

# Spotlight.

ON COTTON R&D

Winter 2018

Cotton's future: CRDC's bold new  
Strategic RD&E Plan

Startups, agtech and big data:  
where to next for R&D?

The evolving nature of  
resistance monitoring



Australian Government  
Cotton Research and  
Development Corporation



Bruce Finney

# In the Spotlight

Winter largely marks the end of the cotton season around Australia as pickers are put away for another year and attention turns to ginning figures, reflection and registering for the 2018 Australian Cotton Conference, then planning and preparation for the next season.

For CRDC, winter 2018 signals the start of a new five-year Strategic RD&E Plan, which we are very excited about. Over the next five years we expect to see a lot of change in our industry, practically from where we grow cotton (see our story on the Kimberley trials and MIA study) to the technology we will use to grow it. CRDC's role is to support sustainable growth, responsible practices and profitability across a range of endeavours including building capacity. In this edition we look at some of the research underway to place our industry in the box seat for future readiness.

With news in mainstream media of the creation of a cotton 'megapest', we talk to Australian experts about what this means for the industry and Australian growers. Grower and commercial support for robust resistance management plans has to date enabled Australia to avoid growing global resistance to Bt technologies. Importantly, the research community, CRDC and partners are already working on a faster, more streamlined *Helicoverpa* resistance monitoring technique. Congratulations are given to our industry entomologists on their publication in entomology's leading journal.

The cotton industry is not content to sit back and be overwhelmed by the ever-growing and complex world of technology - if it serves our industry - we want to be the drivers of its application and adoption. The way we solve problems and improve through research is also changing. CRDC has been investigating how working with the startup community through accelerators, incubators and venture capitalists can assist in bringing to the cotton industry beneficial new technology products and services. Agtech is already a part of the Australian cotton growing and processing landscape, with many CRDC projects - from canopy temperature sensors, to temperature inversion weather stations, weed sensing for robotics and irrigation automation technology - playing a part in this.

The cotton industry has also been making gains in understanding crop nutrition through RD&E. In particular, nitrogen research continues to shed light on managing efficiency and reducing losses. Irrigation plays a substantial role in nitrogen use efficiency, as was outlined in the recent CottonInfo researchers' tour, which brought the best of research to growers. This is backed up by significant investment in the capacity of research with our many partners, including the CRDC-funded Soil System Research project led by Dr Oliver Knox.

In this edition we have also included the 2018-19 research project list, which we hope you read through to gain a better understanding of ongoing and new investments this coming financial year. Should you wish to know anything further about any of the projects, please contact CRDC.

We look forward to seeing you at the 2018 Australian Cotton Conference in August where "Pushing the Boundaries" through research and innovation is what excites and motivates us everyday.

Bruce Finney  
CRDC Executive Director



*Spotlight* is brought to you by Australia's cotton producers and the Australian Government through the publisher Cotton Research & Development Corporation (CRDC). CRDC is a research and development partnership between the Australian cotton industry and the Australian Government.

**Cotton Research and Development Corporation**

ABN: 71 054 238 316

**Our vision:** A globally competitive and responsible cotton industry.

**Our mission:** To invest in RD&E for the world-leading Australian cotton industry.

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IMAGE: RUTH REDFERN

**ON THE COVER:**

Picking underway on 'Warrawee', the Narrabri NSW property of cotton growers Alan and Kym Redfern.

## Want to see more of Spotlight?

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

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# Winter 2018



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# Fast Facts



2

Billion dollars. The amount CRDC aims to help add to the gross value of cotton production in the next five years through investment in cotton RD&E, under the new CRDC Strategic RD&E Plan.

16

The number of practical field-evolved cases of resistance to Bt crops identified worldwide in 2016 – a significant increase from only three in 2005. (Page 17)



0

The number of herbicides registered for cotton crop destruction by the APVMA. (Page 18)

55

Percent. The amount of the 2016-17 Murrumbidgee Irrigation Area growers' cotton fields (23,105 hectares) that had crop and management data collected for a CRDC project researching emergence issues in the region. (Page 22)



Grassroots Grants have been used by CGAs to facilitate area-wide grower meetings which bring growers from different regions to share experiences and knowledge.

## Grassroots Grants: funding grower ideas

**THE** CRDC Grassroots Grants program is now entering its eighth year and continues to support Cotton Grower Associations (CGAs) to undertake capacity building projects in their regions.

Up to \$10,000 in funding is available from CRDC for CGAs to help fund a project aimed at increasing the engagement of growers in the industry, solving specific regional issues and improving their skills, knowledge base and networks.

Since the Grassroots Grants program commenced in 2011, CRDC has invested \$548,000 in 62 projects across the cotton growing valleys – from weather stations to crop nutrition workshops.

Ten projects were funded in 2017-18, including in-field research trials in Mungindi comparing dryland cotton to dryland sorghum across various row configurations; a spreader calibration workshop in the Upper Namoi; silverleaf whitefly and mealybug area wide management meetings in the Gwydir with leading industry researchers; and grower development programs to improve skills and capacity in the Dawson Valley and the Darling Downs.

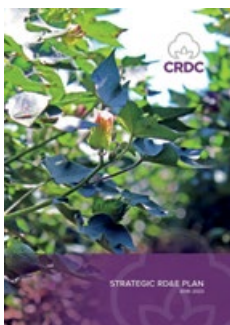
Applications for the 2018-19 round of Grassroots Grants will open on July 1, 2018 and close on November 30, 2018. Applications will be reviewed on a first-come first-serve basis during this period, so CGAs are strongly encouraged to get their applications in when the program opens.

The program's guidelines and application form are available from the CRDC website.

### For more

[www.crdc.com.au/community-and-grower-support](http://www.crdc.com.au/community-and-grower-support)

# New Strategic RD&E Plan kicks off July 1, 2018



**AFTER** 15 months of development in close collaboration with the industry, CRDC's new Strategic RD&E Plan for 2018-23 will commence on July 1, 2018 pending Ministerial approval.

The Plan is CRDC's primary RD&E planning document and provides a high-level overview of CRDC's strategic direction for the next five years.

CRDC Executive Director Bruce Finney said the plan is unashamedly ambitious.

"Our vision as an organisation is to power the success of Australian cotton through world-leading RD&E. This Plan sets out how we are going to achieve this: our goals, our investment approach, and most importantly, our planned impact for the next five years," Bruce said.

"It's a very ambitious plan: over the

next five years, our aim is to contribute to creating \$2 billion in additional gross value of cotton production through our investments in RD&E.

"To help achieve this, in the first year of the plan – 2018-19 – cotton growers and the Government will co-invest \$24.3 million into cotton RD&E, across some 300 projects and in collaboration with over 100 research partners.

This investment will be split across the five key focus areas of the Plan:

- increasing productivity and profitability on 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.

Once officially signed off by the Minister for Agriculture and Water Resources, the CRDC Strategic RD&E Plan will be available from the CRDC website:

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

## Collaboration part of global innovation

A combination of industry research projects supported by Sugar Research Australia, CRDC, Horticulture Innovation and the University of Southern Queensland (USQ) over the last 10 years has resulted in technology being included in John Deere's global commercialisation evaluation program.

Thanks to an ongoing partnership with John Deere, USQ research is lifting farm productivity and developing the next generation of agricultural technology – including machine automation and control, such as driverless tractors. This global partnership supported by investments from both USQ and various RDCs, is helping provide a gateway for the commercialisation of Australian technologies. This partnership will enable machine perception and intelligence technologies for use in applications such as automated weed management systems, to be taken worldwide.

In conjunction with its research partners such as CRDC, USQ researchers are exploring new intelligence-based technologies and solutions for the agricultural industry to deliver real value to farmers and change the way primary producers look at land management and production.

USQ's Professor Craig Baillie said this global commercialisation strategy was a shining example of researchers working collaboratively with industry to understand problems facing the sector, to determine what new technologies would benefit farmers in the future.

"This research partnership will not only benefit Australian communities but also international industries, which illustrates the global reach and relevance of USQ's research efforts in agricultural engineering," Craig said.

"It also highlights the importance that international organisations are giving to the development of future technologies that will transform agricultural industries over the years to come.

"High-tech farming is becoming an everyday tool for primary producers, therefore our researchers are consistently looking to improve the profitability, environmental sustainability and socio-economic wellbeing of our rural industries."

### CRDC's Strategic RD&E Plan 2018–23 snapshot

#### 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

#### Our outcome statement

Increased economic, social and environmental benefits for the Australian cotton industry, and the wider community, by investing in knowledge, innovation and its adoption.

#### GOALS



Increase productivity and profitability on cotton farms



Improve cotton farming sustainability and value chain competitiveness



Build adaptive capacity of the cotton industry

#### ENABLING STRATEGIES



Strengthening partnerships and adoption



Driving RD&E impact

#### KEY FOCUS AREAS

- Optimised farming systems
- Transformative technologies
- Protection from biotic threats and environmental stresses
- Sustainability of cotton farming
- Create higher-value uses for cotton
- Measurement and reporting throughout the value chain
- Science and innovation capability, and new knowledge
- Futures thinking

#### KEY FOCUS AREAS

- Partnerships and collaboration
- Best practice (myBMP)
- Innovation and commercialisation
- Impact and effectiveness



## Kimberley-bound for cotton

**COTTON** growing in the Kimberley was in the spotlight in late March when cotton growers, researchers and representatives from CRDC, Cotton Australia and GRDC participated in the Northern Australia Roadshow.

The Roadshow is one of a series of regional events leading up to the Northern Australia Food Futures Conference in July and included a tour of the Ord River Irrigation Scheme near Kununurra in far northern Western Australia. The group visited Kimberley Agriculture Investments' (KAI) Stage 2 Ord Development. KAI planted 350 hectares of cotton in February this year, with plans to considerably expand its cotton production to help grow a viable northern industry.

CRDC is also supporting trials in the Kununurra area for the second year in a row, under the direction of CSIRO's Dr Steve Yeates and QLD DAF's Dr Paul Grundy. Paul spoke about the CRDC research trials underway in the region to

the assembled crowd of 70 attendees.

CRDC's General Manager of R&D Investment Dr Ian Taylor also travelled to The Ord for the event, saying the crops looked great and enthusiasm for expanding cotton growing was high.

"It was a great sight to see cotton in the region again," Ian said.

"With such a progressive group of people driving the industry to become sustainable in the north, our trials showing good results and KAI ready to expand their cotton acreage, there are certainly opportunities here for the cotton industry."

The Roadshow was supported by Northern Australia Food Futures, the Australian Government's Office of Northern Australia and NT Farmers. See our article on Page 12 for the full story.

**For more**  
**Ian Taylor**  
[ian.taylor@crdc.com.au](mailto:ian.taylor@crdc.com.au)

## Best in the business named

**FINALISTS** have been named for the 2018 Australian Cotton Industry Awards.

The Awards committee has once again had the pleasure and somewhat difficult task to narrow down nominees to the finalists' list and now we'll have to wait until the Awards gala dinner on August 7 at the Gold Coast Convention Centre to find out the winners!

**For more**  
[www.australiancottonawards.com](http://www.australiancottonawards.com)

### **ADAMA Chris Lehmann Trust** **Young Cotton Achiever of the Year**

Sam Simons – Agromax Consulting, Gunnedah NSW  
 William Back – Auscott Ltd, Namoi Valley, Narrabri, NSW  
 Jake Cutcliffe – Auscott Ltd, Gwydir Valley, Moree, NSW

### **Cotton Seed Distributors Researcher of the Year**

Robert Eveleigh – CSD Ltd, Wee Waa, NSW  
 Dr Joseph Foley, Dr Malcolm Gillies and Dr Alison McCarthy – NCEA, Irrigation and Water Management USQ, Toowoomba, QLD  
 Dr Kristen Knight – Monsanto, Toowoomba, QLD

### **Monsanto Grower of the Year / AgriRisk** **High Achiever of the Year**

Glen and Narelle Whittaker – "Wingfield", Warren, NSW  
 Bernie Bierhoff – "Avondale", Rowena, NSW  
 Peter Lennox – "Battery Hill", Gunnedah, NSW  
 Brett Corish – "Mundine", Goondiwindi, QLD  
 Greg & Maryann Bender – "Burradoo Plains", Chinchilla, QLD

## 2018 Grower Survey: Have your say!

**THE** annual CRDC Cotton Grower Survey opens in June, and all cotton growers are invited to have their say.

Growers and farm managers will receive an invitation in early June to participate.

For growers with an email address on file with CRDC, you'll receive an email invitation to participate – simply click on the link to provide your feedback. For growers without an email on file, we'll be contacting you via phone.

This year's survey looks at your 2017-18 crop and seeks your thoughts on a range of topics, including: irrigation and water quality; insect, pest and weed control; spray drift impacts; nutrition management; energy use efficiency; and the uptake and impact of technology and automation. It will take around 15 minutes to complete, and will provide valuable information to CRDC about the industry, on-farm practices, and priority areas for future research.

The survey is conducted by professional researchers, Intuitive Solutions. Importantly, the information collected remains confidential, and only aggregated, anonymous information is passed on to CRDC.

The results are published annually via a new interactive digital dashboard, which allows you to compare the results from your valley against all growers, and via a downloadable PDF report.

**For more**  
[www.crdc.com.au/growersurvey](http://www.crdc.com.au/growersurvey)





Secretary of the Department of Agriculture and Water Resources, Daryl Quinivan; Awards recipient Rhys Pirie; Agricultural Chief Scientist and Australian Chief Plant Protection Officer, Robyn Cleland; and CRDC Executive Director Bruce Finney.

## Rhys's research wins dual awards

**RHYS** Pirie, a PhD student at the University of Queensland, has been awarded two prestigious ABARES Science and Innovation Awards for Young People in Agriculture for his focus on producing low cost, high efficiency fertilisers.

Rhys was selected for the first award – the CRDC-supported Science and Innovation Award – for his focus on re-purposing organic wastes (such as livestock manure, biosolids and cotton gin trash) as fertilisers and soil ameliorants: helping growers optimise resource efficiency and improve their environmental impact.

He was then selected from the field of awardees for the second award – the Minister's Science and Innovation Award – by the Minister.

Rhys is one of 11 young agricultural innovators, researchers and scientists who were awarded up to \$22,000 each through the *Science and Innovation Awards for Young People in Agriculture, Fisheries and Forestry*. The joint industry/government funding aims to turn ideas for improving agricultural productivity into reality. Rhys will receive an additional \$22,000 as part of the Minister's Award.

"High transport costs, lower nutrient density, higher moisture content and determining the appropriate nutrient application rates make the adoption and use of organic wastes not as appealing to

producers," Rhys said.

"This is about trying to close nutrient loops and how to more efficiently fertilise crops."

Rhys will work with a market leading company with expertise in organic waste agglomeration and then test the resulting pelletised fertilisers in greenhouse trials using cotton plants. The next step will evaluate whether the trials can progress to a commercial stage and be economically viable.

"While my project is working with the cotton industry now, there's potential that my research results could be taken up by other agricultural industries, and lead to lower social and environmental impacts from farming systems."

Rhys follows in the footsteps of the 2015 Minister's Award winner Alison McCarthy, who was also supported by CRDC. Alison has developed an integrated image sensing system for soil-water and nitrogen levels in cotton crops which has now been put to use in the sugar and dairy industries.

The Science Awards were presented at a gala dinner as part of Australia's pre-eminent agricultural and economic forecasting event—ABARES Outlook 2018.

**For more**  
[agriculture.gov.au/scienceawards](http://agriculture.gov.au/scienceawards)

## Researchers impress



Australian entomologists working in the cotton industry have further proven themselves as leading experts. Published in the current *Annual Review of Entomology*,

cotton industry entomologists Professor Peter Gregg along with Dr Lewis Wilson, Dr Mary Whitehouse and Dr Grant Herron have shown the world-leading class of researchers in the Australian cotton industry.

*Annual Review of Entomology* is the pinnacle of publication in its field. Entomologists must be invited to prepare a review, with an invitation a clear signal that they are the world authorities in the field.

The two papers, from Peter and his co-authors titled *Advances in Attract-and-Kill for Agricultural Pests*; and the other from Lewis, Mary and Grant on cotton integrated pest management (IPM). For Australian cotton to have two articles in the same issue (and no other Australians at all) is a mark of the quality of our researchers.

"What a credit to these researchers, who have helped shape our industry and overcome many of its challenges," CRDC Executive Director Bruce Finney said.

"The cotton industry is very fortunate to have researchers of this calibre amongst us and I'd like to congratulate and thank them.

"Our IPM systems are now the best in the world, largely due to the work of these researchers."

Soft chemistry to control pests is a dream for any agricultural industry, and Peter brought the industry Magnet, the attract-and-kill tool for crop pest management.

"From his early work helping the industry understand and control its most destructive pest in *Helicoverpa*, to his future thinking and ongoing contribution into novel technology it is very clear the huge contribution he has made to the successful industry we see today."



# Your copy of the industry's Cotton Production Manual

Included with this edition of the CRDC *Spotlight* magazine is your copy of one of the industry's flagship publications, the *Australian Cotton Production Manual*.

**BROUGHT** to you by CRDC and CottonInfo, the Manual delivers the latest in cotton industry RD&E and is a key reference tool for best management practice in cotton.

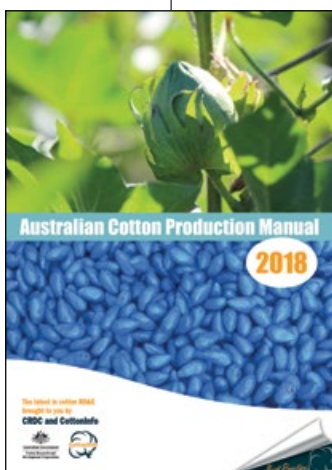
Developed by a team of industry researchers and experts, the Manual brings you the latest information to help you make on-the-ground decisions for your crop and your farm.

It contains four sections, focused around the considerations and decisions that growers are faced with across the cotton growing season:

- **Planning:** The planning section of the Manual covers the key considerations for growers – starting with the ideal climate for cotton growing, the availability of water and the resulting farming system of irrigated, semi irrigated or raingrown cotton. The chapter then looks at the other key determinates for cotton in the planning phase: the selection and preparation of fields; choosing the right seed variety; planning for nutrition and energy use efficiency; and laying the foundations for year round integrated pest, weed and disease management.
- **In-season:** The in-season section of the Manual focuses on the areas of particular relevance for growers once the crop is in the ground. Crop establishment, crop growth, efficient spray application and managing the

crop for yield and fibre quality are the key chapters in this section, along with irrigation management, which showcases the new technologies in development or already in the field.

- **Harvest and post-harvest:** The harvest and post-harvest section of the Manual looks at cotton during its final on-farm stage. This section includes chapters on preparing for harvest and harvest



itself, including managing considerations relating to quality, and managing cotton stubbles and residues post-harvest. It also takes a look at the off-farm process of ginning and classing, providing a beyond the farm gate perspective.

- **Business:** The business of cotton can be complex. This section looks at the business components of cotton production that are relevant all year

round – including economics, marketing, finance, insurance, and the safety and management of the industry's human resources. The Manual is designed to help you increase your input efficiencies and improve your yield; help the industry proactively manage issues that affect all of us; and ensure our cotton remains of very high quality.

- The Manual is also available electronically at [www.crdc.com.au](http://www.crdc.com.au) and [www.cottoninfo.com.au](http://www.cottoninfo.com.au)
- For additional hard copies, please contact CRDC on 02 6792 4088 or speak to your local CottonInfo Regional Extension Officer.
- The sister publication to the Manual – the *Cotton Pest Management Guide* – will be included with the Spring edition of *Spotlight*, which will land in your mailbox on September 1.

## Bush Bots ready to take on the future

A group of country high school students travelled all the way to Texas to look into the future at the Robotics World Championships in Houston.

It's a long way from Wee Waa to the US, but that didn't stop the Wee Waa High School Bush Bots - eight young, tech-savvy, innovative and highly skilled students from making their mark on the world stage. After attending an event in Sydney earlier in the year, the team received a wild card entry to the world stage in Houston in April. After three days of competition, the Bush Bots came 23rd out of the 68 teams in their division of the championships. They were one of few teams from a country Australian high school.

CRDC is proud to have played its part in initially helping getting the Bush Bots to Sydney. Further support from the cotton industry, individuals and businesses meant the team could compete overseas, and buy more parts and spares to make their robot more sophisticated.

Wee Waa High science teacher and Bush Bot mentor Sharon Grellman said the support enabled them to introduce pneumatics to their robot, try new technology and ultimately build a better robot.

"On a deeper level however, this trip to the US allowed the kids to see how wide the world is," Sharon said.

"These students also learned life skills, such as problem solving, resilience and an appreciation of the types of skills and attributes needed for success.

"Building robots also obviously builds skills used in any new technology, and a lot of the skills go beyond the actual fabrication, there is teamwork, planning, repair, maintenance and management.

"These skills can be scaled up to suit real life robotics and applications, as some of our team are finding out through their vocational educational training in mechanics.

"As we head into a future of expanding agricultural technologies, this experience shows that post school options don't necessarily involve university and study, because there are vocational skills being learned as well - skills we will need in agriculture."



# Startups come to life at Conference

Preparations are in full swing for the 2018 Australian Cotton Conference at the Gold Coast Convention and Exhibition Centre from August 7-9.

**THE** program is nearing completion, registrations are open for delegates via the Conference website, and opportunities are available for both potential sponsors and trade exhibitors.

As a proud foundation sponsor of the Conference since its inception, CRDC and the cotton research community will be strongly represented at the event – showcasing key areas of CRDC's investment, innovation and impact.

CRDC's new Strategic Plan will be a focus of a futuristic session titled 'where is cotton going to be in five years', with CRDC's ambition to add \$2 billion in additional gross value of cotton production through RD&E by 2023.

Many CRDC-supported researchers will feature in the agenda, including Dr Linda Smith of QLD DAF on improving the management of cotton diseases including verticillium; Dr Graham Tepper of MRES on the development of the spray drift hazard identification system; Dr Peter Grace of QUT on improving nitrogen use efficiency; Dr Wendy Quayle on optimising the management of manure in southern cotton production; and Dr Joseph Foley on developing automated irrigation systems – to name but a few!

CRDC will also be supporting an exciting new element of Conference with Startup Alley – a space dedicated to showcasing the industry's investments in



startups, and the emerging technologies that are being developed specifically for cotton and agriculture.

"Startup Alley is a really exciting new initiative that is running for the first time at this year's Conference – and, with CRDC being an investor in innovation, digital and disruptive technologies and entrepreneurs – we're delighted to be partnering with Conference to bring this idea to life," CRDC Executive Director, Bruce Finney said.

"We've spent a lot of time in the entrepreneurial and startup space over the past 18 months, investing and partnering in a range of programs to support growers, researchers and the wider industry to turn business ideas into a reality, from the rural. xo microhack and incubation program to Startup Catalyst and the MIT bootcamp.

"Most recently, we've invested in Flurosat, and developed a new partnership

## CottonInfo feature campaigns

Two CottonInfo campaigns will feature at the Conference. CottonInfo Regional Extension Officers will have examples from their soil health program, #soilyourundies at the CRDC and CottonInfo stand; while technical lead Sharna Holman will bring you the top tips for stopping the spread of pests, weeds and diseases as part of the biosecurity campaign Be a good mate, stop it at the gate.



with X-Lab to re-invigorate our investment-commercialisation pathway.

"There's a huge amount of work underway in this space, with some really exciting ideas and innovations emerging: and Startup Alley at Conference provides a great opportunity to showcase these." Note, early bird registrations close 25 June.

### For more

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

## Become a citizen scientist

Fancy seeing how environmental scientists work first hand? In a new CRDC study a multidisciplinary team of scientists from Australian Nuclear Science and Technology Organisation (ANSTO) and UNSW are looking at the nitrogen cycle, from application in the field to atmospheric and surface/groundwater losses.

Project leader Dioni Cendon from ANSTO said areas in the Murrumbidgee, Namoi and Nogoa are being studied, and he is encouraging schools and local

organisations to come and see them at work. ANSTO is a centre of excellence in understanding how environmental systems function and the impact that humans are having on the planet. The researchers are keen to share their research activities with the broader community and promote science to local students.

"We'd love to have local residents come and see what we do and learn more about why these investigations are important for environmental sustainability," Dioni said.

"It would be fantastic to get local science teachers on board so we can tailor field days, small science projects for senior science students and offer some hands-on learning experiences.

"The experience can go beyond the field as teachers can engage with broader ANSTO activities with the resources of our Learning Centre and even visit landmark infrastructure, like our accelerators, where we analyse our data."

Contact Dioni at [dce@ansto.gov.au](mailto:dce@ansto.gov.au)



## A big data approach

**ACHIEVING** high yielding crops with little variability is a major goal of all cotton growers, and big data could hold a major key to help achieve it. CRDC is supporting post-doctoral fellow Patrick Filippi from the University of Sydney Institute of Agriculture in a project being led by NSW DPI investigating how to maximise yield through minimising variability. Patrick is looking at how a big data approach could help identify reasons behind yield variability.

To begin his new project, Patrick is looking to enlist growers from all regions who are happy to share on-farm data (in an anonymous capacity).

"Ideally we are seeking growers with several years of data from sources such as yield monitors, soil testing, EM surveys or other management data," Patrick said.

"We will then make use of the huge increase in the availability of national data – such as remote sensing (eg Landsat), climate variables and soil information, and add this to the on-farm data.

"By combining the two we can create a predictive model to forecast yield at important times in the season.

The seed for Patrick's project was sown after he and fellow students participated in a CSIRO AgData Challenge Hackathon. The task was to extract value from the wealth of data collected by farmers, using data from a large corporate farm in Western Australia. From the data the team produced a model to predict crop yields for the coming season. Using the yield forecasts, suggestions for variable rate nitrogen fertiliser were provided in an easy-to-use online tool.

"We realised the models we had created and the information from the data could have real-life, practical applications and uses for cotton growers to improve their yield, sustainability and profitability," Patrick said.

"It was motivating to know that what we created could have real, practical use in the field."

Growers that feel like they would be good candidates for a case study for this project are asked to please contact Patrick.

## Bringing knowledge together

With its focus on innovation and start-up science, CRDC supported participants at the MIT Innovation and Entrepreneurship Bootcamp held at QUT earlier this year.

**THE** Bootcamp brought together 140 of the best and brightest from around the globe to focus on the theme *Future of Sustainability*. The program challenged participants to build technology-driven ventures that provided innovative and scalable solutions to issues in the environment, agriculture and mining resource sectors. CRDC supported three participants and provided two 'challenges' in line with the theme.

CRDC R&D Manager Jane Trindall developed the challenges and also attended the event. The first CRDC challenge was to find a cost-effective technical solution to meter water at irrigation pump sites and provide valuable real time data to water managers, regulators and users; such as – signalling faulty water meters, automate pump sites, monitor pump sites, real-time assessment of water allocation.

One of the groups taking up the real time water metering team found technology which could be suitable for Australian systems already in operation. This technology is now being looked at by commercial companies for use from a logistics viewpoint.

Subra Ananthram was a part of this team, and had not been involved

in agriculture or cotton previously. His academic research focuses on international business. Subra says the bootcamp highlighted the opportunity for his skills to be used in agriculture, and in particular cotton.

"The bootcamp provided an excellent platform to have business professionals, engineers, legal experts and others from various disciplines come together to identify real solutions (which require technology as well as a viable business model) to the problems that contemporary industries and business face," he said.

"The experience showcased the importance of cross-disciplinary diversity in solving problems that face industries and businesses globally."

MIT Bootcamps are an initiative of the Massachusetts Institute of Technology, and condense curriculum taught in several MIT courses into a concentrated active learning experience delivered by internationally renowned speakers and senior educators.

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# Changing face of R&D

CRDC's vision is for powering the success of Australian cotton through world-leading RD&E. In creating future success our challenge is to deliver better outcomes faster each year through our investments in RD&E. CRDC Executive Director Bruce Finney asks the question: 'How can this be achieved?'

**HAVING** really strong foundations in research, CRDC and the cotton industry are well placed to take advantage of emerging opportunities. A key opportunity is the revolution underway with new technologies being applied across physical, digital and biological spheres.

Breakthroughs are occurring in robotics, big data, artificial intelligence, biotechnology, 3D printing, automation, blockchain and the Internet of Things that are fundamentally changing production, supply chain and management systems. This is now certainly the case for agriculture with more than \$3 billion invested globally in 2017 driving momentum with agtech.

Agtech is attracting investment from global agribusinesses like Monsanto, Bayer, John Deere and Bosch as well a strong start-up business community from which Climate Corp, Blue River Technology and Indigo Ag have emerged. In fact start-ups are now a world-wide phenomenon, with the Silicon Valley joined by major centres in most countries. In Australia we have seen a rapid rise in the number of start-ups and support systems. Accelerators, incubators and venture capitalists are all seeking to play a role in enabling successful new technology products and services.

CRDC began exploring the potential of entrepreneurial skills and the capacity of start-ups in 2016 and have invested in a number of pilot projects to experiment and learn. This included running start-up bootcamps for training of our staff and researchers, then 20 start-up teams in



MELANIE JENSON

CRDC has invested in the ag startup FluroSat, who have enlisted specialists in the regional agtech sector such as McGregor Gourlay Digital Ag Manager Brooke Sauer.

partnership with X-Lab. We have invested in FluroSat, an agtech start-up focused on helping growers understand cotton crop nitrogen status, which emerged through a mentoring program with X-Lab program. We have also sponsored participants in the AgCatalyst international exchange and the MIT Bootcamp held with more than 100 talented participants earlier this year at the Queensland University of Technology (QUT) in Brisbane.

In the agtech space we have continued to grow investment in novel products, imagery analytics, sensors and automation technology to address production, processing and biosecurity challenges. CRDC has also commenced projects with QUT to data-mine the 1400 research projects in our publication library for insights on industry sustainability as well as a seminal piece of work in mapping all the decisions points within cotton production and the supply chain with the goal of collecting the data needed to improve key decisions.

CRDC has also led the Australian Government Rural R&D for Profit Program funded Precision to Decision Agriculture collaboration with the 15 rural research and development corporations (RDCs). The conclusions of that research were that the successful application of digital agriculture in Australia could increase the gross value of all production by 25 percent. Most recently CRDC has partnered with NSW DPI, SparkLabs and Hort Innovation to

create The Gate (Global Agtech Ecosystem), to support start-ups in fast-tracking the development and adoption of agtech.

So, from these seeds what can we grow that will accelerate and magnify the benefits of RD&E?

What if we could create powerful synergies between the 27 years of knowledge and capacity developed through investment in world-leading cotton research with our public research partners and the emerging private sector with their energy and focus on creating new business products and services around agtech? That combination of diverse thinking, skills and resources has huge potential to unlock new opportunities and resolve the big challenges facing Australian agriculture and cotton.

This strategic awareness and experience has strongly informed the future direction for technology based solutions and innovation opportunities within CRDC's new Strategic RD&E Plan. It has also challenged us to think about how CRDC could innovate within our business processes to ensure that the organisation is fit for its purpose now and into the future. With these thoughts in mind, expect to see some changes as we embark on the ambition to contribute to creating \$2 billion in additional gross value of cotton production for the benefit of Australian cotton growers and the wider community by 2023.



CSIRO's Dr Steve Yeates in last season's trial crop in the Kimberley region of Western Australia.

# Heading back to the far North West

With the second year of cotton trials underway in Western Australia's Ord Valley and the first commercial crop in the ground in seven years, cotton's move north is looking promising.

The R&D was started last season near Kununurra by CSIRO principal research agronomist Stephen Yeates, who leads the CRDC-CSD supported project to provide a Northern Australia Cotton Development & Coordination Leader. In this role Steve has developed partnerships with organisations interested in cotton across Northern Australia, including North Queensland, Northern Territory and Western Australia, with the aim of developing local cotton agronomy skills, demonstrating potential of cotton in the region, and providing management and feasibility information.

The R&D undertaken in the Ord was conducted in collaboration with agronomist Penny Goldsmith who is with the Ord River District Cooperative Ltd. With yields from last year's trial just 10 to 20 percent behind those in Northern NSW and Southern Queensland, Steve says the industry has the right to be positive. This year Steve has been joined by QLD DAF's Dr Paul Grundy, who also has extensive experience in growing cotton in northern regions.

"Despite last season's challenges with near record wet season rainfall prior to first flower (December to March), with optimal irrigation management after the deluge we achieved promising yields from our early February plantings of between nine and

11 bales per hectare, with excellent fibre quality," Steve said.

"To achieve yields close to those grown in more favourable regions in Northern NSW by the best growers in the world I would say is promising.

"We've seen less insect pressure than previously and Bollgard 3 has offered a wider planting window, which has allowed us to work with the North Australian wet season, with potentially even higher yields and quality."

Where irrigation is available, varieties containing Bollgard 3 can now be planted mid to late wet season in WA and NT (mid-January to March) on well drained soils, then irrigated in the early dry season so boll-filling coincides with the sunnier milder months of April/May, avoiding the detrimental effects wet season cloud and hot humid nights while permitting a dry pick in June/July.

The introduction of Bollgard 3 has improved confidence in insect control capabilities, as cotton has not had a particularly successful history in the tropics. First grown in The Ord from 1964 to 1974, the industry suffered pest problems, quality and yield issues.

Cluster caterpillar (*Spodoptera litura*) was the foremost cotton pest

The Ord River Irrigation Scheme was given the green light in 1959 with the hopes of transforming the Kimberley's semi-desert country (which was then mostly being used for cattle) into a thriving intensive-agriculture hub. The Ord River flows on from Lake Argyle, which is one of the world's largest man-made water bodies. Despite rich soils and a successful irrigation scheme under way, farmers still face logistical challenges.

at Kununurra during the 1960s, until *Helicoverpa armigera* developed resistance to insecticides. *H. armigera* was initially considered a minor pest but increased populations after the evolution of resistance led to the collapse of the cotton industry in northern WA in 1974.

As a part of current research, Paul Grundy is testing the efficacy of Bollgard 3 technology against cluster caterpillar. *Spodoptera* have been difficult to control with Bt technology with larvae able to develop on Bollgard II varieties.

"The inclusion of Vip3a in Bollgard 3 has provided much better control of other noctuid species but data for *Spodoptera litura* has been very limited," Paul said.

"Initial assessments so far are showing Bollgard 3 to be much more effective on *Spodoptera* negating the need to spray which is important as it will better allow the preservation of numerous predators and parasites that are abundant in Northern Australia where pests such as mealybug and whitefly can also pose problems."

## Updating NORpak

While grower interest, land and water resources and transgenic varieties are key ingredients for a future cotton industry, historical experience from Northern Australia has shown that new industries have a high likelihood of failure, particularly if not preceded by R&D that seeks to understand local factors and tailor production systems accordingly.

The publication of NORpak *'Cotton production and management guidelines for the Burdekin and north Queensland coastal dry tropics region 2012'* stands testament to the industry's R&D in 'new' regions. The publication documents the knowledge derived from the collaborative work undertaken by the former Cotton Catchments & Communities CRC, CRDC, CSIRO, DAF QLD, pioneer growers and agribusinesses in the Burdekin. It also serves as a testament to the diverse research, development and extension skills of QLD DAF's Dr Paul Grundy and CSIRO's Dr Stephen Yeates.

Indications from wet season cotton grown in recent seasons in the Burdekin and Gilbert River areas in Qld are that fibre quality is excellent, creating the opportunity to exploit high value export market opportunities.

As part of his current CRDC research, Steve has been collecting data to validate Burdekin wet season management practices in NORpak. He said the Burdekin management practices were broadly applicable to the Kimberley region, but required some tailoring.

"Due to much higher temperatures crop growth was significantly more vigorous at The Ord and crop went into moisture stress very rapidly after the end of the wet season, and modification to Pix and irrigation scheduling will be required," Steve said.

The trials, which also include Bollgard II and conventional cotton varieties, were grown on Matt and Mel Gray's farm at Kununurra. The Grays were one of the farms in the region where the last commercial crops were grown in 2011. While prices and yields were good, lack of ginning infrastructure meant transport costs for modules to gins at Dalby in Queensland made it unsustainable.

Despite not growing it commercially since 2011, Matt said at the time that he felt that cotton did have a future in the north, as they'd proved a high quality crop could be grown there, if other logistical challenges could be overcome. Research indicates that cotton requires a crop area of more than 10,000 hectares (ha) to support local gin investment.

"Before infrastructure can be developed, to establish, grow and support an industry, our potential crop managers and landholders need quality research and development to give them surety of a long-term prospect if they are going to invest considerable amounts of both time and money," Steve says.

"Growing cotton in a wet season climate is challenging, but the added benefits of Bollgard 3 have resolved one major issue we had in *Helicoverpa*, and

potentially cluster caterpillars which were present in the Bollgard II varieties.

"Our next research challenges are finding the ideal sowing date and determining irrigation scheduling and nutritional needs based on the soil types and climate in the region.

"The importance of farming areas with uniform soils of high soil water availability was highlighted by the experiment along with similar experiences with commercial dryland cotton last season."

Through recent funding from the CRC for Developing Northern Australia, Steve and Paul are also working with the Northern Australian Crop Research Alliance (NACRA), a local research group supported by Ord River District Cooperative Ltd and Kimberley Agricultural Investments (KAI) who are growing a commercial crop this season, with 300 ha planted.

"Through our trials and the collaboration with NACRA & KIA we are aiming to develop a robust cotton management system for well drained soils that can respond to intra-seasonal climate variability, producing reliable yield and quality," Steve says.

"We also will quantify the input requirements and assist assess investment feasibility and production risks."

## Nuffield scholar behind development

Kimberley Agricultural Investment's farm manager Luke McKay is the cotton industry's most recent Nuffield Scholar. Luke's scholarship is supported by CRDC and Cotton Australia. The young farmer has hopes of using the experience to help expand agriculture in Northern Australia. His Nuffield research will focus on issues relevant to tropical cotton-growing systems such as double cropping, rotation crops, irrigation methods, staff requirements, machinery requirements, and resource and environmental management.

"I want to research the best systems from around the world for our region and climate to create a sustainable industry," Luke said.

The Nuffield Scholarship involves amazing overseas learning experiences, and Luke will visit the Netherlands, Brazil, South America, USA and Canada to source information to bring back to share with the industry



Luke (right) with QLD DAF's Dr Paul Grundy.

# Farmers of the future

Farming is changing as technology rapidly becomes more embedded in the agricultural landscape, so what will cotton farming look like in the future and what type of workers and skills will the industry need?

These are the big questions being asked by Nicole McDonald in her CRDC research project *Understanding and planning for the future cotton workforce*. Nicole says that while the situation is constantly evolving, it is expected lower skilled jobs will be impacted by driverless machinery, and higher skilled jobs by augmented reality devices and drone technology.

"However, it's not as simple as thinking automation and robotics will take over our jobs on farm," Nicole said.

"If sectors of on-farm work, for example, irrigation, become automated, the question becomes how we make productive use of workers."



The rate of uptake may also be varied due to costs and factors such as water security which impact return on investment of new technologies. There are also factors such as trust in technology, adaptability and confidence to learn new approaches or use new technology that will impact rates of change and growth.

Another major factor in building capacity in the cotton industry workforce involves equipping people to proactively drive change and innovation both within the industry and on-farm.

"My research seeks to identify the changing skills and talent needed for the cotton industry to reap the benefits and potential gains to be made," Nicole said.

"To date my research has focused on factors that unlock the potential of the next generation of workers, with particular attention to transfer of training, engaging leadership and identifying skills gaps that limit the effectiveness of workers in a range of on-farm and production-related roles.

"Now we are putting the call out to 'early adopter' growers to participate in the next stage of my research project to understand the changing relationship between farming systems and labour requirements as new technology influences the workforce skills and structures on farm."

Have you introduced or trialed any new technology (automation, robotics etc) or made innovative changes to your farming business in the past three years? Are you a grower investigating new technology but aren't quite ready to make changes yet? If you answered 'yes' to either of these questions, Nicole is very keen to hear from you!

#### For more

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## What's the value in skills development?

CRDC is investing in research to quantify the value of training and how best to build workforce capability.

Researchers Gordon Stone and Jeff Coutts are aiming to assign the financial benefit and value proposition of training and increased skills and confidence in the workforce to cotton farms. The outcomes will provide a guide to inform employers about their options when it comes to strengthening skills in their workforce. It will also create a framework for measuring cotton industry and enterprise gains when investing in future capacity development.

"To date we have analysed the findings of past CRDC projects related to workforce and capacity and interviewed a number of growers and industry stakeholders," Gordon said.

"The major on-farm 'people issue'

raised to date is the difficulty in finding/ accessing and retaining personnel plus the need to resolve the level of skills needed in key personnel: this was seen as an issue for both full time and seasonal staff.

"The consensus is that providing staff training, an induction process, ongoing supervision and on-the-job training are essential."

The researchers have found that more formalised staff training is often limited to certification such as ChemCert, First Aid, and equipment operation tickets.

"A key question this has raised is whether there other essential training options," Jeff says.

"myBMP and management training have been raised in relation to developing management capacity.

"When asked about benefits gained

from skill development, growers referred to improved job satisfaction, reduced turnover and improved confidence – as well as better performance outcomes. There is some evidence about the valuable impact of staff skills on production and profitability."

The researchers are keen to add as many grower views and insights as possible to their research, which allows CRDC and its partners better work to find solutions to workforce issues.

Follow the link to the very brief survey: <https://preview.tinyurl.com/yacnhh6e>

#### For more

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# Bt Resistance on the rise globally

CottonInfo Bt and Insecticide Stewardship Technical Lead Sally Ceeney discusses the concerning trend of rising Bt resistance and the implications for Australian growers.

In 2016 there were 16 cases of practical field-evolved resistance to Bt crops identified worldwide – a significant increase from only three in 2005.

An international study published in the *Nature Biotechnology Journal* identified the concerning trend of rising Bt resistance. The identified cases are in a number of pests, (including *Helicoverpa zea* and pink bollworm) in both Bt corn and cotton crops across a number of continents: North and South America, India and Africa.

The Australian situation is viewed as an exceptional case that is bucking the global trend. Susceptibility of *H. armigera* has been maintained against Cry1Ac for more than two decades, and against Cry2Ab for more than 10 years. This can be attributed to a high level of grower compliance to the Australian cotton industry's robust Resistance Management Plan (RMP) and in particular the use of non-Bt mandatory refuges.

Australia has the most stringent mandatory refuge

requirement globally, and it seems to be working. In the United States, practical resistance has developed in the closely related *H. zea* to both Cry1Ac and Cry2Ab where refuge requirements are much more relaxed. In most US regions, no mandatory refuge has been required since the introduction of two-gene Bt cotton (Bollgard II) in 2007.

I recently attended an international workshop on the commercialisation of Bt cotton in Ethiopia, which highlighted the issue. Managing resistance was a key topic for all nations involved. Representatives attended from the US, India, Australia, South Africa, Sudan and Burkina Faso and all had the same message: 'Effective stewardship and regulation of the technology will be key to the products success in the future'.

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# Molecular testing a win for resistance management

The Australian cotton industry's already-successful Bt resistance monitoring program has been significantly strengthened with a new partnership and research project.

CRDC, Monsanto and CSIRO have collaborated on a project that will use molecular testing to identify the diversity and relative frequencies of Bt resistance alleles in *Helicoverpa armigera* and *H. punctigera*, with a view to developing a cost effective, faster technique for monitoring.

The primary aim is to provide a tool that will allow closer monitoring of the success of Bt resistance management in Australia. The tool may also be used to answer questions about the ecology of the pest system to better inform some aspects of how the industry manages resistance.

Since 2002, CRDC, with CSIRO and Monsanto have been monitoring for resistance in *H. armigera* and *H. punctigera* to Bt toxins found in Bt varieties of cotton.

These resistance monitoring programs are regarded as best practice by researchers, growers and regulators around the world. However, they rely on time-consuming, labour-intensive bioassay testing, and collecting and maintaining live insects in the laboratory.

The new molecular testing of the frequency and diversity of resistance alleles will complement the existing strategy and will be largely undertaken by post-doctoral fellow Amanda Padovan in collaboration with fellow CSIRO scientists Dr Tom Walsh, Dr Wee Tek Tay and Dr Sharon Downes.

"These tools could not only increase throughput in a cost effective manner but also provide opportunities in other projects to further validate ecological components of the Resistance Management Plan with regards to slowing or minimising the



The molecular assays can also be performed on trapped or preserved insects.

potential rise of resistance to Bt toxins," Amanda said.

"An added bonus would be to also collect population genetic data (evidence of selection in other genomic regions, early warnings of imminent biosecurity failures, species discrimination in pooled traps) at no extra cost."

Molecular tools do not require live insect bioassays; can be performed in a faster, more efficient manner; and do not require any rearing of insects.

"The molecular assays can also be performed on trapped or preserved insects," according to CSIRO's Sharon Downes, who has led the industry's Bt Resistance Monitoring Program since 2004.

"We will have the ability to test greater numbers of moths more quickly, which gives us a much more robust information to detect resistance as well as starting to provide a picture of what resistance looks like regionally and seasonally.

"It will extend current work in detecting the known resistance

mechanisms as well as making the process of identifying novel mutations more efficient."

This new approach offers research benefits as well as monitoring, and provides Australia with a more immediate picture of incursions from a biosecurity perspective.

This project builds on considerable investments CRDC and CSIRO have already made in characterising the genomes of *H. armigera* and *H. punctigera* and identifying the mechanisms of resistance to Bt toxins in these species. Recent advances in the knowledge of the resistance mechanisms to Bt toxins, developed at CSIRO, enables the application of these molecular tools for known individual resistance alleles and the development of high throughput molecular tools to examine multiple alleles. It also allows researchers to distinguish novel resistance alleles from those that are already known.

The industry relies on a pre-emptive strategy to slow the development of Bt resistance in *Helicoverpa*. CSIRO, CRDC and Monsanto will explore and develop an approach to increase the information available to the industry on resistance allele frequencies, allowing decisions about future and current management practices to be made on the basis of the best and most comprehensive scientific knowledge available.

Monsanto's Dr Kristen Knight said the company is committed to the stewardship of Australia's Bt technologies.

"This project will enhance our ability to develop management plans and make proactive decisions around resistance management to preserve the long term grower benefits from these products," Kristen said.

## For more

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CSIRO have identified hybrid mixes of two very closely related species, *Helicoverpa armigera* and *Helicoverpa zea* in Brazil. *Spotlight* takes a look behind the recent headlines in mainstream media to find out what this means for Australia.

## Creating a hybrid ‘mega-pest’?

In Australia we are – unfortunately – very familiar with *H. armigera* or cotton bollworm. This pest is also present throughout Africa, Asia and Europe, and causes damage to many crops. In North and South America, until recently they didn't have *H. armigera*, but they did have a very closely related native species, *H. zea*, known as the corn earworm. While *H. zea* is economically damaging, *H. armigera* is viewed as a more significant threat as it has a much broader host range and a greater propensity to develop resistance to conventional insecticides and Bt toxins.

The incursion of *H. armigera* into Brazil, continues to cause hundreds of millions of dollars damage each year.

Using whole-genome sequencing, CSIRO recently published research that confirmed hybridisation between these two species in Brazil.

*Spotlight* spoke with one of the paper's authors, CSIRO's Dr Tom Walsh to find out what they had discovered and what it means. He says hybridisation means that each individual contains genes from both species.

“What was really interesting is that there were different combinations in each individual,” Tom said.

“We call this a hybrid swarm, which suggests this is early in the hybrid event where many different combinations are possible.

“There is potential for the hybrid to be worse than either of the individual pests – you could end up with what is the best of both worlds for the pest, eat whatever is grown, and survive whatever is used to try and control it.”

One of the hybrids identified was 51 percent *H. zea* but had known resistance genes from *H. armigera*.

Tom points out that Australia has been successfully managing the worst of the two species, so the likely short term impact will be in the Americas where *H. zea* is more prominent. However he warns that we shouldn't be complacent as the hybrids are a biosecurity risk.

There is a large selection pressure for Bt resistance in South America, with very high use of Bt crops (corn, cotton,



CSIRO

soybean), and a range of one, two and three toxin stack technologies. There is also selection pressure for insecticide sprays. Hybrid species coming to Australia could not only bring new resistance, but may also behave differently. For example if the new host range did not include pigeon pea, the Resistance Management Plan would need to be evaluated.

This finding opens up questions about other less closely related *Helicoverpa* species.

“These species aren't as closely related and we don't have any evidence, however it isn't impossible,” Tom said.

“Full genomic sequencing will make it easier for hybrids to be identified in the future.”

### Biosecurity threat

The Cotton Industry Biosecurity Plan already recognises *H. zea* as well as exotic *H. armigera* subspecies (with different resistance characteristics) as biosecurity threats. As part of the Federal Government's Rural Research and Development for Profit Program, the *Improving plant pest management through cross industry deployment of smart sensors, diagnostics and forecasting* project, CSIRO's Dr Wee Tek Tay, will lead a component that assesses the biosecurity risk of arrival, establishment and co-occurrence of exotic *H. armigera*.

“We intend to particularly focus on China as there is a sub species of *H.*

*armigera* with dominant Cry1Ac resistance traits,” Tek said.

“We hope in the future to use a similar approach to whole-genome sequencing combined with modelling to understand the risk to Australia if there was to be an incursion.

“The industry will now need to consider potential for hybridisation between these two sub-species.

“In biosecurity terms we have to think more about gene flow and rethink what constitutes a species.

“In this era of globalisation, pest species or closely related sub-species that have been separated by physical barriers may come into contact and if there is incomplete reproductive isolation, mating can result in fertile hybrid offspring.

“That means that hybrid pests may become more common.

“For growers this highlights the need to report not only new pests, but to report unusual feeding behaviour, severity of damage or survivorship of existing pests.”

The South American *H. armigera* experience and more recently the resistance issues with fall armyworm (*Spodoptera frugiperda*) in Africa, certainly highlight the impact biosecurity incursions can have. The industry biosecurity group met in May to conduct its annual review of biosecurity threats and to coordinate efforts to ensure the industry is meeting its biosecurity requirements. *Spotlight* will report on this meeting in the Spring edition.



# Effective crop destruction crucial in a Bollgard 3 system

The Bollgard 3 Resistance Management Plan (RMP) offers growers more flexibility in field management after harvest. Pupae busting is no longer mandatory for fields defoliated before March 31 in Victoria, NSW and Southern Queensland.

Under the RMP, all cotton crops must still be destroyed after harvest. The primary purpose of pupae busting is to destroy overwintering pupae, reducing the risk of resistant alleles being carried through from one season to the next. However, as a tillage operation, pupae busting also assists in effectively destroying the crop and minimising the potential for ratoon cotton which could harbour a variety of cotton pests and diseases. Ratoon cotton carries over cotton bunchy top and increases inoculum for diseases such as Verticillium, Fusarium and black root rot.

Without pupae busting, ensuring that post-harvest crop destruction is both effective and permanent is a very important consideration.

CottonInfo's Bt and Insecticide Stewardship Technical Lead Sally Ceeny says effective crop destruction should result in plant death.

"Our concerns are that without pupae busting there is an increased likelihood that ratoon cotton will emerge as a more frequent problem in the farming system," Sally said.

"Ratoon cotton poses a resistance risk as it extends the amount of time

## Can herbicides be used for crop destruction?

Currently there are no herbicides registered for the purpose of cotton crop destruction. There are however, some new usage patterns for existing well known herbicides to be used for the control of ratoons and large volunteers that appear the following season amongst stubble or in fallows.

As part of an integrated weed management strategy, recent CRDC-supported research undertaken by QLD DAF in collaboration with Nufarm, identified three herbicide use strategies for the control of large volunteer or ratoon cotton plants in fallow situations using an optical spot spray (weed seeker) technology. Registrations are currently being sought, however in the interim for limited use for these products is authorised under Cotton Australia's permit (see PER85049 for options and guidelines). The product user must be in accordance with the label instructions.

Helicoverpa are exposed to Bt toxins well after the cotton growing season.

"Furthermore, aphids, silverleaf whitefly and mealybug can use ratoon (and volunteer) cotton to over-winter and re-infest the subsequent cotton crops.

"Ratoon cotton also carries over diseases such as Verticillium, Fusarium and black root rot. Having a high incidence of ratoons in subsequent crop rotations also presents a weediness issue as ratoon cotton can affect grain yields through plant competition."

### More than resistance

John Fuelling is a consultant on the Darling Downs and says crop destruction must be viewed as being about much more than just resistance management.

"The industry is seeing an increase in hard to control pests such as mealybug, and resistant weeds such as barnyard grass and feathertop Rhodes grass. Bunchy top disease was also evident in some crops this season.

"Effective management of all these pests and disease starts with eliminating volunteer and ratoon cotton."

## Implications of not pupae busting

The ability to avoid pupae busting through having crops undergo defoliation prior to March 31 has been beneficial for the broader farming system. However, a recent review of practices used particularly in dryland farming systems together with grower feedback at farming system workshops in 2016-17 suggested that this change may also present some future challenges as well as some unknown implications.

Positive	Negative	Uncertain
Potential to improve soil structure	Lost opportunity to incorporate nutrients such as P and K or animal manures	Impacts on weed species spectrum and seed bank over time
Increased retention of surface stubble and soil moisture	Lost opportunity to remove large weeds that may be resistant	Efficacy of minimum tillage crop destruction tactics
Increased opportunity to double crop (as soil surface is not disturbed) and achieve faster stubble cover	Lost opportunity to use tillage to alleviate compaction and/or renovate tramlines	Increased planting opportunities that come with minimum tillage may result in greater frequency of false starts due to underlying dry profile
Helps to avoid tillage when field conditions are unsuitable e.g. too dry or too wet	Incidence of ratoon cotton likely to increase within farming system	Resultant changes to the status of certain pests and diseases if ratoon cotton survival is greater
Improved moisture infiltration due to minimal disturbance and retention of deep cracks from the surface.	Retention of remanent cereal stubble on the surface could increase cereal disease carry over	Possibility for greater nutrient stratification at the soil surface
Savings in fuel and machinery depreciation.	Managing a cotton crop for an earlier March 31 maturity could compromise yield or quality in some seasons	

# Wirelessly managing drift risks

A major, collaborative project aimed at reducing off-target herbicide drift has been ramped up, with new methodologies and technology to predict unfavourable weather conditions at its heart.

In a continuation of the CRDC and GRDC project started in 2016 on drift mitigation in Northern NSW and Southern Queensland, the roll out of monitoring towers to detect the most hazardous surface temperature inversions will be rolled out across the cotton and grains growing areas in the near future. Planning is currently underway and the use of novel mobile monitoring technology is also being considered. These towers and the technology attached to them could result in predicting long distance drift out to 36 hours ahead, as well as real-time updates for spray applicators.

Unintended herbicide damage is an issue affecting a number of broad-acre and intensive agricultural industries in all cotton growing regions. Off-target spray drift has been identified as a key RD&E priority by growers across a number of regions. As a result, in September 2016, this project to develop a spray drift hazard prediction system was commissioned. With CottonInfo Climate Technical Lead Jon Welsh, private consultant Graeme Tepper then set out to install a wireless sensor network across Northern NSW and Southern Queensland cotton growing areas.

Monitoring towers were erected in the Lower

Namoi Valley, Gwydir Valley, Border Rivers and Darling Downs regions in 2016. The equipment monitors wind and temperature at distances between two and 10 metres. These observations will be compared and calibrated with a high resolution meteorological/air pollution model to provide timely advice and warning of site specific hazardous conditions.

When spray droplets are captured and transported in very stable and highly stratified inversions, these compounds can affect cotton and other crops and severely damage or kill sensitive vegetation. The figure below shows the potential for uplift of pesticides in a range of conditions and the impact of fine, medium and coarse droplet sizes. Vehicles travelling on outback gravel roads leaving a plume of dust can also provide an indication of atmospheric stability.

As Australia moves toward the adoption of 2,4-D and dicamba-tolerant cotton varieties, cotton growers themselves must be mindful of the effect spraying these type of chemicals in unfavourable conditions. Vineyards are highly sensitive to off-target phenoxy herbicide injury from applications on other crops in the vicinity. Vineyards are common in the southern cotton growing region around Griffith and Coleambally. Lucerne pasture and bee colonies are also highly susceptible to phenoxy.

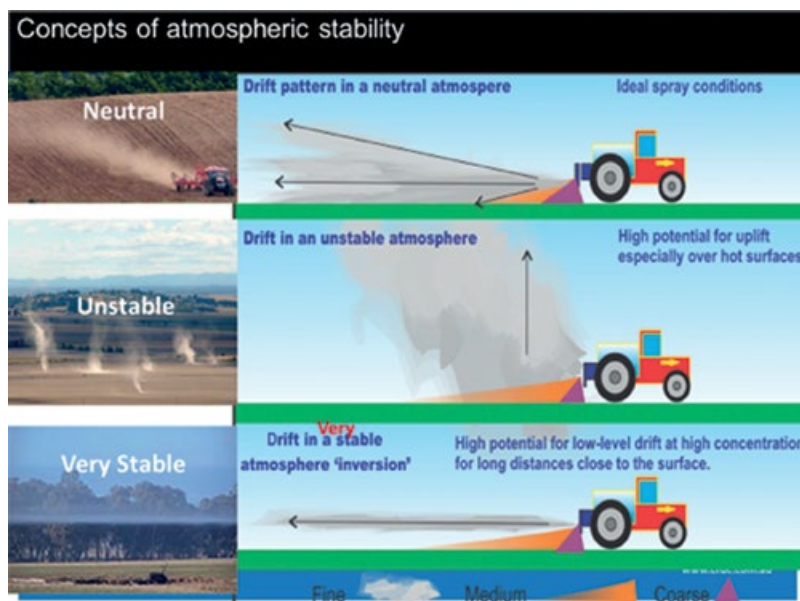
The initial stages of the project involved collating and gathering site observations, followed by in-depth analysis of one-second to 10-minute data to determine hazard variability and associated factors that correlate to hazardous conditions. Once observations are checked and a set of indices developed the decision criterion can discriminate hazardous inversions from non-hazardous inversions. The final objective of the project is to develop a communication strategy alerting users of current and forecast spraying conditions.

CRDC and GRDC have also compiled an inversion fact sheet, which is available at [www.grdc.com.au/GRDC-FS-sprayinversions](http://www.grdc.com.au/GRDC-FS-sprayinversions)

## For more

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# The price of plastic

A single piece of contamination can lead to the downgrading of Australian cotton bales, yarn, fabric and garments or the total rejection of an entire batch. It can cause significant harm to the reputation of Australian cotton as contamination-free, and adversely affect the relationship between growers, ginners, merchants and our customers.

Plastic contamination can shut down a cotton gin and cause harm to Australia's reputation globally. CSIRO's Andrew Krajewski (pictured) was involved in developing gin sensors to detect plastic contamination in gins, yet more still needs to be done by operators in the field to avoid the issue.

While the advent and significant uptake in Australia of the John Deere round module picker and stripper has reduced the risk of certain types of contaminant associated with conventional modules, it has introduced a new contamination risk; the polyethylene (plastic) wrap on the round module.

There are many ways to manage this risk of the module wrap entering the gin, one being a sensor that is placed in the module feeder hood that detects and alerts the gin operator to the presence of plastic caught on the module beaters. Developed by CSIRO with the support of the Australian Cotton Ginners Association and CRDC, Contamination Sensor was first installed in the 2012 season. It is now being used in 10 Australian cotton gins. The system successfully captures contamination events, allowing ginners to react promptly to remove contaminants before they are fragmented and end up in the bale.

"Contamination is not just an issue for Australia; the need to invest in managing contamination is often cited by spinners as a reason to not use cotton at all," CRDC R&D Manager Allan Williams said. "So while Australia benefits from its contamination-free reputation, it is also important

that the cotton industry as a whole reduces its levels of contamination in order to better compete with man-made fibres, which do not require managing for contamination."

A recent joint workshop between fibre quality and ginning researchers from Australia and the United States included a focus on managing plastic contamination. Organised by Allan in collaboration with the US upland cotton research and marketing organisation Cotton Incorporated, a range of issues were addressed with a view to identifying collaboration opportunities between researchers from the two countries.

As well as discussing plastic contamination, trash management and improving the measurement of fibre maturity were agenda items for the participants, which included researchers from CSIRO, the University of Southern Queensland, the United States Department of Agriculture and representatives from Cotton Inc.

"We all felt that there was a need to look at both short-term and long-term solutions," Allan said.

"In the short-term, identifying and/or removing the plastic before it enters the gin was seen as critical.

“Enhancing the ability to detect the plastic, for example through a change in colour or the use of additives, was also discussed.”

Long-term solutions put forward included a system that didn’t require plastic at all.

“We also discussed the importance of avoiding plastic getting into the module feeder bay in the first place, which means good house-keeping at both the farm and the gin is essential,” Allan said.

“Everyone involved in the making, handling, cartage, storage and unwrapping of round modules has a role in ensuring ensure that the integrity of the wrap is maintained: that it’s not faulty, compromised or damaged prior to ginning.

“Care needs to be taken at each stage of the handling of the round module from the harvester through to the gin: everyone involved must appreciate the importance of preserving the integrity of the plastic wrap.”

The key risk areas are:

- In the field – during wrapping, transporting and storage of the modules
- During transport – damage can occur from unsuitable trailers or restraints. Refer to the Cotton Australia guidelines on the transport of bales and modules available from the Cotton Australia website ([www.cottonaustralia.com.au](http://www.cottonaustralia.com.au))
- At the module feeder bay – plastic wrap may be embedded or hidden.

#### What can you do on-farm?

- Educate all harvester operators and workers on preventing contamination.
- Ensure the harvester is in good mechanical order and that daily setup/checks are conducted. In terms of the JD round-module harvesters, pay particular attention to the module chamber, ensuring that the settings and adjustments have not changed, that there is no damage to the components, and that the chamber is free from cotton build-up and debris.
- Check the quality/condition of round module plastic wrap and module tarps.
- Conduct a site inspection before building a conventional module or placing round modules (avoid rocks, grease, dirty and discarded cotton).
- Repair significant wrap tears in round modules in the field prior to module truck pickup.
- Notify your ginner if you suspect a module may be contaminated.

#### For more

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# Late planti

While cotton has been grown in the areas of the Lachlan Valley around Hillston for many years, broad scale production in the Murrumbidgee and Murray systems is relatively new.

The southern cotton growing region includes the river valleys of the Lachlan, Murrumbidgee and Murray rivers. The Murrumbidgee Irrigation Area (MIA) is renowned for its production of rice, maize and horticultural crops. While some growers in the region have been growing cotton for around a decade, for most it’s been less than five years, in what can be a challenging environment.

The region’s climate, while variable, often means growers are contending with cool starts, a short season and wet/cool picking. NSW DPI research agronomist Steve Buster compiled a data base of growers’ fields comprising some 23,105 hectares, or more than 55 percent, of the MIA cotton area for the 2016-17 season.

#### Cool start and finish

“A wet and prolonged winter preceding planting made field preparation challenging, while growing conditions included extreme maximum and minimum temperatures in the early part of the season and at late flowering,” Steve said.

“There were bed preparation issues and a delayed planting and cool weather after planting also affected emergence and early growth.”

The obvious answer for growers may be to plant later, but Steve’s research found that although temperatures for sowing are more suitable later in the season, there was a danger in sowing crops after November 7 in terms of fibre quality (in the 2016-17 season). According to the data, the optimum sowing time for the 2016-17 season was between October 10 and 17.

“The optimal sowing date has to be balanced by delayed sowing in warmer temperatures and the effects of low temperatures at the season end (defoliation and reduced picking opportunity) causing possible yield decline and quality issues,” Steve said.

“The data suggests that planting after November 7 can attract a yield penalty of at least 18 percent

# ng not ideal in MIA

and the lint quality of micronaire is predicted to be in the discount range of less than 3.5 (Figure 2).

“No other lint quality measurement was affected by sowing date, but with these discounts, growers should carefully consider the timing of any late plant or replant should it be necessary.”

Nitrogen application is highly variable and poorly correlated to yield. The data suggests that application of nitrogen (N) over 250 kg N/ha in this season did not contribute to yield.

“When deciding on whether to put out more nitrogen during the season, crop managers need to look at crop potential,” Steve said.

“If the yield potential is there, fair enough, if it is not, a lot of that N will be lost.”

## Fallow v rotation

For the purpose of the study, fields cropped in the previous summer (eg corn, cotton, soybean) were classified as ‘back-to-back’. Fields left fallow over summer regardless of the previous winter crop were ‘fallow’. All summer crops were grouped as it was assumed ground preparation may have been compromised with the wet winter compared with a dry bed preparation in the summer.

Cotton grown after a fallow summer yielded 1.28 bales/ha more (13.8 percent) than cotton grown after a crop (predominantly cotton) the previous summer. The results also show that hills performed better than beds under back-to-back crops by 7.5 percent. In fallow conditions there was no difference between hill/bed geometry. Steve said this raises the question, ‘Do we have a compaction issue from the previous wet winter and harvest that causes compaction on beds compared to hills in back-to-back rotations?’.

“With continued monitoring, building databases like this can be valuable in the long term as trends and farming practices can be identified across seasons and locations to create information and advice for growers,” Steve said.

“We hope this information provides some good feedback and information for growers going forward.” The full report can be found at [www.insidecotton.com](http://www.insidecotton.com)

*“Cotton grown after a fallow summer yielded 1.28 bales/ha more (13.8 percent) than cotton grown after a crop”*

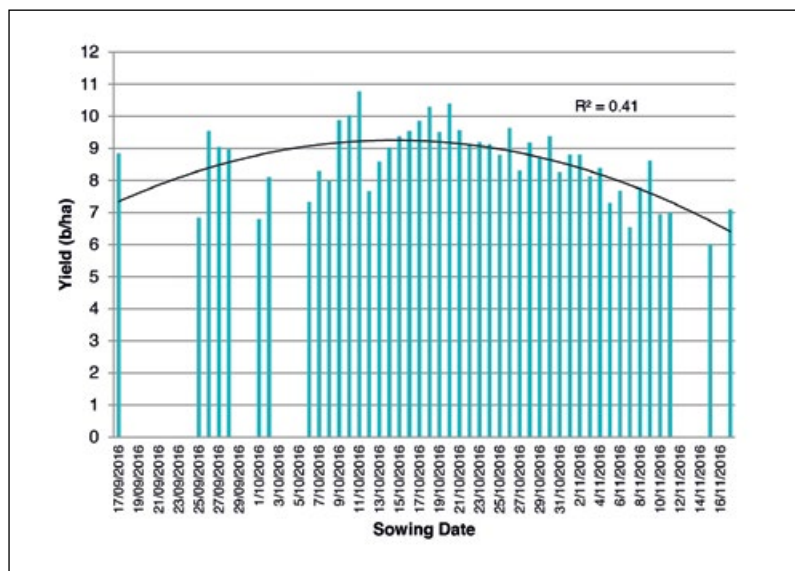


Figure 1. Average cotton yield as function of sowing date in the southern cotton growing region for the 2016-17 cotton season.

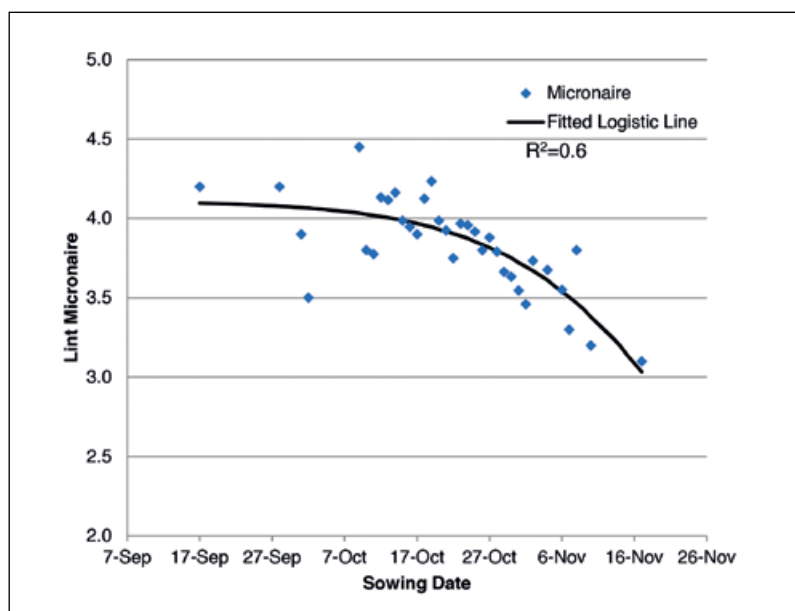


Figure 2. Average cotton lint micronaire as function of sowing date in the southern cotton growing region for the 2016-17 cotton season.

## For more

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# Nitrogen and irrigation management go hand-in-hand



JANELLE MONTGOMERY

Optimising irrigation and nitrogen efficiency was the focus for CottonInfo's annual researchers' tour in February, which attracted over 440 growers and consultants to field days across six cotton growing regions, with support from CRDC.

CottonInfo Nutrition and Water Technical Lead John Smith co-ordinated the tour and said bringing irrigation and nitrogen (N) together was a natural progression for the team.

"In previous years we have held really well attended irrigation and nutrition tours separately, however many gains have been made in these research areas recently.

"Researchers and CottonInfo Regional Extension Officers (REOs) have been quietly working at improving efficiency in N and irrigation and have identified that the real gains can only be made by examining the interaction between the two. We know that you can't talk about one without talking about the other.

"Nitrogen is a key driver of lint yield within the irrigated cotton system but its influence is complex.

"Improving the returns from the key investments of nitrogen and water is reliant on understanding the interactions between irrigation systems, soil type and irrigation management on key loss pathways and crop uptake of nitrogen.

"Irrigation has a huge impact on N use efficiency (NUE), and if you're trying to improve one without considering the other you are facing an uphill battle.

"NUE can be blown out of the water by poor irrigation practice."

Bringing researchers together and in front of growers and consultants is an important avenue to transfer knowledge, increase uptake of best management practices and review how research is being understood and used in the field. It also identifies knowledge and research gaps.



## Making changes

A CottonInfo nitrogen-water trial at Garry Houston's property at Weemelah in the Border Rivers region has highlighted the transient nature of nitrogen (N) in cotton fields. Irrigation evaluation conducted by REO Janelle Montgomery, with NCEA's Dr Joe Foley and Malcolm Gillies confirmed the soil has a high infiltration rate, which can result in the movement of N out of the root zone, particularly at the head ditch where the opportunity time for infiltration is greatest.

"This lines up with low N at head ditch and high N at tail drain which showed up in soil tests and was also evident in yellowing of plants at the head ditch near the end of the season," Janelle said.

"Infiltration will drive irrigation performance and hence the N movement within the field".

Cotton consultant Rob Holmes of HMAg can see significant implications for their nutrient management given the infiltration associated with this soil type.

"The irrigation evaluation has given us an insight into how water moves through this soil," Rob said.

"We were not expecting these results at all, but it all makes sense now to what we are seeing in the field."

As a result of the evaluation and information, Rob will work with Garry to improve the way they manage their N application by implementing variable rate and a possible change to water-run N for more timely application. They are also looking to optimise their irrigation application.

It's getting the questions directly from growers to researchers and vice versa to understand the issues growers are dealing with.

"The practicalities of implementing research need to be considered which gives the researchers the opportunity to get some conversations happening and take grower and consultant issues or concerns into account," John said.

"Conversely, as researchers we can explain where N losses occur and how management affects these losses.

"Getting an understanding of the impacts of irrigation management for individual scenarios is really important for researchers."

During the tour it was evident that there were some areas of the research that are still not well understood. Crop managers still have questions about timing of N application, N losses and when they occur and measuring soil N.

Gwydir Valley CottonInfo REO Janelle Montgomery ran a webinar in late May to provide further information on the major queries and



RUTH REDFERN

knowledge gaps identified on the tour. The webinar can be downloaded from the CottonInfo youtube channel ([www.youtube.com/cottoninfoaustr](http://www.youtube.com/cottoninfoaustr)) and includes discussion around:

- The effectiveness and correct procedure for soil testing. The challenges and impact of irrigation moving N around the field (featuring David Hall).
- Pre-season vs in-crop N application, risk analysis looking at historical weather data and impact of N timing and weather patterns (featuring Prof Peter Grace, QUT).
- Plant demand and impact of N timing. This is about better understanding how critical N nutrition is at different stages of crop development (featuring Dr Mike Bange, CSIRO).

### Timing of N application

The tour was fortunate to have Professor Peter Grace from QUT participate. *Spotlight* asked Peter to identify the major management issues he saw based on questions and conversations with growers and consultants.

"I'm not sure that the actual (high) magnitude of losses of N in irrigated clay soils under certain conditions is well understood," Peter said.

"A saturated soil environment produces an N loss which is directly related to the time under saturation and the amount of mineral N present.

"Dr Joe Foley presented some nice work on furrow irrigated systems and the information required to maximise water use efficiency and minimise the time under saturated conditions.

"The N loss is limited only by the amount of mineral N present in the soil and this means if you have a large amount of N sitting there it could all be lost in the worst case scenario.

"Over application of N is the normal approach to compensate for these N losses but without an N budget (ie N in soil + N potentially mineralised) a grower is not even in the ball park."

### For more

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The CottonInfo Irrigation and N Tour took industry experts to six cotton growing valleys, including Southern NSW.

# How quickly does urea mineralise when water-running nitrogen?

Water-running urea can be an effective way to top up nitrogen levels in-season, but how long does the nitrogen stick around in the water before it's lost to the atmosphere?

Water-run urea is a popular method of nitrogen (N) application, with 46 percent of Australian irrigated cotton growers using this method in the 2016-17 season. Adding urea to irrigation water can reduce labour requirements, increase N infiltration into the soil, and can produce uniform applications (with careful management).

James Latimer is a CRDC-supported PhD student at the Australian National University (ANU) and CSIRO, and is studying nitrogen losses in water-run irrigation systems. James emphasises that timing is key when water-running urea, as it will quickly breakdown when dissolved, resulting in atmospheric N losses. It is important to remember that every minute the fertiliser is dissolved in water is another minute of denitrification occurring.

James says he's often asked how long the nitrogen remains in the irrigation water after the urea has been added.

"It depends on a few factors, the most important being water temperature and the amount of soil interaction. The driving force behind denitrification is the microbes, which are primarily found in the soil," he says.

"So if the nitrogen-rich water is touching lots of soil – like when running down furrows – then there are lots of microbes to eat up the nitrogen and speed up denitrification. Conversely, if there isn't much soil interaction – like in a storage dams or large supply channel – then the rate of denitrification should be lower."

After struggling to find any data that puts

numbers to the rates of N loss from water-run urea, James undertook a small-scale study to estimate the rates of N loss in water-run urea.

"I wasn't satisfied with my answer to growers, so I ran my own study to get some answers."

James' study examines the rates of urea mineralisation (conversion into nitrate and ammonium) in different types of water. In the study he has compared three different scenarios: urea in water; urea in water with soil; and urea in water with sterilised soil.

The experiment indicates that while the water's microbes affect the rate of urea mineralisation, it is the soil's microbial community that really drives mineralisation. Further very small amounts of nitrate and ammonia were present in the water (less than eight parts per million) for all treatments. In the water and soil treatment this means that approximately one quarter of the N is either lost by denitrification or converted to organic N during the experiment.

James's CSIRO supervisor, Dr Ben Macdonald, said these transformation rates "are likely to be greater in the field due to increased water temperature and organic carbon content of the water". He said James is keen to emphasise that this was only a pilot study, and that he is currently undertaking a more comprehensive study to provide more concrete answers to some of these questions.

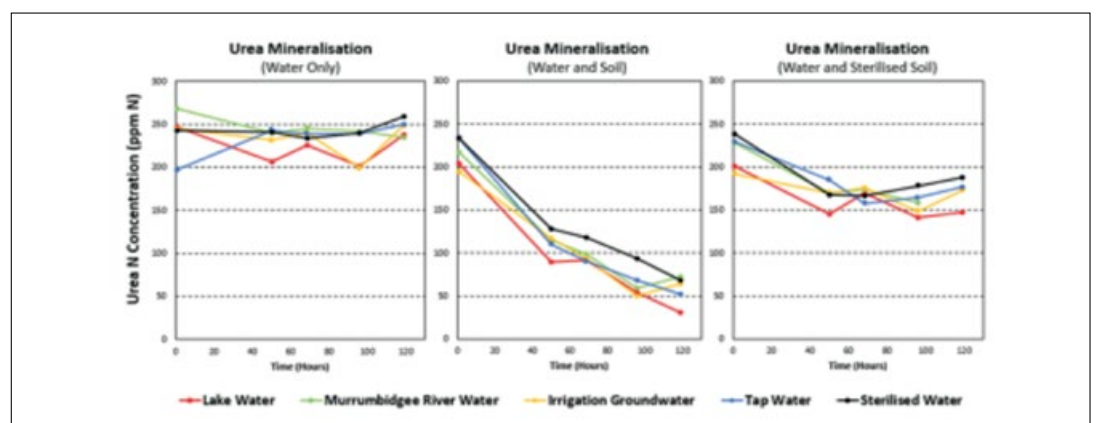
"These results do, however, demonstrate the important role microbes are playing in the farm's nitrogen cycle, and should further emphasise the importance of caring for your soil," James said.

## For more

James Latimer

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**Figure 1.** Urea mineralisation under different treatments at 25°C. The five water types used in this study range in microbial content high to low, left to right. All water types exhibit the same trends in each treatments, indicating that the soil microbes are the driving factor in urea mineralisation. The reduced urea conversion in the sterilised soil treatment indicates that the living microbes are the key component in the soil driving mineralisation.





# Reconsider the importance of soil organic carbon

The pursuit for better agricultural productivity and profitability over the years has resulted in a decline in soil organic carbon globally, and the cotton production system is no exception.

When compared to surrounding remnant native vegetation, most cotton fields have a significantly lower soil organic carbon (C) content, and it is likely to continue to decrease if current management practices are maintained.

Dr Oliver Knox, who leads the CRDC-funded Soil System Research project says the consequences of such decline can be devastating in cotton production.

"It will not only affect the physical structure of soils, but also affect water and nutrient retention and biological activities that control storage and release of nutrients like nitrogen (N)," Oliver said.

"Indeed, soil organic C, or more appropriately in this case, soil organic matter, plays a crucial role in soil N availability.

"Soil organic matter contains C, N and various other elements in an organic form and represents the largest pool of N in the soil. Only a small proportion of N exists as inorganic N, even the amount added to the system through fertiliser application is also

relatively small when compared to the organic component."

The fate of added N is largely influenced by various environmental factors that affect soil moisture and temperature, but also by microbial processes and plant demand. Given that the most common practice is to apply the majority of N fertiliser well before planting, soil conditions and microbial processes determine the fate of freshly added N in the soil, and hence the amount of available N to the subsequent cropping season.

But why is soil organic C important in determining the fate of added N?

"Because soil organic matter provides food and habitat for the microbial community that drives N transformations in the soil," says Dr Yui Osanai (pictured) who examines the mechanisms of soil C and N dynamics within the project.

"However, it is not a one-way relationship - soil organic matter itself is made up of both living and

dead microbial biomass and is a product of microbial processes itself.

“And most importantly, this unique relationship means that soil organic matter (and its living components) could act as a temporal storage mechanism for added N”.

### The need for C

In the absence of crops, added N will be either lost from the soil through ammonia volatilisation, denitrification or leaching unless it is immobilised by microbial community, where it is temporally unavailable to crops. However, this immobilised N can become available again through the mineralisation process, which makes immobilisation of N a far better option than losing N from the system altogether.

However, for the microbial community to immobilise added N effectively, it needs organic C.

“Microbial communities need both C and N (and other nutrients of course) to build cells and grow in population size,” Yui explains.

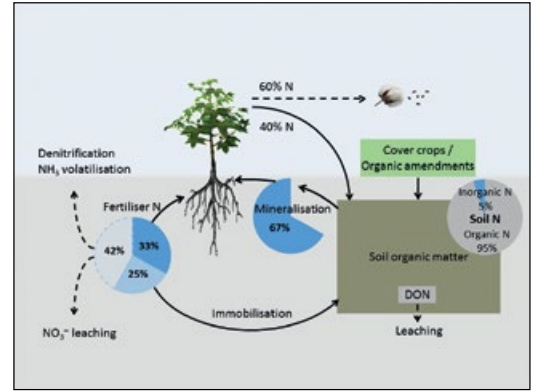
While microbial growth (i.e. increase in cell numbers) requires both C and N, maintaining its population size (i.e. keeping cells alive) requires C, but far less N.

“Microbes feed on soil organic matter for organic C for their energy, and release carbon dioxide (CO<sub>2</sub>) and other components of soil organic matter as waste, and N mineralisation occurs as a result of that,” Yui said.

“This is why we see a build-up of inorganic N during a fallow because there are no plants to remove it, but having no plants to release organic C into the soil and feed the microbes means that they have to switch from growth to a maintenance role. As such we see inorganic N accumulate, but you probably don’t see any changes in soil organic C content.

“It’s basically a supply and demand relationship.”

This might be easy enough to understand in theory, but perhaps difficult to see it in reality.



**Figure 1:** Nitrogen (N) cycling in cotton system showing the fate of fertiliser N, major pathways of N losses from the system and the importance of soil organic matter in providing N through mineralisation. The maintenance of soil organic matter is crucial in meeting plant’s demand for N. It also shows that unlike N losses through ammonia volatilisation, denitrification, leaching and harvest, microbial immobilisation keeps N within the system for future use.

### Types of C

Soil organic C is a collective term, and in fact, there are many different ‘types’ of soil organic C existing in the soil. The type of soil organic C that microbes prefer is a labile component of soil organic C, such as those released into the soil by roots. This labile component, however, is only a small proportion of the total soil organic C.

While labile C is the most readily available form of C for microbes, non-labile C (i.e. recalcitrant C or more stable C) is the biggest C pool and can still provide energy to microbes. What’s also important is that this represents stable C in the soil.

“Stable C is what we want in order to build soil organic C, but labile C is what controls microbial activity, and unlike inorganic N and organic N, there is no clear distinction between labile and stable C; it is more like a gradient,” Yui says.

“So, as labile C is taken up by microbes, it is either released as CO<sub>2</sub> or incorporated into microbial biomass.

“Labile C becomes more stable as it gets incorporated into microbial biomass and turned into more complex compounds. Understanding this process can really help how we can manage the system to build soil organic C”.

So what’s needed to build soil organic C? Patience and understanding, according to Oliver.

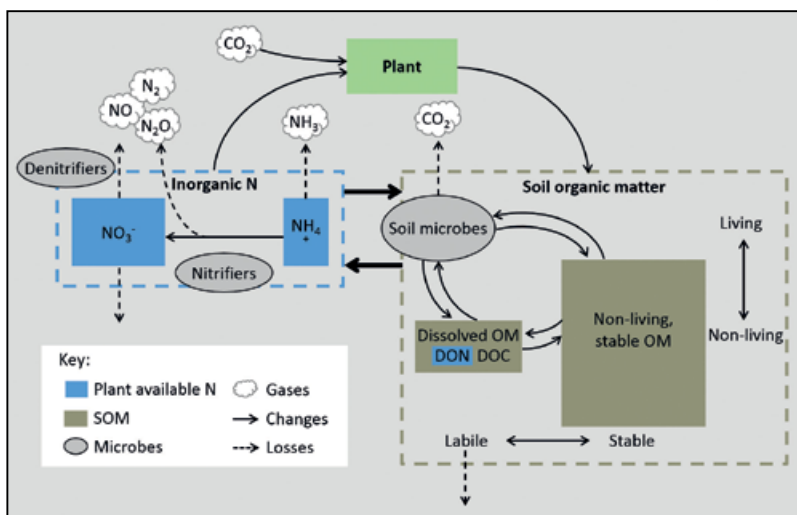
“It will be a slow process and it won’t be fixed in short term,” he says.

“However, that does not mean it’s too late, there are numerous ways in which we can increase soil organic C in the cropping systems (cover crops, minimum tillage).

“But the most important thing is to understand the temporal and spatial dynamics of C and N in the soil, and understand how a particular management will impact those dynamics.

“It will be a wasted effort if management to increase C input into the soil is not followed by management to retain this C in the soil.”

**Figure 2:** C and N dynamics that are intimately linked through plant production of organic matter and microbial processes that affect the nature of organic matter and release of inorganic N through mineralisation. Soil microbes are the mediator of exchange between soil organic matter (SOM) and inorganic N, while soil microbes themselves are part of SOM that go through constant changes/turnovers (e.g. consumption of SOM, microbial death) that influence the stability of SOM.



## Rotation and tillage

Yui's current project is examining the impact of crop rotation and tillage on soil C and N dynamics over two years, with soil samples taken regularly to capture the temporal dynamics. The researchers are not only interested in the overall trend, but also the magnitude of temporal fluctuations, which is useful in understanding the mechanisms. And it's not only temporal dynamics; spatial dynamics also need to be understood.

"We are finding that C dynamics differ between the topsoil (0- 30 cm) and the subsoil (30-100 cm) in the system," Yui said.

"We don't know whether this is linked to the physical constraints of subsoil that many cotton fields are facing, but it certainly raises a question as to what would happen to subsoil C and N dynamics, as a consequence of field management to alleviate the physical constraints for crop productivity – are we going to lose all the subsoil C that was previously inaccessible?"

Productivity-driven field management has led to a decline in soil organic C and its function. If cotton growers were to move towards a more sustainable system that relies less on external input and have a better resource use, there is a need to start managing the system as a whole.

"I think it's great to see more investment to look at the interactions between key issues that were traditionally examined separately, like water and nitrogen," Yui said.

"We certainly believe that soil organic C plays an important role in water and nutrient availability, and so understanding the interactions between them have a huge potential for improving resource use efficiency."

### For more

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UNE researchers Katherine Polain, Associate Professor Brian Wilson and Dr Oliver Knox took soil cores down to a metre.



# Soil your...what?!

The CottonInfo team is inviting cotton growers, farm workers, contractors, researchers and students to ... soil your undies!

### Simple steps to SOIL YOUR UNDIES!

1. Request undies from your local REO
2. Bury undies
3. Wait two months
4. Dig up undies
5. Share photos on Twitter (#soilyourundies) and discuss outcomes with your local REO

All in the name of good soil health, the fun soil science experiment is being run by CottonInfo to raise awareness of soil health, and allow people to easily see how healthy their soil is.

CottonInfo REO Sally Dickinson says it's easy to participate: just bury a pair of white, 100 percent cotton undies in topsoil for two months and then check the level of decomposition. Local REOs will supply the undies, and after two months it's then time to share these experiences with local CottonInfo REOs and the Twitter community using the hashtag #soilyourundies.

With proper management, the ground beneath crops should teem with millions of tiny lifeforms including bacteria, fungi, protozoa, nematodes, arthropods and earthworms – all busy transferring nutrients, eating and decomposing organic material through nutrient cycling in processes that help plants thrive. If there's not much left of the undies after a couple of months, this indicates good biological activity, which indicates healthy soil, as the soil organisms breaking down the processed cotton break down plant materials in much the same way.

Soil scientist Dr Oliver Knox has had the 'dubious' task of tackling the soiled undergarments, and what he is finding is...

"Moisture, management and

marsupials are all having a big impact on your soiled undies," Oliver says.

"We've had growers compare native vegetation sites with their fields and the good news is that in most soils we've had undies reduced to little more than the elastic waist band.

"Because the biodegradation of cotton requires several enzymes from a variety of microbes to be effective this implies that these soils are biologically healthy.

"Others have picked different parts of the field with one pair of undies from a tail drain being almost still fit for purpose, with the lack of plant residues and prolonged periods of flooding of the drain during the season being the most likely reasons as to why these pants did not break down."

To participate, contact your local CottonInfo REO to request a pair of undies and document your journey on Twitter using the hashtag #soilyourundies (be sure to mention or tag CottonInfo using our handle @CottonInfoAust so we can retweet your great work!).

### For more

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



# Accreditation – it's more than just a piece of paper

It was not so long ago in Australia that anyone, regardless of their background, qualifications or experience, could set themselves up to provide financial planning advice to unsuspecting investors and retirees.

Perhaps it was the bloke you played footy with or an old bank employee. Most commonly it was an ex-insurance sales person, whose commission-based sales model would lead to cases of poor quality advice and some bad financial outcomes.

It is interesting to note that the crop consulting industry has been borne out of a very similar set of circumstances. To this day in fact, it is possible legally for anyone to call themselves an agronomist and offer clients advice – all without qualifications and or experience. The onus lies with the client/grower to check the experience, qualifications and ongoing professional development of their advisor, prior to contracting them.

## Voluntary accreditation scheme

There have been ongoing discussions with the agricultural sector for many years around the development of a formal accreditation system for the Australian agricultural consultants. This mantle has been taken up by the Ag Institute of Australia, and Crop Consultants Australia Inc (CCA) looks forward to being part of the ongoing negotiations to develop a flexible, voluntary accreditation scheme. Such a scheme will see practitioners earning professional development points, which when accumulated to a certain level, will earn them the right to promote their current credentials. The introduction of accreditation has long been a source of conjecture in the industry, but ultimately, the success or failure of the system will be driven by demand from growers for professionalism in the consultants whose services they use.

While this system will be widely recognised across industry, it is important to note that CCA as an organisation has been successfully running a program which recognises professional development for many years. To be recognised as a 'Professional Consultant' member with CCA, a consultant must have an established consulting career with more than 10 years of industry experience and must spend a significant amount of time providing agronomic advice. They must have relevant tertiary qualifications or more than 20 years of consulting experience and wish to be recognised for their completion of a minimum of 30 hours of up-skilling per year. Anyone contracting the services of such a

CCA member knows that they bring with them a commitment to professionalism that they renew on an annual basis through avenues such as study, attendance at seminars, research presentations and product information sessions. They have more than just a piece of paper to say that they are qualified.

Do you use an agronomist or consultant to provide advice on your crops? Are they a professional or young professional member of the CCA? Perhaps this is the simplest way of establishing the person you are hiring is suitable to advise you on your crop management.

## Save the date for Seminar

CCA as an organisation came together over 25 years ago to provide an opportunity for independent agronomists to network, share information and develop the profession. The key element of this professional development and upskilling has been its two-day Cropping Solutions Seminars, the content of which is set annually via feedback from the membership. The information is timely, highly technical and is backed up by personal connections that allow our members access to further information should they need it.

This year, CCA will run one seminar on June 21 and 22 in Narrabri, to be supported by a newly developed local workshop series which will run in late August and early September. The Seminar agenda offers attendees a diverse range of topics – from a panel discussing the latest in crop technology and innovation, to weather modelling and understanding the impact of temperature on plant growth. A team of researchers and agronomists will also examine a 'beneficial' approach to whitefly management and how to better share information during a season to manage pest numbers regionally. As always, our seminar will include a special session debrief for 'young agronomists' and our seminar networking dinner which this year will feature guest speaker Mark Sowerby.

While the agenda is specifically developed by agronomists, for agronomists, we welcome all members of industry including researchers, growers and resellers. It is the mix of people in the room that makes for diverse discussions, networking and information transfer. Membership of CCA is not restricted to Professional members, and for more information regarding membership and this years' upskilling opportunities, please visit our website.

## For more

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

# CRDC Investments 2018-2019

The 2018-19 year will mark the first year under CRDC's new five year plan: the 2018-23 CRDC RD&E Strategic Plan. Under this Plan, during 2018-19, CRDC will invest \$24.3 million into approximately 300 RD&E projects across five key areas, in collaboration with around 100 researcher partners, and on behalf of Australia's cotton growers and the Australian Government. This table outlines the projects that CRDC will invest in, along with the lead researcher, their research organisation, and the commencement and completion dates for the projects. Please note that this table is current as of 9 May, and is subject to change.

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
<b>Goal 1: Increased productivity and profitability on cotton farms</b>							
1.1 Optimised farming systems	1.1.1 Improved yield and quality	Increased yield through improved management of soil constraints in cotton farming systems	1819FRP073	Bennett, John	USQ	Jul-18	Jun-21
		Precision management for improved cotton quality	CMSE1802	Long, Robert	CSIRO	Jul-17	Jun-20
	1.1.2 Improved input efficiencies	Improving the nitrogen use efficiency of cotton crops through better understanding the role of dissolved organic nitrogen	1819FRP018	Macdonald, Bennett	CSIRO	Jul-18	Jun-21
		Improving water use efficiency in a changing climate	UNSW1802	Triantafyllis, John	UNSW	Jul-17	Jun-20
		Improving water use efficiency in a changing climate	CSP1804	Broughton, Katrina	CSIRO	Jul-17	Jun-20
		IREC Field Station Automated Irrigation	IREC1801	Ayliffe, Emma	IREC	Apr-18	Jun-19
		IREC Field Station: Automation of recycle system	IREC1701	Houghton, Rob	IREC	Mar-17	Aug-18
		More Profit from Nitrogen - enhancing nutrient use efficiency in cotton	RRDP1712	Schwenke, Graeme	NSW DPI	Jul-16	Jun-21
		More Profit from Nitrogen - Improved nitrogen use efficiency through accounting for deep soil and mineralisable N supply, and deployment of Enhanced Efficiency Fertilisers to better match crop N demand	RRDP1717	Van Zwielen, Lukas	NSW DPI	Jul-16	May-20
		More Profit from Nitrogen - Increasing nitrogen use efficiency in dairy pastures	RRDP1714	Rowlings, David	QUT	Jul-16	Nov-19
		More Profit from Nitrogen - Optimising nutrient management for improved productivity and fruit quality in cherries	RRDP1721	Swarts, Nigel	UTAS	Aug-16	Jun-21
		More Profit from Nitrogen - Optimising nutrient management for improved productivity and fruit quality in mangoes	RRDP1720	Bristow, Mila	NTDPIR	Aug-16	Jun-21
		More Profit from Nitrogen - PMA Meetings	RRDP1722	Williams, Allan	CRDC	Jul-16	Jun-20
		More Profit from Nitrogen - Project Communications	RRDP1735	Williams, Allan	CRDC	Jul-16	Apr-20
		More Profit from Nitrogen - Quantifying the whole farm systems impact of nitrogen	RRDP1716	Eckard, Richard	UMELB	Jul-16	Apr-20
		More Profit from Nitrogen - Science leadership and project coordination	RRDP1711	White, Marguerite	ICD	Nov-16	Jun-20
		More Profit from Nitrogen - Smart blended use of enhanced efficiency fertilisers to maximise sugarcane profitability	RRDP1718	Wang, Weijin	DSITI	Jul-16	Apr-20
		More Profit from Nitrogen - YourData platform	RRDP1727	Coutts, Jeff	Coutts J&R	Feb-17	Jun-21
		More Profit from Nitrogen - Improving dairy farm nitrogen efficiency using advanced technologies	RRDP1715	Suter, Helen	UMELB	Jul-16	Nov-19
		More Profit from Nitrogen - New technologies and managements: transforming nitrogen use efficiency in cane production	RRDP1719	Redding, Matthew	QDAF	Sep-16	Jun-21
		Optimising the management of manures in southern NSW cotton production II	1819FRP035	Quayle, Wendy	Deakin University	Jul-18	Jun-21
		PhD: Monitoring soil water dynamics for improving water use efficiency	UNSW1801	Zare, Eshan	UNSW	Jul-17	Jun-20
	PhD: Next-generation fertilisers for nutrient stewardship in cotton production	UQ1702	Pirie, Rhys	UQ	Jan-17	Jan-20	
	PhD: The impact of irrigation methods and management strategies on nitrogen fertiliser recovery in cotton in southern QLD	UQ1502	Smith, John	UQ	Jul-14	Dec-20	
	Utilising plant-based sensing techniques for improving water profitability in fully and partially irrigated cotton	1819FRP043	Jamali, Hizbullah	CSIRO	Jul-18	Jun-21	
	1.1.3 On-farm sustainable development is supported	National Soils RD&E Strategy	COMM			Jul-18	Jun-19
		National Water RD&E Strategy	COMM			Jul-18	Jun-19
		Science leadership for cotton development in Northern Australia	1819FRP013	Yeates, Steve	CSIRO	Jul-18	Jun-21
	1.1.4 Improved reliability of cotton production	A sprayable water barrier to line irrigation channels - scoping study	CSE1802	Bristow, Keith	CSIRO	Oct-17	Sep-18
		Biodegradable sprayable polymer to improve crop water productivity in cotton production systems	1819FRP069	Bristow, Keith	CSIRO	Jul-18	Jun-21
		Minimising yield variability to maximise yield in a cotton farming system	DAN1801	Nachimuthu, Gunasekhar	NSW DPI	Jul-17	Jun-21
		Opportunities for dryland cotton with Bollgard 3	DAQ1703	Grundy, Paul	QDAF	Jul-16	Jun-21
		Optimising seedling emergence	DAN1701	Slinger, Deb	NSW DPI	Jul-16	Jun-19
PhD: Utilising novel plant growth regulators to develop resilient future cotton systems		CSP1604	Welsh, Claire	CSIRO	Apr-16	Mar-19	
Quantifying the effectiveness of cover crops as a means of increased water infiltration and reduced evaporation in the northern region		GRDC1801	Lawrence, David	GRDC	May-17	Apr-20	

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
1.2 Transformative technologies	1.2.1 New technologies are adapted for use in cotton	Application of molecular tools to monitoring for resistance alleles in <i>Helicoverpa</i> spp.	CSE1801	Walsh, Tom	CSIRO	Jul-17	Jun-20
		Assessing the potential of a new monitoring tool (Zappa trap) for managing sucking pests on cotton	1819FRP006	Mensah, Robert	NSW DPI	Jul-18	Jun-21
		Commercial development and evaluation of a machine vision-based weed spot sprayer	NEC1402	McCarthy, Cheryl	NCEA	Jul-13	Apr-19
		Future Farm (Phase II): Technology solutions for improved nitrogen application decisions	COMM			Jul-18	Jun-21
		Identifying sensors for better IPM in cotton	1819FRP019	Long, Derek	USQ	Jul-18	Jun-21
		PhD: Characterisation of brassinosteroid effects and brassinosteroid-responsive genes in cotton for growth and stress tolerance enhancement	UNE1605	Al-amery, Anahid A Essa	UNE	Sep-15	Feb-19
		Precise real-time automated cotton irrigation for improved water productivity	1819FRP064	Foley, Joseph	NCEA	Jul-18	Jun-21
		Precise real-time automated cotton irrigation for improved water productivity	1819FRP084	Hornbuckle, John	Deakin University	Jul-18	Jun-21
		Precise real-time automated cotton irrigation for improved water productivity	1819FRP098	Gall, Louise	GVIA	Jul-18	Jun-21
		The platform for monitoring and analysis of cotton canopy nitrogen status and yield projection using calibrated aerial and satellite imagery	FLUR1801	Volkova, Anastasiia	FluroSat Pty Ltd	Dec-17	Aug-18
1.3 Protection from biotic threats and environmental stresses	1.3.1 Increased understanding of the impact of pests, diseases and weeds, and environmental stresses	IPM to support management of emerging cotton pests	1819FRP038	Heimoana, Simone	CSIRO	Jul-18	Jun-21
		PhD: Biology of <i>Amarathus hybridus</i> , <i>A. mitchelli</i> , and <i>A. powellii</i>	UQ1703	Khan, Asad	UQ	Jan-17	Dec-19
		Transformation of <i>Verticillium dahliae</i> , causal agent of <i>Verticillium</i> wilt of cotton, with the GFP gene	DAN1809	Gregson, Aphrika	NSW DPI	Dec-17	Dec-19
		Understanding the ecology of reniform Nematodes in cotton	DAQ1803	Smith, Linda	QDAF	Nov-17	Jun-19
	1.3.2 Improved identification, surveillance and management systems for pests, diseases and weeds and environmental stresses	Biological based products for improved cotton production	1819FRP076	Singh, Brajesh K	UWS	Jul-18	Jun-21
		Biological control and taxonomic advancement for management in the <i>Noogoora</i> burr complex	DAN1805	Johnson, Stephen	NSW DPI	Sep-17	Jun-19
		Conventional insecticide resistance in <i>Helicoverpa</i> - monitoring, management and novel mitigation strategies in Bollgard 3	DAN1506	Bird, Lisa	NSW DPI	Jul-14	Jun-19
		Cotton Disease Technical Lead (CottonInfo and myBMP)	1819FRP077		NSW DPI	Jul-18	Jun-21
		Development of a spray drift hazard prediction system	MRES1701	Tepper, Graeme	MRES	Jul-16	Jun-19
		Digital technologies for dynamic management of disease, stress and yield program	AGWA1701	Waters, Liz	AGWA	Jul-16	Jun-19
		Fitness cost of Vip3A and Cry1Ac resistance in HP	COMM	Walsh, Tom	CSIRO	Jul-18	Jun-21
		Improved management of silverleaf whitefly on cotton farms	1819FRP066	Sequeira, Richard	QDAF	Jul-18	Jun-21
		Improving plant pest management through cross industry deployment of smart sensor, diagnostics and forecasting	HIA1802	Tay, Wee tek & Brooks Dean	HIA	Feb-18	May-22
		Improving the management of cotton diseases in Australian cotton farming systems	RRDP1724	Smith, Linda	QDAF	Jul-16	Jun-19
		Innovative solutions to cotton diseases	DAN1703	Le, Duy	NSW DPI	Jul-16	Dec-20
		IPM Technical lead and pest management for high yield research	1819FRP107	Grundy, Paul	QDAF	Jul-18	Jun-21
		Managing Climate Variability Program (Phase 5)	MLA1701	Tom Davison	MLA	Jul-16	Jun-21
		Managing <i>Verticillium</i> risk for cotton	RRDP1723	Kirkby, Karen	NSW DPI	Jul-16	Jun-19
		Mirid and mealybug best practice management	DAQ1802	Sequeira, Richard	QDAF	Jul-17	Jun-20
		Monitoring silverleaf whitefly insecticide resistance	DAQ1701	Hopkinson, Jamie	QDAF	Jul-16	Jun-19
		Novel products and agronomy to maintain yields under high heat stress conditions	CSP1601	Bange, Michael	CSIRO	Jul-15	Jun-19
		Novel topical vegetable & cotton virus protection BIOCLAY	HIA1803	Mitter, Neena	UQ	Jul-17	Jun-20
		PHA Membership	COMM	Fraser, Greg	PHA	Jul-18	Jun-19
		PHA Secretariat support (Biosecurity RD&E strategy)	COMM	Fraser, Greg	PHA	Jul-18	Jun-19
		PHA Secretariat support (National Working Party on Pesticides Applications)	COMM	Fraser, Greg	PHA	Jul-18	Jun-19
		PhD: Building climate resilience in cotton through translational physiology	ANU1704	Gamble, Demi	ANU	Feb-17	Mar-20
		Ready to use soil test to manage black root rot risks	1819FRP048	Manjarrez, Maria	Microbiology Laboratories Australia	Jul-18	Jun-20
		Reducing cotton discolouration risk (stages 2 & 3)	COMM		Xinova	Jul-18	Jun-19
		Reducing the impact of weather, insects and microbes on cotton colour	1819FRP060	Heimoana, Simone	CSIRO	Jul-18	Jun-21
		Regional approach to weed management	COMM			Jul-18	Jun-21
Resistance research and monitoring to enhance stewardship of Bt cotton and management of <i>Helicoverpa</i> spp.	CSE1701	Downes, Sharon	CSIRO	Jul-16	Jun-19		
Staying ahead of weed evolution in changing cotton systems	UQ1501	Chauhan, Bhagirath	UQ	Jul-14	Jun-19		
Surveillance and studies for endemic and exotic virus diseases of cotton	DAQ1601	Sharman, Murray	QDAF	Jul-15	Jun-19		



Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
		The sustainable chemical control and resistance management of aphid, mites and mirids in Australian cotton, 2014-2019	DAN1507	Herron, Grant	NSW DPI	Jul-14	Jun-19
		The use of area wide management, IPM, detergents and oils for the suppression of whitefly population in cotton for the reduced reliance and use of chemical controls	CRDC1803	Ayliffe, Emma	Elders	Jul-17	Jun-19
	1.3.3 Industry is prepared for a biosecurity incursion	Large scale biosecurity scenario to support cotton industry preparedness	1819FRP053	Dibley, Stephen	PHA	Jul-18	Jun-19
	Plant Biosecurity Research Initiative	HIA1801	Luck, Jo	HIA	Jul-17	Jun-20	

Goal 2: Improve cotton farming sustainability and value chain competitiveness							
2.1 Sustainability of cotton farming	2.1.1 Improved environmental footprint for cotton farms	Alternative energy technologies and policy solutions for the Australian cotton	1819FRP056	Li, Li	UTS	Jul-18	Jun-21
		Alternative irrigation pump management strategies for healthy water systems	EOI0161			Jul-18	Jun-21
		Appropriate land-use methodology for Australian cotton life-cycle assessments	UQ1701	Visser, Francois	UQ	Jul-16	Jun-19
		CottonMap	COMM	Cottee, Nicola	CA	Jul-18	Jun-19
		Development of next generation evaporation mitigation technology with increased resistance to wind	UM1801	Qiao, Greg	UMELB	Sep-17	Aug-18
		Evaporation mitigation solutions for Australian cotton farm water storages	1819FRP087	Qiao, Greg	UMELB	Jul-18	Jun-21
		Feasibility study of managed aquifer recharge for improved water productivity	1819FRP005	Jakeman, Anthony	ANU	Jul-18	Jun-21
		Improved natural capital (biodiversity) on Australian cotton farms.	1819FRP031	Smith, Rhiannon	UNE	Jul-18	Jun-21
		Improving the ability of the Australian cotton industry to report its sustainability performance	QUT1705	Peterson, Erin	QUT	Jul-16	Oct-19
		Managing natural landscapes on Australian cotton farms to increase the provision	GU1701	Capon, Samantha	Griffith University	Jul-16	Jun-19
		National Residue Survey for Cotton	CA1705	Cottee, Nicola	CA	Feb-17	Feb-19
		PhD: Improving precision agriculture and environmental performance for the Australia	ANU1602	Latimer, James	ANU	Feb-16	Jun-19
		PhD: Sustainable water extractions: Low flow refugia and critical flow thresholds	UNE1406	Pearson, Marita	UNE	Jan-14	Dec-19
		Post doc: Oliver Knox - Professor of soil biology	UNE1403	Knox, Oliver	UNE	Jan-14	Dec-18
		Quantifying the nitrogen cycle: from farm gate to catchments, groundwater and atmosphere	ANSTO1801	Cendon, Dioni	ANSTO	Jul-17	Jun-20
		Quantifying the potential environmental impacts of pesticides used on cotton farms	DAN1803	Rose, Mick	NSW DPI	Jul-17	Jun-20
		Scoping study: Understanding the methodologies and data being used in life cycle impact assessments to assess the impact of man-made fibres in cotton	COMM			Jul-18	Jun-21
		Soil System Research – physical, chemical and biological processes for plant growth and nutrient cycling down the whole soil profile	UNE1601	Knox, Oliver	UNE	Jul-15	Jan-19
		Synthesis of natural resource assets in the cotton growing region of eastern Australia	FWPA1801	Wall, Julian	EcoLogical Aust	Jul-17	Jun-20
		Understanding environmental impacts and resource impacts with changing demand for Australian cotton, assessed using a change modelling life cycle assessment approach	1819FRP108	Wiedemann, Stephen	Integrity Ag Services	Jul-18	Jun-20
2.2 Create higher value uses for cotton	2.2.1 Increased value for Australian cotton	An eco-friendly treatment to improve look and handle of cotton fabric	DU1701	Rajkhowa, Rangam	Deakin University	Oct-16	Sep-18
		Continuous mercerisation of loose-stock cotton without fibre shrinkage	RMIT1802	Padhye, Rajiv	RMIT	Feb-18	Dec-18
		Developing renewable fine chemicals from cotton biomass	SRA1601	Doherty, William	SRA	Feb-16	Apr-19
		Ever dry self cooling fabrics - commercialisation investigation phase	COMM		Deakin University	Jul-18	Jun-21
		Exploring nanofibrous coating on cotton fabric with versatile protection and dynamic comfort	RMIT1702	Gavrilenko, Olga	RMIT	Feb-17	Jan-20
		Identifying high value uses for recycled cotton	1819FRP030	Zhang, Jin	Deakin University	Jul-18	Jun-21
		Managing cotton quality to maintain Australia's premium status	CMSE1801	Van der Sluijs, Rene	CSIRO	Jul-17	Jun-20
		Novel anti-wetting and self-sterilising cotton fabrics	DU1802	Lui, Xin & Zhao, Yan	Deakin University	Jan-18	Dec-18
Scoping study: Identifying opportunities for blending cotton with high tech / novel textile materials	1819FRP063	Miao, Menghe	CSIRO	Jul-18	Jun-19		

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
	2.2.2 Increased understanding of market requirements and opportunities throughout the value chain	Bio-degradation of dyed cotton fabrics	NCSU1701	Vinueza, Nelson	NCSU	Jan-16	Dec-18
		Consumer perceptions of Australian cotton - Roy Morgan	EO1172		CA	Jul-18	Jun-19
		Micro particles generated from laundering of cotton and other fabrics	NCSU1702	Venditti, Richard	NCSU	Jan-17	Dec-18
		Strategies for improving labour conditions within the Australian cotton value	1819FRP051	Payne, Alice	QUT	Jul-18	Jun-21
2.3 Measurement and reporting throughout the value chain	2.3.1 CRDC collaborates in global leadership for sustainability initiatives	Sustainable Apparel Coalition Membership 2017	CRDC1817	Robinson, Glen	SAC	Aug-17	Jul-18
	2.3.2 The value chain is transparent and understood by participants	PhD: Sustainable value chain analysis of the Australian cotton industry	1819FRP052	Payne, Alice	QUT	Jul-18	Jun-21

Goal 3: Build adaptive capacity of the cotton industry							
3.1 Science and innovation capability, and new knowledge	3.1.1 Science and innovation capacity is strengthened and strategically fit for a digital future	2015 Horizon Scholarship - Scott Nevison	RIRDC1503	Nevison, Scott	AgriFutures	Mar-15	Dec-18
		2016 Horizon Scholarship - Sam Knight	RIRDC1602	Knight, Sam	AgriFutures	Jul-15	Dec-19
		2017 Cotton Young Farming Champions Program	CRDC1728	Strong, Lynne	PYIA	Dec-16	Jan-19
		2017 Horizon Scholarship - Holly Chandler	RIRDC1702	Chandler, Holly	AgriFutures	Jul-16	Dec-19
		2018 Australian Future Cotton Leaders Program	CA1806	Eady, Jo	CA	Mar-18	Dec-18
		Accelerating Precision to decision (Phase 2): Industry digital strategies the foundations for success	COMM		D2D CRC	Jul-18	Jun-21
		AgCatalyst 2018	CSP1805	Purtell, Gavin	CSIRO	Aug-18	Aug-18
		Agri-intelligence in cotton production systems (Stage 1)	QUT1701	Perez, Tristan	QUT	Jan-17	Dec-18
		ARLP Cotton Industry Leadership Development	COMM	Woodhill, Phillipa	ARLF	Jul-18	Jun-19
		Australian Rural Leadership Course 24 - Richard Malone	RIR1802	Malone, Richard	ARLF	Aug-17	Oct-18
		Australian Rural Leadership Course 24 - Timothy Chaffey	RIR1801	Chaffey, Timothy	ARLF	Aug-17	Oct-18
		CRDC Summers/Honours Scholarships	COMM		CRDC	Jul-18	Jun-19
		Data analytics capacity and solutions developed for digitising the Australian cotton industry	COMM			Jul-18	Jun-21
		Design of versatile protective cotton fabrics with colour and patterns	RMIT1801	Williamson, Olivia	RMIT	Feb-18	Nov-18
		Evaluation of relative damage caused by two-spotted mite, bean spider mite and strawberry mite in cotton	DAN1808	Shafto, Christopher	NSW DPI	Jan-18	Dec-20
		Facilitate Start Up Alley at the 19th Australian Cotton Conference	XL1802	Parsons, Tim	XLAB	May-18	Aug-18
		Honours: Establishing precision/digital agriculture at 'Llara'	US1802	Ginns, Bradley	USYD	Dec-17	Nov-18
		Honours: Estimating soil water use in cotton systems	CSP1803	Gaynor, Harry	CSIRO	Jan-18	Nov-18
		Improving grower decisions in complex systems	1718FRP017	Wunsch, Geraldine	USQ	Mar-18	Jun-21
		Irrigation data science research capacity for the Australian cotton industry	1819FRP080	Roth, Guy	USYD	Jul-18	Jun-21
		Nuffield Australia Farming Scholarship 2017 - Daniel Kahl	CRDC1711	Kahl, Daniel	Nuffield	Jul-16	Sep-18
		Nuffield Australia Farming Scholarship 2018 - Luke McKay	CRDC1801	McKay, Luke	Nuffield	Jul-17	Sep-19
		Nuffield Australia Farming Scholarship 2019	COMM	Dean, Jodie	Nuffield	Jul-18	Jun-19
		Partnership with Deakin University for fibre and textile R&D capacity	COMM		Deakin University	Jul-18	Jun-23
		Start Up Alley at the 19th Australian Cotton Conference	CA1805	Anderson, Fleur	CA	May-18	Aug-18
		3.1.2 Increased understanding of the diverse human capital in regional communities	People on farm - Employment Starter Kit Initiative (ESKi)	DA1502	Hellwege, Shane	DA	Jul-14
Rural Womens' Awards	COMM		Medway, Jennifer	AgriFutures	Jul-18	Jun-19	
Understanding and planning for the future cotton workforce	USQ1801		McDonald, Nicole	USQ	Oct-17	Oct-20	
Understanding motivational factors for improved spray application on farms	1819FRP093		Hine, Don	UNE	Jul-18	Jun-20	
3.1.3 Increased opportunities for innovation skills development	Catapult program CRDC Innovation (Phase I)	XL1801	Taylor, Ian	XLAB	Apr-18	Jun-19	
3.2 Futures thinking	3.2.1 Australian cotton growers are able to adapt to change	19th Australian Cotton Conference Foundation Sponsorship	CA1804	Anderson, Fleur	CA	Dec-17	Sep-18
		Collaborative Partnership Primary Industries Health & Safety	COMM	Medway, Jennifer	AgriFutures	Jul-18	Jun-19
		CRDC Grassroots Grants	COMM		CRDC	Jul-18	Jun-19
		Thresholds for resilience in regional communities	1819FRP028	Nettle, Ruth	UMELB	Jul-18	Jun-20
	3.2.2 Increased opportunities for strategic foresighting	Cotton Australia Board Portal	COMM	Cottee, Nicola	CA	Jul-18	Jun-19
		Grower RD&E advisory panels - Capacity Building	COMM	Cottee, Nicola	CA	Jul-18	Jun-19
		Grower RD&E advisory panels - Travel	COMM	Cottee, Nicola	CA	Jul-18	Jun-19

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
<b>Goal 4 (Enabling Strategy 1): Strengthening partnerships and adoption</b>							
4.1. Partnerships and collaboration	4.1.2 CottonInfo partnership is maintained and practice change improved	Benchmarking water use efficiency and crop productivity in the Australian cotton industry	DAN1505	Chaffey, Alison	NSW DPI	Jul-14	Jun-19
		Climate and energy for cotton farming businesses	AE1801	Welsh, Jon	AgEcon	Jul-17	Jun-20
		Communicating cotton best production practices with video	1819FRP091	Grundy, Paul	QDAF	Jul-18	Jun-21
		Cotton industry database management	CRDC1804	Armson, Lee	Making Data Easy	Jul-17	Jun-20
		CottonInfo: field demonstrations	COMM	Waters, Warwick	CRDC	Jul-18	Jun-19
		CottonInfo: monitoring and evaluation support system	CRDC1818	Coutts, Jeff	Coutts J&R	Jul-17	Jun-19
		IPM and Insect Resistance Technical Lead (CottonInfo and myBMP)	1819FRP034	Ceeneey, Sally	Ceeneey Agricultural Consultants	Jul-18	Jun-21
		National biosecurity and disease extension and coordination and CQ regional extension	DAQ1801	Holman, Sharna	QDAF	Jul-17	Jun-20
		NRM Technical Lead and extension campaigns (CottonInfo and myBMP)	CRDC1805	Vogel, Stacey	Stacey Vogel Consulting	Jul-17	Jun-20
	Technical Lead - Nutrition & Water (CottonInfo and myBMP)	DAN1807	Smith, John	NSW DPI	Jul-17	Jun-19	
4.1.3 Partnerships are strengthened to engage multi-disciplinary and multi-institutional resources	AgVet Collaborative Forum - Plant Industries (Phase 3)	RIRDC1701	Medway, Jennifer	AgriFutures	Jul-16	Dec-19	
	Climate Change Research Strategy for Primary Industries 2017-2020	CCR1801		CCRSPI	Jul-17	Jun-20	
	WeedSmart (Phase 4)	UWA1801	Mayer, Lisa	UWA	Jul-17	Jun-20	
4.2 Best practice (myBMP)	4.2.1 Best practice is based on science and measured impact	Boyce Cotton Comparative Analysis	COMM	Alchin, Phil	BCA	Jul-18	Jun-19

<b>Goal 5 (Enabling Strategy 2): Driving RD&amp;E impact</b>							
5.1 Impact and effectiveness	5.1.2 CRDC monitors and evaluates RD&E impact	Annual consultant qualitative and quantitative surveys	1819FRP082	Todd, Liz	CCA	Jul-18	Jun-21
		Communications support projects	CRDC1744	Pilling, Bernadette	House of Communications	Jun-17	Dec-18
		CRDC Grower Practice Survey	CRDC1733	Sparks, Michael	Intuitive Solutions	Mar-17	Dec-19
		Longitudinal assessment of the cotton industry's people investments	CRDC1710	Moffatt, Jennifer	Jennifer Moffatt	Jul-16	Dec-18
		Measuring and reporting the value of capacity building on farms and in research	CRDC1701	Stone, Gordon	QualDATA	Jul-16	Jun-19
		Reinventing Australian agricultural statistics	AFI1802	Keogh, Mick	AFI	Apr-18	Nov-18
		Risk management in Australian agriculture	AFI1803	Keogh, Mick	AFI	Apr-18	Nov-18
	5.1.3 CRDC funded projects demonstrate value and return on investment	Impact assessment of selected clusters of projects	COMM	Chudleigh, Peter	AgTrans	Jul-18	Jun-19
		More Profit from Nitrogen - mid-term evaluation	RRDP1736	Coutts, Jeff	Coutts J&R	Jun-18	Sep-18

Key	
AFI	Australian Farm Institute
AgriFutures	AgriFutures Australia (formerly the Rural Industries Research & Development Corporation)
AGWA	Australian Grape and Wine Authority
ANSTO	Australian Nuclear Science & Technology Organisation
ANU	Australian National University
ARLF	Australian Rural Leadership Foundation
BCA	Boyce Chartered Accountants
CA	Cotton Australia
CCA	Crop Consultants Australia
CCRSPI	Climate Change Research Strategy for Primary Industries
CRDC	Cotton Research and Development Corporation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
D2D CRC	Data to Decisions Cooperative Research Centre
DA	Dairy Australia
DSITI	Queensland Department of Science, Information Technology and Innovation
GRDC	Grains Research and Development Corporation
GVIA	Gwydir Valley Irrigators Association
HIA	Horticulture Innovation Australia Limited
ICD	Initiated Coordinated Delivered (ICD) Project Services
IREC	Irrigation Research and Extension Committee
MLA	Meat and Livestock Australia
MRES	Micro Meteorology Research & Education Services
NCEA	National Centre for Engineering in Agriculture
NCSU	North Carolina State University
NSW DPI	NSW Department of Primary Industries
NTDPIR	Northern Territory Department of Primary Industries and Resources
PHA	Plant Health Australia
PYIA	Picture You in Agriculture
QDAF	Queensland Department of Agriculture and Fisheries
QUT	Queensland University of Technology
RMIT	Royal Melbourne Institute of Technology
SAC	Sustainable Apparel Coalition
SRA	Sugar Research Australia
UMELB	University of Melbourne
UNE	University of New England
UNSW	University of New South Wales
UQ	University of Queensland
USQ	University of Southern Queensland
USYD	University of Sydney
UTAS	University of Tasmania
UTS	University of Technology Sydney
UWA	University of Western Australia
UWS	University of Western Sydney

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