Spotlight

ON COTTON R&D

SUMMER 2021-22

Game changer for Central Queensland

Going beyond a plan: PLANET. PEOPLE. PADDOCK.

On the leadership trail

CRDC

Dr Ian Taylor

In the Spotlight

Welcome to the Summer edition of *Spotlight* and one of the largest cotton planting in four years.

It's an exciting time for growers and our cotton communities, and for CRDC, as we continue to lead RD&E and initiatives to improve the sustainability of our growers and industry.

In this edition, we bring you an update of the progress and reasoning behind the industry's PLANET. PEOPLE. PADDOCK. Sustainability Framework.

The 2021 CRDC Grower Survey – out now and featured in this edition of *Spotlight* – shows that 18 months after its introduction, there is increasing awareness of PLANET. PEOPLE. PADDOCK. among growers, with a majority believing it is very important for the cotton industry.

While some sustainability targets are still in development, others are close to being reached. Growers have been hard at work, with significant investment and powered by world-class RD&E, to improve water use efficiency and pesticide use.

Some targets need further action from the industry. An increase in greenhouse gas emissions from cotton farms, due largely to inefficient use of nitrogen fertilisers (as outlined in the CRDC and Cotton Australia *2019 Sustainability Report*) is of concern.

We are all aware of the focus on climate change globally and the role agriculture plays in emissions. The cotton industry has a unique opportunity, due to the depth and breadth of our research into nitrogen use efficiency, to lead the way in emissions reduction by improving optimisation. We've just wound up the More Profit from Nitrogen project, which has increased our knowledge of steps towards optimisation. Nutrition research has been a significant investment for CRDC - now we are looking to see a greater uptake of the outcomes to ensure we are leaders in our field, and are taking our responsibility to regarding sustainability seriously.

In line with our commitment to improve sustainability outcomes, we recently held the first meeting of the Australian Cotton Sustainability Reference Group. And, we're about to kick off the fourth independent environmental assessment of Australian cotton, continuing the 30 year commitment to openly and transparently assessing our impact.

Helping the industry continuously improve its practices is part of the reason CRDC exists. We're also focused on tackling the 'wicked' problems – like spray drift. Which is why we're excited about the increasingly innovative R&D coming from our partners under the Business Research and Innovation Initiative. This program gave us the opportunity to partner with small business innovators from across Australian to revolutionise spray application to solve spray drift. There are now two promising technological solutions being developed by LX and SwarmFarm, which you can read about in this issue.

And we're almost ready to bring the artificial intelligence PestDetect app to growers and consultants. Speaking from experience as someone who has counted their fair share of insects, this is game-changing technology for silverleaf whitefly and in the near future, aphid management.

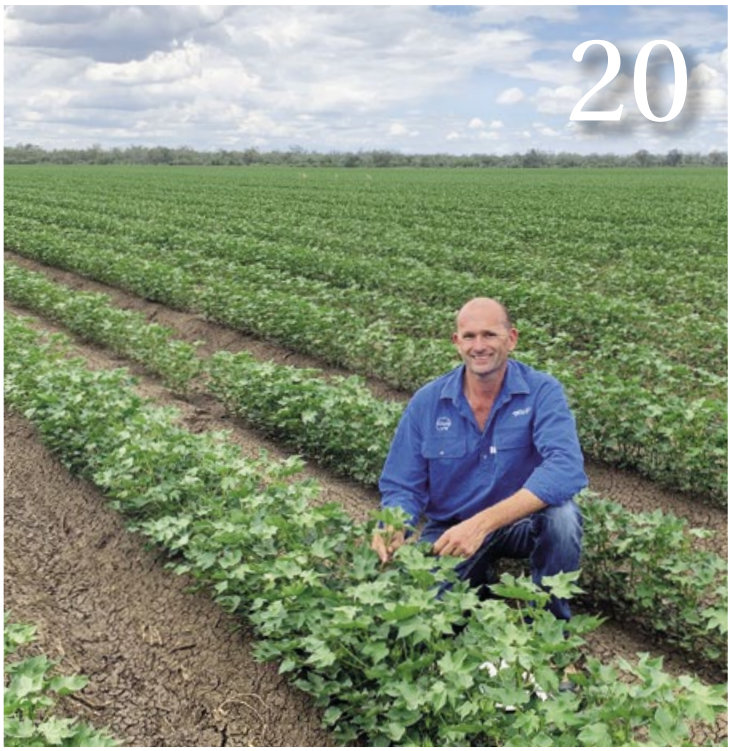
Finally, we were thrilled to hear the news that one of our CRDC-supported start-up founders, Anastasia Volkova, was named the Number 1 innovator in Australia by *The Australian* newspaper. An amazing achievement from one of our world-leading research partners.

Until next time, we wish you all the very best for the cotton and Christmas seasons.

Dr Ian Taylor
CRDC Executive Director

CRDC acknowledges Australia's Indigenous people as the traditional custodians of our country, and recognises their continuing connection to lands, waters and culture. We pay our respect to Elders past, present and emerging, and extend that respect to all Indigenous people.

Summer 2021-22



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

CRDC
COTTON RESEARCH AND DEVELOPMENT CORPORATION

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

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ON THE COVER: Neek Morawitz 'Argoon' Comet and CRDC R&D Manager Susan Maas in Neek's late May-sown cotton, a week into flowering by early October.

Want to see more of Spotlight?

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

COTTON NEWS

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ON THE COVER

Bring on the future

ARE you committed to the future of the cotton industry and have an interest in developing your leadership knowledge, skills and experience? If so, apply today for your chance to join an established network of over 100 emerging leaders across the Australian cotton industry.

The Australian Future Cotton Leaders Program (AFCL) is an initiative of Cotton Australia and CRDC. Participation in the course has been described as 'life-changing' by former participants (including Aaron Kiely, read the story of his journey on page 18).

Facilitator Jo Eady continues to receive accolades from past participants, who are always quick to credit Jo with helping them find their path and support them on their journeys. The network of alumni is another major factor in the success of the course.

CSIRO's Rose Roche is one of the industry's best-known researchers and was in the first AFCL intake. Rose credits the course with connecting her with growers and industry, as well as creating life-long friendships and support. (See CRDC *Spotlight* Spring 2021 edition).

The program is best suited to people keen to progress their leadership skills and actively involved in a cotton enterprise or related position, such as seed production, extension, research, consulting, ginning, marketing and shipping.

Applications for the next round of AFCL close December 10 2021. The program will run from early 2022, concluding at the Australian Cotton Conference in August.

For more
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Giving disease a microwave

USING microwave technology to inhibit the effects of disease has been trialled in southern cotton fields.

CRDC is working with NSW DPI and Australian start-up Growave Ag to test its microwave technology's impact on early season disease management of black root rot. The shorter and sometimes cooler climatic conditions in southern regions can favour the disease, resulting in the young seedlings' inability to compensate for the delays in plant growth and maturity. Research has shown severe black root rot can lead to delays in maturity of up to four weeks and yield reductions as high as 40 per cent.

Growave's microwave technology has already been shown to remove weeds, seedbanks and control disease.

CRDC R&D Manager Elle Storrier said it was very early days for the black root rot trial, but some results are promising.

"We ran a small exploratory trial, treating a few different test strips of thermal heating/microwave technology to test the efficacy in suppressing the black root rot pathogen temporarily," Elle said.

"This is to allow the cotton seedling to establish without the impact from the disease.

"The technology has shown promise at a lab level and has been successful in controlling similar pathogens in other crops.

"Exploring the use of this technology is very much in its infancy but this was just a look to see if it has a fit for the suppression of black root rot before we consider overcoming some of the practicality and logistical challenges."

Black root rot is caused by the fungus *Thielaviopsis basicola*, which can be dispersed in soil adhering to vehicles, machinery and trash floating in tail water. The pathogen is capable of surviving for years in the soil, producing two types of reproductive spores. Inoculum builds up in the soil from previous host roots. *T. basicola* is an obligate soil pathogen, so cannot grow on dead organic matter.

Crop rotations can be a major contributing factor for *T. basicola* inoculum levels in soil and are very important for reducing the risks and severity of black root rot.

One of the recommended strategies for reducing the risks is to rotate with non-host crops, such as cereals, sunflowers and brassicas like canola, for up to three years, avoiding legumes and controlling weeds. Growing non-hosts will prevent the build-up of the fungal load in the soil, as the fungal spores may germinate. In the absence of a host, the pathogen is unable to complete the life cycle or produce new spores.

CRDC is continuing to support research projects into black root rot and other priority diseases such as Verticillium wilt using novel methods. Research is currently underway using DNA testing to distinguish between defoliating and non-defoliating strains of Verticillium wilt.

For more
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Will a changing climate affect how you grow cotton?

MORE than one in two growers surveyed for the 2021 CRDC Grower Survey believe their regional climate patterns will result in a change to their production systems over the next 10 years.

With the results of the 2021 survey now out, it found that larger farms were more likely to believe this proposition than medium or smaller farms.

In addition, twenty-nine percent of growers surveyed reported they were actively assessing the carbon footprint of their production system. Compared to small and medium-sized farms, larger farms were more actively undertaking assessments, which varied across the regions. That said, almost six in 10 growers were making or planning to make changes to reduce their carbon footprint.

The inclusion of questions around climate and carbon in the 2021 survey comes at a time as targets for emissions are being set and refined by governments around the world – and as the cotton industry works to formalise its own targets under the PLANET. PEOPLE. PADDOCK Sustainability Framework.

The framework was introduced in April 2020, and measured in both the 2020 and 2021 CRDC Grower Surveys. Awareness of the framework has increased from 32 per cent to 46 per cent in just 12 months, while a majority of growers (67 per cent) believe it is very important for the industry.

MELANIE JENSON

A total of 233 growers participated in the survey, representing 20 per cent of all cotton growers in 2020-21. The survey covered a range of topics, including the impact of R&E on farming systems, water, diseases, sustainability, and workforce and training.

The survey results are available to download from the CRDC website. An interactive digital dashboard is also available to enable growers to explore the data in more depth, including comparisons of farm sizes and growing valleys.

The 2022 CRDC Grower Survey will open in June 2022, with all cotton growers and farm managers invited to participate. It provides valuable information to CRDC and the cotton industry about on-farm practices and priority areas for future research.

For more
CRDC Grower Survey
www.crdc.com.au/publications/cotton-grower-survey

Review of research proposals for 2022-23 are underway

CRDC'S annual procurement round is the key opportunity for researchers and research organisations to apply for funding for research into CRDC's priority areas. The procurement round begins annually in May, with a strategic review of each of the goals under the CRDC 2018-23 Strategic RD&E Plan through discipline and research priority forums involving CRDC, Cotton Australia, the research advisory panels, CottonInfo and researchers, to identify research needs and gaps.
Following this review, in September CRDC releases Expression of Interest (EOI) documents, inviting researchers to submit Full Research Proposals (FRP).

This year CRDC developed 26 EOIs for RD&E projects across a broad range of topics for its 2022-23 investment round. They included water use productivity benchmarking, validating soil testing guidelines, disease management, soil carbon management, resistance monitoring, reusing textile waste, integrating irrigation technologies, guidelines for integrating cover crops, demonstrating integrated weed tactics, and agtech to improve field scouting of pests.

The deadline for submitting FRPs closed mid-October with CRDC R&D Managers and the Cotton Australia research advisory panels now evaluating the proposals. CRDC's Board will determine the successful projects in April 2022, with projects set to commence on July 1, 2022.

For more
www.crdc.com.au/research-development

Creating space for innovation to solve ag's challenges

Robots and aeronautical-style technology are creating opportunities for agriculture to improve sustainability and environmental challenges, as the cotton industry aims to make spray drift a thing of the past.

It's been made possible through the Australian Government's Business Research and Innovation Initiative (BRII). In partnership with the Department of Industry, Science, Energy and Resources (DISER), BRII provides $12 million annually to solve five environmental challenges.

BRII, with the help of Research and Development Corporations such as CRDC and GRDC, identify some of the biggest challenges facing agriculture, then invite Australian businesses and innovators to help solve them. CRDC and GRDC were successful with their separate challenge submissions: Revolutionising spray applications to reduce drift and Transforming crops into renewable hydrogen sources.

After a series of proposals were received, the field was narrowed to six successful applicants for each challenge, who were awarded up to $100,000 to undertake a feasibility study.

Two proposals were then chosen to receive $1 million to develop a 'proof of concept' for these two transformative agricultural challenges. Over the course of the two challenges, GRDC and CRDC collectively secured and facilitated almost $5 million of investment into Australian agricultural innovation.

Revolutionising innovation and agriculture

CRDC was successful with their proposal to DISER focusing on the challenge of pesticide spray drift. The goal was to discover ways to reduce off-target spray drift, and so improve the efficacy of the application and avoid damage to the surrounding environment.

SwarmFarm Robotics and LX were announced as the successful innovators in September.

SwarmFarm was recognised for developing a system for robots to make informed, autonomous decisions on pesticide application. LX was recognised for its creation of an easy to use, globally scalable and real-time spray application feedback system, which utilises artificial intelligence technology.

CRDC's General Manager R&D Investment Allan Williams said the benefits of the partnership with BRII and GRDC will be far reaching.

"Addressing spray drift has been a long-term challenge across all of agriculture and solving it for cotton and grains will have positive flow-on benefits to other agricultural sectors," he said.

"The BRII investment has not only supported the successful applicants – but critically, also provides distinct benefits for our two industries, the wider agricultural sector and the environment.

"Solving the problem of spray drift and commercialising a renewable hydrogen source will have positive impacts for our growers, our communities, and our environmental sustainability."

Crops as renewable energy

The GRDC challenge of transforming crops into renewable hydrogen sources has discovered ways to generate hydrogen for renewable fertiliser production through recycling farm biomass, potentially generating significant advantages for the nation's grains industry.

The two companies chosen for the proof-of-concept phase were Wildfire Energy (QLD), recognised for its development of a commercial process of converting crop residues to hydrogen, and HydGene Renewables (NSW), recognised for designing a bacteria engineering process that supports the conversion of sugars from biowaste to hydrogen.

GRDC's Manager Business Development & Commercialisation – West, Roop Judge said BRII has provided an innovative R&D pathway for the grains and cotton industries to tackle two major agricultural issues.

"This investment is being made in innovative small to medium Australian businesses, who have demonstrated their ability to create tangible solutions through new products and technologies," Roop said.

For more

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Big ideas and innovations are coming out of Central Queensland, thanks to Jocie and Andrew Bate of SwarmFarm.

Seeing the future is 'next practice'

SwarmFarm Robotics is no stranger to agriculture or people in the cotton and grains industries.

Jocie and Andrew Bate are the farmers and innovators behind this agtech company who have forged a path in developing autonomous agricultural robotics from their home in Gindie, Central Queensland (Gayiri country).

SwarmFarm builds small, lightweight robots that operate in 'swarms' or 'fleets' to enable new farming techniques that reduce pesticide and fertiliser usage and increase crop yields through sustainable farming practices.

"As farmers we are passionate about ensuring the future generations of farmers have a vibrant, economic, and sustainable future in the cropping industry," Andrew said.

"Current best practice farming systems are limited by large cumbersome farming equipment, and our robots enable new farming practices, or what we call 'next practice' techniques that are not possible on the back of a tractor.

"Key to our product is the SwarmConnect open developer ecosystem that gives other agtech developers and machinery manufacturers a pathway to deliver their technology to farmers as apps or attachments on board our robots."

The involvement with BRII has given SwarmFarm the opportunity to further develop their technology.

"As grain growers we are well aware of the challenges with spray drift," they said.

"Our technology utilises robots to make data-based decisions on spray applications, removing the stress and pressure on deciding when to start and stop pesticide applications, whilst maximising the available spray window.

"The opportunity to be involved in solving this issue, with seed funding from BRII, means we can accelerate the delivery of this technology and get it into the hands of farmers sooner."

The new technology will:

- Digitally obtain label conditions in a machine-readable format directly from QR codes on pesticide drums.
- Gather accurate data from a number of sources including weather data onboard the robot, fixed weather stations, weather forecasts, inversion stations, and information on the location of sensitive crops nearby the spray application.
- Make data-based decisions, without bias or misinterpretation, ensuring compliance to pesticide labels and best management spray application practices.
- Enable maximum utilisation of the available spray window every week through the use of different 'modes'. Sleep mode will engage when the weather is not suitable for spraying; auto wake up and return to spray when conditions are suitable; auto dock and refill when spraying for extended periods; and path replanning operations for avoiding downwind no spray zones when weather conditions change.

Jocie says they heard about BRII through CRDC R&D Manager Susan Maas.

"The BRII program is unique in that it funds you to complete an initial feasibility study before you progress onto developing a commercial solution to take to industry," Jocie said.

"The program is focused on solving real problems and supporting small business and start-ups to create commercial opportunities.

"Universities and research organisations are not eligible to apply, so this is genuine support of innovation and development of new ideas at the small business level, through to commercialisation.

"Having the CRDC and Susan involved throughout the project was super helpful and we were able to link up and collaborate with a lot of different partners across the challenge.

"As a result of these introductions, we have now engaged and are actively working with a number of these partners in the commercialisation of this project."

For more

SwarmFarm

www.swarmfarm.com

An atmosphere of innovation at LX

If you want innovation you need to create the space for it.

That's what LX CEO and creator Simon Blyth says of the Business Research and Innovation Initiative (BRII) challenge aiming to revolutionise agricultural spray application.

"This program and being a part of it has been absolutely fantastic," Simon said.

"CRDC and our key contact Susan Maas should be commended for bringing more visibility to the challenges they are trying to solve."

The LX innovation is the creation of a system called Maverick, a real-time spray application feedback system, which utilises artificial intelligence technology and augmented reality to help forecast spray conditions and the level of favourability or risk. The system includes existing LX-designed hardware and software, building on these to create an interface that primary producers would find intuitive and effective to use.

"Farmers are expected to do their best to pull so much information at each moment to make decisions, but the reality of this is that it can lead to errors," Simon says.

"We want to open the spraying window, not close it, and a more sophisticated understanding of spraying conditions may offer more opportunity to operate.

"This can be done with a broad range of sensors putting accurate, real-time data in the operator's hands and coupling it with our decision-making software."

LX is what is called a 'full stack' company because it produces everything from the electronic hardware and firmware, through to the cloud backend and software that users interact with. LX was started by Simon, who hails from a sheep and cattle property near Inverell in NSW. The team at LX specialise in Internet of Things (IoT) and electronic product development and have been designing for tech start-ups through to multi-nationals for over a decade.

The technology can be quickly retrofitted to any machine.

"We created a 'Lite', 'Standard' and 'Pro' version of Maverick, so there's an entry level available to any producer impacted by this industry-wide issue," Simon said.

"My thinking is that to maximise profitability of a new product you focus on the most lucrative section of the market: but to solve an industry problem you need mass adoption, so these versions needed to cater for operators at every level.

"The Lite version is the entry-level system, while our mid version takes in more data for example boom data, atmospheric data and plant stress, so it can fine tune the advisory service to the operator, and is capable of predicting events we need to avoid like inversions."

Simon said LX is changing the assumption that spraying is only a land-based activity, when in actuality we are mostly dealing with atmospheric data, so has drawn on flight technology and aeronautics for inspiration.

"While it is easy to see via GPS where you've been, it is hard to see 'atmospherically' and it's not very intuitive," Simon said.

"Using the flying analogy: we can pretty much fly in all weather, safely.

"But if we try to fly/navigate without the proper training and technology, flying is unsafe, and this can be applied to spray applications too.

"In the past we have not given farmers the tools to navigate this issue safely.

"We must fly, so we navigate to make people safe."

Simon says often when working on a product, we are "working and thinking in 10 years into the future – because it does take a lot of time to bring products to the market".

"So we think about what 2030 could look like. If you can't see the future well, you can't design products to suit it or they are outdated by the time they come to market," he said.

"It is great to see an industry like cotton dealing with this but also looking to the future."

For more
LX
www.lx-group.com.au

Making it to the top: supporting start-up innovation

The Australian newspaper launched the inaugural edition of *The List: 100 Innovators* this year, with start-up guru Anastasia Volkova coming in as number 1.

CRDC has been partnering with Anastasia and her start-up FluroSat (now Regrow Ag) since 2017, when it supported her through a series of start-up workshops allowing her to incubate and grow the project.

Since then, she's gone on to secure millions in investment to further develop the state-of-the-art remote sensing technology that allows farmers to measure crop health 'from the air'. With the acquisition of Dagan's soil modelling capability and combining it with FluroSat to create Regrow, there is an enhanced focus on sustainable agriculture by using scientifically vetted crop and soil models, connectivity to farm management platforms and terabytes of satellite imagery to support equitable ecosystem markets and programs.

Anastasia says to go far and achieve big things, you can't go alone, you need partners.

"CRDC and start-up incubator X-Lab have been invaluable in connecting us with government officials and other ag organisations which has led us to where we are today," Anastasia said.

"We have attracted numerous partners along our journey and some of them have been supportive ever since, some have only stayed a certain time.

"This is inevitable and a good founder should seek to always have a long-term perspective of any partnership in mind to pick the right partners along the way."

Of being named number one in *The Australian's* Top 100 Innovators list, Anastasia said consideration of the judging panel made the honour even

greater. The panel included former Netflix chief marketer Jackie Lee-Joe, Engineers Australia chief engineer Jane MacMaster, Cicada Innovations CEO Sally-Ann Williams, Atlassian work futurist Dominic Price and UTS innovation advisor Roy Green, among others.

"I'm glad that I didn't actually know they were evaluating me as an innovator on that list, so I was simply focused on my work and hoping to make the biggest impact I can with it," Anastasia said.

"After finding out about the ranking, I felt honoured to be included and inspired by other innovators on the list!"

We hear the word 'innovative' used a lot – so how does Australia's top innovator describe what this word means and how it's evolving?

"I think of innovation as the creation of something where there was nothing - market, solution, product - anything can be innovative if it solves a problem or offers opportunities that haven't been offered before," Anastasia said.

"At the very beginning I thought of innovation as a product or service that does something nothing else is capable of. I realised quite quickly though that such innovative products require even more extraordinary business models and distribution channels.

"You can't launch innovation without an ecosystem for it to go to market with."

Anastasia is no stranger to the start-up community, so with this experience, *Spotlight* asked what advice she has for those starting out.

"My journey began long time ago, when I met some early start-up founders. They came from very different walks of life and ran very different, often unexpected businesses.

"I loved that they identified and were solving a problem than no one has solved yet, and they could choose their path as to how to achieve their goal, how to find or develop a solution.

"I took the opportunity to learn from these founders by working alongside them in their businesses to learn 'the start-up kitchen' and how to operate one.

"My advice therefore to those starting out and wanting to learn how to develop a business is to find a way to make that learning a job. For me it was extremely satisfying!"

The Australian says the Top 100 list celebrates and highlights the future-focused leaders, ingenuity and products that are 'set to make Australia an innovation nation'. The list covers categories including energy, technology, education, medicine, agriculture, food, sport and the arts.

The list is curated and edited by *The Australian's* technology editor David Swan who said with a backdrop of the pandemic, a lot of Australian start-ups are now worth more than a billion dollars. A couple of years ago, there were only one or two, now there are over 20.

"It feels like a real moment in time for innovation in Australia," he said.

When asked what they were looking for and what disqualified people from the list, David said they were looking for the unique.

"I think that there are a lot of copycat ideas around. We wanted to highlight the fresh sort of underdog companies who were the new kids on the block."

For more
Regrow Ag
www.regrow.ag

MELANIE JENSON

Going beyond reporting: industry's call to action

Since becoming the first Australian agricultural industry to benchmark its environmental impacts via an independent audit in the early 1990s, the Australian cotton industry has been working to continually improve its sustainability performance.

The creation of the PLANET. PEOPLE. PADDOCK. Sustainability Framework allows the industry to better coordinate existing work to achieve targeted sustainability outcomes.

Led by CRDC and Cotton Australia through the Sustainability Working Group, the framework is the culmination of decades of research, development and extension to improve cotton production practices.

The industry's first environmental audit was conducted in 1991. At that time, the Australian cotton industry was the first cotton industry in the world to conduct a full, independent environmental audit of its operations to benchmark environmental sustainability performance and impact and devise industry-wide measures for improvement.

A second audit in 2003 showed major improvements and made recommendations for additional work primarily in the areas of water use efficiency and biodiversity.

The third independent environmental assessment in 2012 found that the Australian cotton industry, through its research and development investments and effective interrelationships between industry research institutions, grower organisations, commercial service providers and growers themselves, had been substantially transformed since 2003.

CRDC General Manager R&D Investment, Allan Williams, has a long history working in sustainability and led the development of the BMP program in the 1990s.

"Importantly for the Australian cotton industry, we scientifically measure change over time," Allan said.

"We currently conduct environmental assessments every decade and report our progress to stakeholders via formal Sustainability Reports.

"On the back of the 2012 environmental

assessment, the Australian industry committed to expanding its focus beyond environmental sustainability by producing a Sustainability Report at least every five years that also covers social and economic sustainability.

"In recent years we have gone beyond just reporting our impacts, to actively seeking to understand what is important to the industry and its stakeholders, what we should be aiming to achieve, and what we need to do to get there.

"The diverse range of issues that are relevant to the industry's long-term sustainability, and the even-more diverse range of stakeholders with an interest in how sustainability efforts and credentials requires a plan."

Sustainability expert Chris Cosgrove is working with industry to develop and implement the sustainability framework and said it comes from a need to go beyond reporting on sustainability and move towards science-based outcomes that meet the expectations of stakeholders inside and outside the industry.

"Companies up and down the cotton value chain have their own individual sustainability measures and frameworks, but this framework covers cotton farms only – it's an obvious place for CRDC and Cotton Australia to focus," Chris said.

"PLANET. PEOPLE. PADDOCK. is not a compulsory standard or a brand and doesn't replace any of the market-based sustainability initiatives many innovative people in the cotton industry are working on.

"It provides a framework to help coordinate research, extension and adoption the entire industry can benefit from, and to measure industry-scale sustainability outcomes to demonstrate our accountability."

Setting targets, hitting targets

Where baseline data is in place, the industry has set draft targets for 2024 and 2029. Using past trends as a guide, these draft targets are designed to be achievable but challenging, and as much as possible are in line with the United Nations Sustainable Development Goals (SDGs).

The SDGs are seen to provide a blueprint for what the world needs to be achieving in 17 sustainability areas by 2030; demonstrating the cotton industry is playing its part to meet those goals means targets and actions are not arbitrary and allows the cotton industry to talk in the same language as the many stakeholders past the farm gate who use the SDGs widely.

In some of our sustainability topics – such as biodiversity, greenhouse gas emissions and soil health – accurate industry-scale baseline data and/or agreed metrics and methodologies for measuring change are missing. The Sustainability Working Group is very mindful of the fact that cotton farmers

Still leading the way in independent assessments

The Australian cotton industry has commissioned an independent expert to conduct the fourth assessment of its environmental performance.

Cotton became the first major Australian agricultural industry to seek a full external examination of its environmental performance when it commissioned a third-party environmental audit in 1991.

"This marked the first cotton-wide commitment to improved sustainability," CRDC Natural Resource Management R&D Manager Stacey Vogel says.

"Further assessments in 2003 and 2012 have showcased achievements and driven further improvements, and the industry has committed to undertake assessments every 10 years."

As per this commitment, CRDC, Cotton Australia and the industry's Sustainability Working Group are supporting the fourth environmental assessment of the Australian cotton industry. CRDC has commissioned respected global firm GHD to conduct the assessment that will do three things:

1. Assess the industry's response to the third environmental assessment recommendations.
2. Identify current and emerging environmental issues and their implications for the industry and on-farm management.
3. Assess current industry action on environmental issues in light of issues identified in the first two steps. This will include:
   - Impact – if the industry's on-farm environmental practices and outcomes are in line with current and future expectations and trends.
   - Responsiveness – how well industry bodies, *my*BMP, CottonInfo and sustainability programs are aligned, and how well the industry is able to identify and respond to environmental issues.

MELANIE JENSON

Cotton growers are being urged to take part in the industry's fourth independent environmental assessment, which makes it unique in Australian agriculture.

The assessment will involve a combination of desktop research, interviews with industry stakeholders, and on-farm visits to assess environmental practices and impacts. Cotton growers are invited to be involved, with interviews running from December 2021 through to June 2022.

"Consultants will be visiting farms of all sizes across all growing regions to form an assessment of the overall environmental performance of the industry," Stacey said.

"This is not an audit, there won't be any judgement made of individual farms, growers and properties won't be identified, and there is no preparation needed to host a visit.

"The assessment is extremely important to the industry – it allows us to understand what we're doing well but importantly what we can do better and how we can do it.

"The GHD team will work with CRDC and Cotton Australia to arrange on-farm visits at times that will be least disruptive."

A report will be released in late 2022 and the findings will help inform the industry's sustainability efforts, driven by CRDC, Cotton Australia and the Sustainability Working Group under the PLANET. PEOPLE. PADDOCK Sustainability Framework.

For more

PLANET. PEOPLE. PADDOCK Sustainability Framework

www.crdc.com.au/for-growers/sustainability

produce a range of commodities, and want to ensure that the same metrics are used across the farming operation irrespective of the product, be it cotton, beef or wheat.

But while targets are yet to be finalised, the industry is not waiting to act: work to reduce emissions, to increase carbon stored in soil and vegetation, to preserve and enhance biodiversity, and to improve soil health is ongoing.

"One thing that setting targets does is focus attention on a concrete outcome we can all work towards," Allan said.

"The industry has been delivering significant improvement like water use efficiency and insecticide reduction over the past 30 years because we have identified a need to improve and provide clear research and adoption pathways to drive change.

"The industry's track record gives us confidence we can continue to see dramatic improvement in new areas we identify."

This is particularly the case for reducing emissions from nitrogen fertiliser use.

"We are confident, through our vigorous research into nitrogen over decades, and new research through the Rural R&D for Profit's cross-sector More Profit from Nitrogen Program (led by CRDC) that we have the tools to tick this target off our list as well," Allan said.

"Setting targets focuses attention on a concrete outcome we can all work towards.

"This five-year research program has improved our understanding of the intricate relationship between nitrogen source and irrigation management allowing the industry to refine the nitrogen management strategies in the Australian Cotton Production Manual.

"We are now at the stage where we need to make our growers aware of what this research is telling us and helping put it into practice.

"Importantly, through our existing industry programs such as *my*BMP, CottonInfo and focused R&D investments, we have the tools to do this.

"Sustainability isn't something new that's bolted on to create more work for everyone – it's embedded into our existing programs."

With targets being firmed up, attention will now be moving to ensuring growers know what they can do to contribute to industry level targets.

Five year targets	What growers can do
WATER 12.5% increase in water use efficiency	Continue adoption of practices to reduce losses in storage and transmission and improve application efficiency.
PESTICIDES 5% reduction in environmental impact	Continue adoption of new pest control tools, including new technologies, targeted application, and new crop protection methods.
GREENHOUSE GAS EMISSIONS Target to be set. Ambition: contribute to a climate-neutral world.	Improve nitrogen use efficiency (fertiliser accounts for almost 60% of cotton production emissions, and increased from 2014 to 2019) Reduce electricity and energy from fossil fuels Keep carbon in the soil and vegetation on cotton farms.
BIODIVERSITY Target to be set. Goal: improve biodiversity condition on farms and across the cotton landscape.	Avoid habitat loss Protect and restore biodiversity on cotton farms through key practices such as fencing, pest control and revegetation.
SOIL HEALTH Target to be set. Goal: deliver sustained cotton productivity growth by improving soil health	Protect soil habitat: maximise soil cover, minimise soil disturbance Feed soil organisms: maximise living roots, maximise biodiversity.

Gaining an outside perspective

The Australian cotton industry is looking to groups outside the industry for input into its sustainability framework, PLANET. PEOPLE. PADDOCK.

The Australian Cotton Sustainability Reference Group (ACSRG) will provide a formal platform to help the industry understand stakeholder expectations and improve its sustainability performance. The group's first meeting was held in early November. The ACSRG involves representatives from retail brands, environmental organisations, First Nations, governments, merchants, regulators, social organisations and health and safety, as well as growers, researchers, input providers and other broadacre agriculture sustainability frameworks.

PLANET. PEOPLE. PADDOCK. is managed by an industry Sustainability Working Group, comprised of representatives from Cotton Australia, CRDC, CottonInfo, Australian Cotton Shippers and cotton growers. Feedback from ACSRG will be used by the Sustainability Working Group in a two-way process for exchange of information to support cotton industry efforts to understand stakeholder expectations, monitor material sustainability topics, and guide reporting to stakeholders.

"This group will guide the Australian cotton industry's sustainability decision-making," CRDC General Manager R&D Investment Allan Williams said.

"Our aspiration is to deepen the participation level of the ACSRG over time, to more actively involve or partner with ACSRG members in decision-making through a permanent forum.

"We're looking forward to working with internal and external industry stakeholders to support cotton industry efforts to understand stakeholder expectations and improve sustainability performance."

As a permanent group, ACSRG will provide a platform for the Australian cotton industry to communicate to our stakeholders our progress, barriers to progress and key R&D and grower experiences.

CRDC Executive Director Dr Ian Taylor said the group is one part of the work being done by the industry to make evidence-based decisions on sustainability progress and investments.

"Just as important is gathering stakeholder feedback on our sustainability management and pathways," Ian said.

"This group also has the ability to identify non-material, or emerging risks and opportunities for Australian cotton.

"It also gives us the opportunity to discuss and assess stakeholder perceptions raised in surveys, materiality assessments and other processes."

MELANIE JENSON

The cotton industry works closely with retailers and brands, through engagement with growers and researchers. Pictured is Cotton Australia's Brooke Summers and representatives from some of Australia's leading brands on-farm at Auscott Narrabri (Kamilaroi country).

Planet. People. Paddock

PLANET. PEOPLE. PADDOCK. is the Australian cotton industry's sustainability framework. It has been created to guide work to:

- Set sustainability targets in the areas most important to industry and stakeholders
- Coordinate a whole-of-industry strategy to achieve these targets
- Engage effectively with stakeholders on actions and progress.

PLANET. PEOPLE. PADDOCK. is currently targeted at on-farm cotton production. It is not a compulsory standard or a brand; it provides a framework for the entire industry to benefit from continually improving sustainability performance. Individual businesses across the value chain will continue to deliver their own tailored sustainability plans and initiatives as they see fit.

Through a process of consultation and review, nine topics have been assessed as being most important to customers, cotton growers and other stakeholders.

- PLANET: Water, greenhouse gas emissions, pesticides, biodiversity, soil health
- PEOPLE: Workplace, wellbeing
- PADDOCK: Productivity, profitability.

AUSTRALIAN COTTON SUSTAINABILITY FRAMEWORK
PLANET. PEOPLE. PADDOCK.

Country Road goes on-farm for biodiversity

Unique partnerships are being formed to address biodiversity on cotton farms.

Over the past 12 months a partnership between Landcare Australia, Country Road and the cotton industry has resulted in 34 hectares of biodiversity improvements in the Namoi Valley (Kamilaroi country) in North-West NSW.

Two well-known cotton farming families, the Kahls and Watsons have so far been involved in the project, funded by a corporate contribution and the sale of Verified Australian Cotton Heritage Sweats. Country Road has committed $600,000 over three years.

"It's brilliant to see the impact this partnership has had in just one year," said Country Road Managing Director Elle Roseby.

"Country Road is so proud to support the great work being undertaken by local cotton farmers to leave a positive biodiversity legacy."

The project has seen weeks of restoration work including planting thousands of native trees and grasses on the Namoi River. Landcare Australia CEO Dr Shane Norrish said the organisation was very proud of the achievements of this partnership to date.

"The project will assist to increase biodiversity, restore local ecosystems, protect soil health, provide natural habitats for threatened species, improve water quality and contribute to the sustainable management and productivity of the landscape," Shane said.

The Kahl family are working with the cotton industry, Country Road and Landcare to rehabilitate a section of the Namoi River.

The work draws on a 2019 CRDC project that mapped biodiversity in Australian cotton landscapes, identified threatened and endangered species and recommended ways to protect them.

The first project kicked off at the Kahl's family farm near Wee Waa where part of the Namoi River is being revegetated and stock excluded to increase habitat and shelter for native animals, reduce erosion and improve water quality.

The second project is with the Watson family at 'Merriendi' near Boggabri where 3.7 kilometres of trees and grasses are being planted to improve ecology along the Namoi River on a newly acquired property. Plans are also underway for projects three, four and five which will all be located in priority biodiversity zones.

The Australian cotton industry is providing additional support through CRDC and the Australian Government's National Landcare Program Smart Farming Partnership Initiative's *Cotton Landcare Tech Innovations 2021 project.*

"This includes a five-hectare research trial by the University of New England to investigate which revegetation methods have the greatest survival rates on floodplain soils, drone plantings and a native plant propagation training workshop that's been held with Kamilaroi traditional owners," CRDC Natural Resource Management R&D Manager and CottonInfo Biodiversity Technical Lead Stacey Vogel said.

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

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

"These projects are providing much needed funding for farmers to undertake important biodiversity works.

"Using research undertaken by CRDC we can prioritise where and how we restore biodiversity to get the best outcome for threatened and iconic species found in cotton landscapes.

"The partnership not only provides significant funds, it showcases the benefits of improving biodiversity to other cotton farmers and demonstrates to the non-agricultural community, such as Country Road customers, some of the positive ways cotton farmers are managing biodiversity."

Improvements to date

- Hectares repaired via weed control and planting native species: 34
- Number of tree planting days: 20
- Kilometres of river frontage improved: 6.5
- Country Road have raised $200,000
- Habitat enhanced for threatened species like the koala, large-eared pied Bat and barking owl

For more

Country Road

www.countryroad.com.au/man-our-world-edit-the-biodiversity-project/

We need to talk about 'N'

Results from the 2019 Sustainability Report show that while water and pesticide use have decreased, the volume of greenhouse gases emitted to grow, gin and transport a bale of irrigated cotton increased by 12.6 per cent over the previous five years.

At a glance

- Reducing greenhouse gas emissions associated with cotton production is one of the most important sustainability issues for cotton customers.
- From 2014 to 2019 greenhouse gas emissions per bale increased; we need urgent action to reduce emissions.
- Fertilisers contribute about 60% of the greenhouse gases to grow, gin and move to port a bale of cotton, so it is an obvious priority for reducing emissions.
- On-farm greenhouse gas emissions are dominated by emissions of nitrous oxide.
- Increasing N above the crop's needs does not increase yield. Research shows it can cause economic loss through extra defoliations and lint quality discounts.

The increase in emissions is mainly due to a decrease in nitrogen use efficiency (NUE) on some farms.

Cotton production is responsible for about 0.2 per cent of Australia's greenhouse emissions. The main sources of emissions to grow a bale of cotton and ship it to port (from 2014-19) were nitrogenous fertiliser (58 per cent), on-farm fuel (15 per cent), and ginning energy (10 per cent).

"It is very clear that every sector of the economy is expected to urgently reduce its contribution to climate change, and the cotton industry is no different," CRDC General Manager R&D Investment Allan Williams said.

"We need to reduce the emissions released in cotton production, while sustaining carbon in the soil and vegetation on cotton farms.

"Reducing emissions from fuel and electricity is important, but with fertiliser being the major source of emissions from cotton production, reducing the amount of fertiliser applied and improving nitrogen use efficiency is an obvious priority.

"That is why research and adoption of better nitrogen use strategies is so important to the industry, and the More Profit from Nitrogen project is an important part of that research and adoption."

Past studies across all growing regions have shown that conversion of fertiliser nitrogen (N) into lint is not occurring uniformly at N application rates greater than 200 to 240 kg N/ha. This indicates that factors other than N availability may be limiting yield, and that the observed nitrogen fertiliser-use efficiency (NFUE) values may be caused by subsoil

constraints or irrigation timing and application, for example.

In 2018 *Spotlight* reported Dr Ben MacDonald from CSIRO saying that 'gains in NUE will be made through improved N fertiliser application timing, better targeting the amount of fertiliser applied for the expected yield, and improved soil N management'. He said there is also a need to improve the ability and confidence of growers to estimate the contribution of soil N mineralisation to the crop N budget.

Cross-industry research focus

One of the largest nitrogen-focused projects across agriculture has addressed these aspects of N management. The Rural R&D for Profit's More Profit from Nitrogen (MPfN) was a five-year project managed by CRDC, in partnership with Dairy Australia, Sugar Research Australia and Hort Innovation – Australia's four most intensive users of nitrogenous fertiliser.

Comprehensive research and development was conducted to increase NUE across the four sectors whilst improving profitable and sustainable use.

By better understanding the influence of contributing factors upon NUE in farming systems, MPfN has generated greater knowledge and understanding of how to best manage N.
This includes:

- the interplay of factors to optimise N formulation, rate and timing across industries, farming regions and irrigated/non-irrigated situations;
- the contribution (quantifying rate and timing) of mineralisation to crop or pasture N budgets; and
- how enhanced efficiency fertiliser (EEF) formulations can better match a crop or pasture's specific N requirements.

Cotton-industry specific projects looked at increasing understanding of the influence of rainfall/irrigation wet-dry cycles on mineralising soil organic N into plant available forms and trial of a potentially available organic N rapid soil test, with work undertaken with University of Queensland on the Darling Downs (Bigambul country).

NSW DPI's Dr Graeme Schwenke led research which encompassed the intricate relationship between N supplied through soil mineralised and fertiliser sources, phosphorus (P) supply, fertiliser placement and timing and irrigation strategy to reduce N losses, achieve greater NUE and improve P soil nutrition.

The effects of N fertiliser timing, product and application strategies on irrigated cotton yields and soil N movement were explored, as was matching N plant demand using enhanced efficiency fertilisers. The research also looked at the implications for N run-off in irrigated water.

Graeme says that even before MPfN, research by Queensland University of Technology's Climate Change Professor Peter Grace and others found that the rate of nitrous oxide emissions turns from linear to exponential when N fertiliser is applied beyond the plant's needs.

> ***"This tells us that NUE is going down. The first thing you can do about it is bring the rate back to what the plant actually needs."***

"Industry surveys and research showed N rates were going up every year, yet this wasn't translating to increased yield," he said.

"This tells us that NUE is going down. The first thing you can do about it is bring the rate back to what the plant actually needs.

"Responses to N fertiliser products and application strategies were difficult to observe in on-farm trial work where fields had high residual soil N that was not being accounted for in N budgets."

R&D has created tools for calculating N rates, which are freely available to growers. Graeme says the next challenge for research was to optimise efficiency using fertiliser N more strategically for crop needs rather than a blanket approach.

Nitrogen that is excess to plant needs either runs-off in irrigation water, undergoes denitrification to di-nitrogen and nitrous oxide gases, or is left behind in the soil. Residual soil N is available to a subsequent crop, but is also subject to potential further losses

"In no year of a four-year trial did excess nitrogen give us extra yield," Graeme said.

"It actually causes more drawbacks than positives, in terms of economics and crop management.

"It can lead to the cost of applying growth regulants and potentially increase irrigation requirements.

"We must remember that the loss of nitrogen into the environment is a major consideration for the industry, in light of the Sustainability Report that our NUE has decreased.

"Our social licence and the wellbeing of our regions and its people are paramount."

The combined research outcomes of the MPfN cotton projects have been integrated into the nutrition chapter of the *Australian Cotton Production Manual* and *NUTRIpak*.

For more

More Profit from Nitrogen

www.crdc.com.au/more-profit-nitrogen

Graham's got the goods on matching nitrogen to plant needs

For Central Queensland (Gayiri country) cotton grower Graham Volck and his son Ollie, nutrition is about matching nitrogen (N) to target yields, not just applying 'more' or 'less' N.

To do this, he increased soil testing from once to three times per year to better understand N movements before, during and after the cotton crop. Using yield maps and adding an in-crop soil test gives him confidence there is sufficient N in the soil for plant needs and that his aim of maximising yield is being met. Guidelines from the *my*BMP check level: 2 are also used as a resource and followed to ensure best management practice. He's now eliminated an in-crop side dressing by doing in-crop and post-season soil tests to match N to target yield.

"Make sure you have an adviser who knows plant nutrition is critical to interpret the soil test," Graham says.

"Start small if you want: if the in-crop tests show you have sufficient N but you just don't want to risk not making that extra application, start with a portion of the crop and trial the results."

Importantly, when the right rate of N is being applied, other constraints to yield can be identified. These include irrigation management, seasonal conditions, soil type, and soil condition. These yield-limiting issues need to be identified and managed. When they are all managed together, yield will increase and so will N use efficiency (NUE). Graham's key steps are:

- Study yield maps. N tends to track from the head ditch to tail drain with irrigations. Yield maps show if there any differences down rows and across the field. The aim is for uniformity of yield, rather than having an N deficiency at the head and lush growth needing defoliation at the tail end. High yield comes from having consistent N down and across the field.
- Soil tests for nutrient budget. This involves two soil tests: a comprehensive pre-planting soil analysis is used for the nutrient budget to work out how much of each nutrient is needed for the target yield. Then, an in-crop nitrate test shows if existing soil N is sufficient.
- Interpret the in-crop test. Work with an adviser who understands plant nutrition to decide if N is sufficient. The more tests you do over time, the more confidence you will have in decision-making.
- Soil test to validate the numbers. A post-crop soil nitrate test is done to confirm nutrition assumptions. If there is N in the soil, the assumptions were correct and yield wasn't limited by lack of N.

There's also an economic benefit to growers.

For the cost of two nitrate soil tests, at $30 per test, this equates to about $0.60/ha for a test done every 100ha. With the benefit of then removing one side dressing, Graham can save $68-$80/ha in fertiliser and $10-$12/ha in application.

"The money saved mightn't seem much in the total cost of cotton production, but all the little costs add up," Graham said.

"I think of it in terms of holidays: if I spend an extra $80/ha on 500ha for a side dressing that will have no impact on yield, that's a $40,000 family holiday I've just spent.

"That would have been a pretty good holiday and for about 60 cents/ha, I can save that money."

RENEE ANDERSON

Ollie Volck among a healthy looking crop on their Central Queensland farm, where nitrogen use efficiency is a focus.

TRAIL puts grower on his path

A Central Queensland cotton grower says the leadership road makes for one amazing journey.

Aaron Kiely of Emerald (Gayiri country) participated in the Australian Rural Leadership Foundation's TRAIL program in 2020 with support from CRDC and describes the experience as 'life changing'.

It wasn't the first leadership course he's participated in. Aaron's journey began in 2016 when he joined the Future Cotton Leaders (AFCL), which he credits for setting him on a path to share his passion for agriculture and what being a leader can offer others. He also participated in Cotton Australia's Cotton 20 initiative and is now a mentor for others in the course.

Of his first experience, with AFCL, he says he "went down to the course and was a bit nervous and not sure if it was for me".

"I had had some leadership experience as vice president of local cotton grower association (CGA) at the time, but what AFCL course facilitator Jo Eady did for my confidence and enthusiasm to keep moving forward is still with me today," he told *Spotlight*.

Aaron's hunger for leadership skills and knowledge led him to TRAIL.

"Being sponsored by CRDC to attend this program was an amazing opportunity," he said, "It was life changing.

"It's also an honour to be sponsored by your industry, it encourages you to do your best."

And the success is as much about the people in the group at the course content.

"The group of people I was with, from different groups and ag sectors teaches you so much, the personalities that are in these groups help you grow.

"I'm still connected to those other participants, from live export, agribusiness, lot-feeders, fine wool growers, fisheries and banking, from places as remote as Thursday Island, and they are achieving in ways they didn't ever expect.

"Being a part of the alumni is so incredible, connecting with those that have done it before you and after you – it's like having mentors mentor each other."

TRAIL was confidence-building and offered an important opportunity for self-reflection.

"It definitely puts you out of your comfort zone, and that's where you need to be to grow," Aaron said.

"If you are willing to be open and change these courses are invaluable, but you have to put yourself out there and do the work on yourself, which is where the self-reflection comes in and being more self-aware."

Aaron feels that there is a need to build more medium and high-level leadership in the industry.

"It's about building continued leadership within our industry, and TRAIL is an opportunity to do that," he said.

"I see participation in leadership programs as enabling me to give back to industry and the people

around me, and using what I've learned about myself to help others grow.

"It's given me the confidence to stand up and say what I believe in and have the confidence to tell my story and the industry's story."

Aaron sits on two advisory panels, Central Highland Development Corporation's (CHCD) agtech panel and the Cotton Australia/CRDC research advisory panel.

In addition, in 2020 Aaron was one of 10 growers CRDC supported to attend evokeAG. and says it was another integral moment. With a focus on agriculture, innovation and technology, the conference was right up Aaron's alley. He has a love of technology and his built his own mobile network of sensors and rain gauges on his farm to monitor irrigation and fine tune his system (stay tuned for another story on Aaron's innovative system).

It was after evokeAG. he agreed to be a part of the agtech panel.

"That was a great experience and gave me the drive to further the journey," he said.

"I went on the CHDC agtech panel and the next year ran the 'Irrigation big day out' along with fellow AFCL participant Simon Green in Emerald.

"We got people from agtech on board who were outside the industry, so it was a new way of looking at a field day. We also had a coffee van on farm, which was a first!

"After that I was invited to sit on the research advisory panel."

Aaron has been a part of his CGA for 10 years now, and after four years as president, has this year stepped down.

In typical fashion before he stepped down, Aaron organised a tour which saw growers from the Central Highlands and Dawson Valley regions travel to St George, connecting growers and CGAs. Through a CRDC Grassroots Grant, Aaron along with Andrew French (Dawson Valley CGA President)

Aaron Kiely says being a part of industry-supported participation in programs such as TRAIL is life-changing.

and the Cotton Australia Regional Managers organised farm tours to look at infrastructure, irrigation and technology, and to connect with a new group of people from the region.

The group also visited Dirranbandi, meeting growers in the field and at dinners with Dirranbandi, St George and Mungindi CGAs.

"I'll still be involved in the CGA here, but I want to focus on other things, and me stepping down makes room for others to have opportunity in leadership roles," he said.

"Above all else, it needs to be noted that committing to these leadership roles take time away from my business, family and other support networks, I am so very thankful for their support and encouragement to help me to achieve my goals.

CRDC will be supporting two developing cotton industry leaders to participate in the Australian Rural Leadership Foundation's TRAIL program in 2022.

"If you are on the fence and not sure if TRAIL is for you I encourage you to step out of your comfort zone and give it a go, you will not regret it!" said Aaron.

For more
Aaron Kiely
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Keen to see where TRAIL leads you?

The Australian Rural Leadership Foundation's TRAIL program is a cross-sector, challenge-based leadership program for Australia's emerging rural leaders.

The program takes diverse people from different occupations, communities and backgrounds and expands their leadership skills.

TRAIL will be delivered from March 10 to 16 in 2022 in Canberra and regional NSW and CRDC is inviting applications for participation.

"We'd love to hear from people interested in attending this life-changing course," CRDC's Executive Director and ARLF Alumni, Dr Ian Taylor said.

"We understand the need to help future leaders develop their skills and roles in the industry, which is of such benefit to the individual, the communities and the wider cotton industry."

Those interested are encouraged to email research@crdc.com.au.

For more
Australian Rural Leadership Foundation
https://rural-leaders.org.au/programs/trail-emerging-leaders/

Unlocking the potential of Central Queensland an industry success

The ongoing rise of cotton yields is one of the major achievements of the Australian cotton industry over the last 30 years. These gains, well documented by CSIRO studies, have been achieved through the interaction of improved cultivars and more targeted management practices.

However, in Central Queensland (CQ – Gayiri country), yields remained largely stagnant and became more variable following the uptake of Bollgard II in 2005 (Figure 1).

A collaborative investigation of potential causes by QLD DAF and CRDC led by Dr Paul Grundy found that CQ yields were routinely stymied by weather events such as humid heatwaves, cloudiness, intense rainfall and summer cyclones – a consequence of the region's subtropical location east of the Great Dividing Range.

An analysis by CSIRO's Dr Stephen Yeates of CQ weather records coupled with an understanding of the cotton plant's response to climatic factors indicated that spring to early summer was a more optimal period for flowering and boll maturation. This period has higher (and less variable) solar radiation, fewer temperature extremes and a lower

Dr Paul Grundy, along with associates from QLD DAF and CSIRO have deciphered the puzzle of how cotton can fit successfully into the climate of Central Queensland, which has resulted in yields above the averages of those in well-established growing regions.

risk of monsoonal rainfall.

Sowing during late winter (August) would synchronise boll setting with this period, but a significant unknown was whether crop establishment would be successful when accepted industry practice was to avoid sowing during periods of low temperature. With an average of 23 nights below 12° (10 of these well below 8°C), August sowing appeared to be a risky proposition.

Subsequent research demonstrated establishment to be reliable, primarily due to the region's high solar radiation that solarised the soil and rapidly increased daytime temperatures, compared with southerly locations during August. Flowering about two to three weeks earlier (very late October) enabled August-sown crops to complete cut-out prior to the summer solstice and reduced crop exposure during boll filling to the

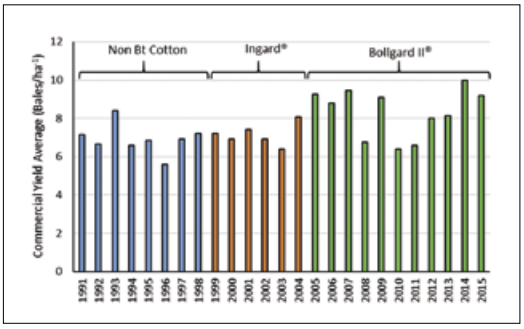

Figure 1. Commercial yield average for subtropical CQ (Emerald – Gayiri country) from 1991–2015. Yield data and reports of weather-related crop impacts sourced from Australian Cottongrower Cotton Yearbook editions 1991-2015.

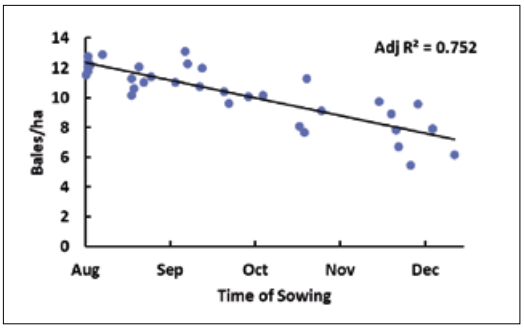

Figure 2. The relationship between sowing day (spanning 1 August to 31 December) and lint yield picked from commercial fields selected at sowing for benchmarking. Depicted yields represent commercially-ginned lint yield kg ÷ the field unit area.

hot days, warm nights, prolonged cloudiness and rainfall that increases from late-December.

Improved growth rate and reduced stress-related fruit shedding enabled higher yields. The risk of wet picking – the other key risk for CQ cotton production – remained but was comparably less than for spring-sown crops, with the earlier picking minimising late summer exposure (when monsoon influences peak).

Research found that August sowing did not hinder crop production and enabled up to 40 percent higher yields (10.2-14.6 bales/ha) than traditional spring sowing (9.0-9.6 bales/ha). Importantly, the lowest August-sown yields were similar to the recent five-year industry average for irrigated cotton (10.9bales/ha) and well exceeded historical CQ production records (Figure 1).

The planting window flexibility enabled by Bollgard 3's introduction in 2016 provided an opportunity for researchers and industry to benchmark the performance of crops sown from August to December under commercial conditions.

Measurement of more than 30 crops over four years clearly validated the superiority of earlier versus later sowing (Figure 2). Put simply, the earliest sown crops produced the most biomass with the highest harvest index and least variability compared with later sowing dates. While late sowing during November and December avoids the risk of rainfall during picking, the flowering of these crops coincides with mid to late summer heat, cloud and rainfall that induces fruit shedding, with compensation requiring extended crop period.

For the latest sown crops, extending the season length is difficult due to declining daylength and temperature.

Late May-sown cotton 10 weeks after sowing.

GAIL SPARGO

Is that the end of the early sowing story?

No, far from it, it's only the beginning. While August-sowing has increased yield, defoliation and picking coincides with January, the second wettest month for CQ.

Dr Paul Grundy asked the question: 'What if planting even earlier could maintain the yield advantage but shift defoliation and picking into December and very early January to avoid monsoon-influenced rainfall for most seasons?'

Commercial scale research is now underway as part of a QLD DAF and CRDC project to investigate late Autumn or early winter sowing in CQ. The aim is for cotton to square during September and flower by early October, with the trials this season so far having done exactly that.

This takes advantage of rapidly lengthening days and favourable temperatures, and targets picking by early January. Conducted under a strict AVPMA permit, this year's experiment is comparing late May, mid-June and early August sowing in a replicated trial spanning 50 hectares. It is not clear whether this will be a viable option for CQ in the short term, however the research will build on fundamentals developed in earlier projects and is expected to inform thinking for CQ as well as other regions, especially for future climate scenarios.

A key focus for this research is to inform future resistance management planning for Bt cotton that may enable the adoption of alternative production tactics.

An independent qualitative and quantitative impact assessment of this CRDC investment showed a high returns to growers from this R&D project. Helping CQ growers overcome climate challenges by changing their cotton season, has resulted in yield increases of 40 per cent. The project's benefit-cost ratio is 17.1 - a $17.10 benefit to growers for every $1 invested.

As part of this objective, structured sampling of *Helicoverpa* is being undertaken in the unsprayed cotton refuge together with tissue sampling of the various sowing time treatments. This will provide information regarding Bt expression and inform resistance management modelling assumptions.

What about 'walk-away', 'grown-on', ratoon cotton and that 20-bale crop?

Reports of a 20-bale crop harvested in CQ in April this year certainly got people's attention, but is this possible year-in, year-out?

The lack of irrigation allocation from Fairbairn Dam (still at 16 percent at time of print) has challenged growers during the last three seasons. Faced with limited water, various approaches to growing a viable cotton crop have been tried.

Walk-away cotton describes establishing a crop early in the planting window and not irrigating again until rainfall and/or in-season temporary water allocation becomes available. It is a tactic used by some growers around St George (Waka Waka country) that has also found favour with growers in CQ.

In 2019-20, January rainfall and temporary allocation enabled successful walk-away crops to be grown. In the case of high-yielding walk-away crops, extended flowering has underpinned yield potential. In the 20-21 season, crop response has been more variable depending on the timing and amount of in-crop rainfall and availability of temporary irrigation allocation.

Reports from CQ of a 19 to 20 bale/ha crop picked in April 2021 captured the attention of many in the industry. This crop was planted with the prospect of limited allocation in early August and received five (including watering up) stretched irrigations up until December at which point the crop cut-out.

Upper catchment storm rain inflows enabled re-commencement of irrigation during January with two more irrigations applied between then and March. An extension of flowering and production of

additional fruiting branches in addition to earlier set bolls was the driver of the very high yield.

Grown-on cotton is a tactic that some growers have used to overcome pre-defoliation rainfall-related yield loss. Initially considered risky from the perspective of secondary pest outbreaks or repeat rainfall, the tactic has been used successfully over a number of years with positive outcomes.

The success of these crops is underpinned by the ability to produce four to seven bales via canopy regrowth, recouping yield loss but importantly diluting the contribution of weather-damaged lint from bolls in the lower canopy, thus improving overall quality. Grown-on crops during the previous two seasons enabled yields of 12 to 20 bales per hectare (albeit on limited crop area). These were grown on due to variable water availability rather than weathering losses.

Given the risk associated with repeat rainfall, a small trial was conducted under permit to investigate whether August planted cotton picked in late January, and then ratooned for a second cycle of flowering for picking at the same time as the grown-on cotton (May) could have similar potential.

Over two seasons around 18 to 19 bales of cotton were collectively produced with this ratoon method. In each case, early August-sown cotton was picked in late January with the crop then side-dressed and re-grown. Despite the unusual appearance of the ratooned plants, a second cycle of flowering enabled an additional seven to 7.8 bales of cotton to be picked in May, in a similar overall timeframe as crops grown-on following weather damage (see Figure 3 and images).

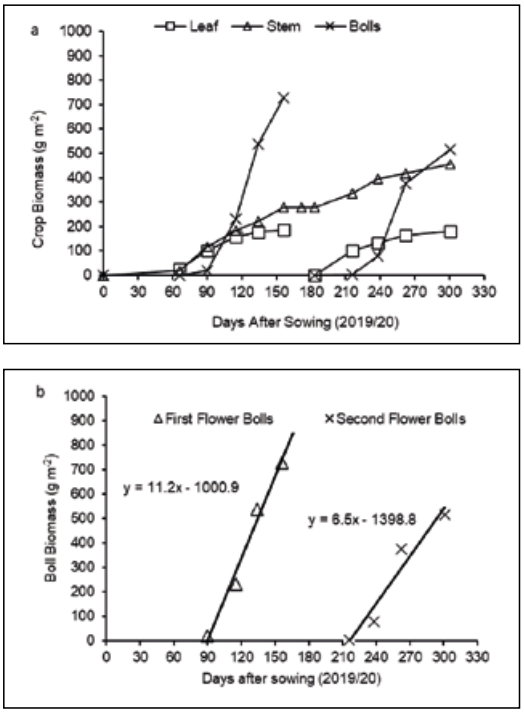

Figure 3. The top figure (a) depicts the biomass of stem, leaf and bolls accumulated over time following planting in early August, defoliation and picking in January and then ratooning. The bottom figure (b) shows the relationship between boll growth and days after sowing for the two cycles of flowering. The first and second boll setting cycles are consistent with boll growth rates for August (11.2 g/m^{-2} per day) and very late December (6.5 g/m^{-2} per day) sown cotton. Essentially it is a high yielding early crop merged with a lower yielding very late sown crop.

Implications

The last seven years have provided a lot of information on crop production parameters for CQ. We have learnt that very early-sown cotton (August) provides the greatest yield potential, even if it is tempered by the risk of rainfall at picking. Spring sowing can also produce high yields but the risk of fruit shedding due to weather disruption is high.

Compensation can overcome shedding losses but crop length often exceeds 200 days. For early summer sown crops picking is well clear of wet weather. However, yield potential is often limited due to the high risk of unfavourable weather during flowering followed by declining radiation and temperature limiting yield compensation if shedding occurs.

The flexibility afforded by Bollgard 3 has enabled growers to turn the tables on CQ's sub-tropical climatic constraints and exploit the region's very long season length.

While this might seem like a good place to sign off, the story would not be complete without also considering the potential down-side and risks of these production tactics. From a farming system perspective, grown-on crops leave little time between cotton crops for CQ's largely back-to-back cotton production system. When Fairbairn Dam refills and water ceases to be the primary limitation, grown-on cotton may hamper the ability to turn fields around between seasons and reduce the potential of the following crop.

The extended growing periods of grown-on crops, whether the motivation is compensating for weather-related yield loss or supersized yields, comes with the risk of additional exposure to *Helicoverpa spp.* generations.

The current flexibility of Bollgard 3 is made possible through pre-emptive Bt resistance management based on three principles:

1. Minimising the exposure of *Helicoverpa spp.* to the Bt proteins Cry1Ac, Cry2Ab and Vip3A;
2. Providing a population of susceptible individuals that can mate with any resistant individuals, hence diluting any potential resistance; and,
3. Removing resistant individuals at the end of the cotton season.

Crops that extend past the usual time frame of five to six months increase *Helicoverpa* exposure to Bt proteins beyond the original assumptions of the Bollgard 3 Resistance Management Plan (RMP).

Other changes have also occurred for *Helicoverpa* within the CQ farming system. Twenty years ago, Dr Richard Sequeira of QLD DAF conducted an extensive survey of *Helicoverpa spp.* recruitment within the farming system so that area wide management tactics could be devised.

During the mid-90s it was common for chickpeas to recruit 50 to 100,000 pupae/ha whilst insecticide escapes in conventional cotton frequently numbered five to 10,000 pupae/ha. When

Bt cotton (Ingard) was introduced to CQ in 1998, there was potentially massive potential for resistant Bt allele dilution from susceptible *Helicoverpa spp.* recruited within the broader farming system.

Helicoverpa spp. pupae sampling since 2017 has found major changes. Chickpeas no longer support mass recruitment. The advent of highly effective Group 22 and 28 insecticides (indoxacarb and chlorantraniliprole) and increased commodity price has resulted in more stringent efficacious control, and thus recruitment is a fraction of what it once was at zero to 500 pupae/ha. Recruitment in other crops such as maize and sorghum has also reduced. The highest numbers are now found in pigeon pea refuges, underscoring the importance of refuges for resistance management.

Reflecting on the CQ RMP

Questions about the long-term sustainability of these different systems and the appropriateness of the RMP have been raised within CQ and in broader industry forums.

This August workshops were held in Emerald and Moura, providing local growers and consultants the opportunity to understand the science, raise R&D priorities and discuss approaches to mitigating risks.

Ahead of these workshops, a small working group of growers, CRDC, Cotton Australia, QLD DAF and Bayer met to prepare. Through this process Bayer undertook modelling to better understand how the CQ system may now compare with the original assumptions (parameters used in modelling that underpinned the Bollgard 3 RMP).

The workshops were well attended and highlighted both gaps in research as well as growers' preferred approaches to managing identified risks. Productivity of refuges and Bt expression in grown-on crops are key objectives together with examining the potential impacts of natural enemies for *Helicoverpa* recruitment in both Bollgard and refuges.

Ratoon cotton in recovery mode five weeks post picking (leaves removed RHS).

GAIL SPARGO

A typical grown on cotton crop undergoing a second cycle of flowering.

GAIL SPARGO

Second cycle flowering on a grown on crop in CQ.

GAIL SPARGO

A high yielding grown on cotton crop showing two distinct cycles of boll set.

The way in which cotton is grown may at times change, not just in CQ but throughout the industry. A changing climate and expansion to new areas may lead growers, researchers, TIMS and technology providers to reassess how any changes affect existing assumptions, and require new data to inform decision making where gaps exist.

Bayer's Kristen Knight says it may be the case however that a change to a growing system cannot be accommodated by the RMP: that is the change in the system increases the risk of the evolution of resistance to such an extent that an RMP would become onerous to the grower.

Continual reassessment will ensure that the RMP remains effective both now and into the future.

For more

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COMMENT: WITH CROP CONSULTANTS AUSTRALIA

Industry seeking new methods to enhance IPM

Recently, Cotton Australia has been promoting the advances that have been made by the Australian cotton industry.

It has detailed the enhanced water efficiencies, reduced chemical usage and the sustainable practices that have been achieved by the industry through investment in research and development and the adoption of its outcomes. The figures are an illustration that the industry has been highly successful in implementing alternative agronomic strategies to achieve better economic and environmental outcomes.

The rate of change has been rapid and has been aided by a demonstrated willingness by the industry to be proactive and readily adopt practices and technologies. While being responsive to change is generally seen as the domain of the young, it is often the more experienced in the flock who are better positioned to lead the charge. There is no better example of this than in the case of pest management.

Pre the days of Bollgard, populations of mirids and other pests were inadvertently controlled as part of the pesticide regime aimed primary at the pest of the time, *Helicoverpa*. With that pest now managed, mirids have become the main pest of concern in cotton. As the industry has sought to manage this through species-specific pesticides, the sometimes-detrimental impact of these chemistries upon beneficial species has been substantial.

In such cases, the grower is left highly reliant on the efficacy of chemical application alone as a tool of management and data from the 2020 Crop Consultants Australia Cotton Market Audit indicated that over half of the sprays used for mirid control were Fipronil based. Combined with ever increasing regulatory pressures and public scrutiny, the cotton industry is facing the possibility of another pest management crisis. It is vital that the industry be on the front foot in finding solutions and alternatives.

Funded by CRDC, CCA is collaborating in a new project with IPM Technologies – a private research company that specialises in practical training and research in the area of integrated pest management (IPM).

Through a combination of research, information gathering forums and field trials, *Novel Options and Strategies for Integrated Pest Management in Australian Cotton*, looks to develop alternative IPM-friendly management options for mirids and other cotton pest species. In doing so, it aims to reduce reliance within the industry on existing chemistries and to assess the suitability of newer products or practices for integration into an effective IPM system.

Given the geographical spread of cotton production in Australia, it is recognised that the prevailing conditions in each area have an impact on season mirid numbers, and therefore upon preferred management strategies. Consequently, the project does not aim to come up with a 'one size fits all' outcome. Instead, the research is being informed by a series of participatory research forums based in each of the growing valleys.

While rollout of the forums has been hampered by COVID, the first was held in September in Dalby and the balance will be held in early 2022 to fit in with the local growing season.

These forums tap into the knowledge and understanding of mirid management of the experienced consultants and growers within CCA's extensive network. Participants are asked to share their experiences about what has worked in relation to mirid management and under what circumstances. Just as important however are the stories of less successful strategies. Combined with survey data, this input will enable the development of a regionally based assessment of current mirid management practices and challenges faced by the industry.

CCA is very aware of the potential intellectual property aspects that may impact on such discussions. To date, participants have demonstrated an appreciation of the overarching importance of area wide management in tackling this issue and have been generous with their time and input. It is these cotton professionals who have witnessed the changing landscape in cotton pest management and their combined experience is invaluable.

Equally however, continual education and upskilling of less experienced professionals is integral to sustainable pest management. In 2022 the project will deliver an upskilling event for 'young' agronomists to engage and educate this demographic in the importance of IPM.

CCA looks forward to sharing more information regarding the research and trial aspects of the project as it rolls out. Integral to this project is collaboration across all areas of the cotton industry including growers, researchers, resellers and consultants. CCA is uniquely positioned to enable not only the research aspects of this project to progress, but also to continue to deliver outcomes and training well beyond the scope of the project.

CCA was formed as the Cotton Consultants Association in 1986 by a small group of likeminded independent agronomists who were seeking a forum to share information. Little did they know of the key role that information sharing process would have in the future of the cotton industry. It is, after all, the experienced who are better informed to lead the charge... and the change.

For more

www.cropconsultants.com.au

Taking clever to new levels

Pest detection is about to get more clever, as CRDC and USQ partner with tech specialists Clevvi to create a world-first tool for use in the field.

The Cotton PestDetect App is a digital tool to assist with sampling for silverleaf whitefly nymphs by providing image-derived insect counts using a phone camera, with work underway to add cotton aphids to the capability. The software is based on research and development undertaken with support from CRDC by Dr Derek Long and Dr Alison McCarthy from the University of Southern Queensland (USQ) Centre for Agricultural Engineering in partnership with QLD DAF and CottonInfo IPM Technical Lead Dr Paul Grundy.

PestDetect is used in conjunction with the new decision support tool (DST), which came into cotton fields this season. The DST was developed by QLD DAF's Dr Richard Sequeira and is based on sampling SLW nymphs rather than adults. It counts SLW nymphs and integrates this information with crop development and pest density thresholds to assist agronomists and growers to make better-informed management decisions. Using geotagged image analysis, the app also allow users to create maps of where pests may be building more rapidly on individual farms or fields. It can also enable timely, impartial measurement of the efficacy of insecticides.

CRDC has been seeking partners to take PestDetect past the research stage technology and into the field.

"We are really excited to be partnering with Clevvi, an award-winning Australian leader in digital marketing, web and app development, and software engineering," CRDC R&D Manager Susan Maas said.

"With extensive experience in Australian agriculture and both marketing and software engineering capacity, we believe Clevvi will be the ideal partner to commercialise the PestDetect App.

"The USQ and QLD DAF research team has delivered exciting new capacity to automate pest decisions in the field.

"Clevvi have taken this technology and are focussed on ensuring a great end user experience."

Susan said while the app is available for use this season, there are some aspects of the technology still being developed.

"The capacity to detect viable from non-viable nymphs is underway and is expected to be completed and incorporated into the app by mid-2022," Susan said.

"The opportunity to have technology support crop decision making is well and truly here and in the future we hope to expand to include the ability to identify and count pests such as aphids."

Professor Craig Baillie, Director of the Centre for Agricultural Engineering, said it was exciting to see university technology enter the market with Clevvi from a relatively short runway and remarked how this was made possible by the collaboration with scientists from QLD DAF.

In addition to the partnership with Clevvi, CRDC and the project partners are also seeking an app sponsor for PestDetect. For a prospectus email susan.maas@crdc.com.au

ABOVE: **Clevvi's Brendan McDonald, Dr Derek Long and Dr Alison McCarthy and at the opening of the AgTech and Logistics Hub in May where the PestDetect App was demonstrated.**

For more

PestDetect

www.cottoninfo.com.au/index.php/insect-and-mite-management

Expanding networks bring innovative partners

The opportunity to be involved in PestDetect was promoted via grow$^{AG.}$, a platform launched this year by AgriFutures Australia and the Minister for Agriculture and Northern Australia to create a global gateway into the Australian research and innovation system through its 15 Research and Development Corporations (RDCs).

The grow$^{AG.}$ program has a focus on deal-flow, attracting capital investment and driving collaboration and makes R&D outcomes transparent for growers and the community. It was designed by a steering committee made up of individuals from CRDC and 18 other organisations across Australia and New Zealand's agricultural innovation network.

As well as connecting pathways to commercialisation that enable research innovation to be delivered back to the farm and the food supply-chain, grow$^{AG.}$ is enabling research organisations and funding bodies to reduce duplication and readily identify potential collaborators.

"It expands our network exponentially," CRDC R&D Manager Susan Maas says.

"For example when traditionally we call for projects and commercial partners we rely on our own networks.

"grow$^{AG.}$ give us access to the tech community and other RDCs, tapping into a much larger pool of researchers and potential collaborators."

This collaborative effort by the Department of Agriculture, Water and the Environment and the 15 RDCs has hit the ground running. Between launching in April and June 30, grow$^{AG.}$ showcased 31 commercial opportunities including one from CRDC (PestDetect) to more than 10,000 users from 117 countries, with 70 per cent from Australia. It features more than 2000 research projects including 170 funded by CRDC.

For more
grow^{AG}
www.growag.com

There's something in the air: and we want to know what it is

CottonInfo's Southern NSW Regional Extension Officer Kieran O'Keeffe has helped kick-off a new era in pest detection.

The sophisticated Sentinel 5 aims to add mobile and autonomous pest surveillance capacity to Australia's plant industries and was deployed into a cotton field near Whitton (Wiradjuri country) in the Riverina in late October. The sampling unit takes air samples with two and six-metre insect suction traps, a pathogen spore suction trap, and features a weather station. The unit was developed as part of a project between CRDC and fellow plant industry Research and Development Corporations.

During the trial, Kieran will monitor the Sentinel, collecting samples weekly and sending them to researchers from South Australia Research and Development Institute and Agriculture Victoria Research (AVR) who are also involved in the project. They'll identify key pest targets, such as green mirids, thrips and silverleaf whitefly. The gut contents of green mirids from trap samples will be analysed to better understand the hosts they are feeding on before moving into cotton.

The team at AVR will report on the biodiversity of insect trap samples, including the presence of key beneficials. The results will be shared through Kieran's CottonInfo networks to growers.

The trial will run through to early Autumn next year, and the Sentinel will be at the Irrigation Research and Extension Committee (IREC) site for the field day in late January. It will then be re-deployed using a yet to be released 'Sentinel-box' for the remainder of the trial.

The Sentinel is part of the iMapPESTS: Sentinel Surveillance for Agriculture program, supported by the Department of Agriculture, Water and the Environment's Rural R&D for Profit Program. It is led by Hort Innovation in partnership with CRDC, Grains Research & Development Corporation, Sugar Research Australia, Wine Australia, AgriFutures Australia, and Forest and Wood Products Australia.

For more
iMapPESTS
imappests.com.au

Research continues to protect fish species

CRDC has been supporting researchers from QLD DAF in developing best management practices for minimising the impacts of irrigation infrastructure on fish.

THIS IMAGE: Researchers have found saratoga don't seem to be susceptible to entrainment through irrigation offtakes.

BELOW RIGHT: A sample of fish caught from an irrigation outlet, which includes olive perchlets.

The team, led by Michael Hutchison has been at Emerald in Central Queensland (Gayiri country) to examine the effect of flow type (natural or allocated), pump size and pump inlet location on fish entrainment rates.

The results of this study will help to guide the configuration of future irrigation intakes to minimise the impacts on fish.

"We chose the Emerald region to do this work because the fish fauna in this area contains a mix of tropical and temperate freshwater fish, so the results can be applied to both northern tropical rivers and southern rivers such as those in the Murray-Darling Basin," Michael said.

"There is a lot of data we need to capture to identify what best practice looks like.

"Our aim is ultimately to lessen the effect of irrigation infrastructure on fish."

Some preliminary findings have shown that pump intake location seems to be a better predictor of fish entrainment rates than pump size. Larger pumps do not necessarily entrain the most fish per megalitre.

QLD DAF biologist David Nixon is leading much of the fieldwork and said there can be very large differences in fish entrained per megalitre for any given species, depending on intake location (bankside, mid-river channel or from within a short constructed channel perpendicular to the river).

"For example, the number of golden perch larvae entrained per megalitre is up to 20 times greater in some pumps than in others, depending on intake location," David said.

"This means that a reduction in entrainment rates for this species may be achievable by changing the positioning of pump intakes.

"This can also help guide positioning of new irrigation infrastructure."

To mitigate fish impacts on fish from existing infrastructure (as opposed to a new installation), this study will help to prioritise the intakes where works, such as screening, should be undertaken. Significant reduction in fish/larvae entrainment may be achieved by adjusting intake configurations, without the need for screens in some locations.

Some fish species are more susceptible to entrainment than others. Not all fish species present in the river are being entrained through pumps.

"Some species, like saratoga, are yet to be detected passing through pumps while juvenile bony bream are regularly observed, however they are highly abundant in the river so tend to have relatively low susceptibility scores," David said.

"In contrast, olive perchlet (glassfish) seem quite susceptible to entrainment, being over-represented in pump samples when compared to the number of fish sampled in the river.

"For most species of fish, allocated flows and overbank natural flows seem to result in less fish entrainment than within-bank natural flows."

Meanwhile, Michael says, self-cleaning screening technologies are continuing to evolve with robust options available for flowing environments.

"These may be adopted in future at some locations to help protect fish stocks, with the added benefit of maintaining good flow rate by minimising the impacts of debris, reducing maintenance costs and prolonging the life of pumping equipment," Michael said.

The research in ongoing, with sampling continuing over summer.

For more

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The Northern Territory is set to gin cotton near Katherine in 2022, with work already underway at the site just north of the town.

Ginning set to move north

Currently, cotton grown in the NT and Western Australia is trucked to St George – more than 3000km one way – to be ginned, which is naturally time consuming and expensive for growers in the north and a barrier to expanding the industry.

Production could soon be ramped up with the formation of Western Australia Northern Territory (WANT) Cotton, with the express purpose of enacting a plan to build a 100 per cent grower-owned cotton gin in the north, according to WANT Chair David Connolly.

David is the general manager of the Tipperary Group, where cotton is now being grown near Katherine, and he said the gin would be owned exclusively by all potential cotton growers in the Top End of the NT and WA. The facility will be constructed and operated by Riverina-based RivCott Ltd and is expected to be operational by the 2022 season.

NT cotton is picked from June to August, while Ord cotton is picked from August to October.

IMAGE DAVID CONNOLLY

Cotton on Tipperary Station in the Northern Territory. Plans are well underway by WANT Cotton to open a gin near Katherine next year.

Meanwhile in September this year the Northern Australia Infrastructure Facility (NAIF) board approved a $32 million loan to build a gin in WA in the Ord region. The NAIF approval comes after local farmers signed a memorandum of understanding with Namoi Cotton. The gin will have the potential to process cotton grown on up to 15,000 hectares and produce 120,000 bales of cotton each year. This season 1500 hectares was picked across the Ord. With construction expected to take between 18-24 months, it is hoped the Ord cotton gin could be processing cotton by late 2023.

New links to improve resilience and innovation

CRDC and CottonInfo are working closely with the Drought Resilience Adoption and Innovation Hubs recently created by the Department of Agriculture, Water and the Environment.

Focusing on collaboration, the hubs provide networks for researchers, primary producers and community groups to work together to enhance drought resilient practices within their region. CRDC General Manager R&D Investment Allan Williams, says with four of the eight hubs covering cotton growing regions, industry RD&E has a role to play through both CRDC and CottonInfo.

Hubs have been attached to university and are situated in their towns or cities. The Southern QLD/Northern NSW (Toowoomba) and Southern NSW (Wagga) hubs cover most of the current cotton growing areas of Australia. Other hubs of particular interest to cotton are Tropical North Queensland and Northern WA/NT hubs, based in Cairns and Darwin, and contact has also been made with the Victorian Hub, which has its core site at the University of Melbourne's regional campus in Dookie.

"The hubs aim to ensure agricultural research is useful and accessible, which is also the aim of CottonInfo," CottonInfo Program Manager Warwick Waters said.

"We have been in contact with the hubs and will work with their objectives, which vary from hub to hub.

"Each hub is quite different, and core activities are currently being developed, so we are in conversation with them around what they will deliver and activities in that region."

Warwick travelled to Cairns to help planning of the Tropical North Queensland Hub in November.

"Our intention is to work closely with the hubs via CottonInfo, as it connects growers with research and drives participatory research outcomes," he said.

"CottonInfo is keen to take a systems approach to improving drought resilience as a cotton farm usually has broadacre and stock, so a business's ability to diversify is greater because they have options.

"We also see this as an opportunity to learn from and work with other industries."

Innovation is a major focus for the hubs.

"The aim is to be developing tools to support growers through drought," Warwick said.

"A lot of the technology is common across industries, so through collaboration we can get better tools for drought resilience and planning."

For more

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Correctly optimising limited water means big things for yield

In limited water systems many cotton growers have water available for a single in-season irrigation only with farm profitability heavily relying on this decision.

Continuous monitoring of crops reflects crop conditions approaching the need for irrigation and avoiding plant stress. This infra-red sensor technology will enable growers to make an irrigation decision based on crop's response to current soil water status rather than relying on a fixed soil water deficit. Being a plant-based approach, canopy temperature offers different but complementing information to soil and weather-based approaches.
The canopy temperature technology including the algorithms to convert data into an irrigation decision is being delivered by Goanna Ag through a commercial agreement with CSIRO and CRDC.

Irrigation researchers have found that applying this irrigation too early or too late could result in a nearly 60 percent yield reduction, however growers have the tools at hand to avoid this pitfall.

Using canopy temperature sensor technology a CSIRO team led by Drs Hiz Jamali and Chris Nunn conducted field trials where they applied a single irrigation during flowering but changed the timing in four treatments.

The researchers' aim was to find the optimum time to apply a single irrigation to maximise yield and, importantly, understand the processes that drive those yields. Canopy temperature was monitored continuously using infrared sensors as it is an indicator of water stress because of its inverse relationship with stomatal conductance.

Plants grow optimally in a narrow range of species-specific canopy temperatures known as the "thermal kinetic window (TKW)" which for cotton is around 28°C. Plants maintain canopy temperature closer to the TKW by releasing their heat load through evapotranspiration which requires energy.

Conversely, when water availability becomes limited, plants respond by closing the stomata which results in reduced transpiration and elevated canopy temperature because of plants' reduced capacity to release energy.

Wireless infra-red sensors monitoring canopy temperature.

As such the canopy temperature of a water-stressed crop is generally higher than the temperature of a well-watered crop (Figure 1), resulting in a strong relationship between yield and canopy temperature. In this field trial during the 2020-21 cotton season, the treatment which was irrigated 108 days after sowing yielded the highest (treatment 3 in Figure 2). Plants that received an irrigation earlier (e.g. treatments 1 and 2) or later (e.g. treatment 4) than 108 days after sowing incurred a yield penalty (Figure 2).

"These losses were up to 56 per cent or 2.7 bales/ha as a result of watering too early or too late, which shows how important optimised irrigation scheduling is to achieving high water productivity in these systems," Hiz said.

"We observed similar results in previous seasons as well and are in the process of synthesizing the data from different years to understand the variability between years."

"Canopy temperature data showed that the treatment with highest yield experienced the lowest cumulative stress during the season (Figure 3), which shows the effect of strategic timing of an irrigation on managing crop stress. This was also seen in the strong relationship between yield and total stress time derived from canopy temperature observations (Figure 4)."

Does this mean a grower will get the best yield

every year by applying an irrigation around 108 days after sowing?

"Probably not, because the stress profile of a crop is different every year because of variability in weather and its effect on crop development," Chris says.

"Therefore, a more direct plant-based measurement of canopy temperature is important as it integrates the effects of several factors including weather and water stress which affect crop development.

"We are able to repeat a successful strategy (e.g. treatment 3) across years by using algorithms derived from canopy temperature data.

"Canopy temperature infrared sensors are affordable, easy to use and maintain, and will hopefully be a valuable addition to the suite of tools available to growers for making important irrigation decisions."

Highlighting compaction

Hiz's most recent research demonstrated that soil constraints such as compaction caused by farm machinery alters the soil-plant-water dynamics. Compaction hinders root penetration in the soil profile and reduces crop water use and soil water recharge following irrigation and rainfall, which affects root zone and plant available water. Sensors can help avoid this.

"Integrating canopy temperature and soil water data in real time helps understand the presence of water in the soil profile and its availability to a crop which helps growers make a more informed decision," Hiz said.

This research was undertaken as part of the Department of Agriculture, Water and the Environment's Rural R&D for Profit Program's Smarter Irrigation for Profit Phase 2 project, led by CRDC in collaboration with Sugar Research Australia, Dairy Australia, AgriFutures Australia and GRDC.

For more
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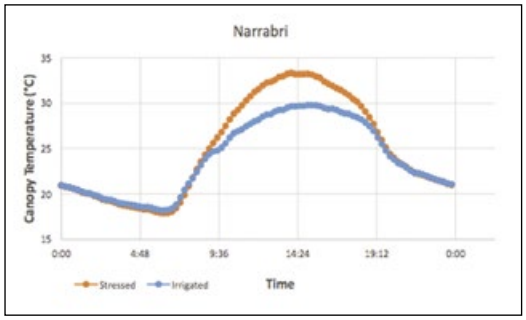

Figure 1: The difference in canopy temperature of a well-watered (blue) and a water-stressed (orange) crop at CSIRO trials in Narrabri during a 24-hour period.

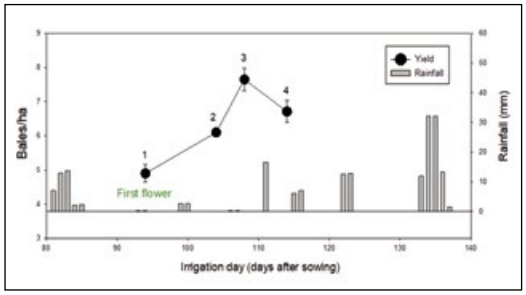

Figure 2: Timing of irrigation expressed as days after sowing and lint yield in different treatments; treatment 3 yielded the highest.

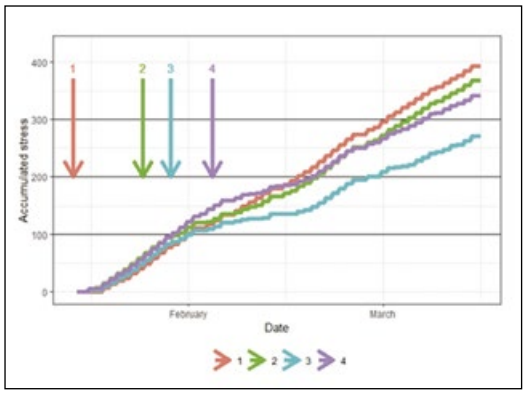

Figure 3: Cumulative stress measured using canopy temperature sensors; vertical arrows show the timing of irrigation in treatments; treatment 3 showed lowest stress compared with other treatments.

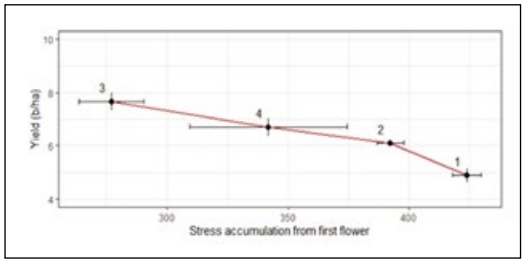

Figure 4: Relationship between total stress and lint yield; treatment 3 showed lowest stress and highest yield.

A culture of innovation and impact, driven by CRDC and RD&E

The Australian cotton industry has built a culture of innovation, driven by the industry's world-class researchers, transformational research and development (R&D) projects, and highly adaptive growers.

CRDC's role is to foster this culture and deliver tangible innovation impacts, helping to increase the productivity and profitability of Australian cotton farms, improve our sustainability and value chain competitiveness, build our adaptive capacity, strengthen our partnerships and the adoption of our research outcomes, and ultimately drive RD&E impact.

In this special *Spotlight* feature, the CRDC Annual Report review, we take a look at some of the highlights of the 2020-21 year.

A note from CRDC's Dr Ian Taylor

CRDC has been driving innovation for the cotton industry for 30 years. In the early years, we supported the development of the first GM cotton varieties, the industry's world-leading insect resistance management strategies, and the development of cotton's best management practice program – all were innovative for Australian agriculture at the time.

Today, CRDC-supported research and collaborations remain at the leading edge of technological advancements. We are delivering a revolutionary insect monitoring system using smartphones; sensing technology and automation using the internet of things; and transformational new products using biotechnology to allow plants to fight pests, diseases, drought and climate change.

We are also seeing long-term investments into critical research areas such as water-use efficiency paying dividends for growers, the industry and the environment. In 2020–21, CRDC-supported research has found that over the past 25 years, the industry has almost halved the amount of water needed to grow a bale of cotton. This is primarily due to improvements in irrigation infrastructure and management efficiencies, underpinned by CRDC-supported RD&E, which demonstrates the industry's commitment to sustainability and continuous improvement.

Just as the world in which we operate is ever-changing, the way CRDC invests in innovation is evolving. For 30 years, CRDC has worked with scientists to solve cotton's greatest challenges. That hasn't changed, but we cast our net deeper and wider now.

There is a world of innovation waiting to be harnessed by Australian agriculture, and CRDC is creating new pathways to capitalise on it, including pathways like the creation of Agricultural Innovation Australia Pty Ltd, and the partnership with the Australian Government's Business Research and Innovation Initiative (BRII) program.

Critically, collaboration remains at the heart of everything we do. There isn't a single research project we invest in that isn't delivered in partnership with our growers, cotton researchers and collaborators. We also partner with those outside our sector to solve issues that are bigger than cotton alone. In 2020–21, 55 per cent of CRDC's investments were in cross-sectoral RD&E.

You can find more detail in our *2020-21 Annual Report* and *Performance Report*, both of which will soon be available via the publications section of our website: www.crdc.com.au/publications. You can also find a full list of our current research projects online at www.crdc.com.au/research-development.

YEAR IN REVIEW

CRDC RD&E achievements 2020-21

R&D finds industry has almost halved water use

CRDC-supported research has found that over the past 25 years, the industry has almost halved the amount of water used to grow a bale of cotton. Findings by NSW Department of Primary Industries (NSW DPI) researchers from in-depth water productivity benchmarking in 2007, 2009, 2013 and 2018, combined with all other available water use data going back to 1992, showed that the amount of water needed to grow one bale of cotton has fallen by almost 50 per cent since 1996. This is primarily due to improvements in irrigation infrastructure and management efficiencies underpinned by RD&E. This demonstrates the Australian cotton industry's responsible use of shared natural resources and its commitment to continuous improvement in water-use efficiency.

RDC collaboration results in Agriculture Innovation Australia

In 2019–20, CRDC worked closely with the Research and Development Corporations (RDCs) to develop a framework for collaboration across the whole of agriculture. In 2020–21, this partnership was formalised with the establishment of Agriculture Innovation Australia (AIA) Ltd: a new not-for-profit company established by the collective RDCs to drive cross-sectoral research, leverage private sector investment, and target transformational innovation. AIA Ltd is designed to prioritise and streamline co-investment to tackle difficult cross-sectoral challenges and drive greater impact for agriculture and the broader community. CRDC has been actively involved in the establishment of AIA Ltd and its first investment project, the Climate Initiative, which aims to foster thriving agriculture, fisheries and forestry industries, regardless of pressures from a variable and changing climate.

Innovative approach to revolutionise agricultural spray drift

To help solve the challenge of agricultural spray drift, CRDC took an innovative approach in 2020–21, partnering with the Australian Government's Business Research and Innovation Initiative (BRII) to approach entrepreneurs, innovators and small to medium businesses for potential solutions. BRII seeks effective ways to deal with challenges that affect the environment, while providing opportunities for startups and businesses to develop new products and technologies. Of the

52 applications received through the program, six groups were selected to test the feasibility of their ideas with CRDC, Cotton Australia, and the NSW Environmental Protection Agency (NSW EPA). Two of these applications will be selected to deliver a proof-of-concept approach.

CRDC-supported research underpins John Deere commercialisation

New vision-based plant detection technology released by the company John Deere was developed through projects supported by CRDC with researchers from the University of Southern Queensland (USQ). The See & Spray Select™ technology, integrated into John Deere's new 400 and 600 series sprayers, is the only technology of its type available in Australia, and the industry's first factory-installed, targeted spray solution. The technology rapidly detects green plants within fallow ground and automatically triggers an application to those plants, achieving a similar hit rate to traditional broadcast spraying but using, on average, 77 per cent less herbicide. The initial experimental work to develop the vision-based plant detection technology was funded through a combination of industry research projects with CRDC, Sugar Research Australia, Hort Innovation, and USQ.

Progress towards commercialisation: R&D on path towards commercial release

In 2020–21, several CRDC-supported R&D innovations continued their progress towards commercial release: an artificial intelligence smartphone app to help identify silverleaf whitefly (underpinned by a new silverleaf whitefly threshold also supported by CRDC and released in 2020–21); BioClay, the non-toxic, clay-based biodegradable product for crop pests and pathogens; AquaTill Injeticide, the ultra-high pressure water-cutting technology for crop termination; and VARIwise, the software that combines in-season imagery with crop production models to provide yield predictions throughout the season. Commercial development of these innovations will continue in 2021–22 with support from CRDC.

Groundbreaking trial to help soil health and solve textile waste

Reducing waste and increasing soil health

are just two of the benefits expected from a ground-breaking trial, supported by CRDC, that involves spreading approximately two tonnes of shredded cotton products onto a cotton farm near Goondiwindi. It is hoped that the fabrics will break down in the soil, increasing microbial activity, locking in carbon and improving soil moisture, while also diverting cotton clothing from landfill and reducing greenhouse gas emissions. This trial is part of a partnership between circular economy specialists Coreo, the Queensland Government, Goondiwindi Cotton, Sheridan, Cotton Australia, Worn Up, and CRDC-supported soil scientist Dr Oliver Knox of the University of New England (UNE). If successful, the trial could lead to large-scale recycling of cotton textiles, helping to solve the issue of textile waste through a circular system.

Country Road and cotton: helping to protect biodiversity

CRDC and Cotton Australia are supporting a partnership between iconic Australian brands Country Road and Landcare Australia to improve biodiversity on cotton farms in the Namoi Valley. Country Road will contribute a minimum $600,000 to the partnership over three years, with funds raised going to Landcare Australia to support biodiversity restoration projects. The partnership will draw on a CRDC report, published under the Australian Government's National Landcare Program Smart Farming Partnership Initiative Round 1, which mapped biodiversity in Australian cotton landscapes, identified threatened and endangered species, and recommended ways to protect them.

Stakeholders consulted on cotton industry sustainability targets

The *PLANET. PEOPLE. PADDOCK* Sustainability Framework has been developed by the industry to coordinate work to make Australia a global leader in sustainable cotton production. An important part of the framework is setting targets and coordinating a whole-of-industry strategy to achieve them. Draft targets and indicators of progress have been developed for each of the core focus areas under the framework. These are PLANET: water; carbon footprint, biodiversity, pesticides, soil health; PEOPLE: workplace, wellbeing; and PADDOCK: productivity, profitability. In a consultation process during July and August 2020, 356 stakeholders gave feedback on these draft indicators and targets to validate the level of ambition, to test they are the 'right' ones to use, and to elicit suggestions for partnerships and solutions to achieve targets. In addition, the industry is working with other sectors to ensure consistency; the targets will be launched when this work is finalised.

Collaboration to tackle major cross-sectoral challenges

Of CRDC's 2020–21 investments, 100 per cent have been in partnership with the cotton industry, and 55 per cent in cross-commodity collaborative projects with fellow RDCs. CRDC led three major collaborations: Smarter Irrigation for Profit Phase 2 and More Profit from Nitrogen, under the Australian Government's Rural R&D for Profit program; and Cotton Landcare Tech Innovations 2021, under the National Landcare Program Smart Farming Partnership. CRDC has also partnered in four other projects under the Rural R&D for Profit program, addressing cross-sectoral issues in weeds, biosecurity, energy and diseases.

RD&E supporting continued northern industry expansion

The Australian cotton industry continues to grow in Northern Australia, with 14,000 hectares of cotton grown in the north in 2020–21, compared to less than 1,000 hectares in 2016–17. A key focus for CRDC is to ensure this development is done sustainably, with best management practices and biosecurity as core priorities. CRDC continues to support the $2.1 million research program for Northern Australia, announced in March 2020, in partnership with the Cooperative Research Centre for Northern Australia and GRDC. In addition, 2017 Cotton Researcher of the Year Steve Yeates continues his role as cotton development and coordination leader for northern cotton with support from CRDC, delivering science leadership and coordination for current and future cotton developments and linkages for biosecurity initiatives. CRDC is also supporting grower-led initiatives, like Grassroots Grants, in Northern Australia.

CRDC
COTTON RESEARCH AND DEVELOPMENT CORPORATION

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

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