

Spotlight.

ON COTTON R&D

Spring 2016

Soil under the
microscope

Building industry
resilience

Investigating
dryland systems



Australian Government

Cotton Research and
Development Corporation



Bruce Finney

In the Spotlight

It was wonderful to catch-up with so many of you at this year's Australian Cotton Conference.

As a major sponsor CRDC was proud to support the Conference Committee, Cotton Australia and ACSA deliver this major industry event. The impact of CRDC research investments on the productivity, sustainability and competitiveness of the industry was evident throughout. Similarly evident was the calibre of cotton researchers and the talented young people in whom we invest to become the next generation of industry, research and community leaders. After all "people are the business" to quote conference speaker Alex Malley of CPA Australia.

This season marks a new era for the Australian industry as Bollgard 3 becomes commercially available. Integral to the success of this new technology is the Resistance Management Plan and the technology and time required to produce it. In this edition we outline the process and highlight the role that good refuges play in keeping resistance at bay. This proactive risk management goes toward building resilience in our industry, which was highlighted in the recent release of the *Resilience assessment of the Australian cotton industry at multiple scales* commissioned by CRDC. Preparedness for issues and events that may affect our industry is integral at the farm and industry scale. This report (outlined on pages 8 and 9) gives us the tools to safeguard the industry we have so successfully built.

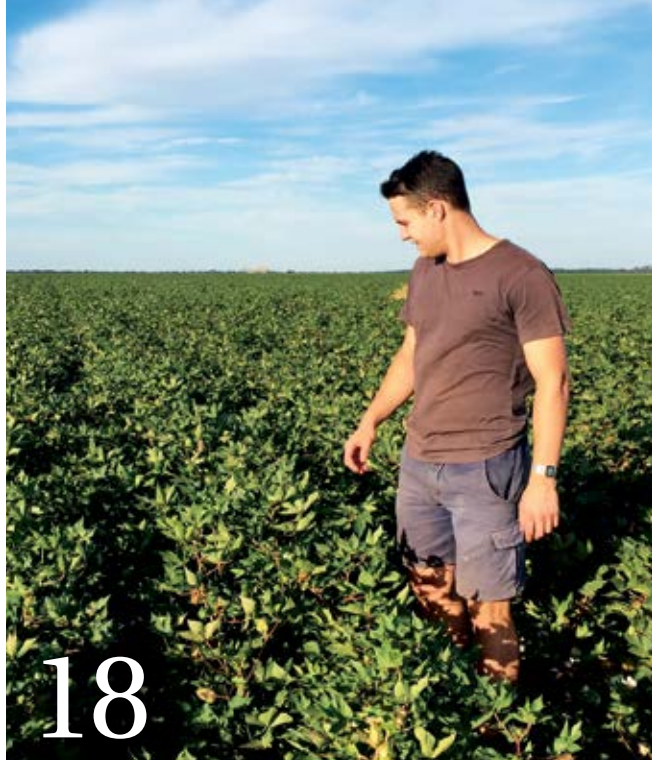
CRDC is always working to meet the research needs of industry. Strategy forums were held earlier this year to work through priorities for new investment in 2017-18. Taking account of the advice received from Cotton Australia R&D Advisory Panels CRDC has fast-tracked additional and new investments commencing this year to address concerns with spray drift, silverleaf whitefly control and Verticillium disease management. We have focused on priority research issues affecting two programs, farmers and industry, in this issue, and will cover customers and people in our December edition.

Soil and nutrition is also a focus in this Spring *Spotlight*. Dr Oliver Knox has brought together a summary of our soil asset based on CRDC's research to provide growers with knowledge to better manage the 'earth beneath our feet'. We also look at novel measures using satellite telemetry to measure nitrogen status in crops and how long-term CRDC research is tracking changes in salinity in the south. In a related article we look at research undertaken of floodplain soils and the role they have in deep drainage.

We are pleased to report on a new five-year project into dryland farming systems. This significant CRDC investment is focused on assisting growers to take advantage of the introduction of Bollgard 3 for cotton production within their farming systems.

With a convergence of the availability of new technology, wetter seasonal conditions and above average cotton prices the outlook for growers and the Australian cotton could not be brighter. On behalf of the team at CRDC I wish you a highly successful season ahead.

Bruce Finney
CRDC Executive Director



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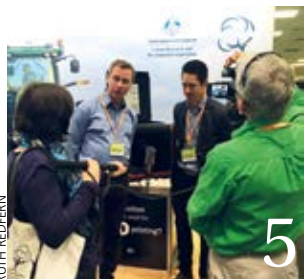
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Fast Facts



1,941

The number of delegates who attended the 18th Australian Cotton Conference – the largest attendance ever (Page 5)

11

The percentage of total green acres of cotton that was replanted or abandoned in 2015-16, spread across 34 percent of farms who responded to the CRDC Cotton Growing Practices Survey (Page 6)



5

Kilometres – the length of fungal hyphae (thread-like filaments that make up a multicellular fungus) found in a single gram of soil – along with 10 billion bacteria and thousands of protozoa! (Page 13)

2007

The year Japanese research scientists uncovered the El Niño Southern Oscillation “Modoki” phenomenon (Pages 34-35)



CRDC Directors on farm with growers

IRRIGATION automation and disease research were the focus of a farm tour for CRDC Directors near Wee Waa in August.

The tour, which coincided with the Board meeting at CRDC’s headquarters in Narrabri, involved CRDC’s Directors going on farm with grower Steve Carolan and manager Andrew Greste of “Waverley”, and grower Jono Phelps and manager Quentin Kelly of “North Nowley”.

The tour was designed to showcase some of the CRDC-supported RD&E in action and give Directors an opportunity to discuss issues affecting Namoi growers directly. Topics covered particularly focused on resource efficiencies and crop protection.

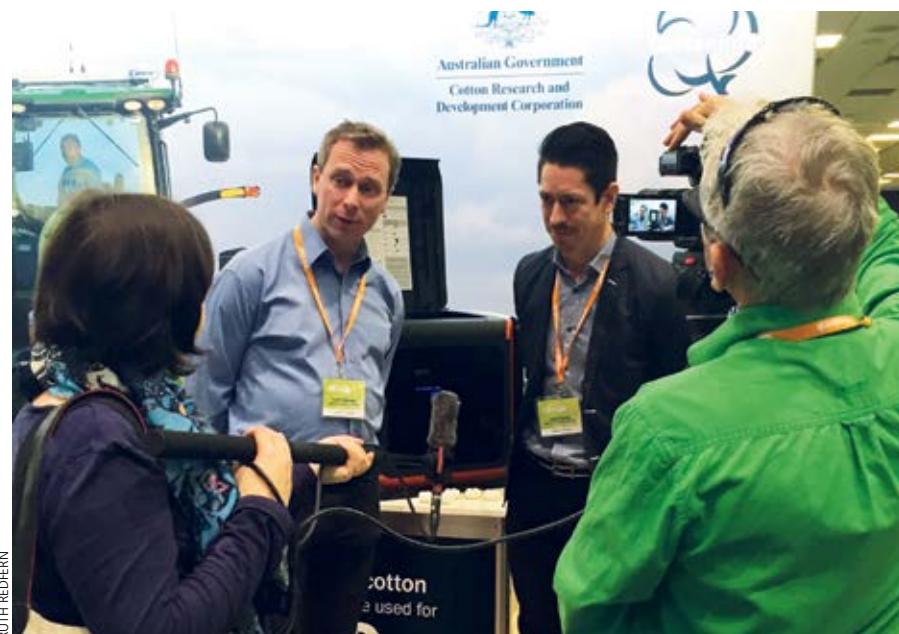
At “Waverley”, Steve and Andrew demonstrated their irrigation automation infrastructure (which featured in the *Spotlight* winter edition). Steve and Andrew first saw the automated configuration at the CRDC-supported CottonInfo Irrigation Technology Tour in 2015 at “Redmill” Moree, where CRDC and the National Centre for Engineering in Agriculture (NCEA) were conducting automation trials.

They were so impressed with the idea of automation they went home and began to work on converting some of their own fields and in turn hosted a field day with CottonInfo, CRDC and NCEA earlier this year to showcase their system.

At “North Nowley”, the focus turned to Verticillium wilt, and the CRDC-supported pathology diagnostic services, biosecurity preparedness and surveillance capacity. CRDC continues to invest in annual disease surveillance to record the presence or absence of diseases; and is working closely with researchers, CottonInfo and growers to better understand, diagnose and manage issues like Verticillium wilt on cotton farms.

Gold medal for conference

The 18th Australian Cotton Conference held on the Gold Coast in early August gave the industry reason to celebrate.



QUT researchers Dr Jared Donovan and Dr Rafael Gomez, who presented at this year's Cotton Conference on the project they undertook for CRDC, the cotton rapid customisation feasibility study project, investigating the usability of cotton for 3D printing.

"IN the spirit of the Olympics, this year's conference was a gold medallist," CRDC Communications Manager Ruth Redfern says.

"It was also a record breaker – with more than 1900 delegates, over 100 exhibitors and 151 speakers, of which more than half were supported by CRDC through our research, development and extension (RD&E) projects.

"These projects featured right across the agenda – from sessions on digital agriculture and alternative thinking to Bollgard 3 and herbicide resistance.

"CRDC is a proud foundation sponsor and it is very satisfying to hear such fantastic feedback from attendees and see the dissemination of such a huge amount research knowledge.

"It really is a great event to bring industry together in a relaxed yet vibrant, innovative and inspiring context."

CRDC featured a 3D printer at its stand in the Exhibition Hall, and posed the question "can cotton be used for 3D printing?" This generated much interest and highlighted CRDC's ambitious Cotton Future Projects and the possibility of using cotton in this way.

The conference is run by a dedicated committee chaired this year by Darling Downs grower Stuart Armitage, Cotton Australia and backed by Australian Cotton Shippers Association's Tracey Byrne-Morrison. Well known industry grower and advocate Fleur Anderson from Theodore is the incoming chair for 2018.

Asked to describe feedback from this year's record breaker, Stuart had one word – "fantastic".

"We received so many comments that this is the premier agricultural event in Australia in every aspect: from how it's run, to the speaker line up, exhibitors, overall vibe and positivity.

"We always hope to attract more people every conference to share and experience this, yet are still blown away every time we break attendance records and this year was no exception."

Presentations and photos are available through the conference website.

For more

w www.australiancottonconference.com.au

Cotton goes three dimensional

CRDC's Cotton Futures program seeks to transform the industry by supporting blue-sky research through innovative projects. The CRDC *Cotton Rapid Customisation Feasibility study*, conducted by QUT's Dr Jared Donovan and Dr Rafael Gomez, is one such project.

The study explored the feasibility of using cotton-derived materials for rapid customisation. 'Rapid customisation' is a way of creating physical products from digital design files through computer-controlled manufacturing. The most well-known is 3D printing.

The project sought to discover whether materials derived from cotton could be used for 3D printing, and if so, what the best combination of 3D printing and cotton derived materials would be. It found that there are many different ways that cotton-derived materials could be used, and sought to answer the question: 'why would cotton make a compelling choice over other materials?'

To address this, the researchers developed 'design visions' of products that could employ cotton-derived feedstocks in new and novel ways, and where there would be a clear advantage and market opportunity for cotton – like the on-site fabrication of cotton-based filtration products, or on the on-demand manufacturing of cotton bespoke furniture.

This project forms a vital first step in exploring rapid customisation – a rapidly growing industry – as an area of potential for the Australian cotton industry. It recognises that if we can find new and novel ways of using cotton then we can expand the market for cotton products, and allow for innovations in supply-chain and business models.

For more

w www.crdc.com.au/publications

Representing broader industry

It's the biggest night on the industry calendar and this year didn't disappoint as 1100 people came together to celebrate industry's high achievers at the 2016 Australian Cotton Industry Awards.

RECIPIENTS were announced at a dinner held at the Gold Coast Convention Centre at the conclusion of the Australian Cotton Conference on August 4.

The 2016 recipients are:

- **Monsanto Grower of the Year:** Connamara Partnership – Ian, Marilyn and Harry Carter, "Connamara", Pine Ridge, NSW.
- **AgriRisk High Achiever of the Year:** Commins Partnership – Tim and Roger Commins "Tiralee", Whitton, NSW.
- **Chris Lehmann Trust Young Achiever of the Year,** sponsored by Bayer CropScience: Rebecca Fing, Goondiwindi, Qld.
- **Cotton Seed Distributors Researcher of the Year:** Dr Guy Roth, Roth Rural, Narrabri, NSW.
- **IPF Service to Industry Award:** John Marshall, Toowoomba, QLD.

Cotton Australia CEO Adam Kay says the judges' jobs weren't any easier this year than previous awards, as the cotton



Recipients and sponsors of the 2016 Cotton Industry Awards: (at back) Tim Commins; Phil Armytage, CSD; Tony May, Monsanto; Sarah Wilson, Bayer; Paul and Laura Lehmann. At front are Dr Guy Roth; Roger Commins; Geoff Macintyre (for John Marshall); Deidre McCallum, AgriRisk; Rebecca Fing; Trent Cosh, IPF; and Ian and Marilyn Carter.

industry has so many worthy individuals and partnerships.

"It's a fantastic problem to have," Adam said.

"We had a substantial number of nominations this year, which is not surprising given the number of amazing people we are so proud to have in our industry.

"I know the judges found it quite hard to select recipients from amongst the finalists, all of whom have contributed greatly to our industry.

"The awards don't only celebrate and acknowledge the great work and personal commitment of the recipients and finalists, but also the commitment of everyone throughout the cotton supply chain.

"All of this year's recipients are fantastic ambassadors for the industry, and I heartily congratulate them all."

For more

w www.australiancottonawards.com

What are growers doing?

THE latest Cotton Growing Practices Survey has been released and can be sourced on the CRDC website.

The survey is commissioned annually by CRDC to gather information about farming practices, the adoption of research and opportunities to improve cotton research and development. The latest survey relates to both 2014-15 and the start of the 2015-16 season, which both had limited water in many regions.

Each survey includes core questions as well as several focus themes to investigate specific aspects of the farming system. The latest survey focused on strategies used to consider seasonal conditions in management, historical mining exploration wells and perceptions of cotton R&D.

Highlights of findings around the

2014-15 crop include some exceptionally high yields (average 12.8 bales/ha, with individual fields yielding up to 18 bales/ha). Respondents attributed these high yields to a mix of weather and management. Quality discounts were reported by 59 percent of irrigated crops, 58 percent of partially irrigated and 64 percent of dryland crops. Discounts were on average \$13/bale on irrigated cotton, \$26/bale on partially irrigated and \$19/bale on dryland cotton. Costs of production ranged from \$200/ha for dryland conventional cotton to \$5700/ha for irrigated cotton.

In terms of managing limited water



in 2015-16, both dryland and irrigated growers used a range of strategies, including planting configuration (skip-row in irrigation and double-skip in dryland), concentrating on more water efficient fields and planting later or earlier – or a combination of both.

Spotlight will highlight major findings of the surveys in coming editions, with the

full survey results now available on the CRDC website.

For more

w www.crdc.com.au/publications

Consult before you act



The must-have resource for every season is the *Cotton Pest Management Guide*, which is updated and published annually. Free with this edition of *Spotlight* and produced by CRDC and CottonInfo, this guide provides information regarding insect, mite and weed management in crop for the new season. Industry's researchers agree that this guide must be consulted before any decision is made to spray, as guidelines change annually, and new research is included relating to thresholds, preserving beneficials, herbicide resistance and products registered for use.

The guide can also be downloaded from:
www.crdc.com.au/publications/cotton-pest-management-guide

Cotton's first Workforce Development Strategy



CRDC and Cotton Australia have collaborated to deliver the industry's first Workforce Development Strategy. The strategy is focused on delivering workforce outcomes for growers on farm, and ultimately will ensure that the cotton industry is able to attract, retain and develop people that will drive industry competitiveness. It will provide a shared and focused plan to ensure investments in workforce target key priorities are well

coordinated and deliver maximum outcomes.

The strategy was a feature of the People Power session at the Australian Cotton Conference in August, with a joint presentation by CRDC and Cotton Australia. The strategy is available to download from www.crdc.com.au/publications

Take a look...

Are you ready for planting? If you are looking for tips to improve planter set-up for better establishment, head to the great on-line resource of short film clips available on the CottonInfo youtube site.

Well known industry researcher Paul Grundy has produced five clips focusing on planting and planter setup and maintenance which are very easy and interesting viewing. Paul's broad research and practical experience in cotton means he is able to tailor these clips perfectly for grower or consultant needs. Once you've checked out the planting clips, be sure to have a look at those relating to early season, integrated pest management, or the science behind refuges and the importance of maintaining them to the highest standard. Go to www.youtube.com/cottoninfoaustr to watch.

CottonInfo extension program continues



Cotton Conference 2016 marked four years of the CottonInfo extension program and saw the partnership extended to at least 2021. The joint venture partners CRDC, Cotton Australia and CSD formalised the continuation of CottonInfo with an official signing. Pictured are CSD Managing Director Peter Graham, Cotton Australia Chair Simon Corish, CSD Chair James Kahl, CRDC Chair Dr Mary Corbett, CRDC Executive

Director Bruce Finney and Cotton Australia CEO Adam Kay.



Milestone publication

2015 marked 25 years of CRDC, and CRDC has produced an anniversary publication to mark the occasion. In it, CRDC takes a look back at 25 years of delivering RD&E outcomes for the benefit of Australia's cotton growers, the cotton industry and the wider community.

The publication outlines the 25 major achievements in cotton RD&E over the past 25 years: 25 key areas in which the co-investment into RD&E by cotton growers and the Australian Government has significantly benefited the industry - like strong improvements in water use efficiency; efforts to improve environmental performance; contributions to building the capacity of the industry's most important resource, its people; and contribution to the industry's best management practices program - all examples where investment in RD&E has helped to deliver highly valuable outcomes.

The publication also features 25 key industry people who provide their thoughts on CRDC and the contribution of cotton RD&E. Download your copy today at www.crdc.com.au/publications/



Safeguarding your future

Agricultural production, including cotton production, is an increasingly complex business requiring continuous adaptation to changing circumstances.

ABOVE:

Launching the CRDC-commissioned *Resilience assessment of the Australian cotton industry at multiple scales* at the Australian Cotton Conference in August were authors Jeremy Cape, and Anne Currey, CRDC R&D Manager Jane Trindall, CRDC Executive Director Bruce Finney, reference panel members Fleur Anderson and Juanita Hamparsum and at front CRDC Chair Dr Mary Corbett and author Francesca Andreoni.

RESILIENCE thinking is an approach designed to understand a complex and changing operating environment and maintain capacity to manage future challenges. It is now being widely adopted globally to help communities, industries and governments alike deal with uncertain futures.

CRDC commissioned the *Resilience assessment of the Australian cotton industry at multiple scales* to better understand how to best adapt to change and identify critical threats and opportunities for the industry, and strategically target investment and resources. The resilience assessment is structured around the three scales of cotton production in Australia – the farm, the region and whole of industry. The report was launched at the Australian Cotton Conference in August.

What is resilience thinking?

Resilience thinking is a new way of looking at complex systems. The cotton industry is the first agricultural industry in Australia to apply this thinking. Fundamental to the process is that resilience thinking takes into consideration that a cotton production system is made up of many interacting elements with links and connections between them. A change in one element affects many others and if not managed can lead to unintended consequences.

“Resilience thinking tries to understand the relationships between the elements of a system and how they interact so it can be managed better,” said project leader Dr Francesca Andreoni.

“Resilience planning looks at the whole system and identifies the critical drivers of change and the potential shocks as a way of determining when it might reach a threshold beyond which a current production system is no longer possible.

“At the farm scale, the project has shown that the key drivers of change are price, climate variability and policy: they all affect the critical assets on farms, resulting in thresholds associated with water quality and quantity, soil health, profitability

Resilience – key concepts

- Resilience is defined as “the capacity of a system to absorb disturbance and re-organise so as to retain a similar structure, function, identity and feedbacks”.
- Complex systems, such as cotton farms, are subject to external and internal influences; some are slow drivers of change such as changing terms of trade, others are sudden shocks such as disease or pest outbreaks. Systems are based on assets which in the case of cotton farms are water, soil, capital, habitat, energy and infrastructure.
- Systems operate within certain boundaries, which if crossed can lead to the system operating in a different way. The points when systems cross boundaries are known as thresholds or tipping points. If a boundary is crossed the system is said to have changed state. As an example a cotton farm may not be able to produce cotton in a particular year because there is not enough water. The threshold would be the amount of water needed to produce a profitable cotton crop.

and proximity to native vegetation habitat.”

“This understanding led to the development of a number of potential strategies that growers could implement to maintain their production systems (which are fully outlined in the report).

“The best way for growers to identify strategies for their farm is to conduct a resilience assessment by watching the short video that was also produced for the project.”

Recommendations for elements such as water quality included investing in BMP, particularly for land management, to improve and maintain water quality. In terms of water quantity, potential strategies include investing in on-farm water use efficiency measures.

In terms of profitability, the report recommends auditing financial management capacity as a way of identifying weaknesses, strengths and where to make improvements; benchmarking financial performance by using comparative analysis or industry figures; or investigating alternative farm finance models that might allow better debt management.

For more

Download the Resilience assessment of the Australian cotton industry at multiple scales and watch the short explanatory clip at www.crdc.com.au/publications



MELANIE JENSON

Speaking from experience...

“Understanding how the entire farming system works (people, financial and natural capital), allows us to focus on the areas that will have the biggest impact on our farm productivity, sustainability and profitability when challenges are thrown at us,” says Breeza cotton farmer Juanita Hamparsum.

“We had four challenging years on our farm which knocked us for six.

“First it was a November flood wiping out 12 months of crops, the next year it was extensive 2-4D drift damage, followed by drought and severe sand blasting and finally we had a hail storm at the end of February wiping out 75 percent of the crop.

“Using resilience thinking and mapping the relationships between all the elements of our operation, we got rid of the ‘noise’ and focused on the actions we needed to take so we could keep our operation going and bounce back faster.

“Resilience planning helps you know how things interact and work together and proactively plan for the actions you need to take to keep things humming along.”

Setting research priorities

CRDC has brought forward some areas of research investment as a result of strategy forums held earlier this year.

To establish its research priorities for new investments for 2017-18, CRDC held a strategy forum in Brisbane in May. The forum involved 78 people including 55 growers and Cotton Australia representatives.

CRDC General Manager R&D Investment Ian Taylor says the meeting was very successful in terms of providing relevant feedback and establishing a clear set of priorities for each investment program (farmers, industry, customers, people and performance) as outlined in the 2013-18 R&D Strategic Plan. Under each program 'themes' and priority issues were ranked by participants.

"This forum provides us with the knowledge to prioritise research and set a clear direction for 2017-18, and allows us to identify any gaps or issues which may need immediate attention, which was certainly the case this year.

"It is pleasing for CRDC to see that research is already underway for some priorities outlined in the discussions.

"Furthermore, since this forum we have been able to bring some R&D forward to 2016-17 to address industry concerns, such as integrated disease management and spray drift."

Crop protection issues were ranked as high priority. The most recent Crop Consultants Australia (2015) survey identified herbicide resistance, silverleaf whitefly and diseases including Verticillium wilt as the top crop protection issues, and this was also reflected at the forum. These issues come under the Farmers and Industry programs, which we will focus on in this edition and are overseen by CRDC R&D Manager Susan Maas. The Customers and People Programs will be the focus in the Summer *Spotlight* magazine.

Program: Farmers
Theme: Successful crop protection

Verticillium wilt

Verticillium wilt was the highest ranked individual issue for the forum, with disease issues such as black root rot and sclerotinia also identified as clear regional challenges. It was identified that there is an opportunity to look for innovative product solutions that can reduce the impact of diseases for the cotton industry.

The forum also identified the need to identify strategies that maximise yield and minimise disease and understand how current management for high yielding crops may be affecting Verticillium wilt severity and incidence. For example: is root architecture from irrigation timing/frequency or row configuration linked to disease?

"While a breeding solution will be a key part of the holistic integrated disease management (IDM) strategy, CRDC will need to focus on the other elements of that IDM strategy to ensure the industry remains viable," Susan says.

"While the focus of the day was on 2017-18 investment, CRDC have responded to this urgent need and are investigating the potential for additional investment into these issues to commence in 2016-17."



Silverleaf whitefly

Silverleaf whitefly (SLW) continue to be a management challenge. SLW costs the industry in terms of management and potentially in cotton quality. If uncontrolled, Australia risks its reputation for delivering high quality cotton. Current management relies heavily on a limited number of insecticides, and resistance is an emerging issue.

The forum identified an opportunity to look at novel SLW management as well as alternative early season options. Management strategies to minimise impact and thresholds are currently the focus of new work in existing projects.

CSIRO's Dr Lewis Wilson has been conducting SLW research over his last three projects, including understanding factors in honeydew breakdown, beneficials, hosts and working with QLD DAF's Dr Richard Sequeira, to test the relevance of the current threshold matrix to Central Queensland regions.

A scientific exchange has been supported to bring Dr Steven Naranjo (USDA ARS, Phoenix) to Narrabri in December 2016. A workshop will be organised involving key researchers, extension and consultants to tease out the SLW issue and develop improved management options based on existing data. This will be followed with IPM as a key focus for the CottonInfo tour in late 2016 / early 2017 where consideration of drivers for application will be discussed, for example mirid sprays.



Weeds

Weeds and herbicide resistance were identified as key priorities for both the Successful Crop Protection theme and the Respected Stewardship theme. The incidence of glyphosate resistance in the Australian farming system continues to increase with glyphosate resistance now confirmed in 12 species, nine of which occur widely in cotton farming systems.

“While focused on increasing industry capacity to manage weeds, the recent industry weeds workshops have also identified that there are a number of research and development opportunities for the industry, many of which were also discussed at the strategy forum,” Susan says.

“It was also identified that there would be benefit in taking a cross-commodity approach to weeds.”

Weeds issues identified included:

- Investigating new tactics for weed control
- Better use of current tactics and support on how to integrate (Updating the Herbicide Resistance Management Strategy, selection risk)
- Extension and understanding barriers to adoption
- Management of weeds across the whole farming complex (non-field areas such as irrigation infrastructure and field edges) as well as other crops
- Ecology and management of emerging weeds (eg pigweed)
- Monitoring of herbicide resistance
- Ratoon management, particularly with reduced pupae busting was identified as a gap.



Spray drift

In addition to weeds and herbicide resistance, spray drift and Bt stewardship were identified as priority issues at the strategy forum. Biosecurity preparedness and protecting bees were also identified as industry issues.

Spray drift impacted a number of cotton growing regions and caused significant damage to many cotton crops for the 2015-16 season. Whole chain education, understanding about nozzle types, drift reduction technologies and weather station infrastructure and understanding on inversions were identified as opportunities to address spray drift. As a priority issue, CRDC are looking to bring forward investment into prediction of surface temperature inversions to the 2016-17 season.

Bt technology

Bt technologies are key to the integrated pest management platform for the industry and stewardship of these technologies is critical for the industry. The forum identified the importance of being able to define and quantify the contribution of unstructured refuge, trap cropping in Central Queensland, molecular tools to test for resistance and the need to understand Bt resistance as a biosecurity risk as gaps. It was also identified that the importance of having quality refuges was a key extension priority.



For more

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CRDC R&D Investments 2016-17

w www.crdc.com.au/publications/crdc-rd-investments

New horizons for CRDC scholar and farmer

Ten young Australians with a love of agriculture and the capacity to be future leaders have each been awarded a RIRDC Horizon Scholarship for 2016 – including CRDC-funded scholar, Sam Knight.

SAM is from a family cotton farm at Wee Waa, and is studying a Bachelor of Agriculture and Business at UNE. After getting more involved on the farm during high school, he discovered a passion for cotton growing, which has set his career path. Sam is focused on a career in the cotton industry, with an aim to not just make an impact on his own farm, but more broadly on industry.

“One of the biggest things I love is how the industry is always changing – you look back on cotton farming 10 years ago compared to today and the machinery and practices are completely different. It’s really exciting to imagine what’s going to happen in the future and it’s something I really want to be a part of,” Sam said.

“The biggest benefits of the scholarship are the opportunities, knowledge and contacts you can access. You meet a lot of different people from different businesses, different government departments, farmers growing different crops – it is great engaging with leaders of agriculture and being involved with everything they have to offer.

“I want to get involved with the farmers throughout our region with

“The Horizon Scholarship program was developed to help address the shortage of trained professionals entering primary industries and to promote the diverse career pathways agriculture offers”.



MELANIE JENSON

CRDC supported its Horizon scholars to attend the Australian Cotton Conference in August. At back with CRDC Executive Director Bruce Finney are Felicity Taylor (NSW), Alana Martin (WA), Grace Scott (NSW), Jessica Kirkpatrick (Vic), Alana Johnson (NSW), Emily Miller (WA) and at front Sam Johnston (QLD), Sam Knight (NSW), Scott Nevison (NSW) and Michael Wellington (NSW) with CRDC Manager R&D Investment Ian Taylor. Absent were Camilla a’Beckett (NSW) and Paul Sanderson (Vic).

research and development, trials and even the grower associations. I do firmly believe that through research we can continue to increase yield and profits while reducing cost and not degrading the land,” he said.

CRDC remains a strong supporter of the Horizon program, recognising that people are cotton’s most valuable resource.

“The next generation bring with them new passion, drive and enthusiasm, as well as a wealth of new ideas and we want to do all we can as an industry to support all entrants into the sector, be they farm workers, managers or owners; agribusiness professionals; or future researchers,” said CRDC Executive Director Bruce Finney.

“From our support of the Horizon scholarship, we hope to develop a network of skilled future industry leaders and industry advocates, who go on to become

champions for the great work the cotton industry is doing: not just in developing its human resources, but in being important social, economic and environmental contributors.”

The Horizon Scholarship is for young people passionate about agriculture, with a keen interest in the future of the industry, and who are ready to expand their networks and learn new skills. The scholarship supports undergraduates studying at university by providing a \$5000 bursary per year for the duration of their university degree, plus mentoring, professional development workshops and industry placements.

For more

w www.rirdc.gov.au/research-programs/rural-people-issues/horizon-scholarship

IMAGE: MELANIE JENSON
Research shows that protecting soil health and the plethora of living organisms within it can be achieved with the use of cover crops.

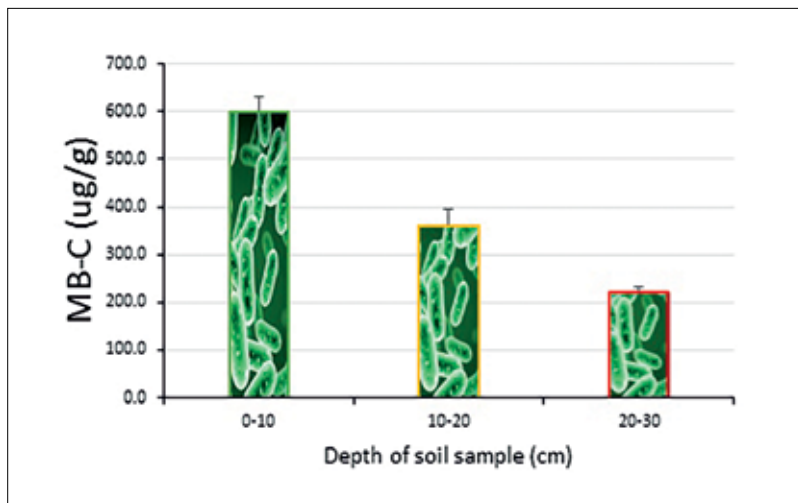
Looking below the surface What it means for you

In this feature article, soil scientist Dr Oliver Knox of the University of New England takes us below the surface using research supported by CRDC to help understand our most valuable asset.

Recently there have been many questions from growers and consultants at industry trial events and field days relating not so much specifically to cotton, but to the biology in the soil.

These questions have ranged in topic from 'how do I increase my soil biology?', 'what benefits does it deliver?' right through to 'how do I best control this pathogen?' and all sorts of issues in between. The reason for the breadth of questions is that soil biology is incredibly diverse both in species and types of organisms present. However, the biggest challenge is that soil biology is incredibly difficult to manage largely because it is incredibly difficult to see.

In this article we are highlighting this diversity and outlining some of the latest findings relating to soil



Changes in microbial biomass from different depths of soil samples taken under a cotton rotation at ACRI (Data: Dr Vadakattu Gupta).

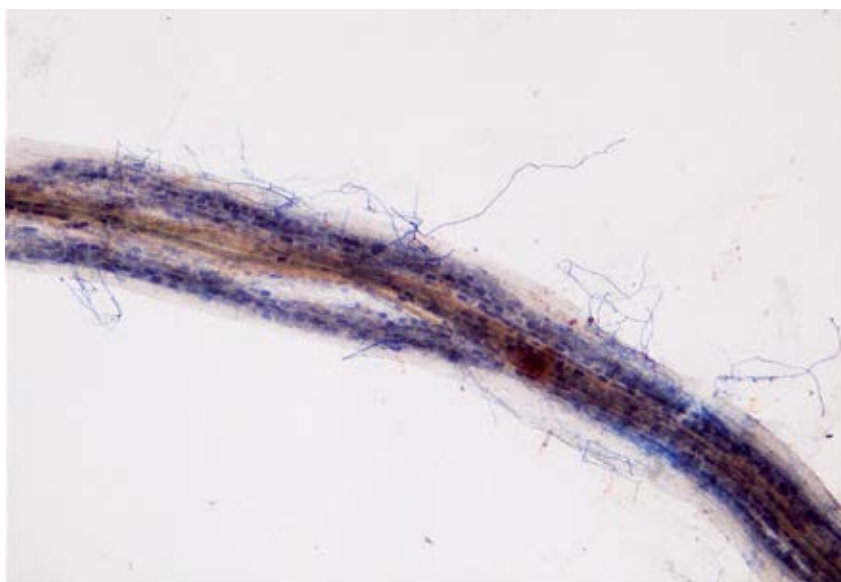
biology. This is by no means a complete coverage of all the CRDC and other work being undertaken, but if you are interested in any of these areas then get in touch with the researchers or ask your local CottonInfo regional extension officer if they can help organise an event in your area to address specific issues.

Tonnes of activity

What we often don't realise is that the soil under our feet, crops and machinery is full of life. A single gram of soil can contain 10 billion bacteria, five kilometres of fungal hyphae, thousands of protozoa, hundreds of nematodes and is home to dozens of insects, such as spring tails, beetles and spiders.

This huge abundance of life is very hard to comprehend for many, but CSIRO's Dr Vadakattu Gupta, has been looking at this diversity in cotton soils. Gupta says there can be as much as a tonne of microbes in the top 10 centimetres per hectare of a cotton field and when you consider the size of

A heavily mycorrhizal colonised cotton root recovered from a non-sodic soil. (Photo courtesy Samieh Eskandari)



most fields, that's a lot of microbes! We generally express this as microgram (μg) of microbes/g of soil and under cotton the research has typically found between 300 to 800 $\mu\text{g/g}$, but the average is nearer to 400 $\mu\text{g/g}$.

"Typically under cotton-cotton rotations the microbial biomass ranges from 300 to 500 $\mu\text{g/g}$ (~440 kg/ha), but when the system becomes more diverse, by say moving to a vetch-cotton-faba bean rotation, the microbes increase to 700 to 800 $\mu\text{g/g}$ (~850 kg/ha)," he says.

This improvement in biomass under more diverse systems continues with depth, but the changes don't stop there.

"If we compare cropped fields with native sites we see not only an increase in the microbial biomass, but also a change in the species of fungi present and the fungi to bacterial ratio increases from roughly 1:1 under monocultures to 3:1 in the more diverse systems – so more diversity more often in our systems is good for the soil microbiology."

Quiet achievers

Most of the time this life goes unrecognised and unrewarded for the role it plays in keeping our soils fertile. This fertility comes from the soil biology's ability to decompose old plant and animal matter and to contribute to the mineral turn over in the soils.

Dr Francois Visser at the University of Queensland is currently looking at the potential for the soil biology to provide nitrogen from mineralisation to our crops. François' current research has shown that the level of nitrogen (N) being mineralised by the soil biology is potentially large: up to 300 kilograms of N per hectare in the top 15 centimetres over the growing season under ideal conditions. So what does this mean for our production systems?

"The contribution of the soil biology in the provision of nitrogen to cotton is probably being under-rated by many, but we've still a way to go in developing our understanding of this process in vertosols," Francois says.

While the role of soil biology in turning over nutrients is obviously important, we must also remember that sometimes the ability of a plant to access these nutrients is also enhanced or assisted by other soil microorganisms. One of the best examples of this is the improvement in accumulation of phosphorus and zinc by plants that form mycorrhizal symbiosis with special fungi. Samieh Eskandari is currently undertaking a PhD at UNE looking at the relationship between cotton and mycorrhizae and her results tell an interesting story.

My oh mycorrhizae

"Cotton is not an obligatory mycorrhizal plant (it doesn't have to form symbiosis with mycorrhizae to survive or produce seed), but there is definitely benefit to early season development when the cotton roots are colonised," Samieh says.

"The ability of cotton to form these important symbiosis appears to be extremely restricted in moderately and highly sodic soils (exchangeable sodium/ESP great than 10), which exist across much of the industry.

"In these sodic soils the colonisation of cotton appears to occur due to live hyphae rather than from spore germination, so the importance of having live roots in the system and avoiding bare ground or long fallows becomes important if there is to be any benefit from this relationship.

"Mycorrhizal association with cotton in non and low-sodic soils (ESP<10) does not appear to be affected, however, keeping live roots in these systems increases the mycorrhizal colonisation and associated early growth of cotton plants grown in these soils as well."

Managing disease pathogens in soil

Of course early season establishment is important in yield determination and during this early crop development some of the less favourable soil biological organisms come into play. Seedling disease like damping off (*Rhizoctonia solani*), soft rot (*Pythium ultimum*), and black root rot (*Thielaviopsis basicola*) all affect how plant stands establish.

To get the low-down on these diseases we turn to NSW DPI Pathologist Dr Karen Kirkby for an update on dealing with these pathogens.

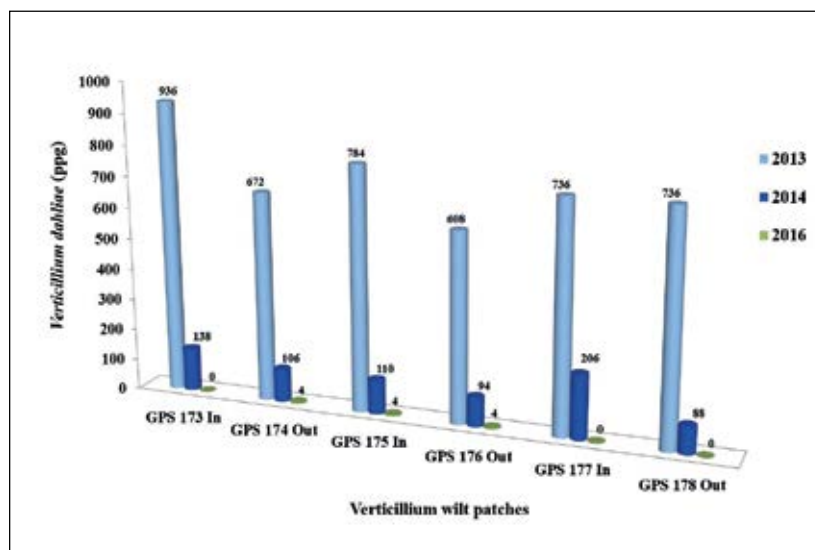
"Precision farming practices place the seed directly over the top of pathogens in the soil from previous crops," she says.

"It is important to provide the best start to emerging and young seedlings by choosing the relevant seed dressing, good bed preparation, planting when soil temperatures are rising, into moisture in preference to watering up and managing nutrients.

"The Bollgard 3 window might allow earlier planting, but soil temperatures will remain critical especially if your fields have a history of high seedling mortality or black root rot issues.

"Symptoms of Verticillium and Fusarium wilt can be obvious in the cotton canopy, but they are a result of soil-borne organisms."

Karen reminds us that: "years of research have gone into delivering the integrated disease management (IDM) practices for each of the major diseases of cotton.



"There is no one solution to minimising the risk of disease, so employing as many tactics as each grower can decreases the risk of yield losses associated with disease.

"Knowing what wilt you have is important as this will determine what variety is best to plant, as indicated by V and F rank. It will also dictate how to manage stubble.

"If Verticillium is the main issue then incorporate stubble as soon after harvest as possible. On the other hand, if Fusarium wilt is the major disease then retain stubble on the surface for as long as possible.

"Rotating with non-host crops has been shown to reduce inoculum levels over time (Figure 1)."

Prevent spreading disease

It is important to control volunteer and ratoon cotton as well as weeds as these can serve as hosts for the pathogens that cause disease in cotton. Currently, there are no eradication options for many of these pathogens. They have specialised survival structures that enable them to survive for very long periods in the soil. Pathogens are easily moved around, which highlights the importance of the Come Clean. Go Clean strategy.

Karen says the isolations of the pathogens that cause Verticillium and Fusarium wilt from plants collected from new farms and new regions remain a concern. The introduction of these pathogens in most cases can be traced back to the use of contractors and second hand equipment.

Dr Linda Smith of QLD DAF heads the cotton industry's Queensland pathology team and says looking beyond our borders there is further evidence for why we should all be ensuring that we adhere to Come Clean. Go Clean.

Figure 1. Results from a field where six locations were tested from within severe Verticillium patches and outside severe patches. Reduced Verticillium inoculum, referred to as propagules per gram (ppg), following a cotton crop in 2011-2012 with a series of wheat, sorghum fallow rotations. Inoculum levels reduced from an average of 745 ppg in 2013 to 124 ppg in 2014 and two ppg in 2016 in soil from six GPS locations where severe patches of Verticillium wilt were recorded in the 2011-2012 cotton season (Data Karen Kirkby/Peter Lonergan).

> continued on page 16

Beware unwanted passengers

"The reniform nematode spread across the US state of Alabama so rapidly, primarily due to movement on vehicles, that almost half of the cotton fields in the state were not only affected, but experienced economic losses within 20 years of the problem first being identified," she warns.

"We now know that we have the reniform nematode in cotton producing areas in Australia and a similar movement would be catastrophic.

"Current lack of resistant germplasm and the loss of nematicides, such as Temik, mean that control options are limited to crop rotations, but these will not remove the nematode, only manage it, and as yet we don't know how it might behave across all the environments where we grow cotton in Australia.

"Keeping it out of your soils is the best defence at present."

Soil is our earth

So the biology in our soils is incredibly important in facilitating our ability to farm both from a beneficial and deleterious stand point and for all life on Earth in general. Improved biology adds resilience to our farming system, improves nutrient turnover and supply and reduces environmental losses – so we get more of what we put into the system into the plant and can help with disease suppression.

This is all good news, but what can we do at a farm level to improve our soil biology? Gupta has some ideas on this. He says plants help to feed the soil biology so increasing ground cover with cover crops and increasing the diversity of crops in the rotation are both ways to improve the soil biology.

Other methods include improving residue returns



Stunted cotton in a reniform nematode infected field in Theodore (top), a cotton root showing egg masses (bottom left) and an excised female nematode (bottom right) . (Images courtesy Linda Smith)

"Keeping it out of your soils is the best defence at present."

or using regular applications of organic manures to increase biologically available carbon inputs, which also feed the biology, the latter being the current focus of work being undertaken by Dr Wendy Quayle from Deakin University in the Griffith area.

Surveying the situation

As an industry we gather a lot of information about our soils. CRDC funded disease survey work captures a lot of information on the major soil pathogens across the industry, but have you considered what soil biological information might be available from other sources?

As an industry we also capture a lot of practice information in both the CRDC Grower Practices Survey and Crop Consultants Australia (CCA) Survey. Surveys can tell us a lot about how an industry is performing, but could we do better?

UNE researcher Dr Lisa Lobry de Bruyn shared her insights with us.

"As an industry we'd like to understand what our growers are doing with the soil information they have collected, either by themselves or with a third party," Linda says.

"We often hear about threats to our soil resource, but episodically, with issues waxing and waning in the media.

"More often than not a loss of soil condition, such as loss of carbon or changes in soil pH, occurs slowly and goes unnoticed unless we are regularly and systematically testing soils.

"Another matter is that our soil tests contain a wealth of information and growers may only use a small portion of that.

"So the reality of our understanding on soil health in cotton systems is very sketchy, with a strong emphasis on the chemical side of things, but not so much on how well the soil is structured, or how biologically active it is.

"This lack of information means the soil's potential ability to hold onto nutrients and water, rather than letting them leach or run-off is poorly appreciated."

The recent CRDC grower survey indicated that roughly one third of growers tested some fields every season on irrigated cotton, but equally another 22 percent are soil testing less frequently (two to five years in every field), and 15 percent either when they have a problem or not at all."

To Lisa this highlights that “the range of grower practice is diverse with a continuum in knowledge from possibly well informed to little idea of the changes occurring in soil health on their farm.

“With soil being essential to all of our cropping systems and biology being integral to the structure and function of these soils then the challenge would appear to be that we need to pay more attention to how our soils are changing over time and start to manage them better.”

Incorporating the results

A lot of the beneficial soil biological organisms are advantaged by soils that support actively growing plants, so avoiding bare fallows is a good way to improve the amount of soil biology in your systems.

Of course some of our fields have issues with less favourable soil biological organisms, which we know better as pathogens. In many cases we have knowledge on how to reduce the incidence and impact of these organisms, but we can rarely eradicate them and so avoiding their spread becomes paramount. Come Clean. Go Clean then becomes our best defence.

In the meantime, the next time you are standing in the field or grab a handful of earth, just spare a thought for the billions of life forms under your feet or in your hand. Be thankful that so many of them do a wonderful job in giving life to your soils and just perhaps think about how you could help them.





Less saline in the south

Mapping the changing soils in the Hillston district of Southern NSW over the last decade has seen a drop in soil salinity on cotton farms.

Ten years ago, the cotton industry in the southern growing region of Hillston was considered relatively new. Today, it is one of the fastest growing and progressive regions in the industry. CRDC has been directing research into this region to gain a clearer picture of and better understand the needs of growers to help them continue to expand and manage crops.

CRDC supported an extensive soil survey in the topsoil and deep into the subsoil around Hillston in 2002 to assess the initial impacts of cotton production on soil condition. Almost every cotton farm around Hillston was surveyed, with 115 geo-referenced soil cores extracted and a suite of soil properties analysed (See *Spotlight* December 2014).

University of Sydney PhD student Patrick Filippi repeated these soil surveys last year (2015) under a further CRDC project. Many of the original sites were resampled for the same soil properties and to the same depths, with 160 soil cores taken. Soil carbon, total nitrogen, pH, electrical conductivity (EC), cation exchange capacity (CEC) and exchangeable sodium percentage (ESP) were some of the soil properties of

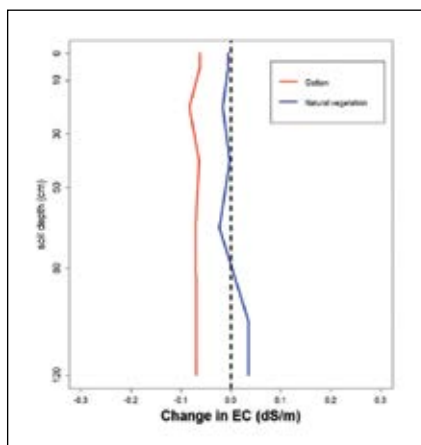


Figure 1 – Mean change in EC (ds/m) of soils from cotton farms, and natural vegetation to the depth of 1.2 m

focus in this study.

“One particularly interesting result was the drop in EC (a measure of soluble salts or salinity) in soils,” Patrick said.

“The original survey highlighted cotton farms typically had double the soil EC level compared to areas under natural vegetation, suggesting that irrigated cotton production increased soil salinity levels initially.

“However, when we looked at sites that had been sampled in both 2002 and 2015 we saw that there was essentially no change in EC under natural vegetation, but consistent decreases in EC in soil under cotton production (Figure 1).”

Patrick says the lack of change in EC under natural vegetation was expected, as it is safe to assume these soils are in equilibrium and lack of disturbance of the

soil would provide no driving force to cause changes. In contrast, he says, decreases in soil salinity levels of cotton sites is likely linked to the volume and quality of irrigation water applied, and possibly the greater availability of higher quality river water from 2010-12 helping flush soluble salts from the upper part of the soil profile.

“Hillston underwent significant fluctuations in weather, climate and land use/management practices since the last survey,” Patrick said, “Drought gripped the area from 2002-2009 and many farms heavily reduced or ceased cotton production all together, and caused a greater reliance on ground water for those with access to it.

“This changed abruptly in 2010, with three consecutive years of more than double the average rainfall through to 2012 and most farms able to enter back into cotton production.”

The researcher says while most soils at Hillston are not saline enough to significantly impact cotton production, soil sodicity is a much more limiting factor in the southern cotton-growing regions.

“Due to the connection between these two soil attributes, we will also be testing soil sodicity levels and it will be interesting to see the effect cotton growing has had on these levels,” he said.

Spotlight will report of these findings in future editions.

For more

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Monitoring crop N status

Deakin University's Centre for Regional and Rural Futures (CeRRF) in Griffith, NSW, has been investigating the potential of new technology for tracking deficiencies in cotton N status and predicting yield.

Results from the CRDC-supported study led by Wendy Quayle have shown that the Normalised Different Red-edge Index (NDRE) has good potential for tracking nitrogen (N) status in cotton, and seems to be an earlier predictor of yield than the commonly used NDVI (Normalised Difference Vegetation Index).

"Farmers and consultants may be able to use crop NDRE taken at early stages of growth to correct nutrition deficiencies in order to optimise yield over the farm," the researchers told *Spotlight*.

"Further research, including gathering more frequent NDRE images, defining new indices that are more sensitive to early season cotton leaf N status and concurrent in-field measurements will provide further insight into the use of NDRE for estimating crop N status in cotton."

NDVI and NDRE indexes

The most common and well-known index for vegetation monitoring is the NDVI. NDVI is a non-specific index that is sensitive to variations in biomass. Plants that have been suffering any biotic or abiotic stress, which



Dr John Hornbuckle collecting multi-spectral images at Whitton, NSW.

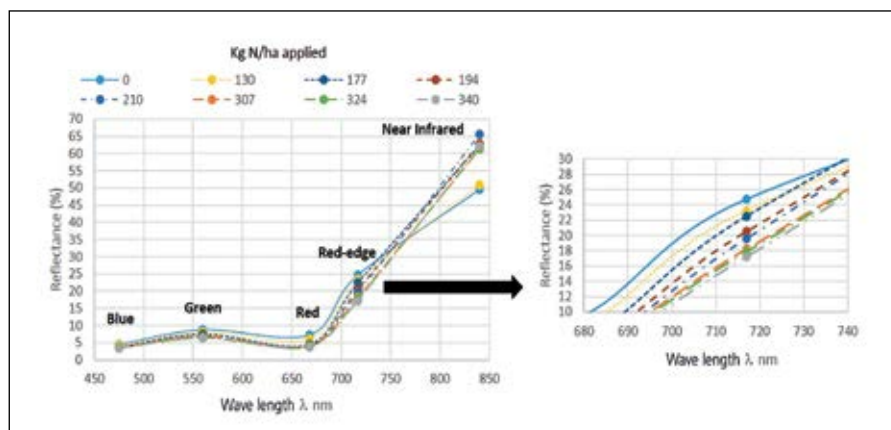


Figure 1. Canopy reflectance spectra, obtained from a Micasense Rededge camera, for the eight N rate treatments (0, 130, 177, 194, 210, 307, 324 and 340 kg/ha) applied in the cotton experiment. Centre wavelengths of the five bands are indicated with a filled circle. Note the higher differences between treatments in the red-edge region of the spectrum, with higher N rates showing lower reflectance.

Fast facts

- NDRE assessment can provide information regarding the crop nitrogen status in cotton.
- NDRE seems to be an earlier predictor of yield than NDVI.
- Satellite and drone platforms can be used to monitor NDRE in large areas at low cost.

is limiting plant growth, will have lower NDVI than plants from the same crop with no such limiting conditions. Although NDVI correlates strongly with N status in wheat, this relationship for the cotton canopy has been observed to be weak.

NDRE however uses different spectrums and therefore may provide a better assessment of cotton crop N status than NDVI. For instance the 'RE' region in Figure 1 shows the sensitivity of RE to a range of N

fertiliser application rates for cotton plants.

Monitoring by remote sensing

Assessment of crop N status throughout the season provides useful information to adjust fertiliser management to meet actual crop requirements.

Crop N status is usually evaluated in the field using leaf-based sensors to measure chlorophyll content (which is strongly related to N content), or by sampling a

representative number of plants across the farm for chemical analysis. These techniques are time-consuming and can be expensive. New techniques that enable a rapid assessment of large areas and carried out in different phenological stages of the crop growth will be of great benefit to growers and consultants.

“Using drones in combination with lightweight multi-spectral or thermal cameras to monitor crops’ performance is one of their applications,” Wendy Quayle said.

“Satellite imagery is also available to monitor crops remotely at no cost. New satellites in orbit include high-resolution optical sensors with spatial resolution down to 10 metres , and a revisit frequency of down to five days. For example, the Sentinel-2 satellites which are available through the IrriSAT website <https://irrisat-cloud.appspot.com/#>.

“Information obtained from these optical sensors can be used to calculate vegetation indexes, which are useful for monitoring canopy growth and for diagnosis of biotic or abiotic stresses such as water stress or nutrient deficiencies.”

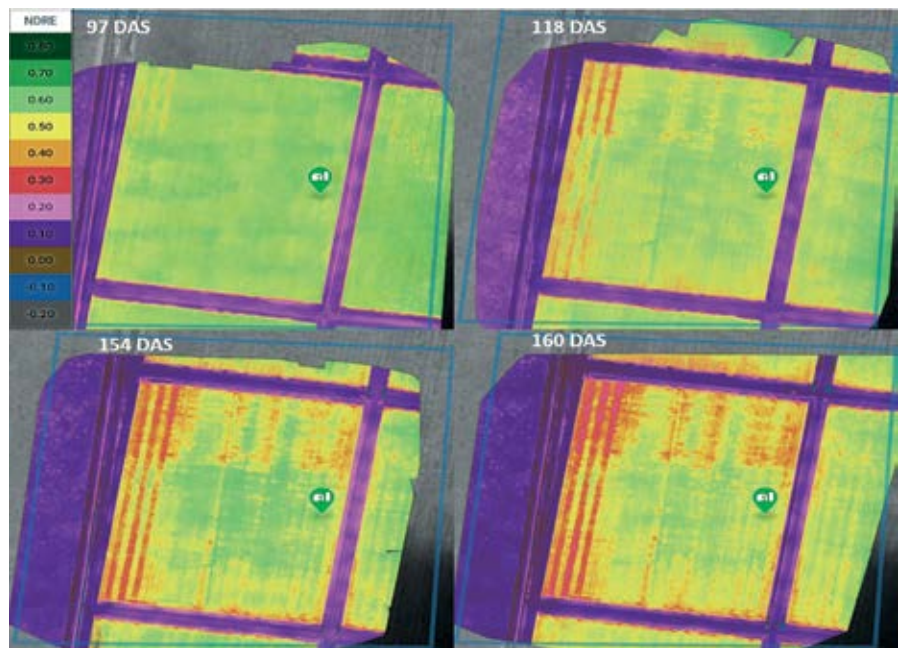


Figure 2. NDRE maps of the cotton farm at 97, 118, 154 and 160 days after sowing (DAS). Note the increase in variability within the site throughout the season due to the treatments applied. The three replicates of the 0 and 130 kg/ha N rate treatments are clearly distinguishable in the left hand side of the site.

Evaluation of seasonal NDRE evolution in cotton crops

Small differences in NDRE were found between treatments early in the season, indicating that plants from the treatments with the lowest N rates were drawing on soil N reserves. Differences between

treatments, however, became more evident as the season progressed, particularly towards boll formation probably due to the increase in boll assimilate requirements.

Plant samples (total biomass) from all the treatments were taken at first flower (86 DAS). Treatments with the lowest N rates had lower N concentration, uptake and NDRE than treatments fertilised with the highest N rates. Figure 2 shows that NDRE was significantly correlated with both N content and N uptake.

In order to study how early in the season variations in NDRE could predict yield, the relationship between the NDRE at each DAS and yield was explored. The results in Figure 3 show that NDRE was well correlated with yield from 83 DAS, when NDRE explained 80 percent of the variability in yield between treatments. Interestingly, NDVI was not well correlated with yield until 97 DAS. This suggests that NDRE could be an earlier predictor of yield than NDVI.

These results could be explained because NDRE is more sensitive to chlorophyll content, while NDVI is more sensitive to biomass. N deficient plants will first show a reduction in chlorophyll content (chlorosis), which eventually will lead to a reduction in plant growth.

Acknowledgements

Researchers Carlos Ballester-Lurbe, Wendy Quayle, James Brinkhoff, John Hornbuckle – Centre for Regional and Rural Futures, Deakin University, Griffith, NSW. The project team also acknowledge the great assistance provided by the Stott family.

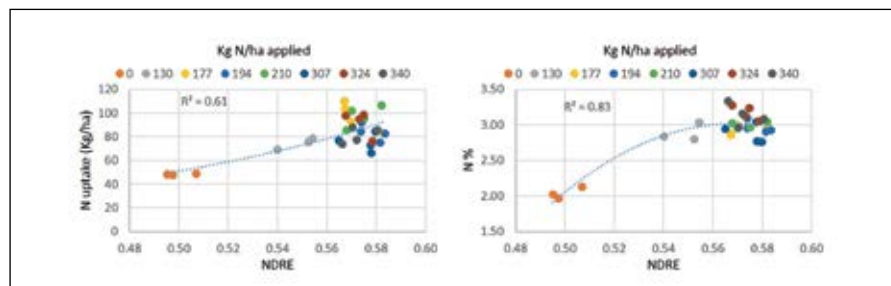


Figure 3. The relationship between NDRE and N uptake on the left ($R^2 = 0.61$; $p < 0.001$), and plant N concentration (N %) on the right ($R^2 = 0.83$; $p < 0.001$) at 97 DAS. Each colour indicates a different N application rate.

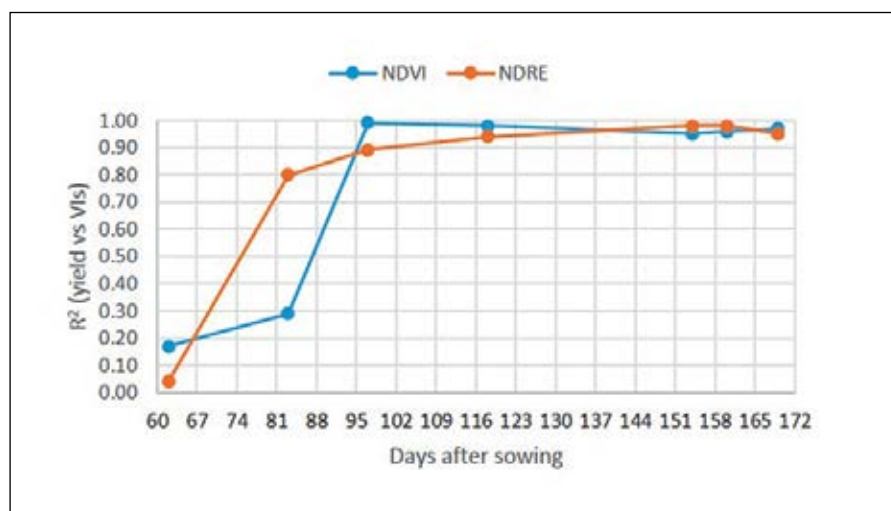


Figure 4. Coefficient of determination (R^2) for the relationships between NDVI and NDRE and yield (bales/ha) throughout the season. Note that NDRE is well correlated with yield earlier than NDVI.

Focus on improving dryland systems

In the new era of Bollgard 3, CRDC is supporting a five-year Dryland Systems project.

The work, headed by long-term industry researcher Dr Paul Grundy, will focus on dryland cotton systems with particular emphasis on deriving benefits and opportunities from Bollgard 3 and the new Resistance Management Plan (RMP).

“With a changed RMP, Bollgard 3 offers new opportunities and challenges for dryland cotton production and the broader farming system,” Paul said.

“Greater sowing window flexibility and reduced end-of-season tillage requirements should enable increased dryland systems’ productivity and expansion.”

Key aspects of the project are:

- Conducting a dryland cotton and systems analysis and review of existing knowledge to identify gaps to develop a series of research and extension objectives to be delivered by the project.
- Increasing capacity to conduct components-based research to solve prioritised dryland cotton technical issues.
- Exploring how the flexibility afforded by the Bollgard 3 RMP can be used for best advantage within the overall farming system. It is anticipated that one or more study sites will be established with a range of dryland production systems and examine the impacts of these systems on overall productivity and profitability. The devised systems will aim to incorporate

likely aspects of the Bollgard 3 RMP, for example systems trade-offs with managing maturity through varying approaches to fit pupae busting dates, impacts of different systems and crop sequences for ease of cotton establishment and improving the transition between cotton and grain crop sequences.

- Review, refine and update dryland cropping extension information – written documents, video and field-based grower/advisor activities.

Developing answers

Paul said there is some capacity to conduct project activities at various locations depending on the nature and scope of the identified work.

“Conducted by dedicated researchers, this is an opportunity to discover and measure the implications of changes to farming operations and systems over five years.

“The immediate focus for many will be on the more immediate gains in soil plant available water content (PAWC) and the benefits of this for a following grains crop but the implications of this change are less clear for crop destruction, weed management and farm hygiene or the opportunity to incorporate P and K fertilisers that might be important for the next cotton crop in three to five years in the future.

“Similarly there will be trade-offs between managing cotton crops for earlier maturity to realise key pupae busting dates (in terms of yield or quality) against the relative productivity gains that may or may not arise following grain crop sequences.” Systems studies conducted during this project will

Scientists Dr Paul Grundy and Kaara Klepper are working with dryland growers on a new five-year CRDC project.



aim to develop data to provide growers with answers to these type of questions.

“CRDC has funded this project in an effort to leverage the opportunities offered by Bollgard 3 for dryland cotton growers: the project proposes an integrated approach to developing a package of measures that aim to increase the potential and success of dryland cotton production and the associated farming system off the back of Bollgard 3,” said CRDC’s General Manager R&D Investment Ian Taylor.

“A more successful, reliable and expanded dryland cotton sector would serve to increase land area productivity, the more efficient utilisation of crop inputs and soil moisture, and thus underpin profitability.

“The RD&E approach proposed by this project aims to equip growers with the tools and knowledge to more successfully farm dryland cotton and contribute to the CRDC’s strategic objective of increasing farm resource use efficiency.”

The project will kick off with a review of existing literature and grower focus group studies to identify opportunities and challenges which may lay ahead with Bollgard 3. The review will be used to refine component and systems-related research questions to the direct benefit of growers.

“Sustainable success will be underpinned by factors such as improved tactics that maximise emergence and crop establishment, particularly when planting occurs outside of optimal parameters for moisture, temperature or soil conditions,” Paul said.

“We also need to ensure the new RMP’s flexibility is used to best advantage for both dryland cotton and the broader farming system in terms of optimal crop sequencing, weed and soil cover management.

“At the same time we must be safeguarding the cotton crop protection system by ensuring that minimal disturbance crop destruction tactics are both effective and registered to limit green bridges that host secondary pests.

“Ensuring the industry’s dryland cotton production extension information is up to date and reflects current best practice for agronomic, crop protection and systems aspects will also be a focus.”

For more

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Better equipping growers at planting

A new project supported by CRDC aims to improve planting and establishment issues for dryland cotton growers.

The past three seasons have exposed a lack of suitable equipment to allow cotton to be planted into difficult conditions where moisture is available at depth but a lack of planting moisture makes establishment difficult.

CottonInfo Regional Extension Officer Geoff Hunter has been working with dryland growers and CRDC to develop an innovative solution, where commercial reality dictates that the Australian market is not big enough to encourage development of this equipment.

CRDC is now supporting a project to build a planter bar to trial new and different planting units to overcome planting difficulties and establishment issues in differing soils and regions.

"New and innovative equipment is available overseas but our relatively small market does not encourage more innovative solutions to a problem that growers feel has cost them hundreds of thousands of dollars through an inability to establish a crop," Geoff said.

"The aim is to build an easily transportable five to six-metre bar and fit it out with different manufacturers' planting units for trials in dryland and

possibly irrigated systems.

"That way we can run a side-by-side comparison of how the units work and their effectiveness in overcoming planting issues: we may even be able to assist in the development of better planting units."

Being transportable means the bar can be used in many locations to assess the suitability of the units under differing planting conditions, moisture levels and soils over a number of growers' farms in any region in Australia.

"Possibilities include trialling variable downforce pressure along with a greater ability to handle stubble and/or trash," Geoff said.

"Depth is obviously an important consideration and we can compare different mechanisms to open and close the seed trench and in the future we may be able to even incorporate other add-ons like biodegradable film or water injection systems.

"These types of modifications could also have uses in limited water situations where growers are trying to establish a crop without watering it up."

Paul Slack is a dryland grower with properties in the Terry Hie Hie and Gurley

area, south of Moree. The Slacks grew their first cotton crop in 1984. As a great supporter of R&D and trials on his farms over many years, he is currently hosting a dryland cotton cover crop trial at his property "Belvedere" and agrees that planting and establishment pose the greatest challenges, so has welcomed the development of the planter bar.

"I'm all for this," he said, "we need to be able to get our crop in on time.

"We do need better planting technology so that, given we've got good sub-soil moisture, no matter what we can get the crop out of the ground.

"Our biggest problem is getting to the moisture through the harder dry band and deal with trash as well.

"It could also answer a lot of questions about suitable row configurations, which can still throw up challenges changing with seasonal conditions, soil types and varieties."

For more
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Growing dryland cotton: Resources at hand

There are many resources available to dryland cotton growers from many industry sources. Some of these are historical, while others are relatively recent.

As planting time looms, a main consideration for growers will be researching seasonal climate outlooks which may show opportunities around management, especially in terms of choosing a suitable row configuration. CottonInfo climate technical specialist Jon Welsh has worked to develop a number of helpful resources for growers and consultants to explain the major climatic drivers and indicators affecting Australian cotton growing regions. These are outlined in the fortnightly e-newsletter *Moisture Manager*, *Spotlight* magazine and the CottonInfo website.

Research has also shown that row configuration can affect quality as outlined in *FIBREpak* and the *Australian Cotton Production Manual*.

Wide row configurations increase the total amount of soil moisture available

The Raingrown Cotton Initiative is a collective of organisations who have joined forces to assist dryland cotton growers access information, resources and support. The Initiative is made up of eight organisations:

- AgriRisk www.agririsk.com.au
- Cotton Australia www.cottonaustralia.com.au
- Cotton Growers Services (CGS) www.cgs.com.au
- CRDC www.crdc.com.au
- CSD www.csd.net.au
- CottonInfo www.cottoninfo.net.au
- Crop Consultants Association www.cropconsultants.com.au
- Monsanto www.monsanto.com/global/au



MELANIE JENSON

to the plants, extending the time before in-crop rainfall is required. In row configuration trials, fibre quality – especially fibre length – is improved with wider row configurations in dry years. Therefore the row configuration chosen, combined with the seasonal conditions experienced, will have a potential influence on the likelihood of achieving base grade at harvest. Recent research and discussion on row configurations are available on youtube and a recent online publication from the CottonInfo team.

When making decisions around planting, stored soil moisture is perhaps one the most important considerations for dryland cotton growers. Analysis using the OZCOT crop simulation model presented in the *Australian Cotton Production Manual* has highlighted the production risk in various regions associated with a less than full profile.

"We'd also like to draw attention to CRDC's Inside Cotton website," says CRDC Executive Director Bruce Finney.

"This is a central site for all CRDC-supported research, publications and even non-CRDC publications related to RD&E.

"It contains more than 1100 RD&E reports and outcomes which feed into the many publications and other resources available."

Resource Review

Australian Cotton Production Manual has a chapter on dryland cotton production (chapter four). Further information relating to management can be found throughout the manual.

www.cottoninfo.com.au/publications

Cotton Pest Management Guide

www.cottoninfo.com.au/publications

Dryland Growers' Booklet and **CottonInfo row configuration fact sheet**

www.cottoninfo.com.au/publications

Expanded row configuration options for Australian rain-fed cotton:

www.regional.org.au/au/asa/2012/crop-production/8090_bangempb.htm

Dryland Cotton website – a specific hub for information at:

www.drylandcotton.com.au

Row spacing video with CSIRO's Michael Bange:

www.youtube.com/cottoninfoaustr

CottonInfo Moisture Manager

Keep an eye out for workshops and field days with CottonInfo's Jon Welsh

www.cottoninfo.com.au/subscribe
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FIBREpak:

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Inside Cotton

www.insidecotton.com



Deep drainage on floodplains: Where does it go?

Surplus water draining below the root zone in irrigated cropping is a well known and unavoidable reality.

In-field water use efficiency does a lot to reduce the magnitude of it, but growers should always understand where this deep drainage goes and what this means in terms of future risks of groundwater rise and salinity.

While most cotton is grown on floodplains, not all floodplains or all parts of floodplains are the same.

A better understanding of the landscapes on the floodplain margins is essential to growers in these areas understanding the scope of risks associated with waterlogged soils, lack of drainage and excess groundwater recharge. Just because the soil is a cracking clay on top, doesn't mean it goes on forever.

To gain a better understanding of floodplain geology to help growers better manage water use,

CRDC is supporting research by the Department of Natural Resources and Mines researchers Andrew Biggs and Jenny Foley.

"There are a variety of tools to assist us in our research, from good old fashioned landscape mapping (understanding the soils and vegetation of an area) through to detailed investigations using drilling, soil coring, geophysics and vegetation measurements," Andrew said.

"In our CRDC research we apply all methods: by better mapping of the thickness of the floodplain alluvium and the fill-status of the buffer zone under irrigated areas on the floodplain margin, we can estimate the likelihood and timeframes for rising groundwater problems.

“Simple calculations using the data we have collected suggest it takes about 10 to 15 years to fill a 10-metre profile, after which groundwater will start to rise.

“In clay-rich areas, the saturated conditions may be difficult to detect, even with a groundwater bore.

“One thing that is certain is under any land use, there is sufficient salt in the soil to cause issues when the saturated zone gets to within a few metres of the soil surface.”

Developing a water footprint

One of the geophysical survey methods used was electrical resistivity tomography (ERT) to take two-dimensional images of the underground landscape (Figure 1).

“These images tell us a great deal about the degree of water filled pores, soil texture and salts occurring below the surface,” Jenny said.

“We are beginning to develop a water footprint that can be used to estimate how saturated or full the buffer zone is.”

In many floodplains (especially in southern Queensland), the cracking clay is less than 10 metres thick, under which lies sand. Depending on location on the floodplain, this clay/sand sequence may repeat with depth and there will be groundwater in the sandy zones.

However on the margins of floodplains, the sand is usually absent and the clay thins out to only a few metres thickness. This is commonly the brigalow/belah country found on the edges of the floodplains.

“The soils and groundwater in these areas are usually naturally saline and often very acidic: they are typically browner in colour, more crusting and often contain a lot of gypsum as well as sodium chloride (table salt),” Jenny said.

“Under any form of cropping, but in particular irrigation, there is some leaching of salts from the upper soil profile and an improvement in root zone salinity over time.

“However in the gypseous cracking clays, not all of the salts leach.

“Sampling in the St George irrigation area shows that even after decades of irrigation, the overall salinity in the root zone can still be high, despite leaching of the chloride.

“This is because gypsum is only sparingly soluble and doesn’t leach as quickly.”

Underlying bedrock

The nature of the underlying bedrock is just as important as the thickness of the alluvium.

The researchers say that west of the Condamine Catchment and Goondiwindi, the bedrock underneath the floodplains is essentially impermeable, which means deep drainage will eventually pond on top of the bedrock. Consequently, in shallow soil profiles, salts are not effectively leached and there is no associated improvement in root zone salinity over time. Instead, salts in the soil profile are re-distributed.

For example – a natural salt bulge (often present at around 50cm to one metre deep in these landscapes) will travel upwards with water that has come from the now saturated deeper soil. This water mobilises salts and moves upwards in response to upwards hydraulic gradients that develop in the soil as the root zone begins to dry out from crop extraction and soil evaporation (see Figure 2).

(More information can be found in the CottonInfo website, WATERpak and SOILpak.)

Modern knowledge of salinity impacts on cotton yields is surprisingly poor, but the researchers suggest

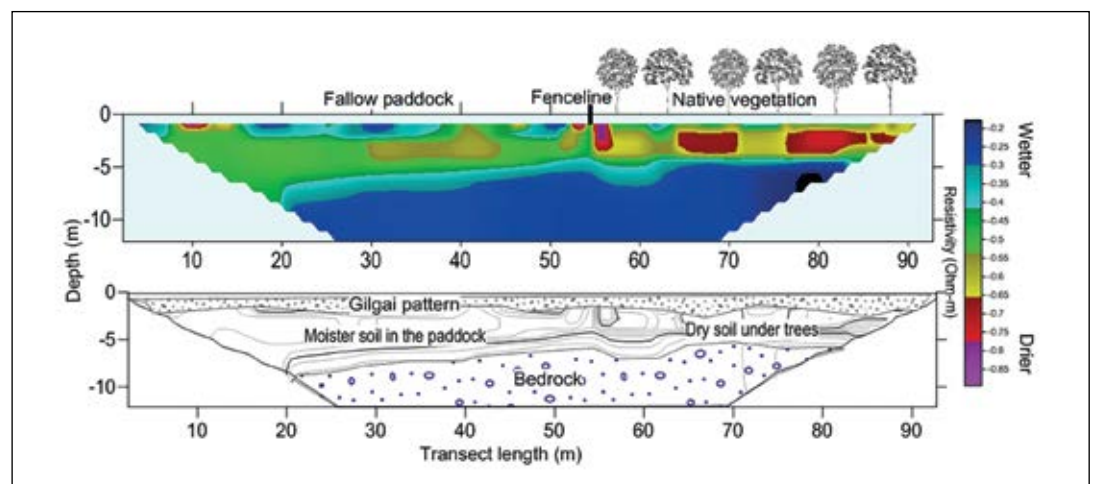


Figure 1. Shows a two-dimensional image of the soil (resistivity) taken on gilgaied cracking clay in the Border Rivers area. The transect runs from an irrigated cotton paddock into nearby native vegetation. The paddock is only cropped and irrigated every few years. Under the native vegetation the red areas in the top five metres of the image indicate the soil is quite dry and resistive. This is also confirmed with soil coring (see Figure 3). In comparison, the soil in the fallow paddock is still quite moist at depth. The blue area on the bottom of the image is due to the presence of highly conductive bedrock.

the soil salinity shown in Figure 2 is high enough to cause a 10 to 20 percent yield reduction. This loss is partly caused by the reduced ability of the plants to extract the more saline soil water.

“Growers don’t necessarily see the yield reduction though, because these areas are generally known to be ‘poor soils’ but growers tell us they do need to apply more water to these soils,” Andrew said.

“There are many interactions associated with high soil salinity, including choice of fertiliser regime, fate of nitrogen in the soil, waterlogging, compaction and disease.

“At present, the cost associated with these interactions in the saline soils of the floodplain margins is poorly understood and an important implication is that it can severely restrict choice of rotation crops.”

What can growers do?

“The obvious solution is to use the water,” Jenny says.

“Dryland crops help, but water uptake may be limited by soil salinity.

“Rotation through pasture phases is the only effective and potentially economic method for drying the profile out to significant depth.

“Doing so not only resets the clock in terms of deep drainage, but provides other agronomic benefits for example disease management, nutrient cycling, improved soil health.”

For more

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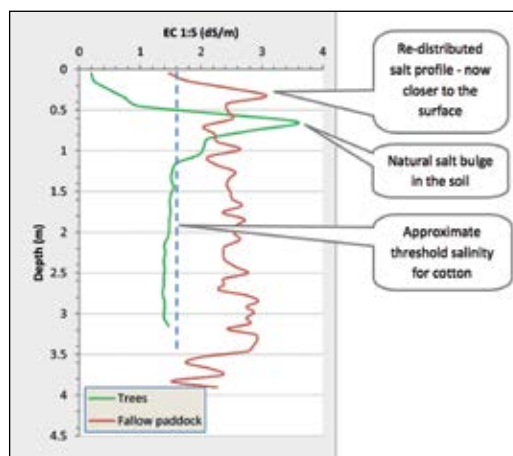


Figure 2. Soil salinity trends in native vegetation (belah/brigalow) and adjacent irrigated paddock showing how the natural salt bulge has been re-distributed.

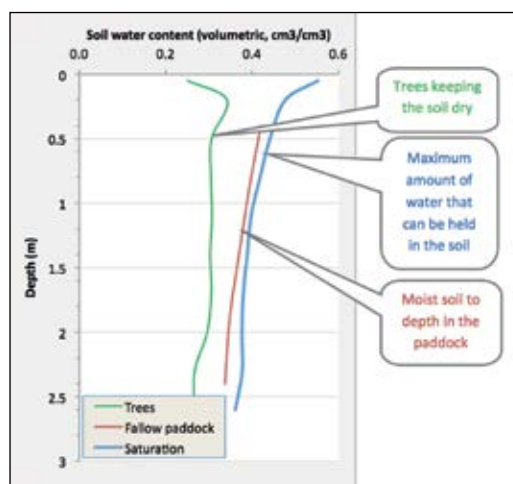



Figure 3. Comparison of soil water content under native vegetation and an adjacent fallow irrigation paddock, illustrating the fallow paddock had very high water content, despite dry years.



Researchers undertaking ERT surveys in native vegetation to produce the maps as seen in Figure 1 on previous page.



World's Best Science

the basis of the Bollgard 3 RMP

As Australia moves into the era of Bollgard 3 it is important to look at the process and research behind bringing this product to the field.

MELANIE JENSON

The approval of the Bollgard 3 Resistance Management Plan (RMP) by the Australian Pesticides and Veterinary Medicines Authority (APVMA) is a result of many years of collaborative research and work between CRDC, Cotton Australia and Monsanto.

Industry contribution and consultation is a key part of the regulatory process in Australia for developing RMPs for products containing biotechnology. The role of CRDC and industry is in providing and reviewing local and international research to assess resistance risks and mitigation strategies.

What are the resistance risks?

Bt cotton has virtually eliminated yield losses from *Helicoverpa* and back-up from insecticides is rarely required to achieve this. It is the reliability of the very high levels of control that have been achieved with Bollgard II that the RMP aimed to protect. This aim will continue with Bollgard 3.

While the threats from *Helicoverpa spp.* are less obvious than the situation experienced by the industry in the mid-1990s, the underlying resistance risks for Bt cotton is potentially much greater than that for conventional insecticides.

Bt toxins are expressed by the cotton plants all season long, greatly increasing exposure and selection pressure when compared to individual spray events. Genes for resistance to two of the three Bt toxins, Cry2Ab and Vip3A, are common in both *H. armigera* and *H. punctigera* populations. Genes for resistance to the new toxin in Bollgard 3, Vip3A, were found to be present in populations prior to its release in the Australian market.

History of RMP development

In order to develop a robust RMP to support the release of Ingard, representatives of the Australian cotton industry and scientific community worked closely with Monsanto to provide scientific research relevant to the Australian pest species and the Australian cropping environment. They also supplied industry knowledge as to how the management of resistance risks might be best achieved in practice.

CRDC plays a major role in RMP development and updating. This involves ongoing and short-term research and reviews.

The science of resistance management is complex and a major priority for CRDC's research investment has been investing in projects critical to determining an effective RMP for third generation transgenic cotton.

The range of research is complex and includes:

- efficacy and expression characteristics of the toxins contained in Bollgard 3;
- determining baseline frequencies to Vip3A, the additional toxin contained in Bollgard 3;
- effectiveness of key tactics in the current RMP such as planting windows and refuges;
- alternatives to pupae busting and trap crops;
- *Helicoverpa* ecology including flight capacity, host preference and landscape influences on *Helicoverpa* behavior; and
- continued resistance monitoring in Bollgard II, including identifying resistance characteristics and potential cross resistance between different Bt toxins and conventional insecticides.

TIMS

The former Australian Cotton Growers Research Association (ACGRA) formed a broad representative grower-led group called the Transgenic and Insect Management Strategies Committee (TIMS Committee). This committee was established to oversee the development of the industry's resistance management strategies for insecticides and Bt cotton and later herbicide tolerant cotton traits.

The TIMS Committee, facilitated by Cotton Australia, functions as a cotton industry stewardship group, with broad representation from growers, research organisations, crop consultants and members of the pulse and grains industries.

The committee is strongly supported by three discipline-based technical panels. The panels offer the committee advice on the scientific merit of proposed new or amended resistance management strategies. The technical panels are comprised of appointed researchers with specific expertise in resistance management. The three technical panels advising the committee cover the areas of:

- insecticides
- herbicide tolerant crops
- Bt insect resistant crops

An important role of the TIMS Committee is to endorse amendments to existing RMPs for Bt transgenic cotton or any proposed RMPs for new Bt products coming into the market, such as Bollgard 3. The TIMS Bt technical panel provides independent, scientific advice to the TIMS Committee on these issues.

The overall process that occurs between the Bt technical panel, TIMS Committee, the Technology Provider and the regulatory authorities when new or amended RMPs are proposed is outlined in Figure 2.

The TIMS Bt Technical Panel has dedicated a large

amount of time over a number of years to review research relevant to the third generation Bt cotton resistance management plan (Bollgard 3). This involved reviewing the Bollgard II RMP and its effectiveness and incorporating new research specific to the efficacy and expression of new Bollgard 3 cultivars.

Reviewing research

In the lead-up to developing Bollgard 3 RMP the TIMS Bt technical panel worked closely with Monsanto to share and review research results. As part of the review of Bt resistance research, the TIMS Committee and CRDC facilitate an annual review of Bt resistance research and extension activities as part of the REFCOM forum meetings.

REFCOM brings together researchers, growers, consultants and representatives from technology providers and the industry CottonInfo team, to discuss research project progress and communication on Bt resistance.

The role of industry consultation via the TIMS Committee in the development of new and existing RMPs is critical, not only through the research and monitoring conducted, but just as importantly from the growers on the TIMS Committee who are able to offer a practical approach to RMP development and amendment. This role is ongoing.

Current RMPs will need to continue to be reviewed, and potentially amended, regularly to ensure they provide a robust and manageable resistance management strategy.

Into the future, as new technologies are developed, the industry must continue to work closely with commercial companies in developing new RMPs that help ensure the cotton industry's continuing success with biotechnology.

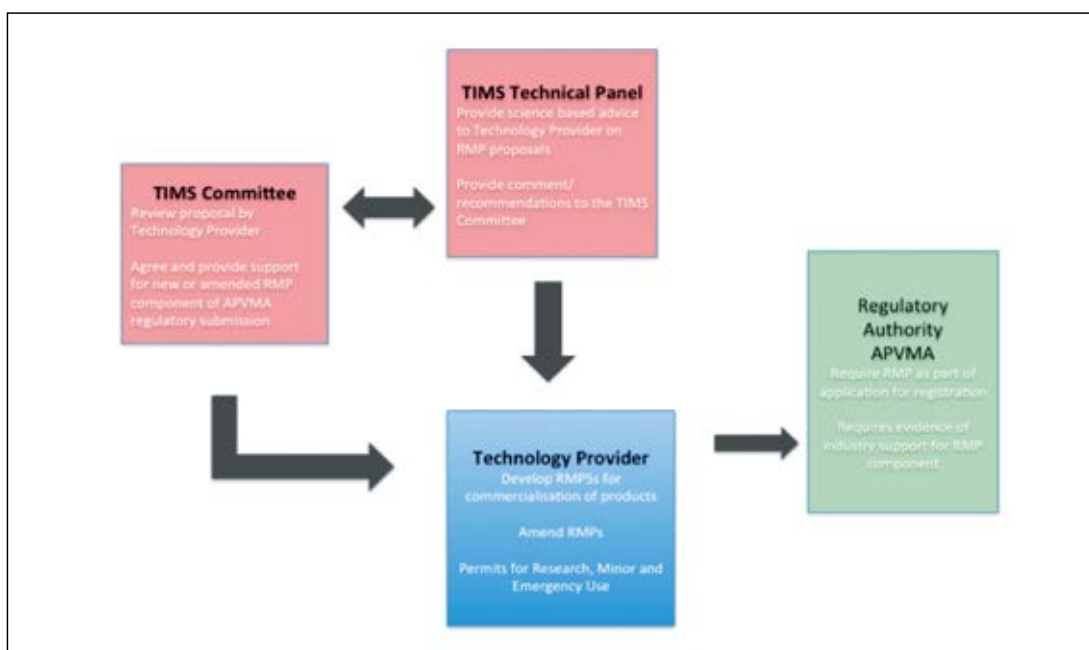


Figure 2.

Refuge health vital

Rogue cotton in refuges poses a serious risk to the efficacy of Bt technology.

As the Australian cotton industry enters the era of Bollgard 3, well managed refuge crops remain a key element of the industry's *Helicoverpa* resistance management strategy and a vital component of the Resistance Management Plan (RMP).

The refuge strategy has been the primary approach used worldwide to delay pest resistance to Bt crops.

Refuges are designed to generate significant numbers of susceptible *Helicoverpa* moths that have not been exposed to Bt toxins found in Bollgard crops. Moths coming from refuges dilute the frequency of any resistant individuals in the overall population.

The Bollgard 3 RMP requires less refuge area than the Bollgard II RMP, hence the imperative for refuges to be even better managed and more effective than previously.

"We really want to make sure that growers are aware that the reduction in required area does not equate to a lessening of the importance we place on refuges, in fact it is quite the opposite," says CottonInfo Bt and insecticide stewardship technical specialist Sally Ceeney.

"A high performing refuge is one that flowers well and on time, and remains attractive to *Helicoverpa* for the entire time the cotton crop is also attracting *Helicoverpa*.

"Refuges must be managed even more carefully to fulfil their function and a major part of this is vigilance around the presence of rogue cotton."

The concept underlying the refuge strategy is that most of the rare resistant pests surviving on Bt crops will mate with the relatively abundant susceptible pests from nearby refuges without Bt toxins. If inheritance of resistance is recessive, the progeny from such mating will die on Bt crops, substantially delaying the evolution of resistance.

CottonInfo's technical specialist for volunteer and ratoon cotton, Sharna Holman says rogue cotton must be removed as soon as detected, ensuring they are removed while still small and manageable.

"Moths that carry a resistance gene may lay eggs in the refuge; larvae emerge and develop in the refuge and may move on to rogue Bt plants as larger larvae when they are able to survive and produce offspring leading to an increase in the frequency of individuals in the population carrying a resistance gene," Sharna says.

"Refuge crops must be managed to ensure they are of high quality and are producing plenty of susceptible moths.

"Furthermore, a farm totally free of rogue cotton is important for a healthy farming system in terms of disease, and general pest management as well as resistance management."

Successful control measures for rogues in refuges can be undertaken throughout the year, not just in the growing season or when they appear. Planting refuge crops into fallow areas or rotation fields is one tactic. Volunteers can become most problematic following dry winters, with potential for large numbers to emerge after spring rain or irrigation.

Volunteer and ratoon cotton farm surveys, along with CRDC's grower surveys show that successful control requires an integrated and targeted approach - usually cultivation and herbicides. Herbicide use is about timing, as none are registered for use beyond nine nodes of growth. The *Cotton Pest Management Guide 2016-2017* lists herbicides registered for use and application rates which give growers options for effective control of seedlings in a range of situations. For all these herbicides, best results are gained with a double-knock strategy, using a registered herbicide to control seedlings prior to crop emergence followed by an early inter-row cultivation to remove any survivors.

For more
Cotton Pest Management Guide 2016-17
www.cottoninfo.com.au

In variable farming landscapes good refuges are vital

Researchers have identified potential high-risk situations exist for resistance in *Helicoverpa* due to the extreme season-to-season changes in wet and dry years.

Cotton industry researchers have investigated the effects of season-to-season changes in wet and drought years on Bt resistance of *Helicoverpa* in Bt cotton. The research shows the importance of well-managed refuges remains critical.

CSIRO's Nancy Schellhorn and University of Wisconsin's Tony Ives' CRDC project explored how the potential development of resistance of *Helicoverpa* to Bt cotton may be impacted by Australia's highly variable cropping landscape. There may be particular times of year, and particular years, when a surge of resistance could occur. Potentially this is when the total amount of habitat in the landscape (other than Bt cotton) is very small, such

as drought years, or where large numbers of *Helicoverpa* could be crowded into small remaining refuge areas.

Due to the variable nature of the Australian cropping environment, these high risk situations can occur frequently.

"Therefore effective resistance management, adherence to the RMP and especially the use of refuges, is critical.

"We cannot rely on the area of unmandated refuge, which will always be variable in Australia.

"Productive and sufficient refuges are critical, especially in cotton-dominated landscapes.

"The research shows the Australian industry is doing a good job of managing resistance.

"There have been indicators of surges in resistance, which may be in part driven by the high season-to-season variability of wet and dry years. The risk of resistance is always present, however complying with the RMP has kept Bt technology safe."

Researching new pigeon pea varieties

Pigeon peas are the most popular choice of refuge in Australia, with past research showing they attract more than twice the *Helicoverpa* egg lays and produce twice as many moths as conventional cotton refuges.

However, what passes for pigeon peas in terms of a varietal consistency is a far cry from the original cultivars that the industry started with at the beginning of the Bollgard II era. As pigeon pea has not been grown as a crop in Australia since the 1980s, the production of planting seed has not been subject to any quality control for 30-odd years, with available seed predominantly coming from harvested refuges.

As part of the Bollgard 3 Resistance Management Plan (RMP) development process, an agreement was reached by industry and Monsanto to work to improve the quality of refuges, especially in light of a reduction in the required mandated refuge, which means refuges must be more effective and better managed.

In order to offer growers a more effective refuge option, work is underway to develop an alternative variety. Work by QLD DAF's Paul Grundy and Yash Chuahan has identified a potential variety that has a series of desirable traits for flowering, indeterminacy and vigour on clay soils.

"Ideally we want a variety to flower and be attractive throughout the entire period cotton is also flowering, as research has shown that pigeon pea is most attractive to *Helicoverpa* when flowering.

"The original varieties of pigeon peas used such as Quest were quite determinate (short flowering window), and often finished flowering around mid-season

particularly when badly damaged by *Helicoverpa*. Since people have been seed saving a secondary problem has emerged whereby a lot of pigeon pea refuges are flowering later and later in the season with some not flowering until March.

"A variety more suited to the varied conditions in cotton growing areas and can be relied on to flower on time is vital for the sustainability of Bollgard technology," Paul said.

"From an initial assessment of 330 lines kept at the Australian Genetic Resource Centre in 2012-13, we have selected two varieties that have shown real promise at a range of sites from Emerald to Griffith.

"In field assessments of these cultivars it shows them to be highly attractive and generating much higher larvae numbers than the old Quest-like cultivars.

"Seed increases are underway with both new varieties in the coming season.

"This will complement larger scale replicated trials that will seek to understand the potential of these lines compared with what is currently being grown."

The commercial development of these varieties is now being undertaken in partnership with Monsanto and Associated Grains with a view to commercial release of quality assured seed for the entire industry in time for the 2017-18 season.

For more

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MEET THE RESEARCHER

At home with cotton

Before leaving his native Pakistan for Australia, Hiz Jamali played an integral role in establishing Pakistan's largest national park.

"Before coming to Australia in 2007 to start my PhD at the University of Melbourne, I was working in Hingol National Park," Hiz told *Spotlight*.

"It was an interesting experience, as the park was in early stages of development.

"My work involved coordinating a multidisciplinary team of local and international experts conducting baseline surveys of terrestrial and marine biodiversity, as well as park infrastructure development."

Hiz said in Pakistan, people are generally very supportive of any initiatives regarding biodiversity conservation which can be seen in many community-driven conservation initiatives across the country. With climate change causing temperatures to go higher than 50°C in central and southern regions of Pakistan, tree planting, for example is increasingly becoming a popular activity.

Being interested in science since his early days at school, the interest only grew stronger as he progressed with his schooling.

"I was more involved in natural systems such as forests as I did my graduation in forestry and PhD looking at greenhouse gas fluxes in tropical savannas here in Australia in the Northern Territory," Hiz says.

"I developed the research interest in agricultural systems after my PhD and would like to continue in this research direction in future."



MELANIE JENSON

Hiz grew up in a regional farming area where his family has been growing mainly irrigated rice and wheat for many decades.

Agriculture in Pakistan is mainly supported by one of the world's largest networks of canal irrigation systems and contributes 24 percent of the country's GDP (by comparison in Australia it's three percent). Major crops include wheat, rice, maize, sugarcane and cotton, and horticultural crops such as mangoes and citrus.

This researcher can speak at least four languages which, he says, is not unusual for anyone growing up in Pakistan as each region has its own language(s).

"Besides my mother tongue, Balochi, I learnt Sindhi naturally as we lived near the boundary of Sind province, while Urdu and English are taught in school," he says.

"The difference between life in Pakistan and Australia is typically that of between any developing and developed countries, however Australia is a very welcoming society which has made the transition easier.

"We have been in Australia for a few years now and my family including my wife and two young kids feel very much at home here."

Before joining the ACRI, Hiz was working on assessing the opportunities to mitigate nitrous oxide emissions and improve nitrogen (N) use efficiency in irrigated crops in the Southern Murray Darling Basin while based at Griffith. This

research, published as three scientific journal papers, identified reduced deficit irrigation as a potential method for reducing nitrous oxide emissions and leaching losses in irrigated crops such as wheat and sorghum, and potentially in cotton.

"I was also involved in similar research from dairy pasture soils in New Zealand during my post-doctoral fellowship in 2011-2013."

Hiz's work now largely focuses on optimising on-farm water management in cotton systems which involves working closely with growers through support from CRDC.

He says looking forward, although Australian farmers are world leaders in producing high yields, there is significant gap in yield and water use efficiency of high achievers and the industry average and therein lies an opportunity to improve decision making using new tools.

"My work builds on research by CSIRO scientists at ACRI in recent years in developing tools to assist growers to make more informed decisions around scheduling and taking any guesswork out of decision making," Hiz said.

"We hope to help growers to adapt and tailor their irrigation management to increasingly variable and water limited future environments."

For more

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COMMENT: WITH CROP CONSULTANTS AUSTRALIA



Industry's big data at your fingertips

CCA Survey Director Ben Dawson outlines the value of the annual CRDC-supported qualitative and quantitative surveys, and the contribution consultants make towards building the bigger data picture for the cotton industry.

As we become overwhelmed with new forms of farm data generated by all sorts of technologies, the value of foundation and trend data collected for the cotton industry since the 1980s cannot be overlooked.

Crop Consultants Australia has been coordinating the collection of survey data of its practising members across the key cotton growing regions of Australia since 1982. CCA started surveying its members in response to a need for reliable product usage records to provide indicators of usage trends.

CCA continues to coordinate annual qualitative and quantitative surveys for the Australian cotton industry with funding provided by CRDC. The survey data plays an important role in informing the cotton industry, wider supply chain, the community and government of practice change within the sector, helping the industry to better tell its story.

What might be less known, is that the quantitative data is analysed and published in a report available publicly on the CRDC website. A very broad range of topics are covered in the survey from staffing and information requirements to every aspect of producing and managing a cotton crop (soils, pests, weeds, fertiliser, technology and water). The quantitative survey consistently represents 50 percent of cotton growing areas and usually achieves over 70 percent coverage.

Additionally, the full set of quantitative survey data is available for purchase and custom analysis can be provided by the CCA project manager. The quantitative survey collects full seasonal agronomic data relating product usage applied on a particular date, over specified hectares applying to seed, seed dressings, herbicides, insecticides, target pests, plant growth regulators and harvest aids.

CCA aims for data coverage of more than 50 percent of Australia's key cotton producing area. This data provides a strong indication of products (type and quantity) used to produce a cotton crop each season. Historical data is available for sale and the most recent season data is available from October each year.

CCA acknowledges the contribution that consultants make



MELANIE JENSON

CCA Survey Director Ben Dawson.

towards building the bigger data picture for the cotton industry. Agworld has been an invaluable partner to the project, enabling client data to be contributed, with their permission, and helping build the overall confidence in the accuracy and quality of the data. It is hoped that other data management service providers will support the survey project and partner with CCA to enable their clients to also participate.

The survey responses are currently being analysed and both data sets will be available in October 2016. The public *Qualitative report on the 2015-16 cotton season: a survey of consultants* will be available on the CRDC website, and anyone interested in purchasing the quantitative cotton data should contact CCA.

For more

www.cropconsultants.com.au

www.crdc.com.au/publications

Introducing La Nina Modoki: she's 'similar but different'...



The low-down with
Jon Welsh

Are we heading for a La Niña Modoki? This coming spring and summer could herald the arrival of this lesser known La Nina event – so what is it and how will it affect cotton growers?

The 2016 spring may see the emergence of an El Niño-Southern Oscillation (ENSO) climatic condition called La Niña Modoki, which according to research agencies, could potentially assist moisture flow into central and northern cotton growing areas this spring.

While commentators tend to emphasise the state of ENSO circulation patterns with rainfall – El Niño (drier than normal), neutral (average) and La Niña (wetter than normal) – climate scientists have gained a better understanding of the subtleties within these ENSO conditions assisting model predictability in some years.

What is an ENSO Modoki condition?

ENSO can be described as a coupled atmosphere–ocean phenomenon that exhibits substantial variations with regionally different outcomes, leading to a diverse continuum of realised ENSO events. Since the late 1970s, conventional ENSO La Niña and El Niño events have become less frequent, while a second “flavour” of ENSO – *Modoki* – from the Japanese

language meaning ‘similar but different’ – has become slightly more prevalent. Both El Niño and La Niña Modoki events can occur independently at times when tropical ocean indices may not achieve thresholds in a classic El Niño or La Niña event.

The word Modoki was introduced by Toshio Yamagata, a University of Tokyo professor specialising in climate dynamics in 2004 while explaining a probable cause behind the abnormal summer climatic conditions over Japan. It has often been used since then by the Japanese mass media.

Japanese research scientists later uncovered the Modoki phenomenon in 2007. Both El Niño and La Niña Modoki events can significantly influence the temperature and precipitation over many parts of the globe. For example, the West Coast of the United States is wet during El Niño but dry during El Niño Modoki.

During the Australian winter and spring when an El Niño Modoki event occurs, the significantly warmer sea surface temperature anomalies (SSTA) in the central equatorial Pacific is flanked by significantly colder-than-normal SSTA in the western and eastern tropical Pacific.

Significant research has since been conducted to identify, describe and understand these El Niño “types”. These differences have been studied in

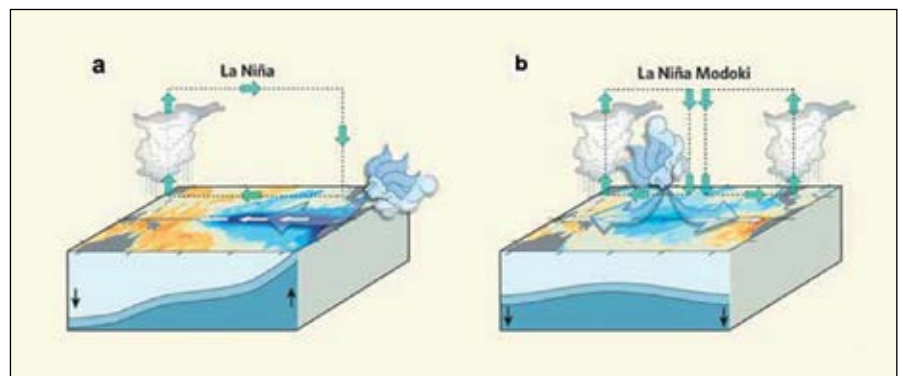


Figure 1 shows key differences in sea surface temperature distributions and atmospheric circulations; (a) A conventional La Niña and (b) A La Niña Modoki. The single-cell broad scale Walker circulation splits into two cells during a Modoki event.

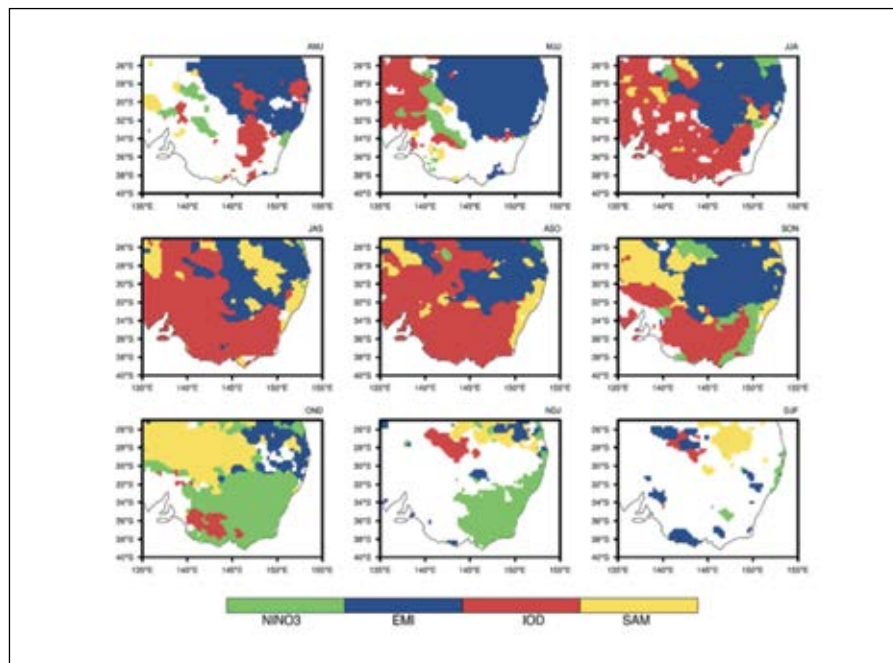


Figure 2. Rolling three-monthly calendar commencing April/May/June to December/January/February showing the leading driver of rainfall (Niño 3, EMI, IOD and SAM) in South-eastern Australia (Source: Lim, Hendon et al., 2012).

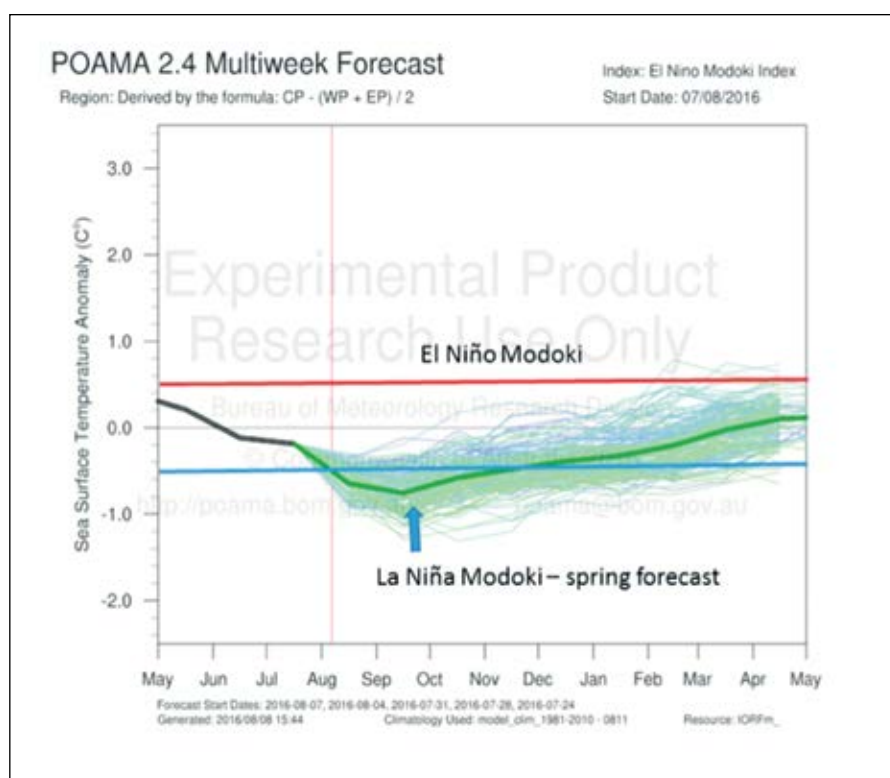


Figure 3 POAMA EMI prediction from base period 7 August, 2016 (Source: POAMA, 2016)

the literature and although they cannot be considered completely separate phenomena, they do have distinct climate impacts.

Modoki events and climate in cotton areas

Researchers at the South Korean Ocean

Research and Development Institute in Ansan, found that in the past 20 years, the Modoki events have increased from about one out of five to half of all El Niño events. Their computer modelling predicts Modoki events may occur five times more often by the end of the century. With these research findings in mind, ENSO Modoki

is definitely a climatic process to be aware of when evaluating seasonal climate risk to understand impacts on seasonal conditions.

In terms of impact on rainfall and climate in cotton regions, researchers at the Australian Bureau of Meteorology and University of NSW found ENSO Modoki is the leading driver of rainfall in some cotton areas during the autumn, winter and spring. The following analysis of rainfall correlation strength through a moving three-month window shows the Modoki Index (EMI, navy blue) as the dominant driver in many Northern NSW and Southern Queensland cotton growing areas. The impact of the Modoki condition is reduced post-spring season, when other influences take over or significance is reduced below 95 percent.

Watching the La Niña Modoki this spring

ENSO events tend to peak during late spring and decay in February- March.

Studies have shown consistent rainfall correlations are found over eastern Australia beginning in winter and extending into summer. The El Niño Modoki Index also has close links to crop evapotranspiration (ET₀) and therefore impacts water budgeting and winter crop harvesting windows.

When ET₀ is reduced (increased), winter crop harvesting opportunities will be less (more). An analysis of ET₀ data across cotton growing areas showed a strong negative (opposite) correlation from regions north of the Macquarie Valley to the Fitzroy Valley. Results of the analysis suggest lower ET₀ in the majority of cropping areas likely in spring 2016. Figure 3 shows the latest POAMA EMI prediction for spring with the solid green line dipping below La Niña Modoki thresholds in August and persisting through the 2016 spring season.

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