors to the CRDC Board by the Minister for Agriculture, Drought and Emergency Management, the Hon. David Littleproud MP.

Led by incumbent Chair Richard Haire and CRDC's Executive Director Dr Ian Taylor, the CRDC Board will comprise former directors Les Copeland and Rosemary Richards, who have been returned for a second term and new directors Ross Burnett, Dr Gary Fitt, Dr Danielle Kennedy and Peta Slack-Smith.

Richard welcomed the directors, who come from a diverse range of backgrounds across the cotton, science, technology and corporate affairs sectors.

"CRDC drives investment, innovation and impact in the Australian cotton industry through world-leading research, development and extension," Mr Haire said.

"Our role in working with cotton growers and the wider industry to set and invest in research priorities is critical – ensuring we have the innovation and transformative technologies to drive the industry forward.

"One of the great strengths of the



Central Queensland grower Ross Burnett is one of four new directors appointed to the CRDC Board.

RENEE ANDERSON

CRDC Board has long been its diversity, with directors each bringing a range of skills to the table.

"Today's announcement is no exception, with expertise in cotton growing and cotton research, commercial operations, technology and innovation, and communication.

"I welcome Les and Rosemary back to the board, and Ross, Gary, Danielle and Peta to the board for the first time.

"I look forward to working with the directors over the coming years to ensure

CRDC continues to achieve strong outcomes on behalf of growers, the Government and the wider industry."

Richard also paid tribute to CRDC's outgoing board, whose term finished on September 30.

"I thank outgoing Deputy Chair Kathryn Adams, and directors Liz Alexander, Greg Kauter and Jeremy Burden for their invaluable contribution to CRDC and the wider cotton industry," Richard said.

## RDCs create new innovation investment company

CRDC and its fellow Research and Development Corporations (RDCs) have come together to create a new not-for-profit company to drive cross-sectoral research, leverage private sector investment and target transformational innovation.

Announced in early October by the Minister for Agriculture, Drought and Emergency Management the Hon. David Littleproud MP and the Council of Rural RDCs, the new company, Agricultural Innovation Australia (AIA) Ltd, marks a historic move for the 15 RDCs.

Chair of the Council of Rural RDCs Mr John Woods said the new company would target opportunities with greatest potential to deliver impact across multiple industries.

"Australia's agriculture industry is world class thanks to the efforts of the RDCs over the last three decades, but we are facing increasingly complex challenges that require new approaches, new ways of working and new strategic responses," John said.

"This new company gives us a new tool through which we can prioritise and streamline co-investment to tackle hard to solve cross-sector problems and drive greater impact for industry and the broader community.

"The RDCs have a long history of effective collaborations and I'm excited to see what we can achieve through this next iteration.

"As a single point of contact for cross-industry strategies, AIA makes it easier for investors to navigate and partner with the Australian agricultural innovation system. Its agile investment framework will attract contributions from a range of sources, enabling large-scale investment on issues of national importance.

"The Council acknowledges the strong support of Minister Littleproud for this new initiative, and welcomes the contribution of \$1.3 million in seed funding from the Australian Government to fast-track action on the ground."

CRDC Executive Director Dr Ian Taylor has been part of the leadership team developing the new company, and its first investment initiative.

"AIA is a great step forward for the RDCs: it will enable greater cross-sectoral collaboration to address the major issues facing all agricultural sectors – things like climate, water use efficiency, biosecurity and soil quality," Ian said.

"The first investment the collective RDCs are partnering on under AIA is the climate initiative: a significant new co-investment program, led by CRDC, to foster thriving agriculture, fisheries and forestry industries regardless of pressures from a variable and changing climate."

### For more

[www.aginnovationaustralia.com.au](http://www.aginnovationaustralia.com.au)

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# CRDC hosts Department of Agriculture head

IN late September, the head of the Department of Agriculture, Water and the Environment, Departmental Secretary Andrew Metcalfe AO, visited CRDC and the research hub of Narrabri.

Hosted by CRDC's Dr Ian Taylor, Andrew and his chief of staff Colin Hunter visited the CRDC office where they met in person with team members and virtually with Cotton Australia Chief Executive Officer Adam Kay. On the agenda was discussion about the strength of the partnership between Cotton Australia and CRDC, key research focus areas for the industry, the development of northern Australia, and the uptake of research outcomes via the industry's extension program, CottonInfo.

The visit to CRDC was followed by a tour of the IA Watson Research Centre, where the visitors met with the University of Sydney's Dean of Science, Professor Iain Young and Director of the Plant Breeding Institute, Professor Richard Trethowan.

With digital technology a key focus of CRDC's investments, Ian invited the GoannaAg team of Chief Executive Officer Alicia Garden and Chief Operating Officer Tom Dowling to present on their work with the cotton industry: helping growers to optimise water management and improve on-farm efficiencies through low cost sensors and connectivity.

The Department team then visited the Australian Cotton Research Institute (ACRI), where they met with CSIRO's Dr Warwick Stiller and NSW DPI's Rod Jackson, director of ACRI.

Andrew has a personal connection to the research station: his uncle is the late Norm Thomson, one of cotton's pioneering researchers and cotton breeders, who helped to establish the research centre for CSIRO in the early 1970s, along with its cotton breeding program.

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***“He was very impressed with the level of collaboration... and the uptake of research outcomes and best practice.”***



**Dr Ian Taylor and head of the Department of Agriculture, Water and the Environment, Departmental Secretary Andrew Metcalfe AO in Narrabri.**

After ACRI, the team conducted a short visit to CSD's seed facility in Wee Waa, before returning to Narrabri for dinner with local researchers and growers. Ian said the visit provided a great opportunity for CRDC to showcase cotton industry research and Narrabri's research facilities to the Department head.

“Andrew has a long association with the Australian cotton industry, through his uncle Norm Thomson, who is well-known as one of the first cotton industry researchers: and he is no stranger to Narrabri, having visited his uncle while he was stationed here,” Ian said.

“Interestingly, he also visited his uncle at Kununurra, where he was conducting

early research into the northern cotton industry – so he was very pleased to learn more about today's expansion of the industry in the north.”

“We were very pleased that Andrew, who is responsible for the implementation of critical policy areas for cotton growers – agriculture, water and the environment – took the opportunity to visit us in Narrabri, to meet with local growers and researchers and to learn more about our current RD&E investments.

“He was very impressed with the level of collaboration within the industry, and the uptake of research outcomes and best practice.”

Biodiverse projects:  
Sam (foreground) and  
Matt Kahl planting trees  
at 'Glenarvon'.

## Protecting biodiversity in cotton landscapes

**COTTON** Australia and CRDC are supporting a partnership between iconic Australian brands Country Road and Landcare Australia to improve biodiversity on cotton farms in the Namoi Valley of NSW.

Funded by a corporate contribution and funds raised via the sale of its famous Verified Australian Cotton Heritage Sweats, Country Road will contribute a minimum \$600,000 to the partnership over three years, with funds raised going to Landcare Australia to support biodiversity restoration projects.

Landcare Australia CEO Dr Shane Norrish says "Landcare Australia is very proud to launch this partnership with Country Road and the Australian cotton industry to develop projects focused on biodiversity conservation with cotton farmers.

"The projects will help to restore local ecosystems and contribute to the sustainable management and productivity of the landscape.

"The partnership is a powerful example of how Landcare Australia brings together organisations to work on projects that will have a meaningful impact for farmers, the environment and the local community.

"We are very pleased to be working with Country Road, the Australian cotton industry and cotton growers on biodiversity projects that will protect habitat for a range of native plants and animals, including threatened species."

The partnership will draw on a

CRDC report that mapped biodiversity in Australian cotton landscapes, identified threatened and endangered species and recommended ways to protect them. This was achieved with support from the Australian Government's National Landcare Program Smart Farming Partnership Initiative Round 1.

The initial project will be implemented by the Kahl family in the Namoi Valley, NSW - a region significantly affected by biodiversity loss and in need of restoration. Third generation cotton farmers, the Kahl family will participate in the program by revegetating a river system that flows through their property and excluding stock to increase habitat and shelter for native animals, reduce erosion and improve water quality.

Farmers in the area will be engaged in future rounds of funding, and all farmers and industry representatives can actively help by purchasing a Country Road Verified Australian Cotton Heritage Sweat online.

According to Cotton Australia, biodiversity is an important area of sustainability work for the industry and will be a focus in coming years following the release of industry wide sustainability targets.

"This is an incredibly exciting opportunity and the first time a corporate partner has come on board to directly support our biodiversity work on farm. We hope the funds from Country Road, and the support of Landcare Australia will help further engage our growers in biodiversity

activities," Cotton Australia CEO, Adam Kay said.

"We know from the research that our farms provide critical habitat for Australia's native plants and animals, and when managed well these areas also bring benefits to the farm by providing natural pest control, improving soil health and storing and sequestering carbon."

The Australian cotton industry is also adding to the launch project in other ways.

"This includes a five-hectare research trial by the University of New England to investigate which revegetation methods have the greatest survival rates on floodplain soils as well as the initial biodiversity mapping work which helps identify target areas for biodiversity enhancement works," CRDC natural resource R&D Manager, Stacey Vogel said.

"Cotton industry research shows that while there have been some great steps forward, more needs to be done to protect and improve biodiversity on cotton farms and adjacent landscapes.

"We hope this partnership with Landcare Australia and Country Road will help focus industry efforts, accelerate our biodiversity work and provide a lasting legacy for our farmers, their communities and the natural environment," she said.

### For more

[www.countryroad.com.au/our-world/land/the-biodiversity-project-with-landcare-australia/](http://www.countryroad.com.au/our-world/land/the-biodiversity-project-with-landcare-australia/)

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MELANIE JENSON

## Ensuring success now and into the future

Work to progress one of the most important programs for Australian cotton growers and the broader industry has taken a big step forward with the completion of extensive stakeholder consultation on sustainability targets.

The *PLANET. PEOPLE. PADDOCK.* sustainability framework has been developed by the industry to coordinate work to make Australia a global leader in sustainable cotton production. An important part of the framework is setting targets and coordinating a whole-of-industry strategy to achieve them.

Draft targets and indicators of progress have been developed for each of the core focus areas under the framework:

- ◆ PLANET: water; carbon footprint,

biodiversity, pesticides, soil health.

- ◆ PEOPLE: workplace, wellbeing.
  - ◆ PADDOCK: productivity, profitability.
- In a consultation process during July and August 2020, 356 stakeholders gave feedback on these draft indicators and targets to validate the level of ambition, to test they are the 'right' ones to use, and to elicit suggestions for partnerships and solutions to achieve targets.

"We have consulted widely with stakeholders inside and outside the

## Global focus is on sustainability

**WHILE** CRDC and the Australian cotton industry has a major focus on sustainability in 2020, so too has the industry at a global scale.

While this important work has been taking place domestically, internationally the global cotton industry is also focused on sustainability - particularly ensuring that brands and retailers keen to source sustainable cotton can access credible, consistent and comparable ways to measure impact data across the various cotton sustainability standards.

To address this, the Better Cotton Initiative, Cotton Connect, Cotton Made in Africa, Fairtrade, the Organic Cotton Accelerator, Textile Exchange, and Australia's *myBMP* program (supported by CRDC and Cotton Australia), have been working collaboratively to align

sustainability impact indicators and metrics. This work has occurred with advisory input from the International Cotton Advisory Committee and the ISEAL Alliance, and support from the Laudes Foundation.

The organisations – convened under the Cotton 2040 Impacts Alignment Workstream and The Delta Project – have published a jointly-signed commitment statement, confirming their intention that the Delta Indicator Framework will become a credible and shared framework to guide impact measurement and reporting of core sustainability issues of relevance to the cotton sector.

CRDC's General Manager R&D Allan Williams has worked on the Delta Project on behalf of the cotton industry. He said the scrutiny on cotton production globally

more often than not focuses on its negative impacts, and irrespective of the specific local conditions underlying those impacts, cotton as a commodity (including Australian cotton) can be tarred with the same brush. Its impact is also often reported at a global scale.

"It is therefore important that the global industry collectively does a better job of telling the positive stories about cotton growing, and the improvements being made in how it is produced," Allan said.

"This core set of 15 indicators developed by the Delta Project is an important step in enabling that."

The Framework builds on existing activities – including the Australian Cotton Sustainability Report.

"The Australian industry has

Australian cotton industry on draft targets developed by growers, scientists and industry experts,” CRDC’s General Manager R&D Investment, Allan Williams said.

“Stakeholder feedback has been used to refine some targets and indicators to ensure they meet stakeholder expectation and are still achievable and consistent with the industry’s ambition to be a global leader in sustainable cotton production.”

Other primary industries such as grains and livestock are also developing or have in place their own sustainability frameworks. Acknowledging that most farms growing cotton are mixed cropping and grazing enterprises, the cotton industry is working with other industries to have sustainability metrics and methodologies that are as consistent as possible across broadacre industries.

For some *PLANET. PEOPLE. PADDOCK.* sustainability topics like carbon footprint, biodiversity and soil health, these common metrics and data collection methodologies don’t yet exist and need to be agreed before targets can be set for the industry. Because these are complex areas involving several industries, this work is taking time to get right. Targets will be launched when this work is finalised, which will be several months yet.

“However we are not waiting for targets to be launched to act,” Allan said.

“The industry has been improving its



Allan Williams (right) meeting Project Delta partners in London in 2019.

been actively collaborating in the development of the indicators, through my representation on the Project Steering Committee, as well as having the Sustainability Working Group provide feedback on the draft indicators,” Allan said.

“While not every indicator is relevant to our cotton production, those that are, are entirely consistent with the approach being taken in our Sustainability Reports.”

## What is sustainability?

*PLANET. PEOPLE. PADDOCK.* is based on an internationally recognised framework to improve long-term performance. Sustainability in the Australian cotton industry means:

- Improving industry performance while creating social, economic and environmental value.
- Engaging those who influence and impact the production of Australian cotton.
- Identifying, prioritising and managing the most important sustainability topics.
- Being accountable for impacts.

### Why is the Australian cotton industry doing this?

Sustainability is about understanding, managing and being accountable for what’s important to the people the Australian cotton industry relies on: customers, growers, and everyone who impacts how the industry operates. It follows that if the industry knows and manages what’s important, it is more likely to be successful – now and for future generations. *PLANET. PEOPLE. PADDOCK.* is the Australian cotton industry’s sustainability framework. It recognises sustainability is integral to the industry’s future and provides a path for the entire industry to stay in business. *PLANET. PEOPLE. PADDOCK.* is currently targeted at on-farm cotton production. It is not a compulsory standard or a brand: it will be delivered through existing industry structures and programs.

### Who is the Sustainability Working Group?

The Australian cotton industry has formed a Sustainability Working Group (SWG) to coordinate its work to become a global leader in sustainable cotton production. The SWG is comprised of representatives from Cotton Australia, CRDC, *myBMP*, CottonInfo, Australian Cotton Shippers Association and growers. The SWG reports to the boards of Cotton Australia and CRDC.

sustainability performance for 30 years and this work will continue, with growers supported through existing industry programs such as *myBMP*, CottonInfo and focused R&D investments.”

The targets outlined in *PLANET. PEOPLE. PADDOCK.* will be a starting point, and the working group along with CRDC and Cotton Australia will seek to frequently and transparently engage with stakeholders on their actions and the progress towards them.

Achieving targets set out in *PLANET. PEOPLE. PADDOCK.* is not a feel-good exercise. Managing sustainability well has the potential to reduce industry risks, improve industry social licence and trust, increase farm productivity and resilience, and maintain or gain access to customers and markets.

Sustainability for the Australian cotton industry means running profitable and efficient businesses while creating environmental, economic and social value. It also means being accountable to stakeholders for the industry’s actions and impacts.

The industry has created the world-leading *myBMP* cotton certification standard to establish best practice and developed the CottonInfo program to drive grower adoption of research.

“*PLANET. PEOPLE. PADDOCK.* does not add a new layer to this proven structure,” Allan said.

“These existing channels will continue to drive industry continuous improvement right across farm operations and remain the path for researchers to connect with growers to adopt change.

“Growers are asked to continue to use these critical programs, and if needed, rise to the challenge of improving performance in areas to benefit them and the entire industry.”

#### For more

[www.crdc.com.au/for-growers/sustainability](http://www.crdc.com.au/for-growers/sustainability)

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# Riparian zones support high biodiversity

CRDC's focus on sustainability via on-farm biodiversity and riparian management is being encompassed through several research projects.

The importance of connected riparian habitats for maintaining biodiversity in cotton growing areas in Northern NSW has been demonstrated through research by CRDC-supported honours student, Laura McCallion of Griffith University. Laura assessed birds, mammals, and reptiles across the Gwydir Valley.

Laura compared biodiversity in riparian versus non-riparian and 'connected' versus 'disconnected' sites to determine if these habitat types were used differently and their influence of connectivity. Connected sites had continuity with other habitat types, and longitudinal and lateral connectivity, whereas disconnected sites were separated from other habitat types by cleared land. This type of study has not previously been undertaken in the arid and semi-arid regions of NSW.

Laura found that riparian habitats support significantly higher biodiversity than non-riparian areas. Of the 90 species observed during the survey, 26 (almost 30 per cent) were only observed in riparian habitats.

"Overall, the results suggest that disconnected riparian habitats are likely to support distinctive and more diverse communities than connected non-riparian habitats," Laura said.

"Riparian habitats with intact linkages to non-riparian areas may represent the most critical habitat for many terrestrial vertebrates in such landscapes and should therefore be prioritised for conservation and restoration."

In the Gwydir Valley's riparian habitats, bird species' richness was almost twice that of

non-riparian habitats, or 70 per cent higher, while microbat species' richness increased by 40 per cent, showing that reliance on riparian habitats increases in semi-arid regions, according to Laura.

"The Gwydir Valley contains extensive floodplains and it is interesting to see reliance on riparian habitats persist and even exaggerated, despite flooding of non-riparian areas."

This research was part of a three-year, CRDC-funded Griffith University project which investigated what human and natural drivers impact ecosystem function and the provision of ecosystem services, in particular which management strategies best promote and maintain ecosystem function and services. A handbook for the cotton industry on managing riparian ecosystems is under development. It will outline the importance of riparian vegetation connectivity for native fauna's survival and its provision of ecosystem services to farmers and the environment, such as natural pest control provided by birds and microbats. It is set to be released via the CottonInfo website in early 2021.

## Improving connectivity

"Improving connectivity of native vegetation in cotton landscapes, especially adjacent or within riparian areas, is one of four priority management actions identified by CRDC to help maintain and restore areas for the benefit of threatened and iconic species in cotton landscapes," CRDC's R&D Manager Stacey Vogel said.

A major industry initiative has been through the National Landcare Program's Smart Farming Partnership, through which CRDC secured a grant to bring Cotton Landcare Tech-Innovations 2021 onto Australian cotton farms to enhance natural resources and biodiversity.

The project builds on international best practice to implement and develop cutting-edge technologies, such as aerial seeding, acoustic monitoring and big data, to help Australian cotton better report on and improve on-farm biodiversity. Under this initiative, biodiversity was mapped in all cotton growing regions to develop a web tool which provides information on biodiversity assets and priority management actions for threatened and iconic species for each local government area in growing regions. This tool is available on the CottonInfo website.

Projects like Laura's allow the cotton industry to create a better picture of biodiversity, as an avenue to improved understanding and management, which are stated industry aims under the industry's **PLANET. PEOPLE. PADDOCK.** Sustainability Framework and CRDC's Strategic Plan.



## For more

[www.cottoninfo.com.au/](http://www.cottoninfo.com.au/)

[managing-biodiversity-cotton-landscapes](#)

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A golden perch caught by electrofishing in river pools to assess populations and species.



## Impacts and solutions: Evaluating interactions between irrigation infrastructure and fish

In line with CRDC's goal to improve sustainability, research is underway to better understand and minimise the impact of irrigation infrastructure on fish populations in rivers.

Specialists from QLD DAF, with support from CRDC, will evaluate how various fish species interact with different types of irrigation infrastructure. This information will enable measures to be developed to avoid fish being entrained - or caught up - in irrigation systems.

Evaluating the relative impact of different irrigation infrastructure types will identify which are lower impact and which types should be prioritised for mitigation measures in the future. Available mitigation measures and the potential costs and benefits will also be examined.

This work is an important step in developing and prioritising best management practices to reduce the direct impacts of water extraction on fish without sacrificing irrigation efficiency. The results of this work could be applied to new irrigation developments and upgrades to existing systems.

There are many variations in irrigation

infrastructure systems, design and function. Pumps vary in size, and the locations and style of the inlets also vary. For example, some inlets are close to the river bank, others extend further out into the river and some are positioned in short side channels perpendicular to the river. Other irrigations systems rely on gravity fed diversion channels. Fish may also behave differently in natural flow events, compared to irrigation flow releases from dams and weirs, says QLD DAF Principal Fisheries Biologist Michael Hutchison, who is leading the research.

"All this variation means some systems are likely to have a lower impact than others when it comes to entrainment of fish," Michael said.

"The intent of this work is to build on existing international and national research and make best practice recommendations to CRDC for irrigators to minimise impacts on fish. These measures may also be beneficial to the irrigation infrastructure operating efficiency and maintenance."

Some of Michael's previous research evaluated movements of small and medium sized fish in the Northern Murray-Darling Basin. Michael and fellow researcher Dr Andrew Norris also have a background in restoring fish stocks through habitat restoration and enhancement.

Their award-winning work in the Condamine River near Dalby led to substantial increases in the abundance of fish at rehabilitated sites. Much of this work involved collaboration and cooperation with landholders. All observed increases in fish numbers occurred without irrigators reducing their use of water.

“Based on our past experience some fish species or sizes are more likely to be entrained than others,” Michael said.

“Some species, even though abundant in the river, may rarely pass through an irrigation system, whereas other less-common, poorer swimming species may be over-represented. For example juvenile catfish seem particularly susceptible to entrainment.”

### Work begins in the north

The experimental work will be undertaken in the Fitzroy River Basin, which has a mix of typical southern and northern catchment fish species. The results from this catchment will therefore be applicable to both tropical and temperate systems where cotton irrigation already occurs or is planned. Some of the well-known angling species that occur in the proposed study region include barramundi, Murray cod, golden perch and saratoga.

Michael said his team are currently preparing a review of existing mitigation technologies, including what is known about the effectiveness of the different systems for eliminating entrainment and impingement of fish, as well as other functional and economic aspects such as cost, ease of maintenance, self-cleaning capacity and impacts on



Fyke nets and electrofishing are used to sample the river reach near irrigation offtakes.

pumping efficiency. Functional self-cleaning systems are important to maintain pumping capacity. Most of the newer designs appear to be very effective.

### Priority research

CRDC Natural Resource Management R&D Manager Stacey Vogel said this project represents the commitment by the cotton industry to identifying key management strategies to protect and improve riverine areas including the condition and resilience of fish populations within cotton landscapes.

“CRDC has prioritised research relating to fish entrainment as an outcome from the industry’s 2019 fish stewardship R&D priority workshop,” Stacey said.

“Representatives from industry, universities, state and Australian Government organisations attending the forum rated fish entrainment as the highest R&D priority due to its potential impact on the resilience of native fish populations and the subsequent threat it poses to the industry’s social license to irrigate.”

Irrigators are proactively investigating methods of avoiding entrainment in the Macquarie Valley. A trial is underway by growers at the Trangie Nevertire Irrigation Scheme and NSW DPI Fisheries.

“We wanted to see for ourselves if it is at all possible or feasible to screen fish, fish eggs, larvae, and other debris at the pump site, while not effecting or reducing flow or extraction rates,” said scheme member Jim Winter.

“If this is doable it would be a win for the environment in healthier rivers and ecosystems.

“It’s a win for our irrigation members, through cleaner water extraction, meaning better pumping conditions with less debris in water and possibly less blockages in both sprinkler and flood irrigation.”

### For more

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## CRDC supporting the Australian Screen Advisory Panel

CRDC is co-investing with OzFish Unlimited to assist with administration of the Australian Screen Advisory Panel (ASAP).

ASAP facilitates the planning and implementation of fish screening R&D with representation from international and national fish ecologists and engineers as well as anglers and irrigators, including National Irrigators’

Council CEO Steve Whan.

“Getting a healthy river environment is about more than the amount of water,” Steve said.

“National Irrigators’ Council has been a strong advocate of measures to improve conditions in our rivers for native fish, that includes getting water temperatures and river management right, connectivity,

reducing feral pests and things like re-snagging.

“Modern fish screening has the potential to offer effective protection for native fish and facilitating safe and efficient pump operation.

“On that basis we are keen to support efforts to further develop and inform irrigators about the screens.”

## Taking a proactive approach at Trangie

After attending an information seminar at Trangie in August 2019 on the benefits of fish screens, a group of local irrigators decided to take a proactive approach.

After the meeting, the Trangie Nevertire Irrigation Scheme expressed interest in working with NSW DPI Fisheries and a commercial screen company to conduct a screen trial. A screening solution was designed and fish exclusion screens were fitted to one of the scheme's pump stations in July this year. The installation was funded via the sale of environmental water in 2018 which is now being reinvested into fish-friendly infrastructure through the NSW Drought Initiative.

Scheme manager Shane Smith said the set-up involves using cone screens, which are designed for shallow water and partially submerged, silty conditions. They meet NSW Fisheries' guidelines to protect fish from entrainment or impingement, along with protecting pumps from clogging with debris and "hopefully reducing running costs via reducing power demand charges and increase pump efficiency".

"The screens have low maintenance requirements and costs.

"Being constructed from 304 stainless steel wedge wire they are strong and hopefully have a long asset life," Shane said.

"There are three cleaning brush arms on each cone which are automated to clean in the event of head loss through the screens, or once a day minimum for a total of four minutes a day."

Shane explained that the advantages in selecting cone screens is they have a positive brushing action to prevent debris building up, sedimentation and bio-fouling and they can be used even if not fully submerged, having large surface area with a smaller footprint. The primary way the screens do this is by reducing approach through-slot velocities. For example a normal pump inlet could have an inlet velocity up to and possibly over



3m/second, meaning the area of influence around the pump inlet is significant which can drag a lot of debris to the pump from a long way away.

A cone screen has an approach velocity of only 0.12m/second at a flow capacity of 600ML/day and much less at lower pumping volumes. By pumping less debris at the pump station, the scheme hopes its members will see less debris being delivered on-farm, which hopefully will also reduce running costs.

"Most of the scheme members now use lateral move or pivot irrigation systems with nozzles prone to blocking with debris," Shane said.

"Another advantage is hopefully for the environment, by not pumping debris, eggs, larvae and even adult fish, we hope it is a win-win for our members and the fish along with other users of the river."

NSW DPI researchers will conduct controlled tests through the 2020-21 season, including monitoring fish and egg larvae and determining the screens' effectiveness.

"Hopefully if we can see a good outcome for fish, this can open the door for more support for growers installing these type of systems," Shane said.

The screening project is a partnership with NSW DPI Fisheries and the NSW Department of Planning, Industry and Environment.

**Fish screens installed this year as part of a trial in the Macquarie Valley to assess the impacts on fish and pumping efficiency.**

Key activities of the group are to recommend R&D needs, and review and promote the latest R&D around biological and engineering performance of screens. It will ensure best practice design criteria and guidelines are supported nationwide and adopted by management agencies, screen manufacturers and industry.

ASAP also complements the recently launched website Fish Screens Australia which is an information hub featuring the latest information on screening from

fisheries, university and industry experts.

"By investing in ASAP, CRDC are supporting the transfer of R&D knowledge between researchers, manufacturers, anglers and irrigators ensuring the best outcome for both fish and irrigators," CRDC's Executive Director Dr Ian Taylor said.

"This is not a new space for CRDC as we have supported earlier industry research to improve fish management.

"During the years of the Cotton Cooperative Research Centres,

CRDC supported a scoping study of international fish screening programs and field experiments in the Namoi River to develop initial design criteria for fish screens at water diversions in the Murray-Darling Basin."

### For more

OzFish

[www.ozfish.org.au](http://www.ozfish.org.au)

Fish Screens Australia

[www.fishscreens.org.au](http://www.fishscreens.org.au)

# Survey identifies current practice and future issues

The feedback from the 2020 CRDC Grower Survey indicates a positive level of confidence and optimism about the future of the industry among cotton growers.



The 2019-20 season was one of scarce irrigation water and rainfall, with an average of just 184 hectares under production across the 225 growers who responded to the survey. This represented 10 per cent of their total farmable area with an average yield of 10.45 bales per hectare on fully irrigated cotton.

The 2020 survey included focus areas of water, nutrition and soil, irrigation, IPM and crop protection, sustainability, workforce, community and social contribution, feedback on CRDC and CottonInfo, and industry sentiment.

Sustainability is a focus of the Australian industry right now with the release in May of the Sustainability Report 2019 and the development of sustainability targets under the *PLANET. PEOPLE. Paddock* sustainability framework.

Through the Grower Survey, respondents described what they felt are the industry's most important environmental, social and economic opportunities and threats between now and 2024. While a range of issues were identified, two major themes emerged for the feedback provided: water and community attitudes and perceptions.

Reference was made to a range of different aspects of water including: water use efficiency; management of water resources; water shortage and availability to water; growers' access to water; and

misinformation around water/politicising of water.

In terms of community attitudes and perceptions, growers made reference to the misinformation circulating about the water issues (particularly across social channels); the poor perception the community has of the industry/growers; the need to keep the community up to date with improvements made by the industry and a need for more community education.

Wellbeing is an important factor in sustainability. The survey of growers' time use showed that 61 per cent reported spending less or much less time with family/friends than they wanted to, with 39 per cent indicating they were spending more, or much more time working than they wanted.

CRDC undertakes an annual survey of cotton growers to gather information about farming practices and growers' views on research, development and extension. This information helps inform CRDC about the benefits of the research it invests in and priority areas for future research. Change in industry practice can be quantified by comparing information across the surveys conducted over the past 20 years.

The results of the survey are published annually via both a user-friendly PDF report, and an interactive digital dashboard, enabling readers to explore the data in more depth. The results from the 2020 survey are now available at the CRDC website.

## For more

[www.crdc.com.au/publications/growersurvey](http://www.crdc.com.au/publications/growersurvey)

The CRDC Cotton Grower Survey is an important avenue for growers to have a say on a range of issues affecting them.



RENEE ANDERSON

# Reoccurring wilt: a possible new cotton disease

LINDA SMITH

With support from CRDC, QLD DAF pathologists are investigating a likely new pathogen as the potential cause of dying plants reported in Central QLD, Gwydir and Namoi valley cotton fields in recent seasons.

Industry research is now focused on identifying the causal agent with bioassays underway in a controlled environmental growth room to see if a microbe that has been consistently isolated in dead plants can cause the disease seen in affected cotton fields.

CRDC R&D Manager Susan Maas told *Spotlight* there is a coordinated industry effort with CRDC, Cotton Australia, CottonInfo, QLD DAF and NSW DPI pathologists working together in the initial response with CSD and the CSIRO breeding team.

“While we are only aware of a few patches, we are still concerned that this may have potential to be a serious issue for the cotton industry,” Susan said.

“Given this could potentially be a new disease

## Have you seen fields with the following symptoms?

- The odd plant or patches of plants that wilted and suddenly died with dead leaves usually remaining on the plant.
- Reoccurring patches of dying plants getting larger over past seasons with no explanation for plant death e.g. seasonal conditions.
- Dying plants amongst healthy plants.
- Bronzing of leaves and petioles.
- Reddening of the roots and root decay i.e. if plants are pulled out of the soil, the taproot snaps due to root decay.
- May see reddening of the vascular tissue.
- Stem canker/lesions may be present.

to cotton, there are many unknowns.

“Plans and resources are in place so that research can address what is causing these plant deaths and how, so then work can begin on how to mitigate any impact.

“I really want to acknowledge and thank the growers and agronomists who identified and reported their concerns - early identification of issues provides the best opportunity for response.”

Reddening of the roots has been described as a symptom of a new pathogen affecting cotton.

Research is being led by QLD DAF pathologist Dr Linda Smith and up-to-date information and details from the ongoing investigation will be provided to industry as it becomes available.

So far the pathologists have ruled out known endemic diseases.

“The symptoms have similarities to Texas root rot, which is a high priority exotic disease of the Australian cotton industry and is a national priority exotic disease for Australian agriculture,” Linda said.

“However we have ruled out Texas root rot as the causal pathogen, along with other high priority exotic diseases.

“The symptoms, which include wilting and plant death, are very similar to sudden wilt, however this potential new disease is different from sudden wilt because the disease was observed in the same area of a field and the affected area was growing larger every season.

“The symptoms were also not quite right for sudden wilt as the affected plants had leaf bronzing.

“There were also no other factors normally associated with sudden wilt, such as an irrigation or rain event followed by bright and hot conditions.”

### Send in samples and focus on biosecurity

As part of the industry response, it is imperative to be on the lookout for any suspicious symptoms in crops, and if seen, or unsure, to contact your local state pathologist or CottonInfo REO and organise a collection for diagnostics. Sending in suspected samples for diagnostics will assist in determining the potential extent of the issue across cotton growing regions.

Good farm hygiene and biosecurity practices are also essential to preventing the spread of this potential disease.

**AT RIGHT AND BELOW:**  
Pathologists have seen a range of symptoms of plants affected by reoccurring wilt, which are very similar to sudden wilt.



IMAGES THIS PAGE: LINDA SMITH

“We currently don’t know how this pathogen spreads, infects and survives, so it’s important to implement a series of biosecurity measures to protect your farm and farms you may visit,” said CottonInfo Biosecurity Technical Lead, Sharna Holman of QLD DAF.

“Regularly monitor fields and be aware of what is happening on farm, if you have any concerns or are seeing any suspected symptoms contact your state cotton pathologist.

“Ensure anyone involved with the crop at the farm level is also clear about what to be alert to.

“Developing a farm biosecurity plan to assess the biosecurity risks specific to your farm and business can ensure you are considering and implementing practices, such as Come Clean Go Clean, that minimise the risk pests, weeds and disease spreading on and off your farm.”

*The Fast Facts: Be Wilt Aware* fact sheet is available on the CottonInfo website. It compares wilt – Fusarium, Verticillium, sudden and reoccurring wilt – plus lightning strikes, to assist in identification and management.

### For more

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Warren and its people are integral to the cotton industry. Building resilience in cotton-growing communities is a priority for CRDC.

# Supporting change for resilient regional communities

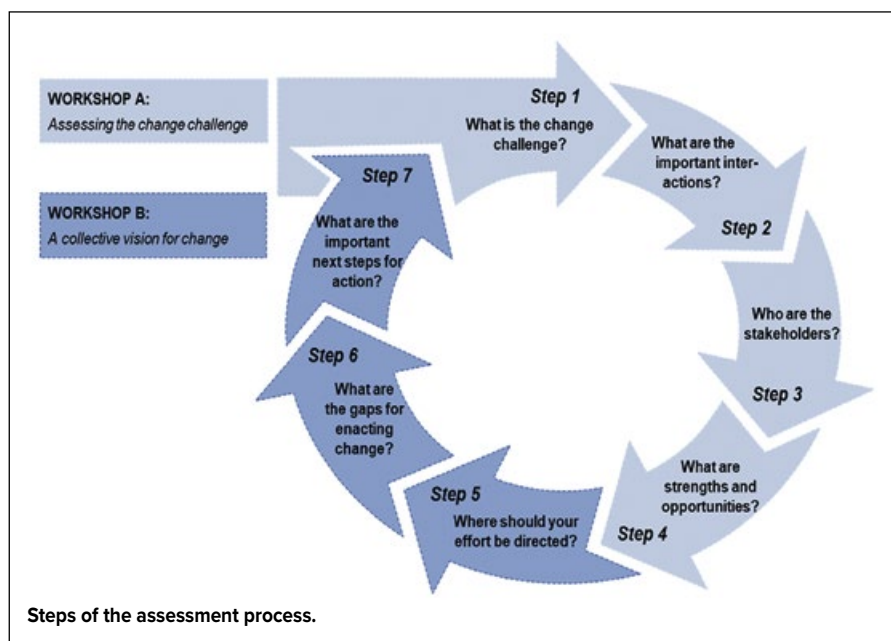
It may sound like a cliché, but it's never been more true: we are living in turbulent times.

People are having to do and respond to things that they perhaps never imagined. Climate, workforce challenges, water policy and technology are evolving at a rapid rates. Each of these present challenges for regional communities and local leaders.

A changing operating environment means we need to develop different skillsets that promote greater collaboration, adaptation and capacity building: we need to be resilient. Fortunately, for many rural, regional and remote communities, these skills are already prevalent. But what is resilience and how do you cultivate it?

In 2016 CRDC initiated a resilience assessment of the Australian cotton industry, which identified resilience as the ability to absorb a shock or change and flourish in spite of change. These drivers of change are pushing the Australian cotton industry towards critical thresholds, leading to significant changes in system dynamics at multiple scales including water availability (farm scale), network connectivity (regional scale) and social licence (industry scale).

This initial resilience assessment did not include how communities are integral to supporting the cotton industry.



The need for rural, regional, remote communities to become self-sufficient is increasing and more than ever, communities need to be able to gather resources, respond, be adaptive and flexible. The question is how?

Researchers have worked closely with communities in Warren and Walgett in NSW and Goondiwindi in South-East Queensland, as case studies to understand what makes regional communities vulnerable, adaptive and resilient, and what support they might require.

The Thresholds for Resilience in Regional Communities project, supported

by CRDC, involved researchers from the Rural Innovation Research Group (RIRG) at the University of Melbourne and the University of New England. Lead researcher, RIRG's Dr Jana-Axinja Paschen, ran two workshops in the towns including local councils, NSW DPI Resilience Officers, CWAs, Cotton Grower Associations, Local Land Services, growers and business owners. The workshops were adapted for these cotton-growing communities from more than a decade of work by the RIRG and international resilience assessment frameworks.

The participants defined many

shared challenges they currently faced and then focused on identifying their community strengths and assets to develop key opportunities for action. The workshops also helped participants discuss and start to define the roles in supporting community resilience, including community organisations, the cotton industry and other agricultural sectors, local and state government bodies.

A planning tool developed by the research team assisted participants in developing action plans for taking the next steps toward goals they identified.

Areas for action towards building community resilience identified by community participants included:

- ◆ improving networks, communication, and opportunities for new partnerships and decision-making at regional

community, cross-industry and local government levels;

- ◆ establishing local/regional think tanks and forums for community organisations, cross-industry groups and business owners;
- ◆ pursuing a full-time grant writing and project management position located in council to assist with the management of and attaining funding for regional resilience building initiatives;
- ◆ pursuing funding for and running capacity building training for grant writing, marketing, leadership, advocacy, community-level governance skills;
- ◆ strengthening local/regional cross-industry agricultural skills training capacities; and

- ◆ environmental groups working with council and education institutions to raise profile of environmental assets and environmental education opportunities.

A *Resilience Assessment Workbook* for cotton communities was also created through the project, which can be used by other regional communities and groups to build capacity to grapple with complex change challenges that require collaborative action. The workbook will be available through the CRDC and RIRG websites.

#### For more

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## Moving forward in the same direction

Previous NSW Rural Woman of the Year Kate Schwager (pictured) is no stranger to helping build and promote rural communities, however, she says resilience workshops near her home in Walgett in North-West NSW have created new ways of thinking.

The workshops were a part of CRDC-supported research to understand how regional communities deal with change and become resilient. Researchers held meetings in Walgett, Goondiwindi and Warren.

“I initially thought it was a great opportunity for community groups to get together to discuss what was needed to go forward and get through the recent drought,” Kate said.

“I think people were a little sceptical and did not quite understand what it was about, but after being given the opportunity to put forward their ideas, most realised how beneficial it is to motivate people to put plans in place that are created by their community, to build its resilience.”

Kate says at the second meeting in Walgett attracted many people from outside the region.

“There were lots of comments on how the meetings were a great opportunity for other regions to use the tools created by the researchers



and template for the workshops to find what is missing in their community to go forward,” she said.

“More and more communities need to be resilient and be aware of how they are seen by people who travel or move to a community: do they have what is needed by people in their community?”

Kate says with the addition of COVID-19 still hanging over our heads and people moving to rural areas, the template could be used to bring groups together “that normally don’t get together”. She also believes the

facilitators coming from outside the community was integral.

“It means less friction which can at times be very confronting in small communities, and not helpful,” Kate said.

“The success of these meetings is in giving groups an opportunity to see their community in a different light and ask the hard questions of how they can go forward and put ideas together without the infighting that can occur.

“The outcome of these meetings has pushed our council and others to promote the community in a different light.

“More meetings need to be facilitated as this was genuinely a different way of getting outcomes to benefit all involved.”

After the first workshop at Walgett, Kate decided to help Walgett with a website, which she set up as part of the Connect North West Group.

“As with the whole network, it is very much community-based work as a large amount of advertising on the network was lost due to the drought.

“The website has been revamped and connected with a business directory, and I’m already getting a lot of calls from that section of the website, even though it’s not finished yet!”

# Early season mirid management

CottonInfo IPM Technical Lead, QLD DAF's Dr Paul Grundy has undertaken a study into retention in Bollgard 3 varieties. He shared with *Spotlight* what this research means for early season insect management decisions.

Retention is a key focus for crop managers during squaring and early flowering. However, opinion on what actually constitutes acceptable retention for securing yield potential varies between individuals and regions, with agronomist survey data suggesting a range as wide as 25 to 90 per cent retention prior to first flower as the trigger for control action.

The measurement of retention first emerged more than 25 years ago to balance the challenge of managing resistant *Helicoverpa* without excessive spraying while preserving yield potential. In that system, early boll retention was a driver for yield potential, simply because holding bolls in the later canopy was very difficult due to *Helicoverpa*.

With the advent of Bollgard varieties, increased yields over the last decade are partly attributed to improved boll retention in the upper and outer canopy, which raises the question of whether pre-flowering square retention still remains the driver for yield potential compared to 25 years ago.

In Bollgard varieties, early retention is primarily affected by mirids and/or environmental conditions.

Industry practice surveys suggest that 51 per cent of farms spend from \$11 to \$50 and a further 40 per cent spend up to \$100 on managing mirids each season. While this might be a relatively low input cost for some farms, there are other aspects that need to be considered, such as the potential to flare silverleaf whitefly (SLW) and mealybugs. Crop managers should consult the Beneficial Disruption Index outlined in this season's Cotton Pest Management Guide to assist decision making.

Consideration also must be given to a product's contribution to the industry's environmental toxicological load (ETL).

While ETL is a term that may currently be unfamiliar to many people, all of agriculture is facing increasing regulatory pressure to reduce their ETLs where possible, driving a need to optimally target insecticide use. The Australian cotton industry's sustainability targets, currently in development, have a focus on ETLs regarding pesticide use.

To better understand the where and when for managing retention, research is re-examining the relationship between early season retention and the growth, yield and lint quality of irrigated Bollgard 3 cotton. In these experiments, squares are removed from fruiting branches (FB) 1-5 pre-flowering, FB 6-10 just after first flower, or both (FB 1-10; removed at two separate occasions) from plants within treatment plots. This work was done at five sites from Emerald to Whitton during the 2019-20 season within commercial fields. Large treatment plots were used (10m long x four rows) which allowed for biomass and hand-picking assessments and machine plot picking at some sites to ensure results reflected commercial practice.

Results indicate full compensation for early season square loss, with no compromise for lint yield, quality and time to maturity or requirement for additional management inputs.

Detailed growth measurements and segmented picking assessments explain why. Fruiting dynamic measurements show that at first flower, 75 per cent of the crop's fruiting sites have not even been grown and by maturity these crops only retain 40 to 50 per cent of the total sites produced. This explains why the contribution of first position bolls on the fruiting branches prior to flowering have little impact on subsequent yield potential.

At every site, final boll numbers were not significantly different despite large



**The research results indicate full compensation for early season square loss, with no compromise for lint yield.**

differences between treatments at cut-out (with damaged treatments having more fruit). This demonstrates a central truth for growers of high yielding Bollgard 3 crops: that yield potential is realised between cut-out and early boll opening and has minimal association with square retention early season.

This research will continue for two more seasons to better capture seasonal variability before recommendations for retention management can be made. However, these preliminary results provide food for thought about how high yields are achieved and where our emphasis as crop managers might be best placed in terms of managing crop inputs to achieve high yields.

This article is not advocating that mirids not be controlled, but instead that as managers we consider the most appropriate timing, with control becoming more critical from very early flowering onwards. When the need to spray does arrive, consider using products with a lower beneficial insect disruption index. The relative ranking of insecticides for mirids can be found in the *2020-21 Cotton Pest Management Guide*.

#### For more

#### Cotton Pest Management Guide

[www.cottoninfo.com.au/publications/cotton-pest-management-guide](http://www.cottoninfo.com.au/publications/cotton-pest-management-guide)

# Keep a closer eye on whitefly with nymph monitoring system

A new silverleaf whitefly (SLW) sampling and spray-decision support system using nymph-based sampling is ready for use this 2020-21 cotton season.

In late July and August 2020, cotton pest management professionals in Queensland and NSW took their first good look at the new system, developed by a team of QLD DAF and CSIRO researchers led by Dr Richard Sequeira.

This system replaces the previous cotton industry SLW management guidelines, as outlined each season in the Cotton Pest Management Guide.

Key changes in the new system are:

- ◆ sampling of large nymphs (third and fourth instars/pupae with prominent red eye spots) within the lower canopy zone encompassing main-stem leaf nodes 11-14, instead of adults; and
- ◆ an Excel-based Decision Support Tool (DST) which provides chemical intervention decision support via a graphical visualisation of check-by-check data.

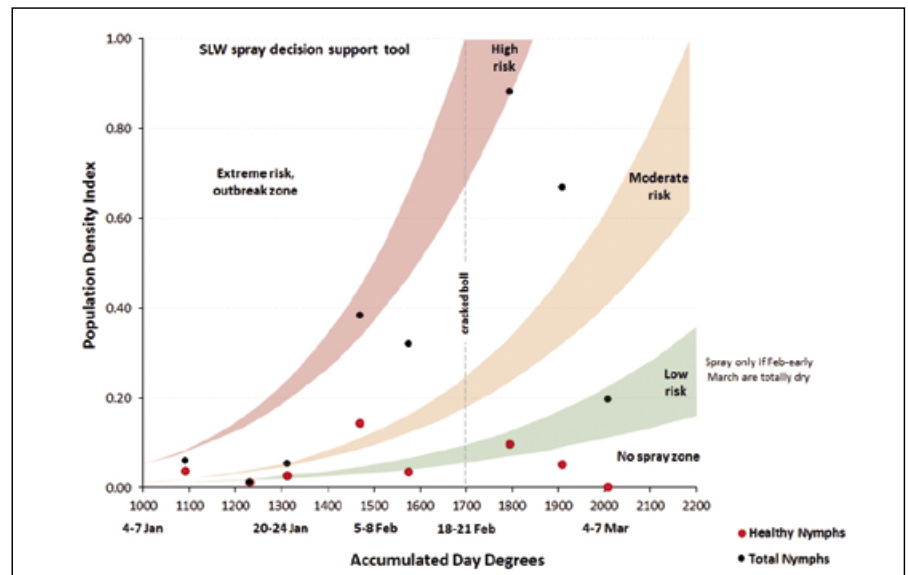
Richard says the new nymph-based system is superior in that it is largely free of the limitations (consistency, reliability, accuracy) of the previous adult-based sampling system and matrix.

“This system will require users to have a working knowledge of how to distinguish viable from non-viable nymphs.

“However once the eye is trained to distinguish between them, the sampling process becomes noticeably more efficient.

“A small investment in training and practice will yield large benefits.”

Richard says it was years of research and data collection that led to the change to sampling nymphs and including day degrees when calculating if control of SLW was required to manage the risk of



**Figure 1. DST visualisation of viable (red dots) and total (black dots) large SLW nymph (3rd and 4th instars/pupae with red eye spots) profiles over several checks from a commercial crop in NSW. The difference in height between red and black dots at any point in time is a direct measure of SLW mortality in the system.**

honeydew contamination.

“The new approach was conceptualised from several years of data on SLW population growth trajectories in cotton fields around Southern Queensland and NSW,” Richard said.

“Our analyses of non-linear trends revealed that when compared on the basis of day-degree accumulation (base 12), SLW nymph populations grew in strikingly similar ways - regardless of region or geographic location.

“As a result, most SLW population-trajectories from commercial cotton fields could be grouped into three distinct pathways which indicated the likelihood of honeydew contamination.”

Low growth (represented as green in the DST visualisation); moderate growth (amber); and high growth (red), are associated with low, moderate and high likelihoods of contamination if control is not undertaken.

The population trajectories that did not fit cleanly into the framework were indicative of substantial deviation, typically from the low or moderate growth pathways into the (higher) pathway above,

ostensibly as a result of flaring due to insecticide application primarily aimed at controlling mirids.

## Graphic visualisation

The Decision Support Tool gives the user a graphic visualisation of the trend in SLW population growth based on a ‘traffic light’ system, along with a quantitative measure of mortality inflicted by beneficial insects within the crop.

To use the system, with each SLW check, the counts of viable (healthy) and total (viable and non-viable) large nymphs on individual leaves, along with crop age expressed in accumulated heat units (Day Degrees; base 12), are entered by the user into the Excel workbook. The result is the creation of two population density (mean number per leaf) profiles: one for viable nymphs and another for total nymphs, superimposed on expected population growth pathways (Figure 1).

The density profile of viable nymphs and how it is tracking over several checks is the key criterion for making an intervention decision. The density of large nymphs at any point in time is a direct

measure of the adult population within the next one or two crops checks (three to seven days).

### The green pathway

Richard says the SLW management objective in using the DST should be to ensure that the profile of viable nymphs tracks within the boundaries, or not much above the upper boundary of the green pathway. A viable nymph profile tracking within or close to the bounds of the green pathway represents very low SLW population density, negligible risk of cotton lint contamination with honeydew and therefore indicates, under typical summer weather conditions (some rainfall in February and March), a ‘no spray’ situation.

The green pathway is a conservative indicator of low population density. Due to inherent variability associated with sampling, one or two data points slightly above the upper boundary of the green pathway does not constitute a ‘breakout’ and cause for concern that the population is increasing rapidly.

A consistent and sharp increase in viable nymph density above the green pathway over at least two checks (six to seven days) should be detected before a viable nymph population trajectory is deemed to have broken out.

### The amber pathway

Viable nymph profiles tracking within or close to the amber pathway of the DST represent populations growing at a moderate rate with a proportionate risk of cotton lint contamination at harvest. In cotton crops planted before the end of October in Southern Queensland and Central/Northern NSW, populations tracking along the amber pathway will become noticeably abundant by the middle of February, and experience exponential growth well inside the open boll stage.

This makes them hardest to manage from an intervention decision perspective because control measures need to be considered and initiated while lint is exposed to potential contamination with honeydew. Effective management of these populations will require more frequent sampling and adherence to the sampling recommendations to determine the population trajectory with greater



**Figure 2. Viable SLW 4th instar/pupae with prominent red eye spots (left) and a non-viable (parasitised) large nymph (right).**

The sampling protocol developed to generate data for the DST involves the sampling location within the canopy, the number of leaves to be sampled from each management unit and the methodology for recording SLW abundance.

There is no recommended cropping unit size for collection of the leaf sample. The reliability of data obtained from the leaf sample will depend on the number of leaves collected in relation to the size of the cropping unit and the distribution of SLW within that unit.

A sampling approach used in commercial crop checking last season used four entry points per field of 100 ha per check two on the head ditch side and two on the tail drain side, with 15 leaves collected at each entry point. For larger fields, two additional entry points x 15 leaves are added for every additional 50 ha after the first 100.

The definition of an effective cropping sampling unit is at the discretion of the user of this system. However, in general, the smaller the size of the sampling unit and the larger the number of leaves collected, the more reliable the data.

### SAMPLING PROTOCOL:

**Sample size:** 30 leaves collected by taking a “M” shaped path in the cropping unit and collecting one leaf from one plant in every third or fourth row. Note: At the beginning of SLW infestation (very low densities) increasing the sample size (up to 60 leaves) will improve detection and reliability of population estimates.

**Sampling location:** Leaf nodes numbered from the top down (First unfurled terminal leaf = 0)

**Option 1: (preferable)** 15 leaves at node 11 + 15 leaves at node 14

**Option 2:** 30 leaves picked randomly from the lower canopy ‘zone’ nodes 11 to 14

**Option 3:** 30 leaves at node 11

**Note:** For quick and easy sampling at nodes 11 and/or 14 – use the 1-5-8-11-14 rule; leaf nodes 1 (first fully opened leaf the size of a 50 cent piece) and 5 face away from each other; leaf nodes 5, 8, 11 and 14 are vertically aligned. With a bit of practice, finding the 11th or 14th nodes down the main stem of a cotton plant is relatively straight forward if the node 1 leaf is selected to point away from the sampler.

### For more

[www.tiny.cc/SLWsampling](http://www.tiny.cc/SLWsampling)

**Richard Sequeira**

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precision (confidence) and ascertain the potential contribution of beneficial insects in a timely manner so as to minimise what Richard calls the 'type one error – holding off spraying when intervention is warranted'.

### The red pathway

Early detection of SLW adults in the crop in the second half of January, much earlier than in moderate (amber) population scenarios, accompanied by above average temperatures over several days and low/negligible rainfall, are typical harbingers of populations tracking along the red growth pathway.

Viable nymph density profiles will exhibit rapid exponential growth well before the beginning of the open boll stage (second half of February). Although these populations represent the highest risk of lint contamination, they are also the most predictable and easier to manage than the amber group for several reasons.

- ◆ The crop manager has much more time to develop and execute a well thought out control strategy prior to the open boll stage.
- ◆ The absence of open cotton during the early stages of exponential population growth reduces the risk of lint contamination in the event of inadequate control from spraying.
- ◆ Insect growth regulators (IGRs) and similar products that exert control by minimising population recruitment can be used to greater effect prior to canopy closure which is the most appropriate time for deployment of such products.
- ◆ Early use of IGRs enhances the contribution of beneficial arthropod communities to SLW control, thereby enhancing the overall efficacy of the control strategy.

The population density profile for total (viable and non-viable) nymphs (black dots) generated by the DST indicates the average number of non-viable large nymphs in the leaf sample for that check. The difference in height between the red and black dots at each check represents the amount of mortality due to beneficial insects, microbial agents and other causes of death, and serves as supplemental information on increasing/decreasing or nil mortality in the system which can then be used to inform the intervention decision.

For example: if the viable nymph profile appears to have broken out of the green pathway but the divergence between red and black dots is also increasing, mortality is therefore clearly increasing; a smart decision would be to hold off spraying, continue sampling and give the established beneficial insect population time to drive down the profile of viable nymphs back into the green zone.

### Southern populations

Data collected in the 2019-20 season from cotton growing areas in Southern NSW (Coleambally, Forbes, Hillston) showed a small number of SLW populations tracking the amber growth pathway, possibly as a consequence of insecticide use for mirid management.

"This result highlights firstly the broad applicability of the new SLW management system, and secondly the fact that cotton crops in the far south are not completely free of lint contamination risk resulting from SLW infestation," Richard said.

## More information

- For information on the new sampling method, a fact sheet and Decision Support Tool will be available in early 2021 from the CottonInfo website or by contacting your local Regional Extension Officer (REO). [www.cottoninfo.com.au](http://www.cottoninfo.com.au)

# Species and resistance suspect: Why mites

The thing about mites is how readily they form resistance.

There are three species of *Tetranychus* spider mites found in Australian cotton crops: two-spotted spider mite (*Tetranychus urticae*), bean spider mite (*T. ludeni*) and strawberry spider mite (*T. lambi*).

From the 1970s to the 1990s, cross-resistance within the organophosphate (OP) insecticidal class caused high levels of resistance in two-spotted mite and to a lesser extent, in bean spider mite populations to certain OP products before commercial release, which was highly suggestive of cross-resistance to current or formerly registered products.

OPs used against *Helicoverpa* species also increased selection pressure in mites resulting in increased resistance and reduced product efficacy. Similarly, over-reliance on the synthetic pyrethroid bifenthrin to control *Helicoverpa* species in cotton resulted in 90 per cent of two-spotted mite strains testing positive for pyrethroid resistance.

The uptake of transgenic cotton and industry adoption of more highly selective chemical control options has helped avoid scenarios of cross-resistance and lowered selection pressure. However, resistance continues to be detected in currently registered products that are primarily or exclusively for mites.

Low levels of resistance to propargite have in the past been reported in two-spotted mites from cotton, and recently detected etoxazole resistant two-spotted mite populations have been identified in fruit trees. Of concern to the cotton industry is the scenario of prophylactic spraying mites in conjunction with mirid sprays, which was found by cotton entomologists Grant Herron and Lewis Wilson to be responsible for increased resistance to abamectin in two-spotted mite.

With the track record of two-spotted mite for resistance development and

# Resistance status might be different to what you think it is. Mites continue to be on the research radar

the current levels of resistance to key control products, the Insecticide Resistance Management Strategy (IRMS) and integrated pest management (IPM) practices are invaluable for extending the useful life of these products.

## Understanding mite populations

The ability to accurately assess pest and beneficial populations and their impact on crop physiology is pivotal to making informed crop management decisions within the IPM framework, however knowledge gaps exist in spider mite ecology in the field and economic thresholds for control. Giving growers and consultants a better understanding of the Australian cotton mite complex in terms of damage and cohabitation can further heighten awareness of optimising the timing of spray applications and enhancing IPM.

To improve understanding, CRDC supported honours candidate Chris Shafto of NSW DPI to compare the damage to cotton caused by each spider mite species and further investigate mite ecology. His research showed that two-spotted mite has far greater ability to cause damage than its two counterparts.

Spider mites damage cotton by feeding on individual leaf cells, removing the cell contents. Two-spotted mite has been extensively researched in cotton and can reduce photosynthetic capacity and stomatal conductance and ultimately lead to decreased yield and fibre quality. However the damage potential and ecology of bean spider and strawberry spider mite had not been comprehensively investigated prior to Chris's research.

Chris found that two-spotted mite caused twice the level of damage as bean spider mites and three times the damage of strawberry spider mite. Damage caused by strawberry spider mite was never significantly different from control plants where mites were excluded. In the experiments, only the plants infested with two-spotted mite defoliated.

The other key finding was that the



**ABOVE:** Female strawberry spider mite  
**ABOVE LEFT:** Female two-spotted spider mite  
**LEFT:** Female bean spider mite

relationship between damage and mite numbers varied depending on species. Chris showed that even when numbers of bean and strawberry mites were at very high levels they still did significantly less damage than relatively lower numbers of two-spotted mites.

"Chris's research further supports previous findings that mite damage potential is significantly greater for two-spotted mite, which demonstrates that economic thresholds for two-spotted are not applicable to strawberry or bean spider mite," NSW DPI's Dr Lisa Bird said.

"This highlights the importance of correct mite identification for targeting two-spotted mite and therefore avoiding the unnecessary use of chemical control of the other species.

"Season-long monitoring and targeted control of two-spotted mite will reduce selection pressure for resistance."

Results from Chris's laboratory competition study suggest strawberry spider mite is unlikely to have the capacity to suppress or displace two-spotted mite (as had previously been postulated) and other factors may be contributing to

changes in mite species' complex.

"It could be influenced by interspecific interactions: changes in cotton pest management over the last two decades has likely benefitted species such as bean and strawberry spider mite, as it has done for many other pests and beneficial insects," Chris says.

"This was an unexpected result as two-spotted mite is considered to be declining in incidence across cotton growing regions and suggests environmental factors are contributing to the changing mite species complex."

Field surveys determined the distribution of strawberry spider mite within the cotton canopy to assess the relevance of the current mite sampling protocol for this species, indicating that the current sampling protocol would be reliable for late season sampling as mite abundance was very similar throughout the canopy. The survey also detected bean spider mite for the first time in recent years in cotton, and in the same fields as an established population of strawberry spider mite.

Chris says resistance in two-spotted

mite remains an ongoing risk requiring management.

“Over the years, resistance screening has continued to add chemistries for which resistance has been detected in Australian populations of two-spotted mite,” he said.

“The IPM strategy for cotton is continually evolving and improving the management of mite populations will optimise the cost of effectively and sustainably managing them.

“Bean spider mite does have a demonstrated history of resistance development from a few decades ago, however bean mite remains largely absent from cotton crops with no clear reason why.

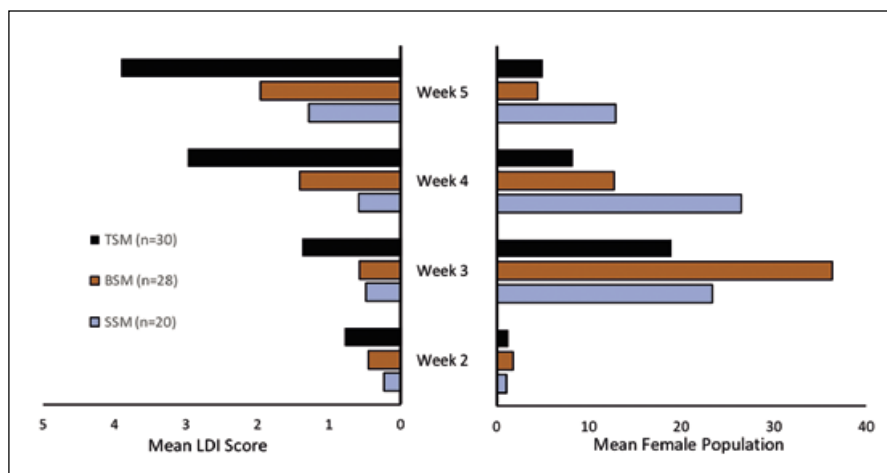
“Meanwhile, there has not been any evidence of resistance detected to date for current chemistries in strawberry spider mite.

“However we shouldn’t underestimate the ability of bean and strawberry spider mite in developing resistance, hence correct identification and knowledge around economic thresholds is essential.”

### Best management of mites

Best management of spider mites requires season-long monitoring of the crop and targeted control.

When broad-spectrum insecticides and prophylactic sprays are used instead of selective options to control pests earlier in



This figure shows the leaf damage caused by each mite species over four weeks on the same leaf which initially had two adult females transferred onto it in week one (left hand side). The right hand side is the adult female population each week on that same leaf where damage was recorded.

the season such as mirids, beneficial insect populations can be negatively impacted which increases the risk of additional pest outbreaks (flaring) and development of resistance. The negative impact of flaring other pests is well acknowledged throughout the cotton industry.

Thrips are an important component in early season IPM because they are extremely effective predators of mite eggs for the rest of the season, helping keep mite populations below threshold level, therefore the early season foliar control of thrips should be limited and based on regional thresholds to reduce the risk of flaring mites later in the season. This approach can be compromised when controlling mirids using fipronil, which is also active against thrips.

Prophylactic spraying for mites also

needs to be avoided as there are a very limited number of management options and resistance remains a concern.

“The situation highlights how important an integrated approach involving regular pest sampling, using economic thresholds and careful consideration of selective insecticides is to pest management in cotton,” Lisa said.

“Correct identification of spider mites is also crucial for maximising the cost-effectiveness of mite control and for managing resistance.”

Carefully monitor for the abundance of two-spotted mite, as early detection of any species and consistent leaf sampling throughout the season to monitor populations will always be key to making the best decision. At the time of sampling, the type of damage and severity should be taken into consideration and may aid in identifying what species you are predominantly dealing with.

If above-threshold presence of two-spotted mite is confirmed, use an alternative miticide to reduce selection pressure on abamectin such as propargite or diafenthiuron (for which resistance risk is currently at very low levels) and consider including petroleum oil in sprays for mite suppression. Over time, this will increase the likelihood of regaining susceptibility to abamectin.

Identification tips for spider mites can be found in the Cotton Pest Management Guide, available on the CottonInfo website.

### For more

[www.cottoninfo.com.au/publications/cotton-pest-management-guide](http://www.cottoninfo.com.au/publications/cotton-pest-management-guide)

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## Abamectin resistance elevated

Industry-wide resistance monitoring in 2019-20 showed mite abundance was generally low. However, according to NSW DPI’s Dr Lisa Bird, there was late season two-spotted spider mite activity in the Gwydir region with above-threshold populations reported in some fields.

- No resistance to propargite or diafenthiuron detected.
- Abamectin resistance continues to be elevated, particularly in the Namoi and Gwydir valleys.
- Abamectin resistance was detected in all populations from the Namoi and Gwydir tested. Resistance within individual populations ranged between 11 and 31 per cent.
- The reason for continued high frequency of abamectin resistance is likely related to its use as a prophylactic treatment in combination with mirid sprays.
- If mirids are present, growers are encouraged to avoid the use of abamectin and base their spray decisions on effective mirid sampling, the use of thresholds to avoid unnecessary applications and the use of selective options for mirid control that will reduce the risk of mite outbreaks.

### For more

Lisa Bird

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COMMENT: WITH CROP CONSULTANTS AUSTRALIA



Consultant Dallas King (foreground) with (from left) QLD DAF's Hugh Briar and Professor Roger Stone of USQ talking potential future scenarios in crop management.

DAVID KELLY

# Tackling the 'what-ifs' of agriculture

In 2019, Crop Consultants Australia started planning their 2020 events. Little did they know that what they were coining as the 'big' issues impacting on Australian agriculture would hardly be a blip on the radar of 2020.

As 2020 unraveled, bushfires were followed by the arrival of the fall armyworm, which was then outdone by COVID-19 and resultant lockdowns and border closures. One thing however became apparent: despite all the planning in the world, sometimes you cannot foresee what is going to shape the season or, for that matter, your lifestyle and profession. You can however, control how you react.

This year has not seen much in the way of face-to-face events, but despite an unsure start, Crop Consultants Australia

were one of the lucky ones to run just one of their regional workshops in early September in Goondiwindi. A sell-out crowd of 30, socially-distanced participants and 100 more on-line participated in a day focused ironically upon visioning and dealing with the 'what-ifs' faced by Australian agriculture.

Potentially one of the more controversial topics of the event was explored by Paul McIntosh (Pulse Australia and WeedSmart) and QLD DAF's Dr Paul Grundy as they unpacked 'What if we need to farm without glyphosate and other chemistries?'

Both Pauls highlighted that government agreements, international market demands and limitations, including maximum residue levels (MRLs), and international and domestic social pressure was leading to increased vulnerability of some of the most commonly used cotton chemistries.

Since 1996, glyphosate use worldwide has grown exponentially, and it has undoubtedly transformed the farming systems of not only cotton, but most broadacre crops in Australia.

"It is our most widely used herbicide, and consultants and



growers need to take up the challenge on behalf of industry and defend the ongoing use of glyphosate,” Paul McIntosh said.

He underlined that while the science confirming the safety of the product was ‘on our side’, use and availability of the chemical is now under critical scrutiny and industry needs to accept that it could be facing a glyphosate free future.

Calling for consultants to develop not only a Plan B but a Plan C, Paul encouraged participants to reconsider the opportunities to implement alternative and currently less conventional weed control including mechanical options, the implementation of sensing technology and even the reintroduction of livestock rotations. His message was clear, that forewarned is forearmed, and the need was real for growers and agronomists to be actively seeking workable solutions.

Paul Grundy reiterated that while the cotton industry was heavily reliant on glyphosate, it was not the only chemistry whose future the industry needed to contemplate. In response to this concern, CRDC have been working on the Cotton Industry Pesticide Loss Preparedness Program, in order to recognise potential chemistry losses, and identify and facilitate adoption of alternatives.

Among other common chemistries, the program is focusing on the cotton industry’s reliance upon fipronil, diuron, and dimethoate. Paul again highlighted the importance of industry members advocating for the retention of these chemistries for as long as possible. He also encouraged the industry to continue the discussions around alternatives through feedback to CRDC and Crop Consultants Australia and to consider the bigger picture of continued reduction of overall chemical use and the impact of sprays on beneficials.



MELANIE JENSON

How adaptive management could play a stronger role in farming systems management is being explored in a CRDC-funded project.

Along with his team, Paul has been exploring the impact of early boll retention on overall yield. While research will continue this season, indications are that the fruiting behaviour of the Bollgard 3 plant is substantially different to that of conventional cotton. The plant’s own ability to compensate for early yield losses, could provide an opportunity to reduce early sprays, without substantially impacting on final yield.

A discussion around ‘what ifs’ would not be complete without the impact of changing climatic patterns on our production systems. Well-recognised climate researcher Professor Roger Stone and his team from USQ gave attendees an insight into how climate change research is informing not only industry, but its associated financial and insurance sectors. Theirs was an important point; that risk management strategies need not come solely from production practices and that financial ‘scaffolding’ through risk insurance is set to become a norm in mainstream agriculture.

While an awareness of what could be coming our way is advantageous, both Chris Teague from CSD and Dr Claire Welsh from CSIRO gave participants an insight into how they could have a better handle on how such issues impact on farming systems. CSD has developed a range of online tools to assist growers and consultants to benchmark their production system and support management decisions. The tools are available online to CSD members for an annual membership of \$20. One of the latest arrivals in the suite – known affectionately as BARRY, boasts the ability to remove much of the guesswork out of yield prediction and ultimately, profitability. Likewise, it is hoped that their newest project, Cotton Tracka, which is currently in Beta testing phase, will prove to be a vital tool for growers and consultants to capture crop metrics and aggregate automated climate data.

The application and implementation of all of this prementioned knowledge, and how it impacts upon decision making, is integral to the work of Claire Welsh. In an extension of her prior PhD work, in her CRDC funded Modern Systems Agronomy for Resilient Cotton Project, Claire will examine how adaptive management could play a stronger role in our systems management. The project will look at how growers and other decision makers could potentially be more flexible and responsive to the variabilities that typify Australian cotton production systems including (but not limited to) climate and water availability.

Crop Consultants Australia is keen to hear the outcomes of this project which is just in its early stages. At its heart, Claire’s project is all about always having the ‘Plan B.’

#### For more

Crop Consultants Australia Inc has made the livestream recordings of the workshop available to public users on its YouTube channel.

[www.tiny.cc/CCAYoutube](http://www.tiny.cc/CCAYoutube)

# Podcast project targets fall armyworm

The rapid progression of fall armyworm south from Northern Australia into Southern Queensland and Northern NSW is a reminder of why all crop managers need to be aware of this newly arrived pest across all regions.

Creating an important resource for growers around Australia, the Plant Biosecurity Research Initiative (PBRI) recently launched a series of podcasts for crop managers featuring first-hand experiences with fall armyworm, its impact and management since arrival in the country this year.

Co-ordination of high priority biosecurity RD&E across Australia's plant industries is a primary aim of PBRI, which is a partnership between the nation's plant Research and Development Corporations working collaboratively with Plant Health Australia (PHA), the Department of Agriculture, Water Resources and the Environment, industry, and state and federal biosecurity stakeholders.

The PBRI podcast project was led by CRDC with co-funding from Hort Innovation, AgriFutures Australia, the Grains Research and Development Corporation, and Sugar Research Australia.

The podcasts feature interviews with:

- ◆ growers and agronomists on their first-hand experience in managing new and emerging pests;
- ◆ leading Australian researchers on their latest findings and observations; and
- ◆ international experts who share their experiences and learnings.

PHA National Manager for Preparedness and RD&E, Stuart Kearns said the podcasts have been developed to support grower awareness and management options following the arrival of fall armyworm.

"Each podcast delivers an understanding of the biology and

***"The extent to which this pest could disrupt cotton growing is still hard to predict."***

behaviour of fall armyworm and explores how we can best prepare ourselves to minimise the impact," Stuart said.

Fall armyworm was first found in January 2020 in Northern Queensland and has since been reported in far north Western Australia, Northern Territory, South-East Queensland and most recently, Northern NSW.

Fall armyworm has not been detected in Bollgard or conventional cotton crops in Northern Australia. NT DPI host preference trials led by Dr Brian Thistleton also found no evidence for fall armyworm moths laying eggs in field-grown cotton plots, however in lab studies were able to show they could survive on conventional cotton.

The cotton industry remains alert not alarmed.

"As the pest becomes established in the Australian environment, the extent to which this pest could disrupt cotton growing is still hard to predict," CRDC R&D Manager Susan Maas said.

"While not currently affecting Bt cotton, fall armyworm's appetite for corn and other rotation crops used could upset our cotton farming systems.

"Corn, for example, has been a valuable tool in controlling Verticillium wilt in cotton.

"We also know from overseas experience there are fall armyworm strains that have more of a host preference for cotton, and this incursion has highlighted the potential range and threat should these strains make it to Australia.

"For this reason, CRDC continues to partner with other RDCs and invest in research and extension for fall armyworm."

Determining how to best manage fall armyworm is a priority, as the Consultative Committee on Emergency Plant Pests concluded in February this year that fall



PAUL GRUNDY

**Fall armyworm has been feeding on corn, an important rotation crop for some cotton farmers.**

armyworm is not technically feasible to eradicate from Australia. This is due to the pest's reproductive capacity, ability to fly long distances, wide host range, spread of known infestations, and potential for re-infestations from Australia's northern neighbours.

The Australian Pesticide and Veterinary Medicine Authority (APVMA) has issued a number of permits for the control of fall armyworm, and is currently assessing additional applications for permits as a priority. Permit information is available from the APVMA website. Readers are encouraged to report any unexpected symptoms in the field by phoning the Exotic Plant Pest Hotline on 1800 084 881, or contacting their local CottonInfo REO.

#### For more

##### Podcasts

[www.pbri.com.au](http://www.pbri.com.au)

##### APVMA

[www.apvma.gov.au](http://www.apvma.gov.au)

# Preparedness is key in biosecurity plan

While no longer formally classified a high priority exotic pest by the Australian cotton industry, the brown marmorated stink bug (BMSB) is still classified as a biosecurity threat.

BMSB are primarily a pest of orchard and viticultural crops and considered a high priority pest for Australian agriculture generally, as once established are difficult to eradicate. Control methods overseas predominantly rely on broad-spectrum insecticides, an approach that would negatively affect Australian cotton's integrated pest management (IPM) program and increase the risk of secondary pest outbreaks.

The University of Queensland's Dr Dean Brookes, via a CRDC project, has been reviewing the threat posed by high priority exotic insect species of Australian cotton, including BMSB.

BMSB was first identified as a high priority exotic pest for the Australian cotton industry in 2015 during a regular review of the Cotton Industry Biosecurity Plan by the Industry's Biosecurity Reference Group. This year, based on a better understanding of the potential yield impacts BMSB has (in comparison to

other endemic stinkbugs) through Dean's research, BMSB has been reclassified and is no longer classified as a 'high priority' exotic pest. BMSB is, however, still a biosecurity threat for the Australian cotton industry.

## BMSB in cotton

"If BMSB was to establish in Australia, the extent to which BMSB would be attracted to cotton and become a major pest is unclear," Dean said.

"Internationally, cotton does not appear to be a primary host for BMSB, but has been recorded in cotton crops in China and the US, however, the extent of feeding, damage and economic significance is often omitted from reports linking BMSB to cotton production."

Insights from overseas suggest that regional cropping outside of cotton will be an important factor for the number of BMSB we would see in cotton crops.

"Primary hosts, including orchard



The exotic brown marmorated stink bug is a biosecurity threat.

crops and corn, are likely to be important for the development and build-up of BMSB populations, particularly during their initial spread into a region in the event of an incursion and before populations are brought under control in other crops," Dean said.

"Significant damage is seen in cotton crops in some parts of the US where BMSB can develop on other nearby crops like corn before moving into cotton.

"We are keeping an eye on the status of BMSB in cotton, as the pest becomes more established internationally."

The damage to cotton caused by BMSB feeding is likely to be occasional and similar to other stinkbugs such as green vegetable bugs, and dependent on other cropping in the region. Stinkbugs can be difficult pests to manage within IPM programs, as once pest populations surpass economic injury levels the only control options are broad-spectrum insecticides. Several insecticide

## Man's best friend and ag biosecurity defender



The Department of Agriculture, Water and the Environment has been working with researchers to train detector dogs to turn their noses to a new target – the brown marmorated stink bug (BMSB).

Australia's biosecurity detector dogs are a critical part of frontline defence against exotic pest and disease risks from overseas. At the border, highly trained detector dogs work alongside their human counterparts to sniff out potential risks that could arrive with incoming cargo, mail or passengers. In 2019, Australia's biosecurity detector dogs intercepted more than 56,000 biosecurity risk items at Australia's international airports and mail centres.

University of New England masters student, Ariella Moser, has been conducting research on new methods for training biosecurity detectors dogs. The dogs are trained on over 200 hundred different commodities, but not insects until now.

### For more

Ariella Moser

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registrations overlap with products reported in overseas studies to be effective on BMSB and therefore it is likely that BMSB is a controllable pest within Australian cotton farming systems.

The cost of green vegetable bug registered products is relatively low, however the use of these products is highly disruptive to natural enemies with broad-spectrum insecticides in cotton often resulting in the outbreaks of secondary pests such as silverleaf whitefly and mites.

“US studies have also shown that there is a wide range of generalist predators of BMSB,” Dean says.

“The insect groups identified in studies are also found in Australia and would have the potential to contribute to the biological control of BMSB as part of a sound IPM program.

“However, as a biosecurity threat to cotton and a high priority exotic pest for Australian agriculture, prompt reporting of suspected BMSB sightings or anything suspicious on farm is essential for giving the agricultural industry the best chances of eradicating or containing BMSB and other exotic pests.”

To develop comprehensive approaches to managing biosecurity risks such as BMSB, Cotton Australia works on behalf of the industry with Plant Health Australia and convenes the Cotton Industry Biosecurity Reference group. The group considers categorisations of exotic pests that could impact the Australian industry and develop the Cotton Industry Biosecurity Plan.

### BMSB ID Guide

Australia has native stinkbugs that may be present in cotton crops which look similar to BMSB. CottonInfo has developed a BMSB ID guide to help identify key features of the exotic BMSB via *Endemics to Exotics: Brown marmorated stink bug* on the CottonInfo website.

#### For more

[www.cottoninfo.com.au/publication-type/id-guides](http://www.cottoninfo.com.au/publication-type/id-guides)

#### Dr Dean Brookes

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# Diversifying smart plant surveillance

Australia’s plant industries, including CRDC, have joined forces to change the way airborne pests and diseases are detected.

The iMapPESTS: Sentinel Surveillance for Agriculture project is investigating advanced pest and disease surveillance and diagnostics technologies, including custom-designed mobile surveillance units (Sentinels) that incorporate specialised trapping equipment and technology to capture airborne samples to identify high priority pests and pathogens.

The surveillance and identification will provide actionable information to primary producers and government, on endemic, established, trade sensitive or exotic pests. This project is supported by Hort Innovation through funding from the Australian Department of Agriculture, Water and Environment as part of its Rural R&D for Profit Program and funding from 16 partner organisations including CRDC.

The prototype Sentinel was deployed to Far North Queensland in early 2020, however due to COVID-19 it was returned to its base in Adelaide. The team took advantage of the situation by examining early learnings and samples to adapt the units. The Sentinels have now been adapted to provide a more-effective, flexible range of options to meet various industry needs and will be deployed at strategic locations around the country in 2021 for trials.

### Identifying what’s in the air

The early trials highlighted the importance of a combination of traditional identification methods and modern techniques. The researchers have investigated the capacity for molecular ID and quantification of in-field samples.

Molecular testing can deal with large numbers of samples rapidly and accurately, but only identify species for which tests have been developed and molecular tests for many pests and pathogens do not yet exist. The iMapPESTS project includes the development of more diagnostic tests using next-generation sequencing by AgVic, Sugar Research Australia and the University of Queensland (UQ).



Researchers with the Sentinel 4.

While the Sentinels trap airborne pests and pathogens, researchers are trialling new and emerging diagnostic tools that aim to speed up the delivery of accurate information on what exactly is captured. In addition to speeding up accurate reporting of target pests, the iMapPESTS diagnostics collaboration is using high throughput sequencing to investigate ways to report on a wider range of insects captured by the Sentinels, including pests and beneficials. These techniques have the potential to monitor for pests and vector-borne diseases of biosecurity interest to the industry.

With support from CRDC, Dr Dean Brookes of UQ will develop cotton species-specific contingency plans for high-priority insect species, and a boll weevil surveillance and eradication plan. In addition, new methods will be developed to analyse the gut contents of high priority pests to better understand their feeding habits, such as the plants they may take refuge in once a crop is harvested, or their preference for one crop over another. This research will inform and better prepare Australia’s cotton industry for the arrival of any high-priority insect species.

Growers are encouraged to provide feedback on this project, including what information is important and relevant by contacting Shakira Johnson at AUSVEG.

#### For more

[www.imappests.com.au](http://www.imappests.com.au)

#### Shakira Johnson

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# Heat and microbes dictate nitrogen loss

How long does nitrogen stick around in irrigation water when water-running urea?

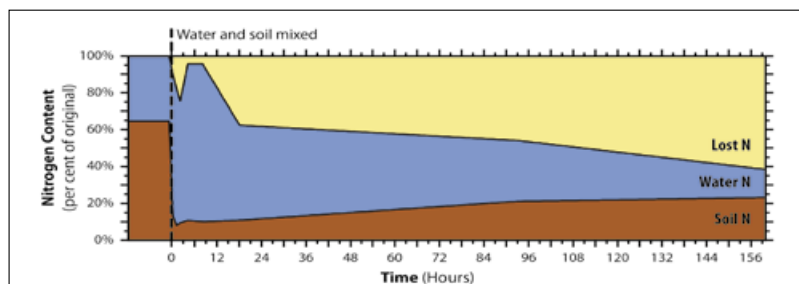
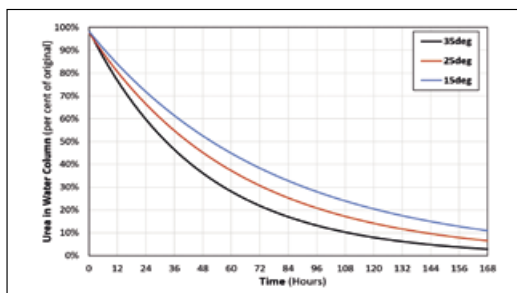
Water-run urea is an effective way to supply in-season nitrogen (N) that minimises labour and infield traffic. It is popular among cotton growers, being used by almost half (46 per cent) of irrigators in the 2016-17 season.

As N-rich water runs over the field during fertigation, most of the dissolved N soaks into the soil along with the irrigation water. When it is off the field in irrigation networks or storage dams, however, the dissolved N is steadily lost to the atmosphere. For growers to successfully manage dissolved N and improve nitrogen fertiliser use efficiency (NFUE), they need to know how quickly dissolved N is lost, and how long they have to recirculate it back onto a field.

CRDC-supported PhD candidate James Latimer undertook a pilot study (*Spotlight* Winter 2018) demonstrating that living soil microbes are the driving force behind urea mineralisation in fertigation water. The results were used to design a much larger study to determine the rates at which urea mineralises at different temperatures.

Urea is chemically stable as a solid, but quickly reacts when dissolved in water that interacts with the soil. Urea begins mineralising to ammonium as soon as it dissolves, which in turn starts converting to nitrate within a few hours. If not immobilised in

**Figure 1. Reference chart for predicting urea mineralisation rates in soil-water systems at three water temperatures. Figure is based on experiment using Narrabri vertosols in deionised water with starting urea concentration of 25 mg N L<sup>-1</sup> (ppm). Mineralisation rates may differ on different soils and starting urea concentrations.**



**Figure 2. Nitrogen partitioning between soil exchangeable N and water over time in a sealed incubation vessel. The 'Lost N' fraction is calculated based on mass totals and represents all unaccounted-for N, which may include gaseous losses and soil microbe uptake. Most of the exchangeable soil N moves into the water when the two are mixed at time = 0, prior to which the water contained only 25mg N/L in the form of urea. The exchangeable soil-N fraction is composed of nitrate, ammonium and dissolved organic nitrogen (DON). The water fraction is composed of urea, nitrate, ammonium and DON.**

the soil, these inorganic forms of N can be lost to the atmosphere as ammonia, nitrous oxide, or dinitrogen.

Depending on when and where urea is added to the main irrigation supply, it can spend hours in the irrigation network before being applied to the crop. At the other end of the field, N-rich tail water can spend days or weeks in irrigation networks and storage dams before being reapplied to another field. All this time the N is being lost to the atmosphere, but how fast?

Most of the time, irrigation water is between 10°C and 40°C. Within this window, urea mineralisation rates increase with temperature as the microbes mediating this reaction becoming more active (Figure 1). This means that N will be lost from irrigation waters faster in January than in October. As irrigation water moves over the field it picks up soil N, especially when passing through the hill from the irrigated-furrow to the non-irrigated-furrow. This soil-water interaction makes determining exactly how long added fertigation N sticks around in the water quite difficult.

"We can, however, make a pretty good estimate based on these results," James says.

Almost 60 per cent of the water N and exchangeable soil N was lost to the atmosphere or utilised by the soil microbiology within a day (Figure 2). In rice paddy systems, measured denitrification losses of applied urea range from 10 to 50 per cent after 10 to 20 days, suggesting that the majority of our unaccounted-for N could be gaseous losses rather than microbial uptake.

"In order to reduce N losses, growers should minimise the time dissolved N spends off the field in irrigation networks and dams," James says.

"This means dissolving fertilisers in the irrigation water as close to the field as practicable, and recirculating N-rich tail water as soon as possible.

"Gaseous N losses are highest eight to 18 hours after dissolution, with N-rich waters preferably on the field during this window to immobilise these emissions.

"Ideally, growers would also try to reduce the amount of runoff as this commonly carries significant fertigation and soil-derived N into the tail drain."

N runoff during a fertigation event can easily exceed 15kg N/ha. For 1000 hectares and urea at \$400 per tonne, that's \$13,000 worth of fertiliser per irrigation event flowing into the tail drain.

"Unfortunately, it is hard to avoid significant tailwater runoff in alternate furrow irrigation configurations and will likely require significant management change to reduce," James said.

"Regardless, reducing the time dissolved N spends off the field will save on fertiliser costs and help the industry improve its NFUE."

## For more

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# Fighting verticillium using an unlikely ally

Ground-breaking honours research by Aphrika Gregson at NSW DPI is using fluorescence created by jellyfish to uncover the resistance mechanisms in Verticillium wilt.

Verticillium wilt, caused by the soilborne fungus *Verticillium dahliae*, is one of the most challenging and economically significant diseases of cotton in Australia and worldwide. Host resistance is regarded as the most effective control strategy, however the biological complexity of the pathogen and a lack of knowledge regarding the mechanisms of resistance hinder plant breeding efforts. Through her CRDC-supported honours degree, Aphrika has been using a new technique in the study of plant-pathogen interactions: the genetic modification of fungi to express the green fluorescent protein (GFP) from the jellyfish *Aequorea victoria*.

Aphrika says GFP-tagged *V.dahliae* is a highly controlled, simplified approach to the study of plant pathogen interactions. Previous studies have utilised GFP-tagged isolates of *V. dahliae* to investigate the host-pathogen interaction on cotton, providing insights into the host resistance-response and little understood areas of the disease cycle.

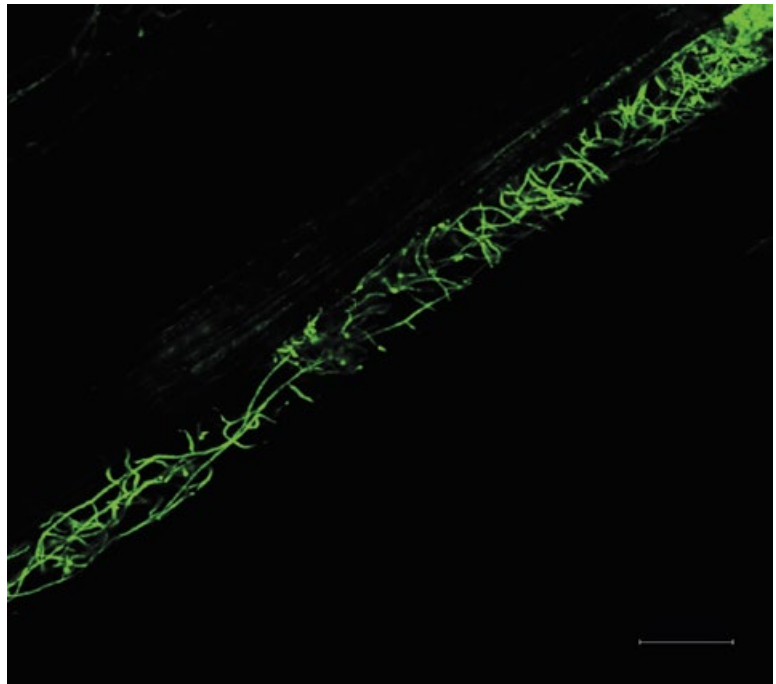
Previous studies almost exclusively used isolates belonging to the vegetative compatibility group 1A, which belong to the defoliating strain of Verticillium. However there are several genetically distinct populations of *V. dahliae* present in Australia, and predominantly non-defoliating isolates are recovered from severely affected plants across NSW.

“At the University of Queensland, we were successful in generating GFP-tagged *V. dahliae* from local isolates,” Aphrika said.

“Excitingly, this allowed us to use GFP-expressing isolates as a tool in studying infection and colonisation on Australian cotton cultivars.”

What the researchers found confirmed existing descriptions of infection on cotton.

Using a non-defoliating isolate recovered from severely affected cotton from the Namoi Valley to inoculate cotton seedling roots, *V. dahliae* spores had germinated and begun infection only 24 hours after inoculation.



Using confocal microscopy, researchers managed to capture an infection peg, the beginning of a potential systemic infection, where a swollen hyphal tip assists penetration into root tissue. Over seven days, the research observations agreed with existing reports that the root tips offer a route of entry for the pathogen. Verticillium wilt is a vascular pathogen, so once the plant roots are invaded, hyphae, the branching strands of the fungus, will grow toward the phloem and xylem vessels. The xylem is a niche for vascular wilt pathogens, and the researchers observed significantly high levels of proliferation throughout xylem vessels in both a susceptible and a tolerant cotton variety one week after plants were first infected. In one observation, the pathogen had reached the leaf petiole by seven days.

“This work was exciting in that our observations fit with the larger body of work into understanding *V. dahliae* as a pathogen of cotton, and because of this, what I think is most valuable from this honours project is having established a tool to continue deepening our understanding of this disease in an Australian context,” Aphrika said.

“This was an innovative and highly collaborative project, involving researchers from CSIRO, QLD DAF and the University of Queensland, and I’m very grateful to CRDC and NSW DPI for the opportunity and support throughout.”

**Fluorescence in *V.dahliae* hyphae and spores within a xylem vessel of a cotton seedling root seven days after inoculation.**



WARWICK WATERS

## Adapting to change, rising to challenges, investing in innovation

This year has thrown some unforeseen circumstances at us all, yet agriculture remains constant. Our primary producers continue to do what they do best: there are crops to plant and harvest, with some recent promising rainfall across many of our drought affected regions. Likewise, despite the challenges and dynamic circumstances, the research conducted by our world-leading team of Australian cotton scientists and researchers also continues, through the investment provided by CRDC.

In this special *Spotlight* feature, the CRDC Annual Report review, we take a look at some of the highlights of the 2019-20 year.

**A note from CRDC's Dr Ian Taylor**

The 2019-20 year marked the second year of investment under our CRDC Strategic RD&E Plan 2018-23.

During this year, we continued to focus on our strategic priorities – increasing productivity and profitability of Australian cotton farms; improving cotton farming sustainability and value chain competitiveness; building the adaptive capacity of the Australian cotton industry; strengthening partnerships and adoption; and driving RD&E impact.

We invest in these areas to ensure our cotton growers, our communities, and the wider industry are all prepared to manage challenges and capitalise on opportunities. If the COVID-19 pandemic has shown us anything, it is how prepared we are as an industry to adapt to change, challenges and uncertainty. Building adaptive capacity is a core part of our Strategic Plan 2018-23 as we recognise our environment is dynamic, and we must be also. Through sound and innovative research and support for our research community, growers and industry, we aim to support the future success of Australian cotton.

A major component of our work during 2019-20 has been the completion and release of our industry's second Sustainability Report with Cotton Australia. This report has been five years in the making, and it reflects how important we as an industry view the impact we have: environmentally, socially and economically.

The report looks at eight critical areas for the industry – water, carbon, biodiversity, pesticides, quality of work life (safety, diversity and training), wellbeing and social capital, efficiency, and profitability – all areas that we invest in to ensure continuous improvement. It's a shared responsibility, and we pride ourselves on the strong relationships that we have with our growers, researchers, government and other core partners, and the work that we're doing to extend, adopt or commercialise our research.

Collaboration is at the very heart of everything we do. Partnerships and co-investments, both within the cotton industry and with other industries, deliver transformational outcomes. There isn't a single research project we invest in that isn't delivered in partnership with our growers, researchers and collaborators. We also partner with those outside our sector to solve issues that are bigger than cotton alone. In 2019-20, 48 per cent of CRDC's investments were in cross-sectoral RD&E.

You can find more detail in our *2019-20 Annual Report* and *Performance Report*, both of which are available via the publications section of our website: [www.crdc.com.au/publications](http://www.crdc.com.au/publications). You can also find a full list of our current research projects online at [www.crdc.com.au/research-development](http://www.crdc.com.au/research-development).

**YEAR IN REVIEW**

# CRDC RD&E achievements 2019-20

**Collaboration to tackle major cross-sectoral challenges**

48 per cent of CRDC's investments in 2019-20 were in cross-commodity collaborative projects with our fellow Research and Development Corporations (RDCs). CRDC has led three major collaborations: Smarter Irrigation for Profit phase 2, and More Profit from Nitrogen, under the Rural R&D for Profit program; and Cotton Landcare Tech Innovations 2021, under the National Landcare Program Smart Farming Partnership. CRDC has also partnered in eight additional projects under the Rural R&D for Profit program, addressing cross sectoral issues in climate, pests, weeds, diseases, energy, digital technologies, and natural resource management.

**Team RDC working towards whole-of agriculture collaboration**

CRDC worked closely with the RDCs to develop a framework to facilitate collaboration across the whole of agriculture and promote participation of a greater diversity of actors within the Australian agro-ecosystem. This collaborative framework links to the cross-sectoral RD&E strategies and provides a mechanism for the RDCs and other participants to partner to address key issues facing agriculture, including climate variability, water-use efficiency, biosecurity and soil quality. The first initiative the collective RDCs are partnering on under the new framework is the Climate Initiative: a significant new co-investment program, led by CRDC, to foster thriving agriculture, fisheries and forestry industries regardless of pressures from a variable and changing climate.

**Release of Australia's Cotton Sustainability Report**

CRDC and Cotton Australia released the highly anticipated *Australian Cotton Sustainability Report 2019*, following on from the inaugural report published in 2014. The report tells a positive story of increasing efficiency in the use of resources, including water and land. It reveals long-term trends that producing a bale of cotton now takes 48 per cent less water, 34 per cent less land, and 97 per cent less insecticide than it did in 1992. The report provides data on eight priority social, economic and environmental topics, and by

comparing performance over five-year periods in these important sustainability areas, highlights areas for improvement. CRDC and Cotton Australia are now progressing the development of the industry's sustainability targets.

### **Bringing the world of cotton to Australia for ICAC**

The International Cotton Advisory Committee's (ICAC) 78th Plenary Meeting was held in Brisbane in December 2019, hosted by the Department of Agriculture, Water and the Environment with support from CRDC as a major sponsor and organising committee member. ICAC is an association of governments from cotton-producing, consuming and trading countries, and is the only global intergovernmental group for cotton and cotton textiles. More than 300 people from 23 member governments attended the meeting, including representatives from five international organisations and five non-member countries.

### **Cotton and grain partnership: spray drift hazard alert and warning system**

A CRDC and Grains Research and Development Corporation (GRDC) collaboration has been working to minimise the potential and impact of spray drift from cotton and grain properties since 2016. Before this, there was no reliable or accurate method

to determine when inversion conditions were hazardous or not for spraying. Research supported by CRDC and GRDC developed a Spray Drift Hazard Alert and Warning System. The partners are now moving to deliver this technology to growers through establishing a network of Profiling Automatic Weather Stations (PAWS) across the cotton and grain belts of eastern Australia.

### **Developing cotton in Northern Australia: major collaboration announced**

A \$2.1 million research program for Northern Australia supported by CRDC was announced in March 2020, to trial high-value crops such as cotton with potential rotation crops. The two-year 'Potential for broadacre cropping in the Northern Territory' project is being co-funded by the Cooperative Research Centre for Developing Northern Australia (CRCNA), CRDC, GRDC and 14 industry partners. This is the largest collaboration to date for the CRCNA. This project will collate historic broadacre cropping data, natural resource information and an understanding of market opportunities to support the development of viable broadacre cropping systems in the NT, helping to de-risk broadacre agriculture in the Top End.

### **Artificial intelligence app to help identify problem pests**

To make identification of silverleaf whitefly, mites and aphids easier, University of Southern Queensland researchers continued their development of a new artificial intelligence smartphone app with funding from CRDC. The app uses vision-detection algorithms, that automate pest counting on each leaf using infield cameras and image analysis software. Through the app, growers and agronomists can then use real-time photo capture, reducing sampling times and offering more precise detection and recording of pests for decision making. The app was first tested during 2019-20, and will be deployed for further testing during 2020-21 on a potential pathway towards commercial release.

### **CRDC support results in new tool for dryland crop destruction**

AquaTill Injeticide, a new tool incorporating herbicide with ultra high-pressure water cutting, offers dryland cotton growers an alternative method of crop termination with minimal soil disturbance post-harvest. The technology was first tested on mulched cotton in 2017, through a CRDC supported project looking at opportunities for dryland cotton with Bollgard 3. CRDC subsequently supported AquaTill's founder as a participant in the Pollenizer start-up rural.xo microhack. He has since partnered with a machinery manufacturer and a herbicide



MELANIE JENSON

registrant. Under a new CRDC-supported project, demonstrations are planned for cotton farms during the 2020-21 season.

**Innovative online biodiversity management guides for growers**

CottonInfo launched new online biodiversity management guides for Australia's 36 cotton-growing shires, giving cotton growers detailed biodiversity information and outlining beneficial practices to support biodiversity on their farms. Growers can select their local government area (LGA) to see a snapshot of the biodiversity in their shire, along with practical tips to improve conditions for the diversity of species in that specific cotton landscape. This initiative is an outcome of the 'New technologies to improve natural resources (biodiversity) on Australian cotton farms – Cotton Landcare Tech Innovations 2021' project funded by CRDC in partnership with the Australian Government's National Landcare Smart Farming Partnership Initiative.

**Focus on biosecurity: the UN International Year of Plant Health**

2020 is the official UN International Year of Plant Health, providing a platform to raise awareness of the importance of plant health and



MELANIE JENSON

biosecurity, and of CRDC's RD&E investments in this area. From a research perspective, CRDC is a member of the Plant Biosecurity Research Initiative (PBRI), which supports cross-sectoral RD&E to minimise the damage caused by biosecurity threats to Australia's plant industries. All seven plant-based RDCs are members of PBRI. From a preparedness perspective, CRDC and Plant Health Australia staged Exercise Blueprint in August 2019. This simulation exercise of a biosecurity incursion brought together key stakeholders within the cotton industry to examine a fictional scenario of the detection of cotton blue disease; only months before a response was required to the discovery of fall armyworm in Northern Australia.

SECTION 1 Executive Summary

**2019–20 investment and impact**

The Australian cotton industry in 2019–20



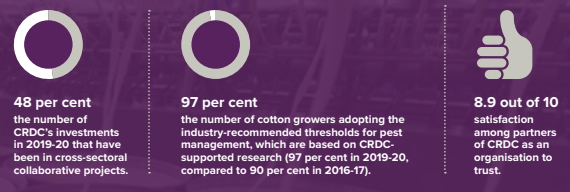
(Source: Cotton Australia)

**CRDC's investment in 2019–20**



**CRDC impact**

**\$2.1 million** the collective investment in the potential for broadacre cropping in the Northern Territory project, involving CRDC.



**5** the number of local, grower-led projects CRDC invested in through its Grassroots Grants program in 2019-20, taking the total number of projects supported since it began to 77.

**11 major collaborative projects**

that CRDC has led or actively participated in during 2019-20 under two government initiatives: Rural R&D for Profit, and the National Landcare Program Smart Farming Partnership.

**4000** the number of cotton, dairy, rice, grains and sugar irrigators set to benefit from the collaborative Smarter Irrigation for Profit phase 2 project, led by CRDC.

**2020** the UN International Year of Plant Health, creating a focus on CRDC's RD&E investments in the area of plant health and biosecurity.

**23:** the number of member governments represented by the 300 attendees at the Australian ICAC Plenary Meeting in December, supported by CRDC.

**36:** the number of cotton-growing shires featured in CottonInfo's innovative online biodiversity management guides for growers.

**100 per cent** the number of CRDC's investments in 2019-20 that have been in partnership with the cotton industry.

**1.2 million** the number of collective views that the 194 CRDC-supported best practice videos have amassed on the CottonInfo YouTube channel as at May 2020.

**8** the number of priority areas for the cotton industry under the *Australian Cotton Sustainability Report 2019*, co-produced by CRDC and Cotton Australia: water, carbon, biodiversity, pesticides, quality of work life (safety, diversity and training), wellbeing and social capital, efficiency, and profitability.



*Spotlight* is brought to you by CRDC: the Australian cotton industry's research, development and extension investment body, jointly funded by Australian cotton growers and the Australian Government.

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