

Spotlight.

ON COTTON R&D

Winter 2016

BIG DATA:
What does it mean
for the future?

Moving to automated
irrigation

Financial analysis
reveals stellar returns



Australian Government

Cotton Research and
Development Corporation



Bruce Finney

In the Spotlight

As cotton harvest wraps up for another year, congratulations to all the growers and consultants who continue to advance the industry in terms of crop management, quality and yield.

We are hearing of some amazing yields achieved despite a season with low water availability. Most important to growers are the financial returns, and the Boyce Comparative Analysis from last season has shown a significant improvement in profits. We have included a short summary of the report in this edition and encourage all growers to go to our website to read the full analysis.

CRDC continues to value the benefits of collaboration in RD&E. Through collaboration synergies in scale, access to new ideas and capability, integration, extension and ultimately the impact are possible. CRDC collaborates in more than 90 percent of all cotton research in Australia and more than 25 percent of CRDC's investments are now made through cross industry research projects with the likes of the dairy, grains, sugar and horticulture industries. With grower encouragement we are looking to grow this further with more collaboration with the grains sector.

In this edition there are many articles that highlight how CRDC collaborates with our research providers and with growers through Grassroots Grants as well as scholarships like Nuffield. Equally there are examples of collaboration at the national scale where CRDC is working with the Australian Government and our fellow rural research and development corporations (RDCs) to lead the delivery of Rural R&D for Profit Program grants "More profit from nitrogen" and "Smarter irrigation for profit".

CRDC is also strategically leading RD&E into digital agricultural opportunities. As we look to the future it is foreseeable that farming will evolve from precision ag to decision ag. The ability to collect so much information (big data) relating to farming practices and outcomes and turn it into enhanced decision making tools is a reality, but how far can it go? At CRDC we are acutely aware of the need to develop systems to make this big data useable to growers to improve efficiency and returns. CRDC has made significant investments in projects to investigate big data, its ownership and methods to capture it, process it and use it in decision making. In this edition we feature by example CRDC research which is enabling growers moving to automate irrigation processes and irrigate fields by mobile phone.

With one season ending and preparation for another commencing we have included updates on managing herbicide resistance and Verticillium disease management. In assisting your preparation for a new season CRDC and our CottonInfo partners are also pleased to provide you with the latest Australian Cotton Production Manual, updated with your latest industry R&D.

We look forward to seeing you at the Australian Cotton Conference.

A handwritten signature in black ink that reads "Bruce Finney". The signature is stylized, with a large, flowing "F" and "n" that extend across the line.

Bruce Finney
CRDC Executive Director



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

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This edition can be viewed online at: www.crdc.com.au



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Fast Facts

\$20.4m

In 2016-17 CRDC will invest approximately \$20.4 million into around 200 projects across the five program areas of the CRDC Strategic R&D Plan on behalf of Australia's cotton growers and the Australian Government (see list on page 31).

\$1188

The increase in return per hectare (over last year) of the average cotton growers benchmarked in the Boyce Comparative Analysis. The group achieved a profit per hectare of \$1899 last season - greater than the 2014 result of \$711 and the five year average (see story on page 7).

\$79b

The digital economy contributed \$79 billion (or 5.1 percent) of Australian GDP in 2013-14 (Australian Computer Society 2015) (see story on page 9).

50

The Australian digital economy is growing in significance and is 50 percent larger in real terms than it was in 2011. If the digital economy was an industry it would be larger than Australia's agriculture, transport or retail industries (Deloitte Access Economics 2015) (see story on page 9).



The farmer zoologist

A zoology degree is not a traditional qualification for a cotton grower, but for Southern QLD farmer Mark Palfreyman it provides an ideal grounding for his new role as national Cotton RiverCare champion.

The role forms part of the newly launched Cotton RiverCare program, which aims to support the responsible management of riverine areas within Australia's cotton growing regions.

Cotton RiverCare program manager and CottonInfo Natural Resources Technical Specialist Stacey Vogel said the program offers a unique way for the cotton industry and broader society to see first-hand how best management practice leads to healthy riparian areas.

Mark and Stacey will be sharing the results via social media so cotton growers and the wider cotton community can follow Mark and his family's progress as they care for their farm and its natural environment.

"This includes documenting biodiversity, how management decisions impact the condition of their riverine areas and the benefits healthy riverine areas can provide their farming business," Stacey said.

"We are establishing long-term monitoring sites on the Palfreyman's farm to look at water quality, the condition of native vegetation and fauna diversity.

"It's all about proactively monitoring the condition of riparian areas and determining how on-farm decisions can positively impact these environments, for the overall benefit of the farm.

"Mark has a real passion for maintaining healthy ecosystems on his farm as part of running his farming business, and a keen interest in native fauna, which makes him the ideal Cotton RiverCare champion."

The Cotton RiverCare program is supported by CRDC and CottonInfo. Further information, and links to the program's social media accounts are available via www.cottoninfo.com.au/cotton-rivercare

Growing more with less

MARY O'BRIEN



Deputy PM marks CRDC's 25th anniversary

While at Dalby for the announcement, CRDC's Chair Dr Mary Corbett and Executive Director Bruce Finney presented the Deputy Prime Minister Barnaby Joyce with a framed photograph to mark 25 years of cotton research, development and extension, led by CRDC. Pictured are Cotton Australia Director Bob Dall'Alba; Mary Corbett; Barnaby Joyce (with photograph by Joshua Smith); Cotton Australia Director Stuart Armitage; and Bruce Finney.

A project aimed at improving the efficient use of nitrogen in the irrigated cotton, dairy, cherry, mango and sugar industries, led by CRDC, has been successful under round two of the Federal Government's Rural R&D for Profit programme.

The project, *More profit from nitrogen*, is a partnership between CRDC and fellow rural research and development corporations (RDCs) Dairy Australia, Sugar Research Australia and Horticulture Innovation Australia and 15 other research partners.

The project aims to improve the nitrogen productivity of 600 irrigated cotton growers; the profit of 500 dairy farmers; the yield of sugar growers; and the yield, fruit quality, storage and packout for 400 Australian cherry and 650 mango growers. It will also help all four industries mitigate the extent and impact of off-farm nutrients on water quality.

The project was announced by Deputy Prime Minister Barnaby Joyce at the Olam cotton gin at Dalby in May. It will receive \$5.8 million from the Rural R&D for Profit programme.

"Cotton growers know that optimising nutrition is essential for maximising yield and profit – the same also applies to dairy, horticulture and sugar," said CRDC's Bruce Finney.

"As a result, CRDC and our fellow RDCs and research partners have decided to work together on this project, which is designed to enhance the use of nitrogen across our cropping and pasture systems.

"Through this joint project growers will gain a better understanding of the various influences on nitrogen use efficiency and improved confidence to adopt management practices tailored to their specific crop requirements. As a result, it'll boost efficiency, and profits.

"Importantly, there's also a strong sustainability component of this project, as more efficient use and management of

nitrogen across all of our industries also has significant natural resource benefits – improving soil health, reducing leaching and run-off to creeks and rivers, and decreasing greenhouse gas emissions.

"This project will deliver a win-win scenario for both growers and our environment and it gives us another opportunity to partner with our fellow RDCs on projects that have mutual benefits across a wide range of industries."

The *More profit from nitrogen* project will run until 2020. It follows the CRDC-led *Smarter irrigation for profit* project, which was announced under the first round of the Rural R&D for Profit programme in 2015.

For more

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Goondiwindi cotton grower and Nuffield Scholar Nigel Corish was a speaker on the CottonInfo Nutrition Tour earlier this year, where he talked about his research into ways to improve nitrogen use in irrigated cotton and how it has changed his farming system.

Get in early for discounted prices

THE 2016 Australian Cotton Conference is already open for business, with savings on early-bird on-line registrations until July 1. This highly anticipated industry event will be held at the Gold Coast Convention Centre from August 2-4 2016.

Early-bird prices start from \$325 for students and \$525 for cotton growers, which is amazing value for a conference of this type and includes delectable morning and afternoon teas, lunches, welcome drinks on day one and of course three full days of world-class speakers and information, interactive sessions and presentations on everything cotton.

The conference committee is committed to making it easy for families to attend, with the free Kids' Club back this year to offer professional child minding during conference hours. There is also a special discounted spousal rate to attend the three-day event.

With early bird savings of up to \$50 only available until July 1, register as soon as possible to take advantage, particularly if planning to register a larger group. Further grower discounts are available for full Cotton Australia levy-paying growers.

"The Australian Cotton Conference remains one of the most cost-effective of all agricultural conferences, made possible by generous sponsorships from corporate partners including Foundation Sponsors CRDC, CSD and Gold Sponsors ANZ Bank, Adama, Case IH, John Deere, Monsanto and S&G Cotton," said Adam Kay of Cotton Australia, who along with Australian Cotton Shippers Association oversees the organisation and running of the event. CRDC is proud to be a foundation sponsor and works with the conference committee to deliver this stand-out event.

For more

w www.australiancottonconference.com.au

Nuffield 2017 call opens

APPLICATIONS are now open for the 2017 Nuffield Australia Farming Scholarships.

Considered the leading program for primary producers in Australia, Nuffield awards farmers with a life-changing scholarship to travel overseas and study their agricultural topic of choice.

Nuffield has been providing scholarships for farmers for more than 60 years, building a network of 300 Australian scholars who have extended their knowledge and skills through their experience in global agriculture. CRDC is a proud supporter of at least one cotton grower a year to undertake the program in partnership with Cotton Australia. Recent scholars include growers Tom Quigley at Trangie, Matt McVeigh of Dalby and Nigel Corish from Goondiwindi.

Scholars are selected annually and must demonstrate they are committed and passionate about farming, are at the leading edge of technology uptake and are potential future leaders in the industry. Nigel Corish said the scholarship changed

his philosophy on farming and farming practices in his own business.

"To be questioned on my farming practices was challenging, but now after completing the scholarship it has given me the confidence to implement change and improve these practices, as well as the ability to make better business decisions," Nigel said.

CRDC Executive Director Bruce Finney said these growers and scholars bring a lot of knowledge back to other farmers, consultants and researchers from their experiences, which CRDC sees as a major impetus for supporting the scholarships.

"It's about growing and learning as an industry through support of individuals," Bruce said.

Applications for 2017 Nuffield scholarships close June 30.

For more

w www.nuffield.com.au

A growing crop of rural leaders

THE Australian Rural Leadership Foundation has announced the next round of its unique leadership development program, with two cotton industry leaders selected to participate.

Matt Bradd, a cotton merchant with ECOM Commodities, and Meagan Laidlaw, a marketing services manager with Olam Queensland Cotton, will represent the industry in Course 23 of the Australian Rural Leadership Program (ARLP).

Matt and Meagan are proudly supported by CRDC, along with fellow industry organisations, Cotton Australia and Auscott.

The ARLP is the foundation's flagship

program, and has been developing leaders for the future of rural and regional Australia for more than 20 years.

Matt and Meagan are among 30 leaders from rural industries who were successful in the competitive national selection process. They will start the program in August 2016 with an experiential session in the Kimberley. Five sessions will follow over 15 months, including immersion in regional communities, involvement in Canberra's political scene, and an eye-opening visit to one of our closest neighbours, Indonesia.

For more

w www.rural-leaders.com.au

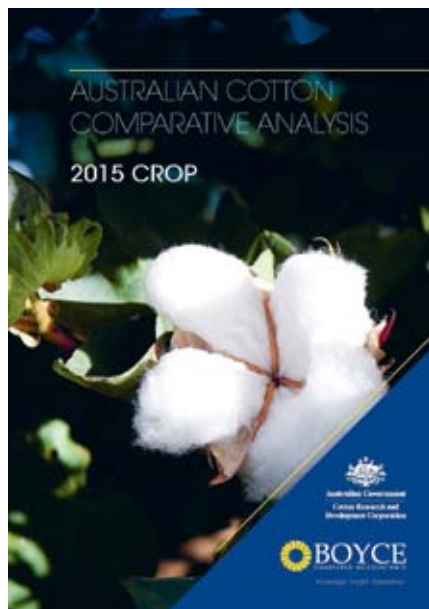
Latest analysis reveals stellar season

In 2015, the top 20 percent of cotton growers in the industry's major benchmarking study showed an increase of \$1200 per hectare profit against the five-year average.

CRDC and Boyce Chartered Accountants have released the 2015 *Australian Cotton Comparative Analysis* which shows that although 2015 was a relatively small season in terms of hectares grown, it was a stellar season for yield and price.

The analysis, conducted annually by Boyce in conjunction with CRDC, provides a benchmark for the economics of growing cotton in Australia. The 2015 report is based on figures from growers who produced 340,000 bales, or 15 percent of total cotton production.

The study found that 2015 was generally an ideal irrigated cotton season in terms of weather, with enough heat, rainfall at ideal times, and low levels of prolonged



cloud and cold shock days all contributing to a good season for growers.

And, as a result, the report reveals that the average group of cotton growers achieved a profit per hectare of \$1899 – greater than both the 2014 result of \$711, and the five year average.

The top 20 percent of growers had an

outstanding season, with a profit of \$3388 per hectare, against the five year average of \$2190.

Report co-author Paul Fisher of Boyce Moree, noted that yield was the distinguishing factor between the two groups.

"Increased yield has two impacts; increased income and reduced cost per bale," Paul said.

"In 2015, the cost of production for the top 20 percent of growers was \$284 per bale, \$63 lower than that achieved by the average growers.

"As such, the focus for growers wishing to increase their profitability should be on increasing yield as cheaply as possible.

"Long term average figures for the top producers prove that it is possible to achieve a benchmark cost of production in the range of \$281 to \$326 per bale in a 'normal' year."

The 2015 *Australian Cotton Comparative Analysis* is available to download at www.crdc.com.au/publications/australian-cotton-comparative-analysis-2015.

For further information, or to participate in the 2016 study, contact your local Boyce office.

Grassroots Grants: funding grower ideas

THE CRDC Grassroots Grants program encourages Cotton Grower Associations (CGAs) to apply for funding to support capacity building projects in their region.

Up to \$10,000 in funding is available 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 more than \$380,000 in 44 projects across the cotton growing valleys – from weather stations to crop nutrition workshops.

Applications for the 2016-17 round of Grassroots Grants open July 1 2016 and close November 30 2016. 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 (log on to the 'For Growers' section) at www.crdc.com.au

**For more
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Your Australian Cotton Production Manual

INCLUDED with this edition of *Spotlight* is the 2016 *Australian Cotton Production Manual*. The manual is a critical reference tool for cotton growers: a one-stop-shop that outlines all the various decisions that need to be made on-farm in preparation for, and during, cotton production. The Manual provides an understanding of cotton physiology, and discusses important considerations for both productivity and profitability.

The manual is published by the industry's joint CottonInfo team and is updated each year to incorporate consistent improvements in industry best practice.

In addition to your hard copy, you can access the manual at www.cottoninfo.com.au/publications/australian-cotton-production-manual



Working together to deliver RD&E benefits

DID you know CRDC is one of 15 rural research and development corporations (RDCs) in Australia?

Last year, the RDCs collectively invested around \$580 million in RD&E on behalf of our growers and the Federal Government to improve the profitability and sustainability of rural industries and communities. It's the largest productivity-driven industry program in Australia.

The RDCs deliver research, development and extension for their specific industries: cotton, grains, meat, wool, fish, wine, eggs, sugar, pork, horticulture and even crocodiles, to name but a few. While the GRDC, MLA and AWI are more familiar RDCs, the Rural Industries RDC, Fisheries RDC and Wine Australia for example may be lesser known to those in the cotton industry.

Each RDC invests in diverse projects, but together form a network enabling primary production through effective RD&E, and deliver substantial benefits at the farm gate, across the economy and society.

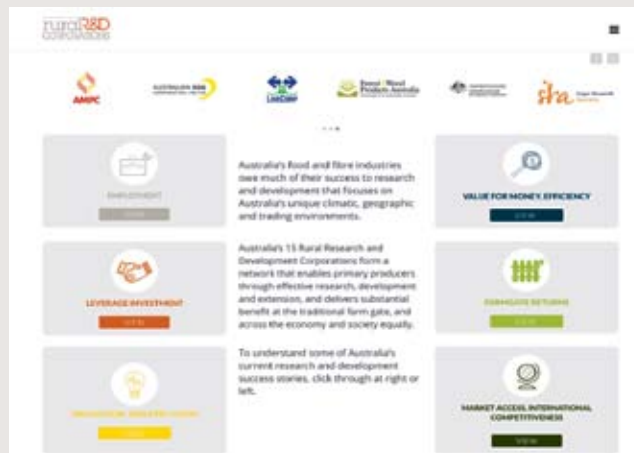
Together, we deliver six key things to our individual industries, and to agriculture as a whole:

Innovation and practice improvement.

Market access and international competitiveness.

Farm gate returns through smarter farming.

Employment through new skills and changed practices.



Value for money and efficiency, ensuring a return on your investment.

Leveraged investment through collaboration and co-investment.

For more on the RDCs and how we're working together to deliver benefits for you, visit the Council of RDCs website:

www.ruralrdc.com.au/performance/

Successful consultation

A relevant program driven by consultants which addresses their information needs and issues is the priority of Crop Consultants Australia's seminars and the key to good attendance numbers and positive feedback.

The most recent seminar was held in Moree, in early May, and celebrated the organisation's thirtieth year. Around 137 attended the two day seminar, with issues such as herbicide resistance, understanding climate, human resource management, nutrition and managing to preserve fibre quality were all on the table.

The committee along with event co-organiser Leisl Coggan and Executive Officer Fiona Anderson say the feedback has been very pleasing.

"Consultants put forward suggestions for topics and speakers directly to the CCA as well as through the CCA Annual Survey," says CCA Executive Officer Fiona Anderson.

"We also talk with CRDC R&D Managers for suggestions and to help us identify research and knowledge around issues we are looking to address.

"These seminars offer a really good catch up for consultants to share challenges and solutions, ideas and contacts and come together to celebrate the end of the growing season.

"It is a great opportunity to ask questions of researchers as you have all of the experts on hand to talk with."

CCA has been coordinating the collection of survey data with its members across key cotton growing regions since 1982. CCA members are currently working on the Cotton Consultants Survey 2016 and the Cotton Market Audit for the 2015-16 season in conjunction with CRDC. Consultants and agronomists are expected to have their data submitted by June 30.

See page 28 of this edition for the CCA regular column which shines a light on its 30-year history.

For more

w www.cropconsultants.com.au



Emerald consultant David Parlato, who is a long-standing member of CCA being interviewed for the CCA History Story in Moree in May, when the consultants' seminar was held.

Agricultural data what's the big deal?

Big data is a phrase heard a lot these days, but what is it, how can it be used, who owns it and why is it important to the future of cotton farming?

Big data is high volume, high velocity and/or high-variety data that needs to be analysed via innovative forms of information processing (data analytics) which produces advanced insights for decision making and automation.

Big data on farms

With the rise of internet and satellite communication, the fall in the cost of sensor technology and data storage and increasing computer processing speed, agriculture is rapidly developing into a data-intensive business where an ever increasing amount and type of information is collected and evaluated. The aim of data analytics is to increase productivity and efficiency on-farm and along the supply chain; and to better communicate with consumers.

Cotton growers now monitor crops using sensors and other technologies, with data collected from weather stations, soil moisture probes, canopy temperature sensors, satellite imagery, drones and yield monitors. Smart sensors are able to transfer information between the sensor and the farm office. Third parties, including researchers and crop consultants for example, also collect data from crop checking, nutrient and disease sampling, irrigation measurement, pesticide use, EM surveys and so on.

The challenge for cotton growers is to turn that data from precision ag into decision ag by extracting the useful information from their data and make management decisions to optimise inputs such as labour, energy, water and agrochemicals and to explicitly account for variability and uncertainty across the production system and the value chain.

Preparing industry for the future

For CRDC, the challenge is to look into the future and support projects which put our growers at the leading edge in terms of using big data to enhance their operations.

"CRDC is investing in R&D to find solutions for Australian cotton production and attempting to sort through issues for Australian agriculture generally in partnership with other sectors," CRDC Executive Director Bruce Finney said.

"A new project with QUT, Agri-intelligence in Cotton Production Systems, led by Professor Tristan Perez, aims to identify all the information required for decisions during the cotton growing season and along the supply chain.

"The project will look for data gaps and ways to integrate that data so growers have the right information at the right time to make the decisions they need to make."

According to IBM, every day we create 2.5 quintillion bytes of data - so much that 90 percent of the data in the world today has been created in the last two years alone. In the broad sense, this data comes from everywhere: agricultural tools and machinery, sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction records from supermarkets, and cell phone GPS signals to name a few. This collectively is **big data**.

Have data. Must analyse.

Data analytics is the science of information processing and brings analytical reasoning to big data.

The use of sensors and other data generators in production and processing systems requires additional transformation and conversion to account for spatial and temporal variability when being used for decision making.

Agriculture technologies using data to offer farmers greater insights (data analytics) into their operations are gathering pace. According to the AgFunder AgTech Investing Report, in 2015 precision agriculture start-ups, which all use data in some way, raised \$661 million. These ranged from data collection hardware devices and drones to pure software companies offering data analysis and decision support tools.

According to Australian Farm Institute's Mark Henry, the holy grail for software companies at present is the objective analysis of data to produce probabilistic or deterministic crop advice for farmers and their advisors.

"There are only a small number of software companies that have developed, or are developing this capability, but it is not currently incorporated in the majority of existing farm software systems," he says.

"Farm profitability is still very much contingent on the knowledge and experience of the human manager, but change is underway."

Analytics research

CRDC is supporting projects in data analytics including an Honours research project at Queensland University of Technology (QUT) using data analytics to classify weeds based on images (data) collected by cameras.

These images are then analysed to give information on what weeds species are in the paddock, what density, and where.

"The next step is to add in a robot which can use the same data analytics to treat the different weed species with different methods: both chemical and mechanical - and that is autonomous farming," Jane said.

"For autonomous farming and robotics systems to work they need good data and a data analytics framework to process and provide information enabling the platforms to operate effectively."

Autonomous farming

Jane says terrestrial and aerial robots will play a key role in agriculture as tools for tighter control and optimisation of production. Robots can be part of the sensing network, but also act on the crop.

"An information infrastructure allows analysis of big data, novel management practices and autonomous systems for decision making," she said.

"This combination of technologies can then be deployed to minimise the use of inputs (energy, labour, chemicals) and at the same time increase productivity and reduce volatility in both yield and quality.

"Some elements required for autonomous farming are already available including sensors, networks, GIS, GPS, robots and drones, with an initial focus on adaptation and integration.

“Further development is required to create autonomous farming capability and CRDC is looking closely at this through investment with GRDC in the Future Farm (nitrogen and crop protection robotics) and the Smarter Irrigation for Profit projects such as the “Waverley” Irrigation Automation Field Day, autonomous weed spraying, and the agricultural robotics makers SwarmFarm in Central Queensland.”

Internet of things

The internet helped to connect society. The internet of things refers to the connectivity of devices, which can generate data and exchange it or extract and exchange information. The internet of things will facilitate management of our environments with increased levels of autonomy.

“In the future, drones may be exchanging information with ground robots in order to manage weeds, pest and diseases, and nutrients autonomously,” Jane says.

“We are already seeing a high degree of automation is possible for irrigation management, where scheduling decisions can be made based on data generated from an array of sensors in order to achieve optimal crop growth: the challenge is take this to other fields like nutrition management and crop protection, for example.”

Drones have potential to perform self-guided flights on-farm without requiring manual deployment. The use of drones to monitor irrigation is being

studied by Derek Long at the University of Southern Queensland as part of a CRDC PhD scholarship.

Current methods for measuring water advance rates down the furrow requires contact sensors installed in individual furrows for each irrigation event. This project will develop a proof-of-concept system that uses a self-guided drone to inspect advance position for each furrow in a field.

In addition to irrigation monitoring, the self-guided drone has potential to autonomously perform other farm inspection tasks, such as optimal searching for in-field pests and diseases.

Meanwhile autonomous robots in the field are already a reality with a small company in Emerald, Central Queensland.

Earlier this year SwarmFarm Robotics launched its small, high-tech, autonomous, lightweight and collision-avoiding weed spraying robots. Developer and farmer Andrew Bate sees the future where these machines will be planting, applying fertiliser precisely and economically, eliminating weeds and insects and harvesting the crop leading to higher yields, lower costs, cleaner and greener food. CRDC has been taking close interest in this technology as it is being developed and has a small project with SwarmFarm where they are reviewing technologies for weed management that are developed, under development or will be enabled by robotics and providing advice on any research gaps.

Through a CRDC project Dr Alison McCarthy is exploring ways to improve crop productivity through real time adaptive control of irrigation application, and this technology may have applications in other areas of crop management such as weeds and nutrition.



Who owns your data?

Agricultural (big) data ownership is one of the hottest topics in the industry.

Data ownership, access and rights are usually regulated in terms and conditions that a farmer accepts while purchasing products/services from an agricultural technology company or farming machinery/equipment company. While that may seem straightforward, there are many different agricultural data sources on farms, including data collected by farmers, machinery and equipment like tractors, third-party providers (weather stations and satellites as well as consultants and researchers) and ag-technology companies who provide analytical software solutions.

There are also many farming business scenarios such as ownership when leasing farms or machinery and contract harvesting, for example. So does the farmer own all the data for their farm or just the data they collected? Who has access or rights to use that data?

These questions were explored via the *Implications of Digital Agriculture and Big Data for Australian Agriculture*

report, undertaken by Australian Farm Institute's Executive Director Mick Keogh and supported by CRDC.

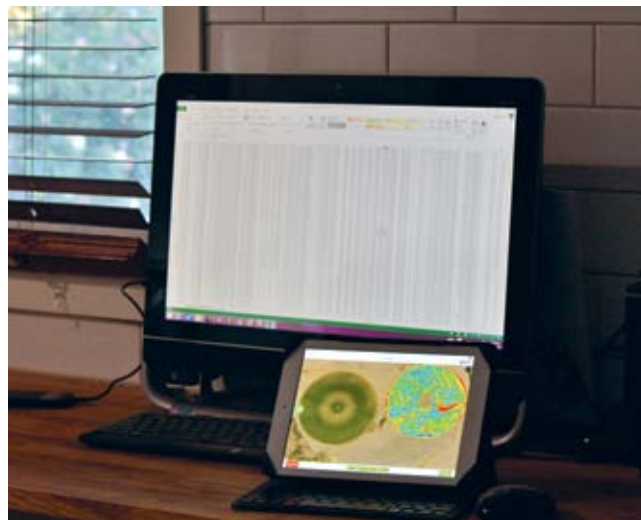
This project researched the development of digital agriculture both in Australia and internationally, to gain an understanding of the implications arising from the collection and distribution of the information. The project aimed to bring all relevant parties together to develop an agreed framework to underpin the collection, storage and distribution of digital data derived from farms in Australia.

"The use of digital agriculture systems to implement more intensive and data-driven farm management decisions enables farmers to economically change from paddock and herd average management, to square metre and individual animal management, with reported subsequent increases in farm productivity," the report says.

"While the extent of productivity gains vary across different agricultural production systems, robust analyses report gains of the order of 10 to 15 percent in cropping systems, with about half the gains coming from input efficiencies, and the other half from increases in output."

The project found that generally speaking, digital information generated by machinery and technology used on a farm is owned by the farmer, although the 'Conditions of Use' agreements that are routinely signed by computer software users when they first register or use a particular application typically curtail the user's data ownership rights, and create exceptions which enable the software provider to use the data in different ways, and often to make that data available to third parties.

"Developing an appropriate regulatory environment which protects a farmer's



ownership rights over farm data is a complex task," the report says.

"Farm machinery manufacturers typically reserve the ownership rights to machinery performance data, and accept some degree of control by farmers over the ownership and use to which digital farm production data can be put.

"Concerns about the misuse of digital agriculture data by service providers has led to the development of Codes of Practice or the strengthening of privacy regulations in the US and New Zealand, with a focus on limiting the uses of data to those agreed to by farmers (who are considered the owners of the data).

"Complexities arise in situations where farm data is transferred to third parties (such as agronomists or livestock advisors) and also in the case of remote sensing data obtained via satellite or drone, over which farmers have no control or rights."

The report said despite these uncertainties, workable arrangements appear to be emerging that are not overly restrictive for service providers, and which give sufficient confidence to farmers.

With this in mind, CRDC is leading a project to help set guidelines for Australian cotton farmers around data generation and ownership.

AFI report recommendations

- Establish an Australian Digital Agricultural Forum
- Adopt a key principle that farmers own their data
- Make agricultural data open access
- Appoint a Farm Data Ombudsman
- Publicly fund soil and climate data
- Publicly fund rural mobile and data networks
- Publish publicly funded agricultural data open access
- Publicly fund knowledge and not commercial platforms
- Digital extension pathways are the future

For more

w www.crdc.com.au/publications

CRDC has made a significant investment in a new project with Queensland University of Technology (QUT).

Major research effort

The *Agri-intelligence in Cotton Production Systems* project will be led by Tristan Perez, a professor at QUT Robotics and Autonomous Systems Electrical Engineering and Computer Science. The research is identifying the information required for decisions during the cotton growing season and along the supply chain and identifying where there are gaps in that data and ways to integrate data along the whole system so growers have the right information at the right time to make the decisions they need to make.

"At QUT we believe the next agricultural revolution will be driven by digital agriculture," Tristan said.

"This will integrate deep agricultural knowledge and systems science with powerful digital technologies – from robots, autonomous systems and sensor networks to data analytics, economic modelling and artificial intelligence.

"Digital Agriculture will help farming and food enterprises to use agronomic, environmental and economic data to run their operations more efficiently, profitably and sustainably.

"The three key components of our agriculture production system are the farming enterprise, the value chain and the enabling infrastructure.

"Each component has its own objectives - farmers seek to minimise the use of inputs (labour, water, nutrients, herbicide and pesticide) and maximise the yield, quality and health of their produce.

"In the value chain, operations seek to maximise food quality, traceability of products and market impact.

"The infrastructure supporting food production seeks to optimise its performance in terms of communications,

"Digital agriculture will make use of data and information far more holistic and effective"



QUT's Institute for Future Environments (IFE) is helping the agricultural sector use robots and autonomous systems to make the farms of the future more productive, profitable, sustainable and safe.

transport, energy and data volume, rate and availability."

Tristan says that as all three components operate in an unpredictable environment. They must deal with uncertainties including crop health, market prices, national policies and legislation, workforce capabilities and the climate. To manage these uncertainties and achieve their objectives, they use various feedback mechanisms to gather data, gauge performance and guide decisions.

"Digital agriculture will make this use of data and information far more holistic and effective," Tristan said.

"Over the next 10 years we expect to see better use of information within each component of the food production system and perhaps the start of a transition to a single integrated system, in which thinking and decision making is based on information about the state of all key components.

"The ultimate result will be a truly optimised and robust food production system from paddock to plate and fibres from the paddock to the user.

"To achieve this, we must thoroughly understand all processes involved in the reverse order: from the consumer to paddock."

The CRDC-QUT project on Agri-intelligent Cotton Production Systems will

identify key factors affecting decision making in all stages of crop production.

"This is very exciting, for it can not only lead to novel technologies, but also guide where future investment in R&D should be directed to achieve best impact," Tristan says.

"We are developing farmer-centric technology to assist them to manage their operations and this requires a trans-disciplinary approach: the next agricultural revolution is not just about agronomy.

"We have put together a team at QUT with expertise in decision and system science, cognitive data science, mathematics and statistics, ecology, soil science, and agronomy.

"Robotics can enable novel ways that augment the set of tools for weed management and we are currently conducting research, with the support of CRDC, on what mechanical robotic weeding methods are best suited to manage weeds affecting cotton. "

For more

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Keep SLW's enemies safe

New research supported by CRDC into a tiny enemy of silverleaf whitefly (SLW) reinforces the importance to adhere to integrated pest management and the preservation of beneficials.



The *Eretmocerus hayati* – a very small wasp with a big impact on silverleaf whitefly.

The tiny wasp *Eretmocerus hayati* is an important natural enemy of silverleaf whitefly and contributes to the natural biological control of this pest throughout the season. It occurs in almost all regions that grow cotton, but due to its small size often goes unnoticed.

Like all natural enemies or beneficials, *Eretmocerus* is susceptible to insecticides applied to control pest species.

In a recent study Jamie Hopkinson of Queensland Department of Agriculture and Fisheries (DAF) looked at the impact of several insecticides used for cotton growing on *Eretmocerus hayati*.

The researchers examined the toxicity of eight products, including recently registered insecticides; cyantraniliprole (Exirel), flonicamid (Mainman),

dinotefuran (Starkle) and sulfoxaflor (Transform).

"Spirotetramat (Movento) and bifenthrin (Talstar) were included in our testing to provide standards as their impacts have been previously published and allowed us to rank the impact of the newer insecticides based on the results of these known standards," Jamie said.

"We looked at both direct exposure and the effect of residues at one, two and eight days after application."

Flonicamid and cyantraniliprole had low toxicity at 10 and 20 percent mortality respectively. Sulfoxaflor (72 g ai/ha) was moderately toxic with a 34 percent mortality rate, while dinotefuran at both the mirid rate and whitefly rate was very toxic at 72 and 82 percent).

Other insecticides tested included spirotetramat which had low toxicity (14 percent), fipronil (12.5 g ai/ha) which was moderately toxic (26 percent), along with clothianidin and bifenthrin which were very toxic with 75 percent and 72 percent mortality rates respectively.

"We also have to take into account that we didn't consider any sub-lethal effects of the insecticides on the wasps, which could possibly include reduced lifespan and rates of parasitism," Jamie said.

"This new research has been added to the *Cotton Pest Management Guide 2016-17*, to be released later this year, so more effective IPM control decisions can be made throughout the season.

"It's important to remember some natural enemies like *Eretmocerus* are basically invisible to the naked eye so can go unnoticed, but are still important."

IPM best practice

Throughout the season it's important to conserve natural enemies like *Eretmocerus hayati*, as they suppress pest populations, which ultimately reduces the frequency of the need to spray. When an insecticide is needed, minimising the disruption of natural enemies may reduce the likelihood of flaring other pests. If a pest has reached the threshold for control and a decision is made to spray, there are often several choices of insecticide registered for control.

When choosing an insecticide, the activity of natural enemies and pollinators is a vital consideration and where the *Cotton Pest Management Guide* guidelines table should be referenced as it allows a decision to be made which also takes into account its impact on natural enemies.

The table lists all the insecticides registered for use in cotton and ranks overall impact on natural enemies from lowest to highest. Natural enemies are further broken down into groups (beetles, bugs, etc), so it's possible to look at impact on specific groups.

Sowthistle: the new threat

Two years ago Australia recorded the first known case of glyphosate-resistant sowthistle on the Liverpool Plains in NSW.

New CRDC research has confirmed the presence of glyphosate-resistant sowthistle (*Sonchus oleraceus*) in four cotton growing regions.

Six cases were confirmed on cotton farms at Emerald, St George, Darling Downs and the Riverina in NSW.

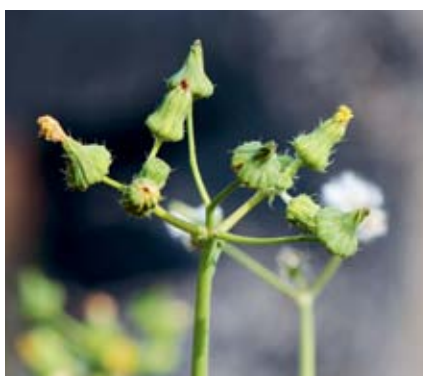
"While CRDC and industry have been supporting research and developed tools and strategies to manage it, this latest news increases the urgency with which the industry must respond to managing herbicide resistance," CRDC General Manager R&D, and weeds specialist Dr Ian Taylor said.

"Due to its wind-borne seed, glyphosate-resistant sowthistle populations can spread rapidly, similar to fleabane.

"The thing with resistance is, we know why and how it happens and how to stop it happening on our farms, yet the list of glyphosate-resistant weeds is growing.

"By following the Herbicide Resistance Management Strategy, integrated weed management and best practice guidelines our growers can manage and in most cases, prevent it."

The new research was undertaken by



"Due to its wind-borne seed, glyphosate-resistant sowthistle populations can spread rapidly..."

NSW DPI researchers Jon Baird, Graham Charles and Sudheesh Manalil. Over the 2014-15 summer, 134 cotton fields were surveyed from Emerald in Central Queensland to Griffith in the NSW Riverina, with 55 percent of the fields containing survivors. Seed samples were collected from sowthistle which had survived a recent glyphosate application, where glyphosate alone was used.

These seed samples were used to grow seedlings which were then assessed for glyphosate tolerance.

Of the 37 plants grown from the collected seeds, six were confirmed glyphosate resistant and two appeared

to have increased tolerance and a high risk of developing resistance. The six resistant plants' seeds were collected from Emerald, St George, the Darling Downs in Queensland, and the Riverina in NSW.

"The remaining 73 percent of the sow thistles plants showed no signs of glyphosate resistance, therefore environmental conditions and herbicide application played a major part in the survival of the sowthistle on the farms surveyed," NSW DPI Research Agronomist Jon Baird said.

"These findings highlight the importance for growers to be proactive in their weed management.

"It is essential that growers implement best management weed controlling strategies that follow IWM guidelines to ensure that glyphosate-resistant weeds don't become a major and very expensive problem for the future.

"CRDC is also supporting further glyphosate-resistance testing of flax leaf fleabane, windmill grass, awnless barnyard grass and feathertop Rhodes grass, which were collected in the industry weeds survey to give us a better idea of incidence and location of resistance."

For more

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How to manage herbicide resistance

The increasing incidence of weeds that cannot be controlled with glyphosate is forcing a rethink of the range and diversity of weed management tactics used in Australian cotton production systems.

To address the issue, a series of 14 Weed Management Workshops developed by Independent Consultants Australia Network (ICAN) on behalf of CRDC and CottonInfo are targeting the needs of growers and consultants. Two workshops

developed with Crop Consultants Australia were held in early June designed specifically for consultants.

"Herbicide resistance in weeds is an issue that CRDC, consultants and growers all recognise as a priority issue and as such we have requested and invested in getting the research and knowledge into the hands of those who are dealing with physically managing resistance," CRDC R&D General Manager Ian Taylor said.

The workshops kicked off in Emerald in late May and continue through to August 2016.

Dates and location

w www.cottoninfo.com.au/calendar

Enquiries and registration

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Tackling Verticillium

This season Verticillium wilt has again been a major issue for some cotton growers and consultants, who are looking for answers as to how to manage this disease which has the potential to cause serious yield loss.

There are defoliating and non-defoliating strains of *Verticillium dahliae* and affected plants exhibit very similar symptoms to Fusarium wilt, so the first hurdle is correct identification.

Crop managers were encouraged by industry pathologists to collect suspect samples for identification, and also to aid the research effort to overcome this disease.

NSW DPI pathologist Dr Karen Kirkby thanked all those who sent in samples.

"These samples are really important, we can't get the answers we are looking for without them," she said.

"Currently we are seeking to ascertain why some fields are so bad, how the pathogen behaves in the soil, how to accurately detect and quantify inoculum in the soil and how to best manage the disease."

NSW DPI and QLD DAF provide free diagnostic services to growers and consultants for diseased plants. The CRDC-backed Annual Disease Surveys undertaken early and late season by the pathologists and their teams also provide industry with valuable data on the incidence of Verticillium wilt by region.

This season NSW DPI received 161 samples suspected of being infected by *V. dahliae* plus an additional 55 samples taken from NSW survey farms. Karen said testing is continuing and results released when concluded.

Pathologist Dr Linda Smith of QLD DAF received 64 suspected samples and took late season survey samples. Of these, 50 were confirmed as *V. dahliae* based on spore morphology; including both defoliating and non-defoliating strains using molecular techniques.

"The surveys also found that although the disease incidence and number of fields with Verticillium wilt in Queensland is generally low, the number of infected fields and disease

incidence is increasing.

"Three new fields in Queensland were determined to be infested with the defoliating strain VCG1A in the 2015-16 season."

Choose rotations carefully

From a management perspective, at post-harvest time it is imperative to incorporate trash straight away, and if planning a rotation crop, select carefully.

"Our glasshouse studies have determined that chickpea and faba bean are hosts of *V. dahliae* and should be avoided," Linda said, which limits winter rotation options for growers.

Linda said studies conducted overseas have confirmed that mung bean is also a host of *V. dahliae*. This has meant that for some growers "the mung bean crop that was planned for this spring is not advisable". Glasshouse studies are underway to confirm if mung bean varieties in Australia host all three strains present in Australian cotton fields.

To determine the best rotation options, QLD DAF is concentrating research funded by CRDC on determining which rotation crops are hosts or asymptomatic hosts (infected but not showing symptoms) and examining the effects of non-hosts on the population of microsclerotia in the soil along with disease incidence.

While cereals and sorghum are currently seen as suitable rotations, research is being conducted to determine if *V. dahliae* is an endophyte of wheat, oat and barley varieties grown in Australia, as it has been confirmed in varieties grown overseas.

Endophytes are organisms living inside plants that exhibit no visible symptoms as a result of this colonization; however they may contribute inoculum to the soil.

"One of the questions we need to answer is whether asymptomatic hosts are as suitable as

> on page18

Feeling the effects in the Macintyre

Iain Macpherson is a consultant based in Goondiwindi. He is a long standing member of Fuscom and has been seeing *Verticillium* increase for a number of years.

"In the Macintyre Valley we have seen increasing disease levels and disease severity for some time but have struggled to find any common trends that cause the increases.

"It is often on our heavier soils east of town but can be found on lighter red soils, and is as bad in flood irrigation as overhead irrigation.

"Some of our worst farms have the best rotations of a one in one out rotation with wheat.

"The yield impact has been severe with losses of 50 percent seen in bad fields.

"We have had both the 1A and 2A strains identified in this area and both can cause severe defoliation of significant patches of crop and is affecting our most resistant varieties.

"Our biggest concerns for the near future is the lack of information on our best rotation options to reduce inoculum levels and what is the resistance status (V rank) of our new varieties as we move towards Bollgard 3."

< from page16

the hosts which exhibit the disease for the survival of *V. dahliae* in our cropping system," Linda said.

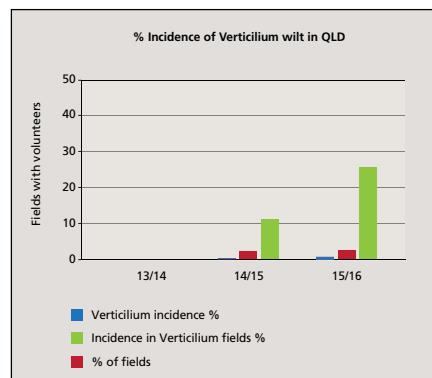
"We need to understand the potential for *V. dahliae* to form associations with asymptomatic plants, and understand the role that population structure plays in asymptomatic interactions, to be able to incorporate rotations effectively into management of Verticillium wilts."

The overwhelming message from the pathologists is the importance of integrated disease management (IDM) and considering the effect of any cropping decision on disease management and/or prevention.

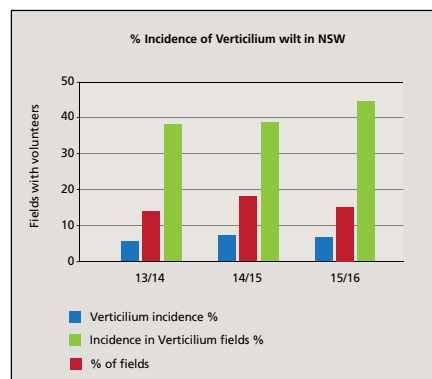
"We know to incorporate trash quickly, select rotations carefully, and be mindful of temperature when irrigating: we know that it can strike early in the season, with surveys detecting symptoms in November," Karen said.

"We know cotton is a preferred host, so growing it year-in, year-out encourages the pathogen to out-compete other microbes in the soil.

"It is essential that farm hygiene is conducted to reduce the risk of moving infested soil and plant material to new fields, farms and regions."



Above and Below: The percentage disease incidence and fields detected with Verticillium wilt during disease surveys from 2013 – 2016.



Moree consultant Stu Doyle with a plant decimated by suspected verticillium wilt. Yield losses have been significant.

MELANIE JENSON

One year on: what has been the experience?

Spotlight spoke with Moree consultant Stuart Doyle for our autumn edition last year to understand the prevalence and effect of Verticillium wilt in some of the fields he manages. We caught up with him again in May this year to see what effect it had this season and hear concerns from a consultant's point of view.

"I am very concerned about the future for back to back cotton, as when water returns to full allocation I have several fields that we will have to seriously consider growing other irrigated crops in, due to the downside risk of disease," Stuart said.

"We have seen common yield losses of five to seven bales per hectare in badly affected areas."

Stuart says this year the Verticillium symptoms started from planting where plant stands were lost early due to both Verticillium and Fusarium.

"This set the tone of the season with vascular browning and leaf mottle commonplace in fields that had any history of Vert," he said.

"The severe symptoms came in slightly later than last season and were not as 'suddenly' severe yet were more widespread. We really saw a big increase in leaf browning after the early March irrigation."

Stuart said that fallowed fields were also hit hard.

"Post-harvest surveys have shown plants which came from cotton planted

into a one-year fallow were up to 100 percent infected with disease (stems with vascular browning)," he said.

"It is yet to be confirmed what percentage mix of vert and fusarium we had however the symptoms looked like vert and ranged from 60 to 100 percent of stems surveyed showing vascular browning.

"We really rely on the researchers to give us results so we can try and plan for the future.

"This is evidence to me that the one year fallow wasn't enough to drop the microsclerotia numbers in the soil: we need to look at different crop sequences to see what will drop the spore numbers whilst allowing a good cash flow!

"We do not have a complete picture as to what the numbers of microsclerotia in the soil means in relation to the disease virulence and risk of having a bad infection in the following crop.

"We still have a long way to go in understanding this disease which is going to take a concerted and co-ordinated approach – it was disconcerting to see the disease topics from the 1996 cotton conference dominated by vert and I suspect we will be talking more about it this year."

For more

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Crop rotation and soil health

Rotation crops have many benefits in cotton farming systems, and there are many things to consider when choosing the right one.

Rotations can improve soil health and subsequent cotton crops by improving and increasing nutrient uptake, sequestering soil organic carbon, improving water infiltration and soil moisture holding capacity, breaking pest and disease cycles, and stimulating microbial activity. A healthier soil requires less synthetic fertiliser and tillage, and forms the basis for providing optimal crop nutrition.

There are many crops able to be grown in rotation with cotton and equally many reasons to plant a rotation crop: cash-flow, improving soil health, managing disease and/or weeds, or a combination. Whatever the reason, the impact of a rotation crop on all these factors must be considered when making a decision.

Crop rotation research supported by CRDC, with NSW DPI and CSIRO aims to further the understanding and assist farm managers in decision making and to develop system-based approach to manage and build resilient soil.

Rotations to improve SOC

Soil organic carbon (SOC) levels are key indicators of soil health.

"Overall soil organic carbon and its flow in soil is the key driver of soil health to enhance biological processes for nutrient cycling rather than sequestration per se," says NSW DPI Soil Scientist Guna Nachimuthu.

"If looking to improve SOC, the carbon input from crop residues or manure/compost needs to be greater than mineralisation induced carbon emission losses and erosion/deep drainage carbon losses.

"Irrigated systems have greater potential to sustain or improve SOC than dryland systems, where an extended fallow is common during dry years.

Positive	Negative
Add soil organic matter	Prevent soil drying
Suppress weeds/roundup ready volunteers	Allelopathy effect in subsequent crop
Suppress disease	Host pathogen for cotton
Alleviate soil compaction	Increased management
N addition (legume crop) and recycle nutrients	Immobilise N
Increase infiltration	Dry the soil profile
Attract beneficial insects	Host pest
Prevent soil erosion	Interfere with equipment
Additional income	Additional cost

Table 1. Pros and cons of crop rotation in a cotton farming system

Whether the soil's organic carbon level decrease or increases will be affected by the balance between on-farm biomass inputs from crop shoots and roots (along with external inputs such as compost), and losses associated with mineralisation, erosion and deep drainage. If there is a fallow period along with soil disturbance associated with operations such as pupae busting or tillage, the rate of breakdown of organic matter is generally accelerated as it

"Irrigated systems have greater potential to sustain or improve SOC than dryland systems...."

is made available to soil microbes.

In an irrigated cotton system, cotton and wheat crops add about 4t/ha of shoot dry matter whereas corn adds 8.7 to 10 t/ha, with approximately 40 percent of the dry matter being carbon.

Managing for disease

The CRDC-supported long-term crop rotation trials underway at ACRI clearly document cotton productivity and disease incidence in cotton monoculture and cotton-cereal or legume rotations.

Previous CRDC research suggested the yield reduction seen in cotton monoculture is a result of soil structure degradation, sodicity, reduced nutrient uptake and increased occurrence of diseases and their interactions with soil conditions.

Cotton lint yields and gross margin per

megalitre of applied water were generally higher for cotton-wheat rotation than back-to-back. However the minimum tillage cotton monoculture has the highest gross margin per hectare over the long term, with higher yields than a conventionally tilled back-to-back cotton.

"Introducing a corn rotation into the cotton monoculture resulted in lower black root rot incidence, complete control of Roundup Ready volunteers in subsequent cotton and higher cotton lint yield," Guna said.

"While the nitrogen benefits of a legume rotation are an established fact, growers need to consider several other factors (Table 1) and prioritise their goals while selecting the rotation crops."

Research by NSW DPI and QLD DAF cotton pathologists shows that legumes are not a suitable rotation if verticillium wilt is present (see pages 16-17 this edition). Further CRDC research is underway to test Australian cereals for their ability to be asymptomatic hosts of verticillium, which has been found to be the case in varieties overseas.

For more

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Sensing a change at Waverley

It takes just one person and a mobile phone to fully irrigate a 100 hectare cotton field set up with automated irrigation at Steve Carolan's property "Waverley" near Wee Waa in North West NSW.

The Carolans have 2478 hectares of irrigation at "Waverley" with both river and bore allocations.

Last year Steve and farm manager Andrew Greste converted 100 hectares from traditional siphons to a fully automated system, consisting of pipes through the bank and a series of gates in the channel delivery system which can be remotely opened and closed - by mobile phone. Steve says the advantages are labour savings, improved uniformity and water use efficiency.

"This is not cheap to set up," Steve said, "but we can justify some of the expense over time in terms of savings in labour and improved water use efficiency.

"This is turn-key irrigation - we easily irrigated this 100 hectares with one man, and he could have easily managed more than five times that.

"In terms of water use efficiency these fields have also gone from a 36-hour to 24-hour turnaround.

"Automation also adds flexibility to the system, with the ability to grow other crops.

"A field set up like this will be able to be irrigated at any time.

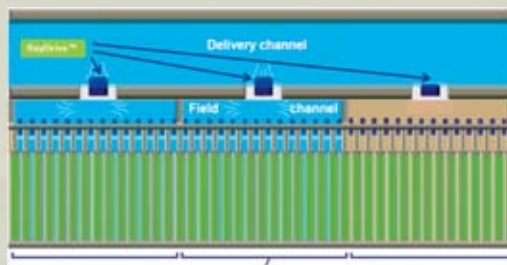
"If we planted wheat on rain moisture and later had water available we could apply an irrigation without having to shift siphons and so on, and we can be more responsive to commodity prices and more easily change what crops we grow and where.

"With remote monitoring of level sensors in channels and down the field we no longer have to drive around to check levels, which is very time consuming, and comes into its own when it is wet and hard to get around.

"Our supply and return channels are monitored so we know when to turn our pumps on and off."

Steve and Andrew first saw the automated configuration at a field day at Australian Food and Fibre's (AFF) "Redmill" Moree, where the National Centre for Engineering in Agriculture (NCEA) and CRDC were conducting automation trials.

They were so impressed with the idea of



How it works: the Carolan's automated irrigation.

automation they went home and began to work on converting some of their own fields.

Farm manager Andrew Greste has been integral in the development of the plan for the farm and said the system is user friendly and reliable.

"Basically, we don't like starting siphons and now we can do a change by phone!" Andrew told those at a CottonInfo field day at "Waverley" in March this year to showcase their system and automation research from NCEA, supported by CRDC.

"Relying on sensors to tell us what is happening may be a little daunting, but the system has alarms and back-ups so we get a text or e-mail if there is something amiss.

"It is almost impossible to blow head ditches, it would be more likely to blow a supply channel."

Steve says ideally he would like to expand the automation system across the whole farm, and while cost is a limiting factor, with the help of the NSW DPI's Farm Modernisation Program, further expansion of the system has begun.

"This field cost us \$1000 per hectare to develop, so there would need to be more than just labour savings to justify the conversion: we need to see increased flow rate, better uniformity and improved yields," he said.

"And while we are only one season in, we are seeing signs that all these aspects will be there to justify the system."

Why, it's automatic

Automated irrigation technology is here and cotton growers are getting on board.

A series of irrigation field days are giving growers something to think about, with some, such as Steve Carolan and Barb and Ralph Grey (featured here) converting fields to this system.

CottonInfo Water Use Efficiency Technical Specialist Janelle Montgomery of NSW DPI was the key organiser of the field days, which have included the CottonInfo 2015 Irrigation Technology Tour of cotton regions, followed by specific automated irrigation days at Moree in Southern NSW. These automation days highlighted research projects CRDC has invested in.

Under a CRDC project, the NCEA undertook automation research at "Redmill" Moree, which generated a lot of interest from growers and consultants.

"To see growers actually take up this technology to improve efficiency in several areas is fantastic," Janelle said.

"Irrigation is a costly, labour intensive operation on a cotton farm and we have been looking at ways to improve efficiency.

"Through the automation trials and field day at Redmill we were able to share with growers and they were able to assess the suitability of this system for their own farms."

CRDC has also invested in the Irrigation Research and Extension Committee (IREC) field station at Whitton in Southern NSW. This was one site visited on the southern automation tour last December, which was so successful a shorter version was run in February to accommodate those who missed the first one.



Trial work on the CRDC-funded irrigation automation project undertaken by the National Centre for Engineering in Agriculture at "Redmill."

"Around 40 irrigators, consultants and researchers from all cotton-growing regions participated in the December automation tour, which included visits to the manufacturing facilities of Rubicon Water and Padman Stops in Northern Victoria.

"The tour also included seven farm visits in the southern irrigation areas, giving participants the opportunity to hear directly from farmers who have already installed automation equipment on their farms.

"The farms visited included a mix of irrigation layouts, enterprises and automation technology.

"The tour not only generated significant interest in investigating ways to automate surface irrigation systems in cotton, but also provided networking opportunities for irrigators and consultants located right across the industry.

"As we all know there is also nothing

like looking over the fence and the chance to talk with irrigators from other industries, including dairy, rice and prime lamb, to learn more and reap rewards.

"While all tour participants said they would like to adopt some kind of automation in the future, the greatest barrier is the cost.

"A number of irrigators have indicated they would conduct small trials before any larger development, as adoption of automation systems can be carried out in stages."

For more

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Funding to improve efficiency

Irrigators in NSW can apply for a share of \$111 million funding to upgrade and modernise on-farm infrastructure through the NSW Sustaining the Basin Irrigated Farm Modernisation program.

Government and industry have injected more than \$75 million into modernising

irrigation infrastructure to date through the program. Irrigators from the Barwon Darling, Border Rivers and Lower Namoi catchments can apply for Round 8 funding. Individual projects funded to date range from \$51,000 to \$5.5 million.

The program is funded by the Australian

Government through the Sustainable Rural Water Use and Infrastructure Program. Applications for Round 8 close July 1 2016.

For more

w www.dpi.nsw.gov.au/info/sustainingthebasin



Having a field day with innovation...

RUTH REDFERN

They say 'necessity is the mother of invention', but in the case of cotton growers Barb and Ralph Grey, necessity may be the mother of irrigation.

The Greys are planning to convert two fields on their property near Mungindi on the NSW-QLD border from siphons to automated irrigation, with the impetus coming last year after a series of events, mishaps and good timing.

"Early in the season Ralph snapped a tendon in his hand, putting him out of irrigation action, and we also had staff away with family commitments, leaving us very short," Barb said.

"Being wholly dependent on people to irrigate, we found ourselves in an uncomfortably vulnerable position.

"Then when you sit down and add in the fact it is extremely labour intensive and costly to physically get water on and off fields, and let's face it - no-one likes doing it, we thought; 'there has to be a better way'.

"We all know the time spent throwing siphons, putting rotor bucks up and ploughing them down, watching head

ditches fill, and getting out to do a change at 3am."

Ralph also did some basic calculations on the dollar cost of irrigating and felt the numbers stacked up to make a change to something less labour intensive.

"We were at that point where something had to change," Ralph says.

"We've seen automation and new technology in so many other aspects of cotton farming, but not in flood irrigation application.

"We now use probes and sensors and new technology around irrigation scheduling, but in terms of over-the-bank siphons, nothing much has changed in 30-plus years."

Fate intervened at this stage and Ralph heard feedback about the CottonInfo and IREC Automation Tour held in Southern NSW and Northern Victoria in December last year.

The Grey's interest was peaked and luckily, due to popular demand, a further, short format tour was held in February this year for those who missed the first tour and Ralph was the first on the bus.

"The tour was really useful, speaking to growers and industry representatives who were very helpful and keen to share

The industry-supported irrigation automation field days like this one at the IREC Field Station at Whitton have been very well received by growers who are looking to improve irrigation and take out the heavy labour aspect of the task.

their knowledge, and showed a good cross section of irrigation methods," Ralph said.

"I saw a method there that I thought would work for us.

"I met Mike Naylor on the tour, an irrigation designer/consultant from Leeton who has been helping us with our conversion, along with local Goondiwindi-based irrigation consultant Mike Henderson, who was on the first automation tour."

The plan is to go with a through-the-bank, automated outlet system, as it will take limited earthworks and outlay.

"We've got two fallowed, re-levelled paddocks we are converting, which if we receive winter rainfall will go into production next season.

"We are basically modifying what is there, and are looking forward to the benefits - labour savings, and yield improvements through a more timely and efficient irrigation process.

"Following on from what we heard and saw on the southern valley tour, we especially welcome the idea of 'lifestyle enhancement' ... remote monitoring and hands-off irrigation, while away on holidays!"

"Being wholly dependent on people to irrigate, we found ourselves in an uncomfortably vulnerable position...."

Conference: just keeps getting better!

The 2016 Australian Cotton Conference detailed session summary is now available on-line.

With almost 80 expert speakers and topics being covered over three days from August 2 to 4 at the Gold Coast Convention Centre, the program provides delegates with a wide range of choices in all areas of interest from agronomic production issues to cotton marketing and business.

New frontiers

This year's conference is tackling the concept of the new cotton frontier: challenging the limits of our knowledge and the most advanced achievement in our field. So, it is apt that the opening session explores personal development with The Naked CEO Alex Malley and new frontiers for agriculture with the CSIRO Chair David Thodey.

iGEN

Move over Baby Boomers and Generation X, generation iGEN (or Gen Y and Z) are looking to step up!

Following on from the successful 2014 Next Gen event, iGENNERS will this year have their own forum at the conference, with an opportunity hear more from Alex Malley; plus a focus on learning how to tell agriculture's story, and the seven habits of highly effective people.

Taking Australian cotton to the world

A global look at the role of our domestic cotton industry: from global cotton



The Australian Cotton Conference is one of the most highly anticipated events on the cotton calendar, as it continues to offer outstanding speakers, relevant programs and plenty of fun.

economics (including consumer demand) to Australia's role within the world of cotton. This session will also include a micro-analysis of the market influences that are impacting the price being paid for your cotton.

Sustainable cotton – global perspectives

Hear first-hand what drives brands and retailers towards sustainability and what consumers want from Australian cotton. Two of the world's largest retailers, Nike and H&M will share their views on sustainable cotton production and what eco-conscious businesses and consumers alike are demanding.

People power

People are our most important resource, and in this session, find out how to make it work through strategy and people

investment, conflict resolution, getting the most out of your people and utilising digital farming to manage staff and workloads.

What's your take home message?

In this unique and powerful closing session, journalist Peter Greste and his brother, cotton grower Andrew, will recount how their family coped with Peter's incarceration and how the community - and the nation - got behind them.

And, love or hate football (or the Broncos!) there's no way not to admire Wayne Bennett, who will share his philosophies on everything from family and friends to footballers; mateship; the business and politics of sport; the importance of loyalty and team spirit; the value of self-confidence and being honest with yourself; battling through testing times; and what it takes to be a winner and to be a leader.

Again, the conference is an event not to be missed, for the latest on fresh approaches to crop management, crop nutrition, weather and forecasting, irrigation, big data, precision agriculture, succession planning, personal wellbeing and new technology.

Free health checks

The health of our industry is paramount, and in particular in preventative care, and that's why the Australian Cotton Conference is offering free health checks to all delegates.

Blood pressure, glucose level, cholesterol level, BMI, lifestyle factors, hearing and skin checks will be conducted, with the aim to pick up any issues before they become a major problem.

The checks will take place in the Cotton Trade Hall, conducted by HealthWISE New England North West, a General Practitioner from Narrabri and medical students from the University of New England.

For more

www.australiancottonconference.com.au

As attention turns to nutrition for next season's crop, growers and consultants should use both the Colwell P and the BSES P soil testing to get a better perspective on the P situation in their paddocks.



Looking deeper into phosphorous

As growers and consultants look to manage pre-plant nutrition, new research is shedding light on measuring and managing phosphorus, a vital nutrient for cotton's root development and energy processes.

The research, undertaken by Brendan Griffiths of UNE with support from CRDC, found that cotton draws phosphorous (P) from a range of pools in the soil, and appears to draw larger amounts from deeper in the profile.

There are various pools of P in the soil, each having a different contribution to overall soil P and plant P nutrition.

Historically the cotton industry has relied on the Colwell soil test method, taken from the top 10 centimetres of the soil profile as the key method of ascertaining soil P status.

Through Brendan's research at an Incitec Pivot long-term nutrition trial site on the Darling Downs, he found that by undertaking a range of soil test methods at both surface and deeper in the profile, a picture began to emerge.

"We used the Colwell P soil test to test the shallow sample, to 10cm, and we used the BSES P and the Colwell P method in the 10 to 30cm segments in the soil profile," he said.

"These were benchmarked against background soil test levels of P from the 30-plus years of trials at the site.

"In our experiment, using the Colwell

soil test method we found no change in P levels in the treatments where no fertiliser P had been applied, yet we clearly showed the plants were taking P up, and in quite large quantities."

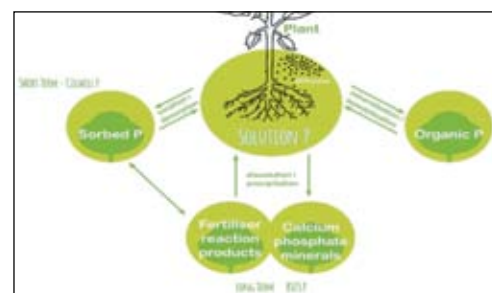
Earlier work undertaken at the same Incitec Pivot site by researchers Juan Wang and David Lester showed that another pool of P existed in the soil. This pool, measured using the BSES soil test, had halved over the duration of the long-term experiment. This method of extraction uses a weak acid reagent and will reflect a different pool of P than that of the Colwell method, which uses a bicarbonate reagent.

"For P to be taken up by the plant, it needs to be in the solution form," Brendan says.

"The pool of P (measured using the Colwell P test), will keep this solution P topped up, as long as the Colwell P pool is not below critical levels.

"The pool measured by the BSES P method will then similarly keep the Colwell P topped up, as long as there is sufficient P in the BSES P pool.

"This BSES P pool will release P much more slowly than that of the pool measured by the Colwell method.



"The key messages from our research include that growers and consultants should be using both the Colwell P and the BSES P soil testing to get a better perspective on the P situation in their paddocks.

"Other key messages from our research include that we absolutely need to apply P, and at least at rates that equal crop removal amounts, so we are not mining the soil of nutrient.

"We also suggest that P needs to be applied deep and incorporated through the profile, to provide a long-term benefit of soil P levels and not necessarily for the immediate response, because once soil P levels are depleted to below critical response levels there will be no 'quick fix'."

Stay tuned for more findings from Brendan's research in coming editions of *Spotlight*.

For more
Brendan Griffiths
e griffb@bigpond.com

Support stacks up

At their graduation in April, University of Southern Queensland (USQ) agricultural engineering students Simon Kelderman and Stirling Robertson were awarded the institution's most prestigious award – the University Medal, along with other major accolades.

Stirling graduated with First Class Honours in a Bachelor of (Agricultural) Engineering and in addition to the University Medal was awarded the Engineers Australia Wilmoth Medal and Prize.

Simon also graduated with First Class Honours in a Bachelor of (Agricultural) Engineering and received the Allan Rixon Memorial AG Institute of Australia Medal.

Both men have been undertaking part of their study with support from CRDC via initiatives to promote students' study, research, practical engagement and network building in the cotton and wider scientific industry.

"These awards represent results of the cotton industry's direct support of students in the Agricultural Engineering program at the university," according to USQ's Dr Joe Foley.

Stirling was awarded a PICSE Cotton Industry Internship with support from CRDC in 2014, in his third year of study. The internship connects tertiary undergraduate students with the industry scientists, university researchers and agribusiness organisations affiliated with the Australian cotton industry. The goal is to allow students to experience practical engagement and develop networks with the cotton and wider scientific industry.

Stirling went on to complete his Honours Thesis with a scholarship on the compaction of cotton soils from round bale cotton pickers, with Dr John Bennett of the National Centre for Engineering in Agriculture (NCEA) at USQ. Stirling has now enrolled in his PhD

study with John, who has undertaken several projects on behalf of CRDC.

Simon was awarded a CRDC Honours Thesis Scholarship in 2015, which allowed him to complete extensive testing and simulation of the application of the Green-Ampt Infiltration model to sprinkler irrigation. Dr Joseph Foley, an Agricultural Engineer who specialises in irrigation at the NCEA, supervised Simon's Honours and also hosted him for work experience. Simon is now a research irrigation engineer at NCEA.

"CRDC has for many years encouraged involvement from agricultural engineering in the cotton industry," Joe said.

"The support CRDC offers goes beyond mere words: the Summer and Honours Scholarships, PICSE Internships and Australian Cotton Conference attendance for these agricultural engineering undergraduates is critical to the on-going interaction and active engagement of these graduates in the cotton industry.

"The value of these opportunities for the students is significant in that the interaction actively engages them with issues and challenges in the cotton industry requiring engineering solutions.

"Their involvement in the formative years of their study allows them to develop a background understanding of the cotton industry, as well as contacts and interaction with the industry that carries on through their career.

"The exposure to real industry issues provides motivation in a challenging field of study, as well as enhancing their existing engineering skill set with real engineering experience."

"These awards represent results of the cotton industry's direct support of students in the Agricultural Engineering program at the University of Southern Queensland." – Dr Joe Foley.

For more
Visit CRDC Scholarships page
w www.crdc.com.au/for-researchers



PHOTO COURTESY USQ

Spotlight spoke to Simon and Stirling about the impact of industry support on their careers...

Making a difference

Simon Kelderman says the CRDC Thesis Scholarship support was very much appreciated, both on a professional and personal level.

Simon said the support had affected his choice of study and career path, for several reasons.

"The scholarship support showed me that CRDC is interested in attracting and supporting new researchers to the cotton

"Financially it meant a lot because our family was operating on a rather tight budget while I was studying."

industry," he said.

"So as I presently look at some potential PhD research project topics, I guess I consider the cotton-related projects more favourably because of the support already received.

"I studied a dual degree and had received a couple of informal job offers in the business/supply-chain sectors. While I was already leaning toward an ag engineering career, the scholarship support

helped to cement that path by getting me more involved with NCEA (at USQ) as a student and now as an ag engineer.

"The scholarship support meant I could spend what was needed to be spent on the research project without making things more difficult at home.

"Motivationally it also made a big difference: I felt that others were interested and even had a stake in the project so I wanted to produce something of high quality."

Simon's thesis explored a real-world application of the famous Green and Ampt Infiltration Model. The potential benefit to irrigators or irrigation designers using lateral move or centre-pivot machines would be to better understand and predict how particular nozzle/system pressure/travel speed configurations affect run-off.

Stirling effort

Stirling Robertson told *Spotlight* in 2014 that the PICSE program was a great experience, but did it influence his career and study choices?

"The PICSE program gave me a great insight into the Australian cotton industry and I was able to see how progressive and innovative the industry as a whole is," he says.

"The program highlighted the importance of research and development

Agricultural Engineering graduates and USQ University medallists Simon Kelderman and Stirling Robertson, with Dr Joseph Foley and Dr Malcolm Gillies.

within Australian agriculture, and this aspect encouraged me into undertaking a PhD in precision agriculture, focusing on (Big-data) as a tool for on-farm decision making.

"I was also lucky enough to receive the Cotton Australia Final Year Project Scholarship for my thesis on delaying defoliation to mitigate the soil compaction risk at harvest, which I completed at the end of last year."

Stirling says he is very much enjoying being involved in the cotton industry research community.

"I found that many people in the cotton industry, including the farmers themselves, were very keen to have research undertaken and were willing to help wherever possible.

"I believe this reflects the industry as everyone is quite progressive to ensure that Australian cotton is of the highest quality in the world."



CCA 30 years on: the growth of a profession

In this edition's regular CCA column, the association looks back over 30 years of operation.

This year, Crop Consultants Australia Incorporated celebrates 30 years since our official formation. As we acknowledge this milestone, we look at our history and the changes that have led to CCA developing into the organisation of professionals that it is today.

The term 'consultant' is a widely assumed title within the agricultural scene and it carries with it a broad job description. The consultant is a 'go to' person, an 'expert' in their field, and a problem solver in everything from financial and HR issues, through to business planning and technical advice. In terms of professions however, the independent crop consultant is a relative newcomer to the block.

Up until the 1960s, as cropping areas across Australia were developed, much of the advice given to growers was delivered by staff employed by the various state and federal agricultural and research bodies. The development and adoption of new chemistries to help tackle ongoing pest infestations saw the evolution of a new role in agriculture – the bug checker.

Armed with advice and support from chemical companies, these staff were 'on the ground' in terms of understanding insect pressures, movements and the success of various chemical applications. They became advisors to growers, and as fledgling farming areas matured, and government advisor numbers dwindled, the profession that we refer to as the private sector 'crop consultant' evolved.

As we look at the history of our organisation, we have much for which to thank the 'statesmen' of our profession.

People such as Geoff Brown, Maurie Fay, Steve Warden, Jeremy Kitchen and the late Chris Lehmann (who is honoured annually in the Chris Lehmann Trust Young Achiever of the Year Award), just to name a few.

These people were instrumental in not only pioneering the industry, but recognising a need for crop consultants to work together with the research and chemical sectors to develop their profession. When they started out, little would they know the changes that the profession would experience in the next 30 years. The introduction of transgenic crops, new chemistries (some more controversial than others) and the ongoing challenges presented by ever adapting weeds and pests, have ensured that there is a constant need for today's agro to be



Looking back: The 'founding father' of the CCA, the late Chris Lehmann, honorary member and ex researcher Neil Forrester and Jim O'Connor from Goondiwindi at the CCA AGM in 2003.

informed and make well researched decisions.

Despite these changes, the original 'Statement of Objects' for the organisation remains remarkably unchanged as the CCA purpose of "maintaining and improving the standard of Agronomic Advisory Services".

Currently CCA has around 200 financial members, and with a regular contact list of almost 500 key industry members and researchers, and ever increasing attendance at seminars, its role as a conduit of information and promoter of research adoption and professionalism has never been more important.

CCA's 30-year celebrations will conclude at a special dinner in Toowoomba on July 19 2016. Members past and present, researchers and industry representatives are most welcome to attend.

For more

w www.cropconsultants.com.au

SAM: Getting to know a key player



The low-down with
Jon Welsh

Understanding climate drivers and the impact of large-scale circulation on rainfall variability in Eastern Australian cotton regions remains a critical component of assessing the likelihood of seasonal predictability of rainfall.

The factors influencing both rainfall and temperature extend beyond El Niño-Southern Oscillation (ENSO) teleconnections in winter and spring. ENSO analyses often tend to dominate media commentary. However there are many other drivers which impact Australian farmers that if aware of, can help decision making and risk management.

The Indian Ocean Dipole can also influence rainfall and run-off in a northeast-southeast rainband through the winter cropping season, particularly in southern cotton growing areas. Parts of Western NSW, notably Menindee and Walgett regions can also be affected by certain modes of Indian Ocean variability in summer. However, in mid-latitudes through the vast majority of eastern Australian cotton growing areas, the Southern Annular Mode (SAM) is the dominant influence of atmospheric variability and spring season rainfall.

What is the Southern Annular Mode?

The SAM is an atmospheric-based phenomenon describing the north-south movement of the westerly wind belt circulating around Antarctica. The changing position of this wind-belt influences the strength and position of cold fronts and mid-latitude storm systems which bring rainfall to much of eastern Australia's temperate agricultural land.

A positive SAM results in weaker than normal westerly winds and high pressure over southern Australia; meaning cotton growing areas can benefit from more easterly winds bringing in moist air from the Coral and Tasman seas. During this mode of variability, the formation of East Coast Lows (ECLs) can also be enhanced assisting run-off in upper Murray-Darling Basin catchments along the Great Dividing Range in the cooler months.

Conversely, a negative SAM sees a shift in the westerly winds northwards from Antarctica creating stronger storms and low-pressure systems over southern Australia. During this phase cotton areas can experience dry, low-humidity westerly airflows originating from Central Australia. This was evidenced by the spring of 2013 during an ENSO 'neutral' phase when below average precipitation and extreme heat occurred through much of the eastern Australian cropping belt.

The SAM index is based on the zonal pressure differences between two different latitudes around Antarctica. As such, the SAM index measures the 'see-saw' of atmospheric mass between the middle and high latitudes of the Southern Hemisphere in much the same way the Southern Oscillation Index (SOI) measures changes in tropical air pressure between Darwin and Tahiti.

The SAM's contribution to record breaking events

There is a relationship between phases of the SAM and rainfall in regions where the rainfall is linked to high pressure systems

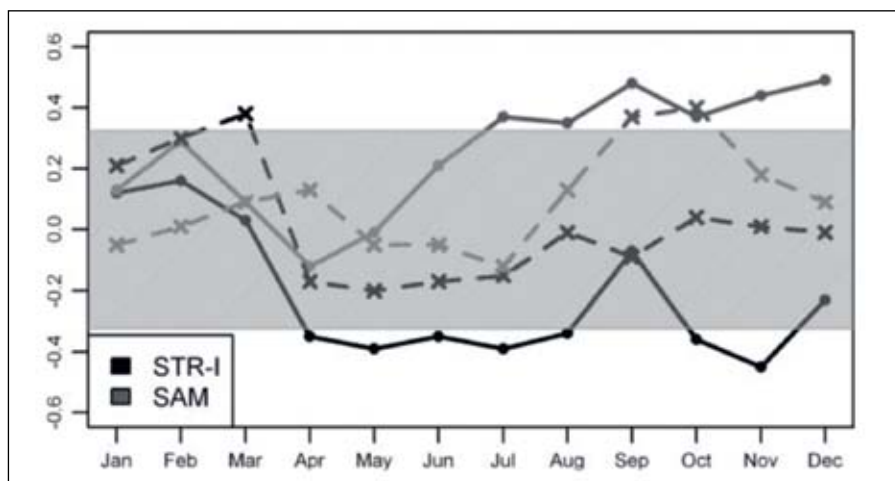


Figure 1. Three-monthly correlations between ECL-related rainfall (solid line) and non-ECL related rainfall (broken line) across the ESB domain with SAM (1970-2006). Shaded areas indicate correlations that are below the five percent significance level. (Source: Pepler et al., 2014).

and easterly circulation patterns in QLD and NSW. The SAM has been at the centre of some recent extreme climatic events.

Contrasting rainfall anomalies in the strong El Niño year of 1997 and the weak El Niño events occurred when rainfall responses were generally assumed to be linearly related to the strength of El Niño. It was generally accepted that the behaviour of the SAM would follow the strength of the ENSO signal. That is, a strong El Niño would coincide with a negative phase of the SAM.

Normal rainfall in 1997 and severe drought conditions in 2002 were marked by differences in the behaviour of the SAM. In 2002 (a mild El Niño year), the severity of the rainfall deficit was significantly amplified by the occurrence of the record strength negative phase of the SAM mode - with uniform higher air pressure in the mid-latitudes. The strength and influence of the SAM did play a primary role on the severity of dry conditions not fully accounted for in forecasting models in 2002.

More recently, the spring of 2010 resulted in record heavy rainfall through eastern Australian agricultural areas in-part, by the favourable La Niña- Indian Ocean Dipole combination.

The impact of this sea surface temperature trend promoted the strongly positive SAM phase beyond what typically occurs with La Niña. This record positive SAM event contributed to increased rainfall through inducing anomalous moist onshore easterly flow and upward motion of atmospheric circulation.

Researchers have also discovered a connection between the formation of East Coast Lows (ECLs) and the SAM.

ECLs have been identified as the one cause of extreme winter rainfall events on the eastern seaboard and can often contribute to in-flows into water storages along the Great Dividing Range.

The SAM is correlated with ECL-related eastern seaboard rainfall from July to December, particularly in more northern sub-tropical cotton growing areas such as the Darling Downs.

Figure 1 shows the grey line (SAM) at the top of the chart with a correlation with eastern seaboard rainfall above 0.37 for July – November.

During spring and summer, the easterly anomalies during the high index polarity



IMAGE COURTESY AUSTRALIAN GOVERNMENT

of the SAM are associated with increased daily rainfall on the NSW eastern seaboard, which appears to result from an increased occurrence of moist upslope flow from the Tasman Sea.

Research has shown that the SAM explains 10 to 15 per cent of the weekly rainfall variability in the southwest and southeast during winter and on the southeast coast during spring/summer, which is comparable to or larger than the variability in these regions associated with ENSO. Research has also shown the SAM is an important contributor to rainfall variability even in regions where the ENSO signal is prominent.

Predicting the behaviour of the SAM

The seasonality of impact of the SAM on precipitation through eastern Australia has important implications for predicting current and future climate.

Anticipating the behaviour of the SAM remains a key challenge of climate scientists as General Circulation Models strive to simulate ocean-atmospheric interactions and improve forecasting skill.

The usefulness of current research results for deterministic prediction of rainfall and temperature is limited by both the signal strength of the climate impacts of the SAM and by the ability to predict the SAM in the first place. Skilful prediction of the SAM beyond 10 days as yet has not been demonstrated. Therefore, limited predictability of the SAM on seasonal

An Australian Government weather station taking air pressure measurements on Antarctica as part of calculations for the SAM index.

time scale places a strong constraint on predictability of rainfall in the mid-latitudes, even during highly predictable La Niña events.

Identifying relationships with various ENSO phases has uncovered a link between the SAM and ENSO during the summer months, when the SAM's effect on rainfall through most cotton areas is reduced. Ongoing research is underway at the Bureau of Meteorology to better understand how to measure and incorporate the behaviour of the SAM in climate modelling techniques.

SAM Climatedog animation can be found at www.youtube.com/watch?v=G-S-YmE-Lkc

Acknowledgments: Dr Eun-Pa Lim and Dr Harry Hendon (BOM), Acacia Pepler (UNSW).

To sign up for the fortnightly e-newsletter (and other CottonInfo communications) visit www.cottoninfo.com.au/subscribe

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CRDC's 2016-17 Investments

In 2016-17, CRDC will invest approximately \$20.4 million into around 200 projects across the five program areas of the CRDC Strategic R&D Plan (farmers, industry, customers, people and performance) 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 June 1 2016, and may be subject to change.

Program theme	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
Program one: Farmers						
1. Successful crop protection	A predictive diagnostic test for black root rot in cotton soils	CRDC1624	Maria Manjarrez	Microbiology Laboratories Australia	Apr-16	Oct-16
	A productive diagnostic test for Verticillium		Karen Kirkby	NSW DPI	Jul-16	Jun-19
	Centre for Biopesticides & Semiochemicals: Development of new tools & strategies for IPM	DAN1404	Robert Mensah	NSW DPI	Jul-13	Jun-18
	Centre for Biopesticides & Semiochemicals: Novel insecticides and synergists from endemic and exotic flora	UWS1401	Robert Spooner-Hart	UWS	Oct-13	Jun-18
	Centre for Biopesticides & Semiochemicals: Semiochemical management for occasional pests of cotton and grains	UNE1404	Peter Gregg	UNE	Oct-13	Jun-18
	Commercial development and evaluation of a machine vision-based weed spot sprayer	NEC1402	Stephen Rees	NCEA	Jul-13	Jun-18
	Cotton industry disease survey		Linda Smith	QDAF	Jul-16	Jun-19
	Crop protection development specialist (CottonInfo technical specialist)	DAQ1502	Sharna Holman	QDAF	Jul-14	Jun-17
	Enhancing IPM in cotton systems	CSP1401	Lewis Wilson	CSIRO	Jul-13	Jun-18
	Establishing southern cotton IPM	DAN1501	Sandra McDougall	NSW DPI	Jul-14	Jun-17
	Management of Solenopsis mealybug in Bollgard cotton	DAQ1501	Richard Sequeira	QDAF	Jul-14	Jun-17
	Northern Australia Cotton Development & Coordination Leader	CSP1602	Steve Yeates	CSIRO	Oct-15	Jun-18
	PhD: Centre for Biopesticides & Semiochemicals: Electrophysiological and molecular identification of novel biopesticides	UWS1601	Michelle Mak	UWS	Jul-15	Jun-18
	PhD: Developing the weed control threshold	DAN1601	Graham Charles	NSW DPI	Nov-15	Jun-17
	PhD: Host plant relationships of green mirids - is alternative control possible?	UQ1402	Justin Cappadonna	UQ	Nov-13	Nov-16
	PhD: Multiple host use and gene-flow in green vegetable bug relative to cotton crop	UQ1403	Dean Brookes	UQ	Mar-13	Oct-16
	PhD: Quantifying and mapping the impacts of herbicide drift on cotton (non-target crop)	USQ1404	Luz Cadavid	USQ	Nov-13	Jun-17
	Post doc: Hard to control weeds in northern farming systems - understanding key processes to improve control methods	DAN1402	Joe Moore	NSW DPI	Jul-13	Jun-17
	Regional weed management workshops for growers and advisors	CRDC1621	John Cameron	ICAN	Mar-16	Jun-17
	Review of technologies that can be enabled by robotics to improve weed control in Australian cotton farming systems	CRDC1615	Andrew Bate	SwarmFarm Robotics	Oct-15	Jul-16
	Staying ahead of weed evolution in changing cotton systems	UQ1501	Jeff Werth and Bhagirath Chauhan	QAAFI	Jul-14	Jun-19
	Travel: Attending the 49th Annual Society for invertebrate Pathology Conference	QUT1604	Christopher Nouné	QUT	May-16	Jul-16
	Viruses, vectors and endosymbionts: Exploring interactions for control	UQ1305	Sharon van Brunschot	UQ	Apr-13	Jan-17
2. Productive resource efficiencies	Agronomy for resilient future cotton systems	CSP1601	Michael Bange	CSIRO	Jul-15	Jun-18
	Benchmarking water use efficiency and crop productivity in the Australian cotton industry (CottonInfo technical specialist)	DAN1505	Janelle Montgomery	NSW DPI	Jul-14	Jun-19
	Carbon farming in the Australian cotton industry - Grant support	CFO1501	Rachel Bowman	Seed Media Pty Ltd	Oct-14	Jan-17
	Carbon farming in the Australian cotton industry (CottonInfo technical specialist)	CFO1401	Jon Welsh	CSD	Jul-13	Jun-17
	Determining optimum nitrogen strategies for abatement of emissions for different irrigated cotton systems	AOTG1401	Graeme Schwenke	NSW DPI	Jul-13	Jun-17
	Improving cotton productivity with crop nutrition	CSP1403	Ian Rochester & Michael Bange	CSIRO	Jun-13	Sep-16

Program theme	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
	Increasing profitability through improved nitrogen use efficiency and reducing gaseous losses of nitrogen	AOTG1601	Peter Grace	QUT	Jul-15	Jun-18
	Mitigating and managing soil compaction for improved sustainable cotton production		Michael Braunack	CSIRO	Jul-16	Jun-19
	Monitoring greenhouse gas emissions from irrigated cropping systems	CLW1401	Ben Macdonald	CSIRO	Jul-13	Jun-17
	More Profit from Nitrogen: enhancing the nutrient use efficiency of intensive cropping and pasture systems			UQ and NSW DPI	Jul-16	Jun-20
	New materials and options for reducing water losses from evaporation and seepage		Andrew Hamilton	NeoTop Water Systems	Jul-16	Jun-19
	Opportunities for dryland cotton with Bollgard 3		Paul Grundy	QDAF	Jul-16	Jun-19
	Optimising management of manure in southern NSW cotton production	DU1603	Wendy Quayle	CSIRO	Jul-15	Jun-18
	Optimising seedling emergence	DAN1701	Deb Slinger	NSW DPI	Jul-16	Jun-19
	PhD: Improving precision agriculture and environmental performance for the Australian cotton industry through fertiliser optimisation	ANU1602	James Latimer	ANU	Feb-16	Jun-19
	PhD: Self-guided drones for tracking irrigation in a cotton field	USQ1402	Derek Long	USQ	Mar-14	Mar-17
	PhD: Soil-specific strategic irrigation: identifying saline-sodic water as a resource	NEC1403	Aaditi Dang	NCEA	Mar-14	Jan-17
	PhD: The impact of irrigation methods and management strategies on nitrogen fertiliser recovery in cotton	UQ1502	John Smith	UQ	Jul-14	Dec-18
	PhD: Utilising novel plant growth regulators to develop resilient future cotton systems	CSP1604	Claire Welsh	CSIRO	Jan-16	Dec-18
	Post doc: Cotton production in a future climate	CSP1501	Katie Broughton	CSIRO	Jul-14	Jan-18
	Post doc: Professor of soil biology	UNE1403	Oliver Knox	UNE	Jan-14	Dec-18
	Resilient cotton-farming systems in irrigated vertosols: soil quality, carbon and nutrient losses, cotton growth & yield in long-term studies	DAN1503	Guna Nachimuthu	NSW DPI	Jul-14	Jun-17
	Smarter Irrigation for Profit: Develop precise and automated control systems for a range of irrigation systems	RRDP1603	Joseph Foley	NCEA	Jul-15	Apr-18
	Smarter Irrigation for Profit: Evaluation of scheduling tools for the sugar industry	RRDP1609	Peter Samson	SRA	May-16	Apr-18
	Smarter Irrigation for Profit: Grower led irrigation system comparison in the Gwydir Valley	RRDP1606	Louise Gall	GVIA	Jul-15	Apr-18
	Smarter Irrigation for Profit: Increasing farm profit through efficient use of irrigation for dairy farms	RRDP1604	James Hills	UTAS	Jul-15	Apr-18
	Smarter Irrigation for Profit: Irrigation agronomy for tailored and responsive management with limited water	RRDP1602	Hizbullah Jamali	CSIRO	Jul-15	Jun-18
	Smarter Irrigation for Profit: Maximising on-farm irrigation profitability – southern connected systems	RRDP1605	Peter Regan	NSW DPI	Jul-15	Apr-18
	Smarter Irrigation for Profit: Optimised dairy irrigation farms	RRDP1607	Monique White	Dairy Australia	Jul-15	Apr-18
	Smarter Irrigation for Profit: Project leadership and coordination	RRDP1501	Guy Roth	Roth Rural	Jul-15	May-18
	Smarter Irrigation for Profit: when and how much	RRDP1601	Mike Morris	DEDJTR	Jul-15	Apr-18
	Soil System Research – physical, chemical and biological processes for plant growth and nutrient cycling down the whole soil profile	UNE1601	Oliver Knox	UNE	Jul-15	Jun-18
	Southern Connected Systems - Trial Picker	DAN1603	John Smith	NSW DPI	Apr-16	Jun-17
	Strengthening the Central Highlands Cotton Production System	DAQ1401	Paul Grundy	QDAF	Jul-13	Jun-17
3. Profitable futures	Agri-intelligence			QUT	Jul-15	Jun-19
	Future farm automation and robotics management	GRDC1601		USQ	Apr-15	Jun-18
	PhD: A National Regulatory Framework Governing Big Data in Primary Production	UNE1606	Gina Wood	UNE	Feb-16	Jan-19
	PhD: Characterisation of brassinosteroid effects and brassinosteroid -responsive genes in cotton for growth and stress tolerance enhancement	UNE1605	Anahid A Essa Al-Amery	UNE	May-14	Apr-17
	Precision to decision agriculture		Tristan Perez	QUT	Jul-16	Jun-19
Program two: Industry						
1. Respected stewardship	Biosecurity: understanding the potential for new threats				Jul-16	Jun-17
	Conventional insecticide resistance in Helicoverpa - monitoring, management and novel mitigation strategies in Bollgard III	DAN1506	Lisa Bird	NSW DPI	Jul-14	Jun-19
	Cotton Map		Nicola Cottee	CA	Jul-16	Jun-17
	Helicoverpa punctigera in inland Australia – what has changed?	UNE1502	Peter Gregg	UNE	Jul-14	Jun-17

Program theme	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
	Investigating the on-farm risks of aflatoxin contamination of cottonseed	DAN1406	Kathy Schneebeli	NSW DPI	Jan-14	Dec-16
	Managing Bt resistance and induced tolerance in Bollgard III using refuge crops	CSE1601	Mary Whitehouse	CSIRO	Jul-15	Jun-18
	Monitoring Silverleaf Whitefly (SLW) insecticide resistance	DAQ1701	Jamie Hopkinson	QDAF	Jul-16	Jun-19
	NCEDD - Stewardship of biotechnologies and crop protection (CottonInfo technical specialist)	SC1601	Sally Ceeney	Consultant	Jul-15	Jun-18
	PhD: Evolution of viral diversity and virus ecology in the management of resistance to biopesticides	QUT1402	Chris Nouné	QUT	Jan-14	Jun-17
	Resistance research and monitoring to enhance stewardship of Bt cotton and management of Helicoverpa		Sharon Downes	CSIRO	Jul-16	Jun-19
	Surveillance and studies for endemic and exotic virus diseases of cotton	DAQ1601	Murray Sharman	QDAF	Jul-15	Jun-19
	The sustainable chemical control and resistance management of aphids, mites and mirids in Australian cotton: 2014-2019	DAN1507	Grant Herron	NSW DPI	Jul-14	Jun-19
2. Responsible landscape management	Baselining Lower Namoi groundwater and evaluating Pilliga CSG developments	UNSW1601	Bryce Kelly & Charlotte Iverach	UNSW	Jul-15	Jun-18
	Cotton Rivercare Champion	CRDC1602	Mark Palfreyman	Capricorn North Pty Ltd	Sep-15	Jun-18
	Developing the groundwater health index (GHI) as an industry-wide monitoring tool	MQ1501	Grant Hose	Macquarie University	Jul-14	Jun-17
	Improving the ability of the Australian cotton industry to report its sustainability performance		Erin Peterson	QUT	Jul-16	Jun-19
	Improving the ability of the Australian cotton industry to report its sustainability performance		Francois Visser	UQ	Jul-16	Jun-19
	Keeping pest populations lower for longer: Connecting farms and natural systems	CSE1501	Vesna Gagic	CSIRO	Jul-14	Jun-18
	Managing climate variability program	GRDC1401	Beverley Henry	GRDC	Jul-13	Jun-17
	Managing natural landscapes on Australian cotton farms to increase the provision of ecosystem services		Samantha Capon	Griffith University	Jul-16	Jun-19
	Managing riparian corridors on cotton farms for multiple benefits	UNE1602	Rhiannon Smith	UNE	Jul-15	Jun-18
	National cotton NRM technical specialist (CottonInfo technical specialist)	CRDC1501	Stacey Vogel	Stacey Vogel Consulting	Jul-14	Jun-17
	National facility for cotton climate change research	CSP1402	Michael Bange	CSIRO	Jul-13	Dec-16
	PhD: Effects of climatic fluctuation and landuse change on soil condition in the lower Lachlan	US1403	Patrick Filippi	USYD	Mar-14	Mar-17
	PhD: Spatial & temporal importance of diffuse & stream recharge in semiarid environments: Implications for integrated water management	UNSW1403	Calvin Li	UNSW	Mar-14	Feb-17
	PhD: Sustainable water extractions: Low flow refugia and critical flow thresholds	UNE1406	Marita Pearson	UNE	Jan-14	Dec-19
	The impact of improved water use efficiency on paddock and catchment health	DNRM1401	Mark Silburn	DNRM	Jul-13	Dec-16
3. Sustainable futures	Resilience assessment of the Australian cotton industry at multiple scales	CRDC1502	Francesca Andreoni	Bel Tempo	Jul-14	Dec-16
Program three: Customers						
1. Assured cotton	Determining the shelf life of round modules and impact on cotton quality	CMSE1501	Menghe Miao	CSIRO	Jul-14	Sep-16
	Enhancing and testing the Cotton Carbon Management Tool	UQ1503	Francois Visser	UQ	Jul-14	Jun-17
	Managing colour grade		Simone Heimona	CSIRO	Jul-16	Jun-19
	Raising the quality of Australian cotton through post harvest initiatives	CMSE1503	Rene van der Sluijs	CSIRO	Jul-14	Jun-17
	Sustainable Apparel Coalition: 2015 membership	CRDC1608	Scott Miller	SAC	Aug-15	Aug-16
	A review of emission methodologies for the Australian cotton industry & development of a detailed study for NW NSW	DAN1508	Pip Brock	NSW DPI	Jun-14	Sep-16
2. Differentiated products	An eco friendly treatment to improve the look and handle of cotton fabric		Rangam Rajkhowa	DeakinU	Jul-16	Jun-18
	Bio-degradation of dyed cotton fabrics		Nelson Vinueza			
	Breathable cotton for compression athletic wear	DU1601	Maryam Naebe	DeakinU	Jul-15	Jun-17
	Measuring and managing fibre elongation for the Australian cotton industry	CMSE1504	Shouren Yang	CSIRO	Jul-14	Dec-16

Program theme	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
	Novel anti-wetting & self-sterilising cotton fabrics	DU1501	Xin Liu and Yun Zhau	DeakinU	Jul-14	Jun-17
	Novel spinning technologies for fine and high quality Australian cotton yarns	DU1502	Xungai Wang	DeakinU	Jul-14	Jun-17
	PhD: Effects of cotton cellulose structure & interactions on dye uptake	CMSE1308	Genevieve Crowle	CSIRO	Jul-12	Dec-16
	PhD: High value bio-extractives and bioethanol from cotton gin trash	DAN1504	Shane McIntosh	NSW DPI	Jul-14	Aug-17
	PhD: Improving length, strength and fineness of cotton fibre	DU1401	Rangam Rajkhowa	DeakinU	Jan-13	Dec-16
	PhD: Low wax Australian cotton - reducing the scouring requirements of cotton fabric	CMSE1403	Katherine Birrer	CSIRO	Apr-14	Mar-17
	Smart cotton/carbon fabrics for electromagnetic interference shielding	DU1602	Jin Zhang	DeakinU	Jul-15	Jun-18
3. Competitive futures	Developing renewable fine chemicals from cotton biomass	SRA1601	William Doherty	QUT	Jul-15	Jun-18
Program four: People						
1. Workforce capacity	ABARES Science and Innovation Award sponsorship		Various	ABARES	Jul-16	Jun-17
	Aboriginal Employment Strategy student scholarships	CRDC1613	Natalie Tighe	AES Ltd	Dec-14	Nov-16
	Aboriginal Employment Strategy student scholarships - Montana Jones	AES1601	Montana Jones	Merced Farming	Feb-16	Dec-17
	Co-investment in PIEF Membership for the cotton industry	CA1503	Adam Kay	CA/PIEF	Jul-16	Jun-17
	Cotton industry leadership development: Australian Rural Leadership Program		Various	ARLF	Jul-16	Jun-17
	CRDC Summer and Honours Scholarships		Various	CRDC	Jul-16	Jun-17
	CRDC Summer and Honours Scholarships: Determining emission factors for cotton residue-induced N ₂ O emissions using 15N isotope tracers	QUT1603	Stephen Leo	QUT	Feb-16	Nov-16
	CRDC Summer and Honours Scholarships: Efficacy of robotic methods for the detection and treatment of herbicide resistance cotton weeds	QUT1602	Simon Thomas	QUT	Feb-16	Nov-16
	CRDC Summer and Honours Scholarships: Identifying and testing commercial root endophytes in cotton	QUT1601	Nathaniel Crane	QUT	Feb-16	Nov-16
	Developing education capacity for the Australian cotton industry (CottonInfo technical specialist)	CSE1602	Trudy Staines	CSIRO	Jul-15	Jun-18
	Horizon Scholarships	RIRDC1602	Various	RIRDC	Apr-13	Jun-17
	Horizon Scholarships 2013 - Jessica Kirkpatrick	RIRDC1302	Jessica Kirkpatrick	RIRDC	Apr-13	Dec-16
	Horizon Scholarships 2013 - Paul Sanderson	RIRDC1304	Paul Sanderson	RIRDC	Apr-13	Dec-16
	Horizon Scholarships 2014 - Alana Martin	RIRDC1404	Alana Martin	RIRDC	Mar-14	Dec-17
	Horizon Scholarships 2014 - Felicity Taylor	RIRDC1401	Felicity Taylor	RIRDC	Mar-14	Dec-17
	Horizon Scholarships 2014 - Grace Scott	RIRDC1402	Grace Scott	RIRDC	Mar-14	Dec-17
	Horizon Scholarships 2014 - Michael Wellington	RIRDC1405	Michael Wellington	RIRDC	Mar-14	Dec-17
	Horizon Scholarships 2014 - Sam Johnston	RIRDC1403	Sam Johnston	RIRDC	Mar-14	Dec-17
	Horizon scholarships 2015 - Camilla a'Beckett	RIRDC1504	Camilla a'Beckett	RIRDC	Jul-15	Jun-17
	Horizon scholarships 2015 - Scott Nevison	RIRDC1503	Scott Nevison	RIRDC	Jul-15	Jun-17
	Nuffield Australia Farming Scholarships		Various	Nuffield Australia	Jul-16	Jun-17
	People in farming - employment starter kit (EKSi)	DA1502	Shane Hellwege	Dairy Australia	Jul-14	Jun-17
	Peter Cullen Trust scholarship		Various	Peter Cullen Trust	Jul-16	Jun-17
	PhD: Career motivational factors of cotton growers' (attraction and retention)	USQ1401	Geraldine Wunsch	USQ	Jul-13	Dec-16
	PhD: Investigating cotton farm workers' experiences of job satisfaction using social cognitive career theory	USQ1403	Nicole McDonald	USQ	Jan-14	Jan-17
	Scholarship: Explore Leadership Development Capacity	CRDC1614	Eric Perez	FRDC	Sep-15	Sep-16
	Skills profile and labour supply structure on cotton farms	UNE1402	Bernice Kotey	UNE	Jul-13	Aug-17
	UNE Cotton Production Course	UNE1604	Brendan Griffiths	UNE	Jul-15	Jun-18
2. Networks	18th Australian Cotton Conference foundation sponsorship	CA1601	Stuart Armitage	CA	Jul-15	Sep-16
	AgVet collaboration		Rohan Rainbow	RIRDC	Jul-16	Jun-17
	CCRSPI			RIRDC	Jul-16	Jun-17
	CottonInfo on-farm trials		Warwick Waters	CRDC	Jul-16	Jun-17
	CRDC Grassroots Grants		Various	CGAs	Jul-16	Jun-17
	CRDC Grassroots Grants: Binnia Valley in-field trials to address local barriers to cotton growing and exposure to the cotton industry	CGA1605	Jon Welsh	Upper Namoi CGA	Oct-15	Jan-17

Program theme	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
	CRDC Grassroots Grants: Gwydir Valley dryland planting date row configuration trial	CGA1602	Ben Dawson	Gwydir Valley CGA	Jul-15	Dec-16
	CRDC Grassroots Grants: Upgrade to Darling Downs weather station network and chemical application days	CGA1606	Chris Barry	Darling Downs CGA	Jan-16	Sep-16
	Grower RD&E advisory panels - meeting travel, capacity building, Board Portal		Nicola Cottee	CA	Jul-16	Jun-17
	IREC field station upgrade (jointly funded with CSD)	IREC1501	Rob Houghton	IREC	Jul-14	Jun-17
	Plant Health Australia membership		TBA	PHA	Jul-16	Jun-17
	Plant Health Australia secretariat support		TBA	PHA	Jul-16	Jun-17
	Primary Industries Health and Safety Partnership	RIRDC1301	Simon Winter	Joint RIRDC Partnership	Aug-12	Jun-17
	RIRDC Rural Womens Award sponsorship		Allanards Williams	RIRDC	Jul-16	Jun-17
	Soils cross-sectoral strategy & National Soil RD&E Implementation Committee membership	DAFF1401	Mike Grundy	CSIRO	Jun-14	Jun-17
	Travel: Attend International Congress of Entomology, Florida	CSP1603	Lewis Wilson & Simone Heimoana	CSIRO	Jan-14	Oct-16
	Travel: Attend International Congress of Entomology, Florida	DAN1602	Robert Mensah	NSW DPI	Dec-15	Oct-16
3. Communication	CRDC 25th Anniversary publication	CRDC1625	Robbie Sefton	Sefton & Associates	May-16	Jul-16
	CRDC Annual Report		Ruth Redfern	CRDC	Jul-16	Jun-17
	Documenting the production of best practice Australian cotton through videos		Paul Grundy	QDAF	Jul-16	Jun-18
	Stimulating private sector extension in Australian agriculture to increase returns from R&D	DA1601	Ruth Nettle	Dairy Australia	Jul-15	Jun-18
Program five: Performance						
1. Best practice	'Science into best practice,' linking research with CottonInfo (CottonInfo technical specialist)	CSP1504	Sandra Williams	CSIRO	Jul-14	Jun-17
2. Monitoring and evaluation	Annual Cotton Grower Practices Surveys: 2014, 2015 & 2016	RRR1501	Ingrid Roth	Roth Rural	Jul-14	May-17
	Annual qualitative and quantitative surveys for the Australian cotton industry	CCA1601	Liz Todd	CCA	Jul-15	Jun-18
	Boyce Cotton Comparative Analysis		Phil Alchin	BCA	Jul-16	Jun-17
	Longitudinal Evaluation - Australian Rural Leadership Foundation's programs	RIR1602	Matt Linnegar	ARLF	Jun-16	Jun-17
	Measuring and reporting the value of capacity building on farms and in research	CRDC1701	Gordon Stone	QualData	Jul-16	Jun-19
3. Reviews	Impact assessment of selected clusters of projects	CRDC1623	Peter Chudleigh	Agtrans Research and Consulting	May-16	Sep-16

Key:

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences	GVIA	Gwydir Valley Irrigators Association
AES Ltd	Aboriginal Employment Strategy Ltd	ICAN	Independent Consultants Australia Network
ANU	Australian National University	IREC	Irrigation Research and Extension Committee
ARLF	Australian Rural Leadership Foundation	NCEA	National Centre for Engineering in Agriculture
ARLP	Australian Rural Leadership Program	NSW DPI	NSW Department of Primary Industries
BCA	Boyce Chartered Accountants	PHA	Plant Health Australia
CA	Cotton Australia	QAAFI	Queensland Alliance for Agricultural and Food Innovation
CA/PIEF	Cotton Australia/Primary Industries Education Foundation	QDAF	Queensland Department of Agriculture and Fisheries
CCA	Crop Consultants Australia	QUT	Queensland University of Technology
CGAs	Cotton Grower Associations	RIRDC	Rural Industries Research and Development Corporation
CRDC	Cotton Research and Development Corporation	SAC	Sustainable Apparel Coalition
CSD	Cotton Seed Distributors Ltd	SRA	Sugar Research Australia
CSIRO	Commonwealth Scientific and Industrial Research Organisation	UNE	University of New England
DeakinU	Deakin University	UNSW	University of New South Wales
DEDJTR	Victorian Department of Economic Development, Jobs, Transport, and Resources	UQ	University of Queensland
DNRM	Queensland Department of Natural Resources and Mines	USQ	University of Southern Queensland
FRDC	Fisheries Research and Development Corporation	USYD	University of Sydney
GRDC	Grains Research and Development Corporation	UTAS	University of Tasmania
		UWS	University of Western Sydney

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