Spotlight
ON COTTON R&D

SUMMER 2019-20

Bringing home the biosecurity message

Cotton growing in a changing climate

Crop health starts from the ground up

CRDC

Ian Taylor

In the Spotlight

Welcome to the summer edition of *Spotlight*.

Despite continued challenging weather and climatic conditions, CRDC is continually assessing how it may support the industry's vital RD&E, our cotton research community, and those who support the industry through leadership and innovation to improve farming practices.

In this edition of *Spotlight* we bring you stories about the people who are passionate about the cotton industry and how, with added support from CRDC and organisations such as Cotton Australia and Auscott, we are helping them achieve their potential. From researchers, PhD students, Nuffield scholars and the Australian Rural Leadership Program participants, CRDC is building capacity and resilience within the industry. We hope you enjoy reading about our inspirational cotton community.

This edition we also include a focus on climate change research within the cotton industry. We've been addressing how a changing climate will affect future cotton growing through several research projects with our partners. We believe that preparedness is the key to future sustainability and R&D plays a key role in this. Read about how the climate has changed in your region and what the future holds in this feature story.

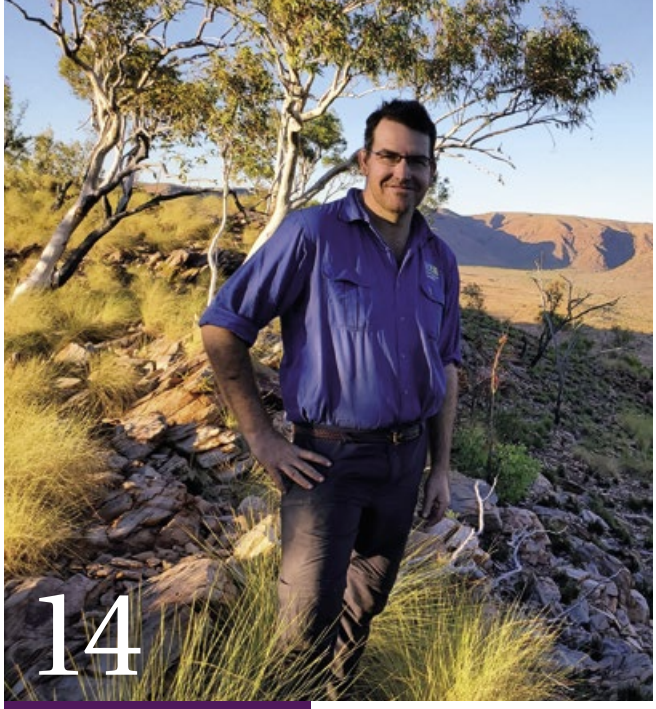
Preparedness is also key to biosecurity and protecting our industry from exotic pest threats. CRDC has been engaging with fellow plant industries to form a cohesive and collaborative front to future incursions. The cotton industry, with Plant Health Australia, recently ran Exercise Blueprint – an incursion scenario focused on cotton blue disease, a priority pest for the industry. It showed that communication is vital in the immediate period following the discovery of an exotic pest, and the industry is well placed to disseminate information and follow a clear management plan.

Australia is no stranger to successfully dealing with exotic incursions and owes much to the quality of the research that provides detailed information about threats before they reach our soil. We also owe much to the growers who continue to support researchers and trials on their farms to improve disease and pest preparedness. In this edition we catch up with Darling Downs cotton grower Graham Clapham, who in his words, 'became famous for all the wrong reasons' but is now highly respected and appreciated for all the right reasons. Graham had the first identified case of Fusarium wilt on his property in 1993 and has been helping researchers and the industry overcome its effects ever since.

Graham's journey and philosophy is inspiring. He says one of the main learnings from the experience has been appreciating the importance of soil health in not only successful cropping, but also in combatting disease, and ensuring sustainability. We've included a wrap up of the recent Crop Consultant Australia and CottonInfo soil health workshops, and an in depth look at research into chicken litter, which has produced some amazing results.

Finally, we hope you enjoy reading our Annual Report wrap up. Despite the prolonged drought, the expansion of cotton into new areas, digital agriculture and people with vision are continuing to drive our industry forward.

Ian Taylor
CRDC Executive Director



Summer 2019-20

STEVE YEATES

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CRDC
COTTON RESEARCH AND DEVELOPMENT CORPORATION

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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MELANIE JENSON

ON THE COVER: Darling Downs farmer Graham Clapham knows first-hand what is involved in finding and dealing with an unknown visitor to a farming enterprise.

Want to see more of Spotlight?

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

COTTON NEWS

FEATURES

Tweeting biosecurity

CRDC has recently been involved in several biosecurity events to create preparedness in the event of an incursion from an exotic pest.

R&D Manager Susan Maas oversees biosecurity investment for CRDC and says the message (below) was the most pertinent in terms of protecting Australia's cotton industry and fellow plant industries in the event unwanted pests or diseases land on our shores.

She said this message really hit home at the Plant Industries Biosecurity Symposium held in Brisbane in August, where all plant Rural Development Corporations came together to focus on biosecurity measures, preparedness and research.

Along with a series of articles relating to industry biosecurity, we thought this would be a good opportunity to revisit one of the cotton industry's most significant events, by catching up with Graham Clapham, the first cotton grower to have Fusarium wilt identified on his property on Queensland's Darling Downs.

The discovery of the disease put Graham and his family on a different trajectory than the one they'd envisioned for themselves. Committed cotton growers, they've been involved in Fusarium research since the discovery in 1990 and are testament to the endurance of our farming community and the importance of early detection of exotic pests and diseases.

CRDC R&D Manager Susan Maas, who lives in Emerald, with Tracey Geddes from the Central Highland Cotton Growers and Irrigators Association at the book's launch.

A dam good read

A new book has been launched which chronicles the story and those involved in the construction of the Fairbairn Dam in Central Queensland and the impact of the first 40 years of its operation.

A Dam Good Story: 40 years of Irrigation from the Fairbairn Dam came about with support from one the early grants awarded under CRDC's Grassroots Grants Program back in 2012, to the Central Highland Cotton Growers and Irrigators Association (CHCG&IA).

The official book launch in late August showcased the book's beautiful historic photos, as well as "our history and stories that are a precious record of our farming families and local community", according to CHCG&IA's Tracey Geddes.

At an impressive ceremony in October 1968, construction of the Fairbairn Dam was officially launched with three explosions set off by the then National Development Minister, the Hon D. Fairbairn to inaugurate construction on the Nogoa River, 25km southwest of Emerald.

Construction was complete by 1972 and as a result, Lake Maraboon became the second largest lake in Queensland, with a holding capacity of up to three times that of Sydney Harbour. The development enabled the establishment of the Emerald Irrigation Scheme and the beginning of the diverse agricultural opportunities it provided farmers across the region.

"It may have been seven years in the making, but as a final report, it is probably the most beautiful and interesting report I've ever received," CRDC R&D Manager Susan Maas said.

"The project team, and especially Tracey Geddes are to be commended on their tremendous effort on this project.

"Tracey put in countless hours on the phone, meeting with people to collect stories and data and overall keeping the book rolling. Her contribution as a volunteer to keep the project going and getting it to completion was invaluable, along with her small band of local volunteer helpers."

For more:
https://adamgoodstory.squarespace.com

CRDC builds capacity through people

CRDC has increased capacity with the appointment of two part-time Research and Development (R&D) Managers.

Agronomist Elle Storrier and cotton researcher Dr Meredith Conaty joined the team in October. Elle will be responsible for overseeing projects relating to weeds, insects and diseases, while Merry is looking after agronomy, soils and nutrition.

Both are well-known in the industry and bring extensive cotton experience to the CRDC team.

Elle has run her own consulting business from Hillston since 2014, and previously consulted in the Namoi, Macintyre and Southern NSW valleys. She holds a Bachelor of Agriculture degree from the University of New England. The accomplished agronomist is a former board director and technical review panel member of Crop Consultants Australia. Elle will remain based at Hillston and will be helping to expand CRDC's engagement with Southern NSW.

Meredith is an experienced researcher who has worked primarily in the private sector bringing new technologies and innovation to the Australian cotton and broadacre cropping industries. She holds a Doctor of Philosophy and a Bachelor of Science in Agriculture from the University of Sydney. For the past eight years she has worked for Bayer Crop Science/Monsanto Australia carrying out research, product development, extension activities and commercial evaluations and registration of agronomic traits and chemicals. Meredith will be joining the CRDC team at the head office in Narrabri.

The new recruits join R&D Managers Susan Maas (farming systems and biosecurity), Stacey Vogel (natural resource management) and Rachel Holloway (human capacity). The team is led by General Manager, R&D Investment, Allan Williams. Allan moved into the role vacated by Dr Ian Taylor, who was chosen as the new Executive Director in March this year.

MELANIE JENSON

MEET THE TEAM: at back – Jane Trindall, Graeme Tolson, Ian Taylor, Emily Luff, Jarrod Ward, Stacey Vogel and Jeevi Arjunan. Middle – Warwick Waters, Megan Baker, Merry Conaty, Susan Maas, Allan Williams, Rachel Holloway, Elle Storrier, Ben Simpson and at front Lynda George, Ruth Redfern and Di Purcell.

Innovation focus

Former R&D Manager Jane Trindall has also moved into a role as CRDC Innovation Broker. In this role Jane will develop a digital strategy for the Australian cotton industry, to ensure the industry capitalises on the increased output and sustainability offered by digital agriculture. Since moving into this role earlier this year, Jane has overseen the Growing a Digital Future in Agriculture project, which has developed a digital agriculture framework and digital skills maturity index and developing data code of practice. Jane will also continue leverage grower levies through grants, such as the Australian Government's Rural R&D for Profit Program. Jane was successful in leading applications for the multi-million dollar Smarter Irrigation for Profit Projects (Phase 1 and 2) and Precision to Decision Agriculture, among others.

Monitoring and Evaluation is critical to ensuring the impact and effectiveness of RD&E. CRDC monitors its progress towards – and achievement of – the outcomes of the CRDC Strategic RD&E Plan 2018-23 via its Monitoring and Evaluation (M&E) Framework, which provides a coordinated approach for measuring, monitoring, evaluating and reporting performance, to inform continuous improvement of CRDC and report on progress towards desired outcomes. Ben Simpson has been engaged to manage this process: measuring CRDC's success in delivering impact and value to growers, industry and government. Previously, Ian Taylor had predominately overseen M&E, however having Ben in the team enables CRDC to make it a priority.

As M&E Manager on a part-time basis, Ben will share his time between CRDC and fellow Rural Development Corporation, Sugar Research Australia.

Jarrod Ward is a patent attorney who has been contracted as Commercialisation Manager. As such, he will lead the commercialisation of research outputs and manage CRDC's intellectual property. Jarrod brings extensive experience in the field of intellectual property and commercialisation to CRDC.

For more
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Taking growers to the future

EVOKEAG is just around the corner, and CRDC is looking forward to taking cotton growers on the ride to a digital future this coming February.

CRDC supported the inaugural AgriFutures Australia international event this year and were so impressed they'd like to see more cotton growers at the event to take advantage of this immersive tech experience, which brings people together to connect, collaborate and evolve in all things ag.

evokeAG will be held in Melbourne on February 18-19, and is the perfect event for growers and the food and agriculture sectors to exchange information and see how technology can shape the future.

With the theme *Food – Farm – Future*, CRDC Innovation Broker Jane Trindall has described the event as "a glimpse into the future, to see the rapid change that is already happening and start thinking about how we can adapt to, capitalise on and drive it".

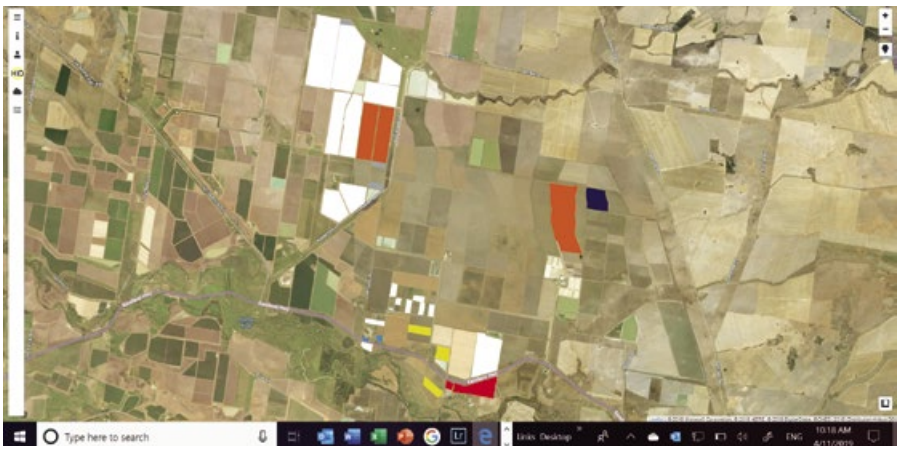
The event also offers growers with big ideas to apply to attend, as the event attract venture capitalists and start up entities from around the world. There is a varied speakers list ranging from producers to corporate heads and start up wizards.

CRDC will be supporting one grower from each cotton grower association to attend evokeAG 2020. Enquiries should be made to local CGAs or to register interest.

evokeAG is also offering discounted primary producer tickets which are available via its website.

For more

www.evokeag.com



Better drift protection

SATACROP is a new platform offering improved mapping technology to better protect cotton and other crops from spray drift.

After a successful trial in Queensland's Central Highlands around Emerald, the new mapping tool is available for the 2019-2020 summer season. Cotton Australia announced the release of SataCrop, in partnership with Precision Crop Technologies (PCT) in June.

Unlike CottonMap, which maps only cotton, SataCrop maps all crop types, allowing growers and applicators of all products to be better informed before spraying. The new technology requires growers to map their fields just once and has the added facility to import field boundaries from compatible software such as PCT, SST, Farmworks, John Deere and Agworld.

To use SataCrop, growers need to register by emailing Ben Boughton at PCT. The platform is easy to use and includes an instructional video which can be found on the website.

For more

Ben Boughton

ben@pct-agcloud.com

www.crop.satamap.com.au

Air temperature in real time

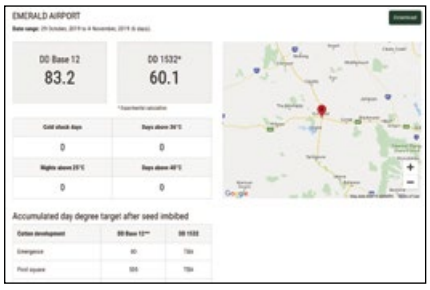
CSD has collaborated with CSIRO and USDA with support from CRDC in developing a new day degree calculator to assist with crop management.

"By contributing data to validate the equations across the industry, we envisage enhanced functionality and development of this tool, and encourage feedback from industry," CSD's Extension and Marketing Lead James Quinn said.

The online day degree calculator uses weather station data from more than 70 weather stations across NSW, Queensland, Victoria, the Northern Territory and Western Australia, based on daily maximum and minimum temperatures, to provide an indication of the amount of crop development expected on a given day.

"CSD's Day Degree Calculator will be an asset for in-field assessments, particularly in conjunction with our other apps under development," James said.

"Users will be able to quickly access



day degree accumulation from their phone or tablet for real-time data."

A handy download option accompanies the calculation. This allows users to download a csv file of minimum and maximum temperatures, as well as for all data. Daily and accumulative day degree data is also provided for easy graphing, and a Google map accompanies the chosen site to confirm location.

For more

www.csd.net.au/ddc

Growing a digital future in agriculture: what will it take?

AUSTRALIA'S agricultural industries have the opportunity to harness the benefits of big data and digital technology, and it's a case of working together at all levels, according to the Australian Farm Institute's Executive Director Mick Keogh.

Mick was the keynote speaker at the Australian Agriculture: Growing a Digital Future National Forum held at Parliament House in Canberra in September. The forum, led by CRDC with support from partners in the Growing a Digital Future project, bought together representatives from Rural Development Corporations, educators, researchers, government, the private sector and the farming community.

Research has shown that digital innovation could lift the GVP of the Australian agricultural sector by $20.3 billion. Four key areas have been identified as benefiting producers across the sector – managing inputs, automation and labour saving, market access and biosecurity and genetics.

The agricultural sector has set a course for Australian farms to produce $100 billion by 2030. In his presentation, Mick outlined opportunities and challenges for Australian agriculture's digital transformation.

"In the past, Australian agriculture was able to increase output, despite low productivity growth, by expanding the amount of land and water resources utilised by the sector," he said.

"That option is no longer available, and in fact the amount of land and water resources available to the sector has declined significantly in recent decades, and is predicted to shrink further.

"Consequently, a key focus of efforts to increase the annual value of agricultural output in Australia must be on improving agricultural productivity."

Mick said the advantages that digital technology can bring are not limited to the farm, and some of the biggest gains in value are likely to be generated from the adoption of digital systems that extend seamlessly through the supply chain from farm to consumer.

"Some of the best avenues Australian agriculture has available to increase the value of output involve targeting higher value and premium markets," he said.

Fortunately for producers, Australian supply chains are well placed to provide this information as part of the 'product', and digital technologies provide opportunities to supply product information at low cost.

MELANIE JENSON

ACCC's Mick Keogh was the keynote speaker at the Growing Digital National Forum in Canberra, pictured with project manager Jane Trindall, CRDC Innovation Broker.

"We now possess unimaginable levels of monitoring, and as such digital technology can supply product information at low cost, with better resource management, environmental outcomes and new career opportunities," Mick said.

Challenges

Digital agriculture also brings with it some new challenges such as connectivity; limited interoperability between systems; data portability; data rights; and creating better co-operation between public and private R&D sectors.

"A flourishing digital agriculture sector will require ongoing public-sector agricultural R&D, and better models of collaboration between the public and private sector R&D systems.

"And perhaps, most importantly, digital agricultural developments are likely to facilitate faster changes to the 'normal' way of doing things, meaning that all involved will need to respond much more rapidly than was the case in the past."

New products launched

Research presented at the forum outlined the amount of potential through agtech and big data is currently equalled by a lack of digital maturity, skills and governance, which is a barrier to adoption and utilisation of digital agriculture to its full potential.

To overcome this, two practical tools were released to help Australian agri-businesses adopt digital technologies in a way that adds value to their farming business.

The Australian Agricultural Workforce Digital Capability Framework and self-assessment tool provides the analysis and framework for education providers to develop a curriculum to meet future demand for digital skills.

Achieving a practical national framework will also guide ongoing investments and priorities as they relate to up-skilling the agricultural workforce to better adopt technology and lift the digital maturity.

Under the project, CSIRO developed the world-first digital maturity index and assessment tool specifically for agriculture.

"To ensure that the journey of digital transformation is purposeful and effective, it is important to first undertake an assessment of the industry to identify areas of digital strength and areas for development," Jane said.

"The development and launch of the on-line digital maturity index and assessment tool is considered a useful first step for digital transformation."

The tool can serve a diagnostic and, monitoring and evaluation function for digital transformation. It helps agribusinesses and individual agriculture sectors to evaluate their current levels of digital maturity, identify areas of strength and weakness, as well as assist them in setting goals, and in developing and evaluating targeted digital-improvement initiatives.

For more

www.crdc.com.au/growing-digital-future

New resistance testing regime

NSW DPI's Dr Lisa Bird is starting a new project on insecticide resistance to focus on pests where and when needed. Resistance surveillance will continue to provide industry with evidence-based resistance frequency data and testing will be prioritised for pests and insecticides identified as emerging issues for industry and/or at heightened risk of resistance development.

CRDC has a long history of working NSW DPI in resistance monitoring programs, previously undertaken by Dr Grant Herron.

"We would like to acknowledge the enormous contribution Grant has made to our knowledge and success in managing resistance," CRDC R&D Manager Susan Maas said.

"While insecticide resistance remains a serious threat, the industry has consolidated our efforts for insecticide resistance monitoring.

"Lisa will continue her work monitoring Helicoverpa, while adding a range of pests to her project including mites, mirids and aphids.

"Dr Jamie Hopkinson of QDAF is still monitoring and testing resistance in silverleaf whitefly.

"It is hoped the change to a risk assessment-based approach delivers efficiencies in our testing and monitoring, allowing a focus on where the need is greatest – as opposed to testing every pest and every insecticide every year."

Lisa will continue working with CRDC, GRDC and the grains industry to address growing resistance levels in Helicoverpa in pulses. Results from the industry-wide resistance surveillance program have shown levels of resistance to indoxacarb in *H. armigera* have increased in areas of Central and Northern Queensland. Resistance surveillance monitoring and detection of early-stage resistance in grains will increase preparedness in the cotton and horticulture industries. Growers and consultants with any concerns about resistance should contact Lisa.

For more
Lisa Bird
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The Sentinel, a mobile surveillance unit offers optimal sampling of airborne fungal spores and insects.

Sentinel on duty soon

A national multi-agricultural industry surveillance initiative, iMapPESTS, is developing novel airborne surveillance and diagnostics technologies to speed up detection and reporting of important pests and diseases in cotton growing regions and beyond.

The iMapPESTS: Sentinel Surveillance for Agriculture program aims to rapidly monitor and report the presence of airborne pests and diseases for multiple agricultural sectors, including cotton, sugar, grains, viticulture, horticulture and forestry.

The five-year program is being led by Horticulture Innovation, with funding from the Australian Government's Rural R&D for Profit Program, along with 16 partner organisations including CRDC.

A key feature of the program is the Sentinel, a mobile surveillance unit that offers optimal sampling of airborne fungal spores and insects. The Sentinel is a specialised trailer equipped with several airborne samplers, a climate sensor, telemetry and an industrial computer to remotely control and monitor the unit, including automated robotics to change pots on the samplers according to the day or capture criteria.

A prototype Sentinel was recently launched at a field trial site for grains in Hart, South Australia. In February 2020 a second Sentinel will be commissioned during North Queensland's wet season before making its way down through Queensland and Northern NSW, where it will target airborne pests of cotton such as green mirid and Helicoverpa.

The iMapPESTS research and industry network will work with growers and industry representatives to determine the best way to communicate the dynamic pest information data it gathers to end users, potentially via mobile devices. This includes which pests or diseases the Sentinel is detecting in an area at a particular time.

The iMapPESTS team will be hosting a show and tell of the Sentinel for cotton growers during autumn. Event details will be shared through CottonInfo and the next edition of *Spotlight*.

Cotton growers and their consultants are encouraged to visit the iMapPESTS website for more information, including where and when the sentinels will be in your region and how to be involved.

For more
www.imappests.com.au

Taking water research to the field reaps award

THE cotton industry's quest to improve natural resource management has been recognised through a prestigious award to researchers at the University of Southern Queensland (USQ) for the development and implementation of water saving technology in the cotton industry.

CRDC supported the researchers in the development and implementation of the irrigation technology IrriMATE which was recognised as having a 'high' impact, the top rating in the Australian Research Council's Engagement and Impact Assessment 2018-19 National Report.

The USQ Irrigation and Water Management team today is made up of well-known faces including Associate Professor Joseph Foley, Dr Alison McCarthy and Dr Malcolm Gillies, 2018 recipients of the CSD Cotton Researcher of the Year Award.

The particular recognition by the Australian Research Council was for their efforts with furrow irrigation improvement through the IrriMATE process with industry and its commercialisation, leading onto the most recent implementation of some of this technology with VARIwise, the irrigation control technology developed by Alison with support from CRDC.

"CRDC funded USQ's research from 1998 to 2005, and an independent analysis undertaken by CRDC of the impact our irrigation research highlighted the significant in-field savings that can be achieved with IrriMATE," Joseph said.

"From 2004 to 2014 USQ's commercial partner Aquatech and extension partners completed over 600 furrow irrigation assessments.

"This unique measurement and modelling process was used widely, with average water savings in furrow irrigation of 10 to 15 per cent."

USQ was the primary irrigation engineering research provider focused on the cotton industry from 2003 to 2012, and the Australian cotton industry reported a 40 per cent increase in water use productivity in that period.

CRDC's cost-benefit analysis conducted by the BDA Group in 2007 credited IrriMATE technology as being the main driver for greater water productivity in the cotton industry. The report showed that water savings across cotton systems were 28.5GL per year with a corresponding economic gain of $33 million per year. This equates to 170GL and $198 million in the six-year period.

MELANIE JENSON

Associate Professor Joseph Foley and his fellow researchers have been instrumental in bring irrigation technology to the field, resulting in increasing water use efficiency.

Smarter irrigation awarded

The recent successful automation of broad-acre irrigation systems through the Smarter Irrigation for Profit Project (Phase 1) was also acknowledged through this award. The Smarter Irrigation for Profit project was led by CRDC and included investment from Sugar Australia, Dairy Australia and AgriFutures Australia Ltd under the Australian Government's Rural R&D for Profit Program. The team at USQ was instrumental in bringing automated and variable rate irrigation practices to the field.

The team was acknowledged for their R&D efforts and impactful engagement with the Australian cotton industry which facilitated the uptake of this water saving technology and other irrigation knowledge.

On the back of this success, funding for Phase 2 of Smarter Irrigation for Profit has recently been announced.

"Our success in the agricultural engineering field has come about from the long history of significant and continuous engagement in the cotton industry by many of our staff from the 1990s to today," Joseph said.

"Living and working as part of the cotton community in regional Australia and understanding the ramifications of limited water in drought periods, drives our continual focus on irrigation research.

"This activity would not have been possible without funding support from Australian cotton growers through CRDC."

For more:
Joseph Foley
Joseph.Foley@usq.edu.au

Award for excellence

COTTON industry researcher Dr Nicole McDonald has received the 2019 Excellence in Career Development Research award from Career Development Association of Australia (CDAA). CDAA is Australia's largest cross-sectoral community of career development practitioners.

"It is wonderful to be recognised by the CDAA for this research as it reflects the reputation the cotton industry has for being a progressive industry that values its people," Nicole said.

As the core of Nicole's CRDC research projects over the past five years, her research seeks to understand how an increasingly digital approach to agriculture is changing the structure and the skills required of the cotton industry workforce.

"Who do we recruit, retain, and how do we support our current workforce to adapt?" Nicole says.

"If we want agile businesses that aim to capitalise on new opportunities, we need agile people.

"This includes identifying what technical skills are required and how best to train for them, but also the research shows we need to be aware of and have a plan to cultivate all of those underlying abilities that help people to thrive at work.

"We're identifying the facilitators and barriers as well as generating potential solutions to developing the mindsets, the attitudes, and the behaviours that strengthen a central part of farm productivity: our future workforce.

"I'd like to acknowledge the support from my supervisor Peter McIlveen and the University of Southern Queensland's ACCELL research team, CRDC, Cotton Australia and the broader cotton growing community."

Nicole's research is now being used to advocate for career development to be part of a national approach to agricultural workforce development. As a result of her research and advocacy, Nicole has been admitted into the 2030 National Farmers' Federation Leaders and Australian Rural Leadership Foundation alumni.

For more
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Grace Scott is excited to have handed in her Masters of Research thesis at University of Nottingham, UK and thanked CRDC and the cotton industry for their support, both academically and professionally.

Supporting the brightest to bigger things

YOUNG Australian scientist Grace Scott is focused on developing sustainable alternative fertilisers in cotton, and recently attended the 2019 Bayer Youth Ag Summit. She was one of 100 students aged 18 to 25 selected from around the world to attend the summit.

Grace has been supported in her study by CRDC through a number of initiatives including the Horizon Scholarship and Cotton X-lab program. She said attending the conference has been a long-term goal over the last three years, which wouldn't have been possible without CRDC support.

"I was absolutely thrilled to be invited to the Youth Ag Summit this year," Grace said.

"The Horizon scholarship program was an excellent platform to develop leadership and networking skills, which set off a chain of career opportunities which led to CRDC supporting my cotton research in the UK."

Grace's research is centred around *Gluconacetobacter diazotrophicus,* a nitrogen-fixing bacteria capable of living within plant tissue. Once colonisation is established, the bacteria can meet up to 50 per cent of the host plant's nitrogen needs. It also boosts plant growth and protects against pathogens. So far, *G. diazotrophicus* has colonised every plant species it has been tested on and there are hopes for use in cotton.

"In the future I hope to work with the cotton industry, implementing continuous product improvement to develop industry specific, market ready biological alternatives to fertilisers and growth promotants," she said.

In 2017 Grace was selected by CRDC to be a part of a start-up accelerator program when CRDC partnered with a leader in start-up science, Pollenizer, and the Fisheries RDC to help take innovative ideas and turn them into a reality. Workshops enabled participants to develop their ideas with experts from across the industry and watch them come to life.

CRDC further supported Grace's research through the commercialisation grant to work with the Cotton X-Lab program, which has helped develop a funding pitch and intellectual property agreements.

"The project allowed me to continue my career as a cotton researcher with a Masters in Research," Grace said.

Breaking down the glass wall

UNIVERSITY of Queensland PhD student Rhys Pirie's glass recycling research continues to draw recognition at the highest levels.

Rhys was one of three winners at The Falling Walls Lab event hosted by the Australian Academy of Science involving 20 emerging innovators gathering in Canberra to present their ideas, research and initiatives on the theme 'Which walls will fall next?'. He will now travel to Berlin to represent Australia at the Falling Walls Lab Finale.

Rhys's ground-breaking research, co-funded by CRDC, has developed a chemical recycling process for the more than 60 million tonnes globally of glass that goes to landfill every year because of its different colours and it is too small to be sorted by traditional recycling methods.

Rhys has led the development of a chemical recycling process that turns glass into low-cost industrial feedstock used to make thousands of different consumer products, including tyres, toothpaste and fertiliser, which is of particular interest to the cotton industry.

Rhys was awarded the CRDC-supported ABARES Science and Innovation Award for Young People in Agriculture in 2018 for his focus on re-purposing organic wastes (such cotton gin trash) as fertilisers and soil ameliorants. He was further honoured with the Minister for Agriculture's Science and Innovation Award.

Rhys Pirie was presented his Falling Walls award by Australia's Chief Scientist Alan Finkel.

The glass processing technology has the potential to revolutionise multiple supply chains and Rhys is also looking at ways in which waste glass could also be used to create a low-cost amorphous silica additive to increase phosphorous (P) fertiliser efficiency.

"The economics of improving fertiliser efficiency are quite challenging, but a step-change decrease in raw material costs opens up the possibility for new products.

"Our initial tests in sorghum have shown that mixing bio-solids ash with our silica-gel results in a statistically significant increase in P uptake.

"It's still very early and cost reductions are reliant on the process first scaling in high-value traditional markets (tyres, toothpaste), but it's exciting to see the research completing the loop!"

The cotton industry was very well represented at the NSW Rural Women's Awards in Canberra in September. Pictured are CRDC's Lynda George, CRDC Director Rosemary Richards, agronomist Emma Ayliffe, Cotton Australia Policy Officer Angela Bradburn, Cotton Australia Central Highlands Regional Manager and Nuffield Scholar Renee Anderson, CRDC researcher Nicole McDonald, CRDC R&D Manager Rachel Holloway, Crop Consultant's Australia's Fiona Anderson and Cotton Australia Director and cotton grower Fleur Anderson.

Finding cover

Trangie farmer Richie Quigley will look at how growers can improve infiltration rates and stored soil moisture through maintaining crop residues as cover, under his 2019 Nuffield Scholarship.

Richie Quigley on the Quigley's farm at Trangie.

With his family, Richie manages their mixed farming operation in the Macquarie Valley in Central West NSW, which includes irrigated and dryland cotton, along with grains, canola and chickpeas and a grazing operation focused on breeding and finishing sheep and cattle.

"Farming in marginal cropping areas, we usually find moisture to be our most limiting factor," Richie said.

"If we can utilise techniques involving ground cover that help us preserve more moisture, it could produce a range of benefits, including increased productivity, soil health, yields and reduced weed pressures.

"This extended dry period has reinforced how important ground cover is to us.

"Cover is so important for rainfall infiltration and protection from wind erosion, particularly on lighter soil types.

"Anywhere without ground cover has or will cause a missed opportunity at some point, and it's hard to grow back to replace cover when it's this dry. If you are forced to plant to regain cover it another expense."

"If we could increase fallow moisture even by 10 per cent that will make a big difference to our farming systems."

Richie said in zero tillage farming systems they seem to only store 20 to 50 per cent of their fallow moisture, depending on when the rainfall occurs in the fallow period.

"If we could increase that even by 10 per cent that will make a big difference to our farming systems," he said.

Richie sees better managing crop residue as a major option in achieving this.

"The outcomes of the research could provide increased planting opportunities within, and outside, traditional planting windows, opening up potential to grow different crop types in marginal environments, including increasing the viability of rain-grown and semi-irrigated cotton production."

Richie plans to visit well-established cotton and grain production areas like Brazil, United States, Canada, and England, where growers are using a range of methods and technologies that may be applicable in Australia.

"On my travels I want to see and learn about the farming system involved with retaining more cover," he says.

"I believe there are benefits from this style of farming that will suit the dry Australian climate.

"I also want to see how people are handling large quantities of crop residue material and investigate any issues and benefits arising from that. I am also hoping to see harvesters set up for stripper fronts to maximise capacity and minimise loss.

"I am also looking to see how this system will benefit rain grown, semi irrigated and fully irrigated cotton production, and how it could be applicable in Australia."

The cotton industry Nuffield Scholarships are supported by CRDC and Cotton Australia.

"It's an honour to be a part of the program and I'm very excited to be a part of it," Richie said.

"I'm also pleased to be able to go through with a fellow cotton grower from the Macquarie, Billy Browning; we are hoping to do a fair bit of travel together."

For more
Richie Quigley
richiequig@bigpond.com

A journey of self-awareness

Cotton industry leaders Fleur Anderson and John Durham graduated from course 25 of the ARLP with a ceremony in Canberra in late October.

Cotton Australia's Mike Murray, ARLP graduates Fleur Anderson, John Durham and Auscott's Bernie George.

Fleur is no stranger to the broader cotton community, with various leadership roles such as a Cotton Australia board member and Australian Cotton Conference Chair. Fleur is also an entrepreneur who runs the Rural Business Collective from her farm in Theodore, Central West Queensland. She is a strong advocate for regional areas and the people who live in them and has worked tirelessly for years promoting her home region and agriculture to the outside world.

So how does someone who we might already think of a successful leader become even more efficient through courses like the Australian Rural Leadership Foundation's?

"I think you never really 'arrive' as a leader and I guess the biggest thing for me was two-fold," she said.

"Firstly, it was the opportunity to step outside of my 'day-to-day' to focus on reflecting on my leadership style and where I want to take that into the future.

"It is an absolute luxury really to take that time, as we rarely get that opportunity in real life.

"Secondly I have heightened self-awareness: I think to be a truly effective leader you need to constantly hone your skills and develop your self-awareness.

"Knowing the impact you are having on others and how to work with a variety of people is probably in my experience the difference between authority and leadership.

"Being an adaptive leader and knowing what's required in certain situations has been a valuable learning – you've got to be able to take people along with you!"

Fleur says despite this, she still experienced moments of doubt.

"I seriously debated whether I had the time to be on the course, and what I was going to get out of it but I think 15 months later I have emerged enthusiastic and excited about what I can contribute back to the industry, and most importantly do it from my own personal style of leadership.

"Every leader in our industry has brought their own strength and experience to their role and the more we can encourage others to do that the more cognitive diversity we are going to have.

"That kind of diversity (not just gender and background) is going to help us face the challenges we have ahead in the cotton industry.

"I strongly believe the greatest risk to any ag industry at the moment is 'groupthink'.

"Cotton does it better than many, but we need to be acutely aware of the strength that kind of diversity brings.

"CRDC, Cotton Australia and Auscott really need to be applauded for the way they approach their investment in people right across the industry and the supply chain.

"I really enjoyed the course overall and am incredibly grateful for the opportunity."

"Being an adaptive leader and knowing what's required in certain situations has been a valuable learning – you've got to be able to take people along with you!"

Grab it with both hands

As the manager of the Riverina-based Southern Cotton farming operation, and president of the Southern Valleys Cotton Growers Association, John Durham is no stranger to the strategic organisation, decision-making and communication that comes with industry leadership.

Over the last 15 months however, through the ARLP, the scope of just what a leader's responsibilities are have shifted and expanded for him.

"Prior to the ARLP, I would typically prefer to avoid confronting conversations and be reluctant to engage with those with a negative perspective of the cotton industry," he said.

"On a personal level, I now have the confidence to share my story and to be proud of growing and supplying the best quality cotton fibre to the world."

Having experienced the ARLP at the same time as his industry has borne its own challenges, is something

John has appreciated.

"Firstly, the cotton industry is extremely inclusive and encouraging, which is how I came to apply for the program.

"ARLP Course 2 graduate and Cotton Australia CEO Adam Kay suggested I consider it.

"I had the support of my industry, my employers and family behind me, and I knew I had to step-up and give it a go."

As one of the youngest members of his ARLP cohort at age 34, the leader says he was never made to feel like he had less to offer.

"The power of being genuine and authentic is one of the biggest things I have learned from the whole experience," he says.

From the "grounding" nature of the Kimberley session, unplugged from distractions, to the cultural barriers broken down throughout the session in Indonesia, the ARLP has added to John's sense that emotional quotient or 'EQ' is a potent power to leverage as a leader.

"Generally, what sets a profitable farming business apart from a less profitable one is relatively simple: operational timeliness and productivity.

"But often what is overlooked is that people are an integral part of productivity. I certainly acknowledge that I have been focused so much on process and productivity that I have overlooked the people.

"Another thing that I have taken from the ARLP is the power of listening: it is critical to listen to people and understand what their needs are."

Looking ahead, John says wherever his efforts are concentrated, he will continue to draw on authenticity and candour to communicate effectively.

"Times are continually changing in the agriculture sector – there's a necessary drive for innovation across all the industries, which has a big flow-on to regional economies," he says.

And if that process includes an opportunity for development like the ARLP, John urges those in agriculture to grab it with both hands.

"You'll have the opportunity to meet and engage with some of the most inspirational and informed people, and you'll be equipped to reach your goals. It's a unique opportunity for personal reflection and growth."

Chantal Corish works with the community to empower them across health, finance and resilience.

Course 26 of the ARLP has kicked off, and the cotton industry is supporting two candidates, Chantal Corish and Rod Gordon.

Chantal is a cotton farmer near Goondiwindi in Queensland, where she also runs a coaching business that focuses on the wellness of employees and community groups in rural Australia.

"Getting into the program was something I really wanted to achieve as I think it has a very good reputation for being the foremost leadership program for rural and regional Australia," she said.

"I feel so fortunate to have the support and am taking every opportunity the ARLP is offering to hone my understanding of what it is to be a leader; and what 'making a difference' actually looks like.

Being a psychologist and a cotton farmer, Chantal see this as a prime opportunity to bridge knowledge gaps

Rod in the Kimberley, WA, which is often cited as one of the most rewarding experiences of the course.

New recruits share passion for industry

between farmer mental health and her profession.

"The ARLP program will help to ensure that the path I take is effective, in that from what I have experienced so far, the program is designed to promote self-discipline, provide pertinent networking opportunities, and enable the 'shoulders to stand on' to give me a broader perspective of the industries and government structures in which I am working."

Chantal already runs a women's wellbeing and mindfulness program called Flourish in her region, and has just launched a similar project for men – The Man Box Challenge, which is designed to help men and their partners understand the pressures put on them by male stereotyping and the effect this has on their mental health and suicidality, particularly in times of drought.

"I'm also having lots of fun with couples when delivering the Love in the Age of Drought topic of these workshops, which I hope will help rural couples sustain their relationships through the hardship of drought."

Chantal is supported by CRDC, Auscott Limited, Cotton Australia and Prime Super.

Rod brings very broad experience in many sectors of the cotton industry to his ARLP scholarship.

He has recently taken on a role as Central Regional Manager at Hancock Farmland Services' irrigated cotton and broadacre investments. For the past 15 years Rod has worked in research, extension and management roles in cotton and broadacre cropping, largely based in the Gwydir Valley around Moree in North West NSW.

"My passion is in delivering outstanding service and striving to continuously achieve benchmarks," he said.

"I always aim to identify and diagnose root cause issues, and develop and implement creative solutions that generate efficiencies and drive performance improvement.

"The ARLP program will help to ensure that the path I take is effective."

"In any industry or business, customer service focus and strong stakeholder engagement and relationship management skills are key and I like to work collaboratively with others to achieve business objectives."

Passionate and dedicated, Rod thrives in a competitive and challenging environment that requires critical reasoning, strategic planning and an outcome focus.

"I'd define success as finding a way to create value in every interaction with customers, staff and key stakeholders."

Rod is a passionate and driven agribusiness professional with a strong research background, holding a Bachelor of Applied Science in Crops and Rangelands and a Masters of Business Administration and Marketing. He's a qualified USDA cotton classer and a graduate of the ACSA International Cotton School.

"I'm passionate about developing effective and lasting relationships between farm managers and key stakeholders throughout the production process," he said.

"I'm thankful and honoured to be supported by Hancock Farmland Services Australia and Hancock Natural Resource Group to participate in the program, and my industry sponsors CRDC, Cotton Australia and Auscott Limited."

For more
Australian Rural Leadership Program
www.rural-leaders.org.au

Cotton in a changing climate: what the research says

The Australian cotton industry is looking to the future through explicit research focusing on what impact climate change and extreme weather events will have on cotton production, and seeking to understand how we can adapt to environmental changes.

Dr Katie Broughton has been using Canopy EvapoTranspiration and Assimilation (CETA) chambers in the field at Narrabri, NSW to generate warmer and higher CO_2 environments for field-grown cotton.

Worldwide cotton production has broadly adapted to growing in temperate, subtropical and tropical environments, but growth and production systems in Australia may be challenged by future climate change. Changes in climate factors such as warmer air temperatures and extreme fluctuations in precipitation as a result of rising carbon dioxide (CO_2) concentration may significantly impact plant growth and crop productivity.

Prior research utilising controlled environment glasshouses and field studies in the US have provided an excellent foundation of understanding potential impacts. However, there has been no specific research into climate change impacts for modern Australian cotton systems, and little research attempted to assess the combined interactive effects (temperature x CO_2 x water) of climate change on cotton productivity; especially in the field.

Over the past several years, a range of research initiatives led by CSIRO and Western Sydney University, and supported by CRDC, have been underway to better understand responses of the Australian cotton system to this changing environment. Research has included simulation modelling, glasshouse and field-based studies, which has revealed some key insights. On-going research requires a multi-faceted approach that incorporates model simulations, glasshouse and field studies to better our understanding and knowledge of cotton system and plant-soil responses to projected environmental conditions for Australian cotton regions.

Climate change will have both positive and negative effects on cotton production. Increased CO_2 may increase yield in well-watered crops and higher temperatures will extend the length of the growing season. However, warmer temperatures also accelerate the rate of crop development and could potentially shorten the time to maturity, which may then impact crop management decisions.

Higher temperatures also have the potential to cause significant fruit loss, reduce water use efficiencies, lower yields and alter fibre quality.

Environmental conditions that encourage excessive shading by the leaves may lead to fruit loss throughout the season. Consequently, fruit loss may exacerbate excessive vegetative growth and further loss of fruit, due to a lower fruit load to restrict vegetative growth.

A prediction of more frequent extreme weather events such as droughts, heatwaves and flooding pose significant risks to improvements in cotton productivity. Inter-annual yield variability is likely to be greater, with benefits from increases in yield potential during favourable seasons, but also large reductions in yield during the seasons affected by extreme weather events.

Research into integrated effects of climate change (temperature, humidity, CO_2 and water stress) on cotton growth, yield and quality will be important. This includes the development of cultivars tolerant to abiotic stresses (especially for more frequent hot, water-challenged (deficit and waterlogged) conditions), and better understanding of whole system management strategies to maximise

production and minimise losses of cotton grown in variable environments. In a systems context, climate change is a multi-factor complex issue that is likely to require more than one solution to address the multi-dimensional, integrated impacts on Australian cotton production systems.

This overview highlights some of the recent research that outlines legacy effects, climate change across Australian cotton regions, and the impacts of extreme weather events on cotton systems.

Legacy effect

The positive effect of elevated CO_2 on cotton growth and yield is generally consistent across studies, however, single-season experiments do not account for 'legacy effect' on subsequent crops.

Cotton plants under elevated CO_2 produce N-poor litter, which can reduce soil N availability for subsequent crops through reduced decomposition rate. As a third of cotton's N uptake comes from mineralised N, reduction in decomposition can strongly limit the yield response to elevated CO_2 in subsequent seasons.

In glasshouse experiments, elevated CO_2 strongly reduced yield in the second year, particularly at ambient temperature. Conversely, warmer air temperature had a consistent effect and seemed to negate the negative effect of elevated CO_2 on yield.

Assessing the strength of this legacy effect in the field will be critical in developing fertiliser recommendations to mitigate the potential negative impact of elevated CO_2 on cotton yield in the future.

Climate change across cotton regions

There have been substantial increases in atmospheric CO_2 concentration since the beginning of the industrial age. Atmospheric CO_2 during the past 800,000 years ranged between 170 and 300 µmol mol-1 in response to natural transitions between glacial and inter-glacial periods.

However, atmospheric CO_2 has been rapidly increasing over the past 200 years due to world-wide industrial activity from a pre-industrial concentration of about 280 µmol mol-1 to 406 µmol mol-1 in 2017 (Tans and Keeling, 2018), with projections for more rapid increases in the future. It is projected that atmospheric CO_2 concentration will rise to 450 µmol mol-1 by 2030.

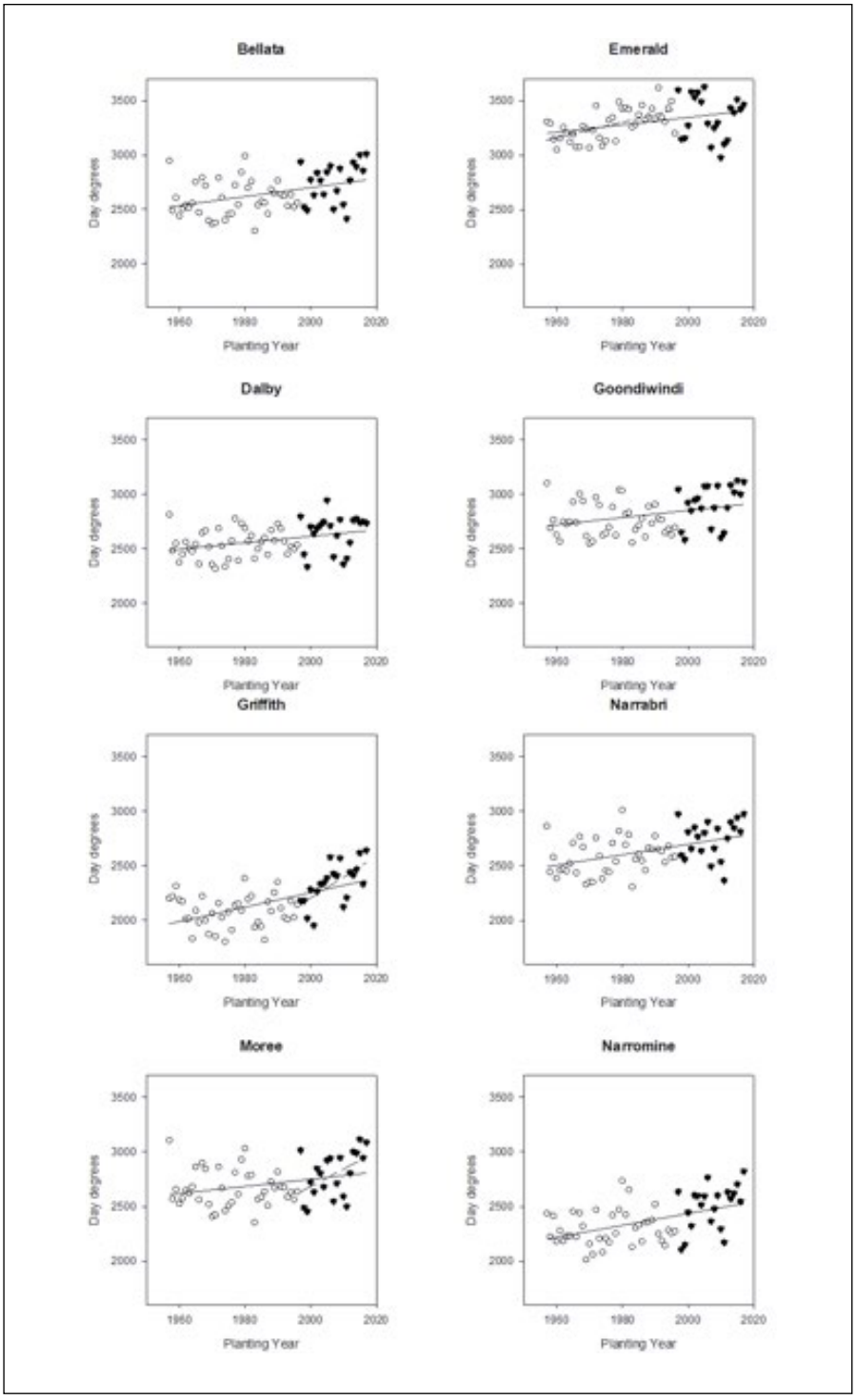


Figure 1: The number of day degrees (a measure of heat accumulation throughout the growing season from September to April) for eight cotton production locations in Australia for three periods: (a) 1957 to 2017 (all symbols); (b) 1957 to 1996 (white symbols); and (c) 1997 to 2017 (black symbols). Regression lines have been fitted for each period where the slope is significant at P<0.05.

As a consequence of rising greenhouse gases in the atmosphere, including CO_2, global air temperatures have also been increasing throughout many regions. Global average air temperature has warmed by more than 1°C since records began in 1850, and each of the last four decades have been warmer than the previous decade (CSIRO and Bureau of Meteorology, 2018). Australia's climate has increased 1°C since 1901 with

an increase in the frequency of extreme heat events (CSIRO and Bureau of Meteorology, 2018).

In a recent study, eight locations across Australia's cotton-growing regions have been assessed to explore temperature trends from: (a) 1957 to 2017 (60 years); (b) 1957 to 1996 (39 years); and (c) 1997 to 2017 (20 years). All eight locations exhibited a trend for an increase in the accumulation of the number of day degrees (a measure of heat accumulation throughout a growing season, from September to April) during the period 1957 to 2017 (Figure 1). Furthermore, from 1957 to 1996, there was an increase in the number of day degrees at Emerald, and during the period 1997 to 2017 there was an increase in the number of day degrees at Griffith and Moree.

Although the slopes of each regression were mostly positive, suggesting a possible increasing trend in day degree accumulation, the variation in the number of day degrees between years was large over a relatively short timeframe. However, the significant increasing trend in the number of day degrees from 1957 to 2017 for all eight locations indicates an increase in the number of hot days and warmer night-time air temperatures.

Current climate projections indicate Australia will exhibit more heatwaves (air temperatures greater than 35°C). Recent examples were during the 2016-17 cotton season, where high temperature records were broken across the country. Moree, in the Gwydir Valley in North West NSW, recorded 54 consecutive days exceeding 35°C. The previous record was 11 days above 35°C. Mungindi, north of Moree, measured 49 consecutive nights of 20°C or above. The previous record was 27 nights.

Climate projections also indicate that there will be changes in rainfall distribution, including an increase in the intensity of drought and flooding. Drought conditions directly affect dryland crops during the season and reduce water availability for irrigated cotton systems. On the other hand, Australia's cotton is often grown on heavier soil textures (clay soils), so crops may experience yield losses due to waterlogging during heavy rainfall events.

Crop simulation studies

Crop simulation studies assessed the potential impacts on lint yield, water use, and water use efficiency across nine Australian cotton locations covering diverse irrigated and dryland scenarios at Emerald, Dalby, St George, Goondiwindi, Moree, Bourke, Narrabri, Warren, and Hillston. The results of these simulations are summarised in Table 1.

Collecting physiology measurements on cotton grown in the controlled environment glasshouse at Western Sydney University, Richmond, NSW.

Cotton grown inside the climate chambers were tall and highly vegetative, leading to large reductions in plant-level water use efficiency.

Leaf, Plant and Crop Level Effects

The integrated effects of warmer air temperatures and elevated atmospheric CO_2 concentration on cotton growth, physiology and soil microbiology have been studied in a number of glasshouse and field studies in recent years. In both field and glasshouse studies, elevated atmospheric CO_2 increased vegetative biomass and photosynthetic rates of cotton compared with plants grown at current CO_2 levels. In glasshouse studies, elevated CO_2 improved leaf and plant-level water use efficiency of cotton, which was associated with improved photosynthesis and biomass production, rather than decreases in water use. However, these studies also showed that improved water use efficiencies were negated by warmer air temperatures, as more water was required to grow the plants.

The field studies showed similar outcomes, but other crop level issues emerged. Increased vegetative biomass and reduced water use efficiency became evident as water consumption also increased. Crops had excessive vegetative growth with large leaf areas significantly increasing transpiration. Further reductions of water use efficiency were then associated with high temperatures, as well as the excessive shading caused by the leaves, leading to the shedding of fruit throughout the season.

System type	Location	Change in lint yield	Change in water use	Change in crop WUE
Irrigated	Dalby	▲ 6% (at 449 ppm)	▲ 2-4%	
		▼ 3.6% (at 555 ppm)		
	Bourke		▲ 2-4%	
	Narrabri		▲ 2-4%	
	Hillston		▲ 2-4%	
	Overall	▲ 0-26%	▲ 0-4%	▲ 0-24%
Dryland	Emerald	▲ 15-26%	▲ 2-8%	
	Dalby	▲ *Only with solid planting config.	▼ -5 to -2%	
	Moree	▲ 15-26%	▼ -5 to -2%	
	Narrabri	▲ 15-26%	▲ 2-8%	
	Overall	▲ 15-26%		▲ 2-22%
▲ indicates increase, ▼ indicates decrease				

Table 1: Simulated cotton lint yield, water use and water use efficiency (WUE) across locations under future climate scenarios for the period centred on 2030.

In turn, this continued to exacerbate the vegetative growth and the loss of fruit because there was little fruit load to restrict vegetative growth.

Varietal performance

Studies have been conducted to explore differences between cotton cultivars in projected climatic scenarios. As future environments are anticipated to produce larger cotton plants with potentially greater requirements for water, plants with smaller, more compact vegetative growth habits and higher photosynthetic rates (eg Sicot 71BRF) may have an advantage over cultivars with substantial plant biomass and leaf area (eg DP16). Therefore, there may be variation in plant performance that could be utilised in the selection of breeding lines for future environments; however, implementation in capturing the needs for climate change in breeding programs remains a challenge.

Soil impacts

Studies have indicated that projected climate change may impact nutrient availability and soil microbial communities. This is important to consider given the key role soil microbes play in nutrient cycling and availability, and the importance of nitrogen use efficiency in cotton systems.

Most climate change effects on soil communities are linked to changes in plant responses, thereby generating plant-soil feedbacks.

Low soil N may reflect greater plant N uptake and thus may not necessarily mean low nitrification rate. Additionally, limitations in plant growth may result in greater soil N levels than when plants are actively growing and utilising N from the soil.

Recent studies determined that climate responses of soil physicochemical (physical and chemical) properties and nitrification rate were also related to crop growth stage; only responding when the crop reached the early flowering stage. The studies also found that the changes were related to the abundance of microbial nitrifiers in the soil. Specifically, warmer air temperatures did not significantly change potential nitrification rates, and these alterations were dependent on the growth stage of the crop.

Changes in the rate of nitrification processes, and functional microbial communities that affect nitrification, could potentially lead to alterations in soil nitrogen availability, which may subsequently affect cotton crop productivity and nitrogen use efficiency.

Impacts of extreme weather events

Climatic projections include far greater variable weather conditions in the future, which is likely to have a more severe impact on cotton productivity. Projected climatic conditions are likely to increase inter-annual yield variability because of the high yield potential in seasons where there are no extreme climatic events, but large reductions in yield during seasons that are affected by extreme climatic events.

Simulation models demonstrated an increase in the number of days above 35°C across all locations in the study (ranging from Emerald to Hillston). There was also a reduction or no change in the number of cold shocks (≤ 11°C) throughout the majority of the growing season, with the exception of increased cold shocks in some NSW growing areas in January and February.

Furthermore, there were reported increases of two to 16 per cent and four to 17 per cent in mean rainfall and rainfall variability, respectively, within cotton growing season for the period centred on 2030, which will have significant consequences on farming system. For example, nitrate is highly mobile in soil, and thus susceptible to leaching in flooded conditions.

Glasshouse studies have shown that flooding caused a rapid loss of N from the soil, contributing to a reduction in growth and yield of cotton, particularly at warmer temperatures.

This article is a condensed version of a more comprehensive review of the recent research into effects of climate change and extreme weather events on Australian cotton systems undertaken by Katie Broughton and Michael Bange (CSIRO), David Tissue, Linh Nguyen and Brajesh Singh (Western Sydney University), Yui Osanai (University of New England), Qunying Luo (University of Technology Sydney) and Paxton Payton (USDA), whose efforts are gratefully acknowledged. The full version is available on the CottonInfo website: www.cottoninfo.com.au

A global assessment of the impact of climate change and adaptation in modern cotton farming systems has also been published by the International Cotton Advisory Committee in association with CABI "Climate change and cotton production in modern farming systems".

Hitting weeds where it hurts

Diversify and Disrupt was this theme of this year's Weedsmart Week. Held in Emerald over three days in August, the main message was conquering weeds with the 'Big 6'.

The event also launched the 'Summer Big 6', to accompany the existing Winter Big 6 messages. The Summer Big 6 relates specifically to summer cropping systems. WeedSmart Week is designed to engage growers and advisors on the Big 6 messages**.**

The three-day program consisted of a one-day forum; a full day bus tour to farms in the Emerald area; and a half day tour at SwarmFarm Robotics.

Several cotton industry consultants and specialists were involved, sharing valuable insights into weed management. Growers and agronomists heard first-hand about integrated weed management practices to minimise the impact of herbicide resistance.

What is the Big 6?

The 'Big 6' aim to make the fight against crop weeds simple to follow and apply. There are six core points to follow along some additional 'WeedSmart Wisdom'. Found on the Weedsmart website: www.weedsmart.org.au, crop managers can follow the links for practical tips and tricks to implement these strategies on-farm and further information on the research to back up these steps.

"This plan is all about the farmer calling the shots, not the weeds," said WeedSmart's Lisa Mayer.

"The Big 6 has evolved since its inception and will now include different cropping systems throughout Australia." CRDC is a partner in WeedSmart, helping to combat herbicide resistance.

Weedsmart – summer cropping Big 6

1. USE DIVERSE ROTATIONS

- Use rotation crops, fallow and pasture phases to drive the weed seedbank down over consecutive years.

2. DOUBLE KNOCK -TO STOP SURVIVORS

- Use two weed control tactics with different modes of action (eg; glyphosate followed by paraquat) on a single flush of weeds to stop any survivors from the first application setting seed.
- Also use non-herbicidal tactics – cultivation can be the second knock
- When executed well (correct rates, timing and application) the double knock tactic can provide 100 per cent control of target weeds.

3. MIX AND ROTATE HERBICIDES AND TILLAGE (2+2+0)

- Rotate between herbicide groups
- Use different modes of action within same herbicide tank mix
- Strategic use of tillage can complement a herbicide programme and help get on top of weeds in a reset situation.
- In cotton systems aim to target both grasses and broadleaf weeds using 2 non glyphosate tactics for broadleaf & grasses in crop and 2 non-glyphosate tactics during the summer fallow and always remove any survivors. (2+2+0)
- For cotton post picking, ensure complete survivor control using all options, including at pupae busting for extra weed seed burial.

4. STOP WEED SEED SET IN CROP AND IN FALLOW

- Aim for 100 per cent control of weeds and diligently monitor for survivors in all post weed control inspections.
- Crop top or pre harvest spraying in canola, pulses, feed barley and wheat in weedy paddocks.
- Consider hay production, brown manure or long fallow in high pressure situations.
- Spray top/spray fallow pasture prior to cropping phases to ensure a clean start to any seeding operation.

5. CROP COMPETITION IN GRAIN CROPS

- Adopt at least one competitive strategy (two is better) including reduced row spacing, higher seeding rates, precision seed placement, east west sowing and competitive varieties.

6. HARVEST WEED SEED CONTROL IN ROTATIONAL GRAIN CROPS

- Capture weed seed survivors at harvest using chaff lining, chaff tramlining, chaff carts, or integrated weed seed destruction.

WEEDSMART WISDOM

- **Never cut the rate**
- **Spray well – choose correct nozzles, pressure, adjuvants, and water rates for efficacy and drift control.**
- **Plant clean seed – don't plant weed seeds.**
- **Maintain farm hygiene – clean borders, fence lines, channels and contour banks.**
- **Test for resistance – know your levels.**
- **'Come Clean Go Clean' – don't let weeds hitch a ride with visitors.**

Your soil's health: field days offer insight

While the term 'soil health' can mean different things to different people, recent industry seminars have given valuable insights into the similarities in maintaining and improving it.

Crop Consultants Australia (CCA), in conjunction with CottonInfo, facilitated soil health workshops in Jondaryan, Griffith and Moree throughout August, with great turnouts and feedback from participants. The events were facilitated by CCA's Leisl Coggan along with CottonInfo REOs Annabel Twine, Kieran O'Keeffe and Andrew McKay. The panel of presenters at each event varied in an attempt to address local issues, but many of the speakers touched upon similar concepts and outcomes, indicative of the broad nature of soil-related issues.

Each seminar kicked off with a question about what soil health means to attendees, followed by a series of presentations, a disease update and inspection of a soil pit to foster more open discussion.

How did you perceive soil health?

At Jondaryan the concept of soil health prompted suggestions around sustainability, disease suppression, being fit for purpose and being unconstrained. At Griffith there were many more offerings from the floor with perhaps a greater focus around water, nutrition, soil porosity and biological processes. Moree responses were slightly less prescriptive, but insightful all the same in that what became apparent was that the ideas and concepts, held by the participants, are being addressed by the industry's investigations into compaction, cover-cropping, organic amendments and soil constraints.

What experts are saying about our soil's health

The world view is that soil health is about a soil being fit for purpose and for most, that purpose is for food and fibre production. A healthy soil then becomes one from which we can derive a crop indefinitely and so there is a need to be mindful of physical, chemical and biological aspects of our soils and how to maintain or improve them.

NSW DPI soil scientist Guna Nachimuthu has been looking at all of these soil aspects in his project investigating yield variability in paired field sites.

Guna told the Moree audience that often there is not a lot of difference between the soil types, but occasionally changes in soil organic matter or an increase in sodicity appears to be the most obvious cause for a change in yield. One way to alter soil organic matter or sodic constraints is through the application of organic amendments, outlined by Wendy Quayle of Deakin University in Griffith, where she has been undertaking her CRDC-supported research. Her research shows it is feasible to consider chicken manure as an alternative to mineral fertilisers (see story next page).

"In a mixed fertility program (manure and mineral fertilisers) yield gains were seen from the organic amendment in the second year, that could not be achieved

with just mineral fertiliser," Wendy said.

Sadly, some crop managers are not able to easily source manures and composts, but the potential to cover crop to deliver ground cover that reduces erosion, provides organic returns and improves rain recovery may exist as an alternative to help improve our soil health.

David Lawrence of QDAF reported on some of his joint CRDC and GRDC-supported cover cropping work.

"The water needed to establish the cover crop was not insignificant, but subsequent rain in the cover crop quickly caught up with the fallow and eventually recharged the field above the fallow treatment," he said.

"The follow-on crop extracted more water from under the cover crop, returning a significant profit per hectare compared to the fallow.

"Cover crops, consisting of cereals or white French millet were superior to pulses, which failed to maintain the essential ground cover once sprayed out."

Consultant David Freebairn spoke at Moree and added that bare fallows are only about 20 per cent efficient in recovering rain water, and more work is needed to address some of the questions about when to consider a cover crop within existing fallows, but progress is being made.

Monitoring soil health

CottonInfo Soil Health Technical Lead, Dr Oliver Knox of UNE, also touched on fallows in his talk on soil biology and reminded participants that if testing biology, it is important to be mindful of when in the season measurements are taken, where in relation to the crops we are sampling and what we are comparing our data back to. Oliver says the reason for his last point was because Australian soils and farming systems are not like those in other countries and "so we need to be wary of comparing our biology against other parts of the world".

He was also asked about the potential loss of mycorrhizal fungi during drought.

"We need to remember the work that (the late) Dr Stephen Allen and others did, which showed that unless we get several wetting (>20 mm of rain) and drying cycles during a drought we don't see a loss of these important fungi," he said.

Consultant and soil researcher Brendan Griffiths continued with the theme in the talks around measurements. He has taken capacitance probe data and looked at soil constraints, initially in terms of rooting depth and water recovery. The results were similar to soil surveys done back in the 1980s, but the probe data set has allowed a wider industry coverage across years.

"On average, we are growing cotton on soils that limit rooting to less than 60cm in about 25 per cent of fields," he said.

In addition to the probe data, the work has looked at the reasons for this constraint to rooting depth. "In many cases the issue is sodium, which has leant to the soils being dispersive, but this has not been the only culprit.

"Magnesium to calcium ratios, high pH and elevated salts have all also turned up as being part of the constraints story.

"Testing and truthing the observations is critical in determining what, if any, remedial actions will be effective.

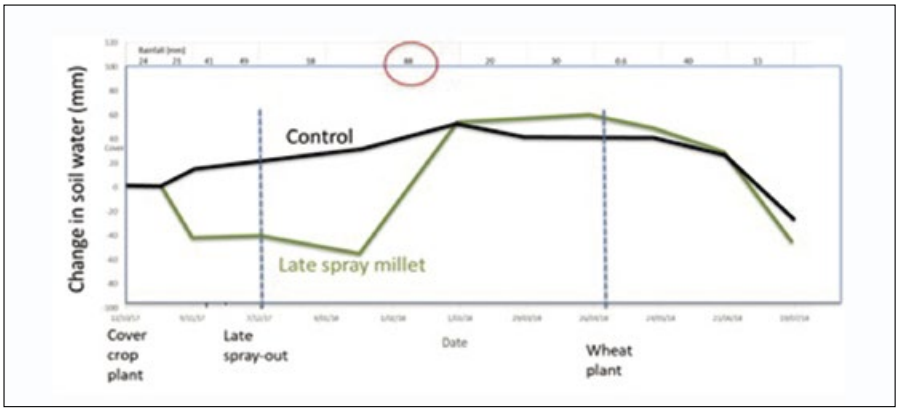
"In some cases we have found that where the rotation and soil are managed, whilst mindful of the constraints, yields are profitable, however, similar soils that are pushed too hard tend to fight back and in those instances profit can suffer."

Just how healthy are our soils?

The soil pit at Jondaryan had a soil with an exchangeable sodium per centage (ESP) of 13 to 15 per cent. The salt load was not overly high, but pH ranged from 8.9 at the surface to 9.4 at depth. Normally it is expected a soil with these chemical properties to be dispersive, but the soil only dispersed at depth. The stability of the upper soil was attributed to the high 1.3 per cent organic carbon in this soil. An FAO's Visual Soil Assessment (VSA) of the

WARWICK WATERS

UNE's Oliver Knox in the soil pit, uncovering soil traits and highlighting differences across cotton growing regions.



Soil water dynamics at Bungunya in 2017-18. The profile was three-quarters full with 130 mm of Plant Available Water at planting, the millet used 50-60 mm to establish, but had an overall fallow efficiency of 17% for the whole fallow compared to 14% for the bare fallow, due to its very high fallow efficiency (>70%) in the shorter period once the cover crop was sprayed out.

soil also returned a score that indicated the soil was 'good', despite adding to the number of cotton fields in which earthworms were not found – the only biological component of the test.

Pat Hulme led the soil pit component in Griffith and highlighted that there were clear bands of horizontal physical constraint within the soil and compaction under the wheel tracks, however, the roots were finding a way through the soil and yields were good. The pit at Moree, in contrast, showed wheel track compaction, but other than that was in good health.

Soil health and disease

QDAF pathologists Dr Linda Smith and NSW DPI's Duy Le gave disease updates, with a big reminder that Come Clean, Go Clean remains essential in the continued fight against diseases spread.

"Potential control options are being tested against various pathogens, but efficacy across years has been varied, so don't expect something too soon, as in disease management there is rarely a silver bullet," Duy said.

Linda also reinforced the positive impact of rotating out of cotton with non-hosts to manage Verticillium wilt. This message was supported by Narrabri grower Brendan Warnock, who has used corn rotations to improve disease incidence in his fields and regain yield

WARWICK WATERS

Attendees at the soil workshops were given an up-close look at soil quality and properties with soil pits, coupled with guest speakers tailored to their region.

(see *Spotlight* Autumn 2019). Both Duy and Linda reminded attendees that if something unusual is spotted, it is imperative to take a sample and send it for testing.

"To sum up our observations from these events, for now it appears that most of our soils are in good condition, with only a few being moderate and so far none being poor, based on the VSA," Oliver said.

"Under current conditions in most growing regions, while drought can have an effect on the soil biology there is not much you can do for it other than follow what research is telling us and consider a prophylactic cover crop or healthy dose of manure."

For more

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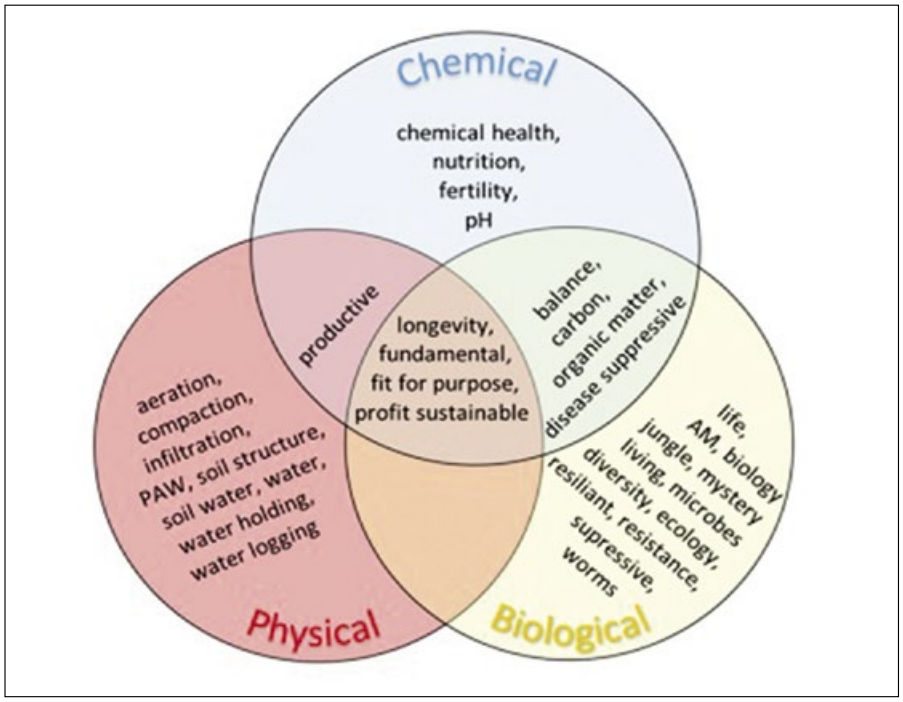

Association and overlap of terms given by workshop attendees that captured their concepts around soil health.

Soil sensing for more timely planting

Optimal soil temperature is key at planting for emergence and early crop development. Crop managers now have new technology to assist decision making.

Planting can begin when soil temperatures reach 14°C (at optimal time of 8am) for three consecutive days, with a rising plane of temperature above 14°C forecast for the ensuing seven days.

CSD's FastStart Soil Temperature Network (developed in collaboration with Syngenta) has automatic weather stations from Comet in Central Queensland to Deniliquin in Southern NSW tracking soil temperatures. Crop managers can log on to the CSD website and track soil temperature over time. The data supplied is sourced in partnership with OzForecast and the Bureau of Meteorology. A map on the site is an output from a statistical model that uses climate and landscape information to predict soil temperature.

A table gives users a rating of forecast temperatures for day degree accumulation and the suitability of planting conditions. It can be used in conjunction with the QDAF and University of Southern Queensland's prototype decision support tool Soil temperature mapping to guide cotton sowing which complements and extends the FastStart™ Soil Temperature Network.

For more

www.csd.net.au/soil-temperature
www.soiltemp.com.au

No s*&%: It really works!

Chicken litter is improving soil condition and yield in irrigated back-to-back cotton fields.

WENDY QUAYLE

Two seasons of trials integrating chicken litter into a soil health program resulted in a six per cent increase in lint yield.

Around Griffith in the Riverina region of NSW, there are upwards of one million meat chickens processed daily, generating in excess of 10,000 m^3 of chicken litter every week. Chicken litter is a mix of faeces, feathers, unused feed and rice hull bedding. Based on average nutrient composition, moisture content, within-year availability and losses, this amounts to approximately 3000 tonnes of plant available nitrogen (N), 1800 tonnes of available phosphorus (P) and 2800 tonnes of available potassium (K) to the soil (in the year of its application).

As an amendment and fertiliser substitute litter could supply 12,000 ha (if crop N requirement is 250 kg/ha) or 36,000 ha if required P replacement for high yielding crops is 50 kg/ha. But is chicken litter a reliable supply of N and P while simultaneously improving soil condition? The research indicates this is likely.

CRDC has supported research with Dr Wendy Quayle at the Irrigated Research Extension Committee (IREC) field station at Whitton, near Griffith in the Riverina. Now with two years of data in back-to-back cotton, (2017-2019), the trials have shown a total of six per cent increase in lint yield over the two seasons. The experiment, undertaken on transitional red brown earths, has compared yields from grower practise urea application with equivalent N rates (250kg N ha) supplied by chicken litter alone or as partial substitution for urea, together with a zero control. In the second year, no synthetic P was applied to any treatments as at planting, Colwell-P levels in surface soils averaged 85.7 mg kg.

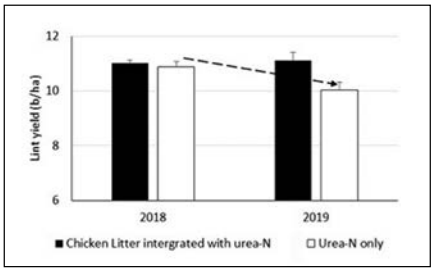

Figure 1. Average yield in two years of back to back cotton in the southern cotton growing region using 250 kg-N/ha supplied by manure topped up with urea-N or urea-N only.

Over the two years, on average 11.1 bales/ha were produced in litter integrated with urea treatments compared with 10.5 bales/ha in equivalent urea N-only plots – a six per cent yield benefit. Based on $550/bale, this equates to $330/ha/year additional lint revenue.

The research has also shown chicken litter can offset yield decline in back-to-back cotton.

Recent research by Steve Buster found that in the southern region, yield decline is 1.28 bale/ha in back-to-back cotton compared to after a summer fallow. While this is often put down to nutrient tie up or compaction, Wendy's trials showed that this decline can be offset by litter-amended treatments, either alone at 16t/ha, or in combination with urea at 4t/ha and 8 t/ha (Figure 1). Topping up to the desired N target with urea performed better than mineral nutrient-only fertiliser programs by offsetting yield decline most likely caused by poor water infiltration.

In terms of soil health, Wendy said it is difficult to ascertain the economic value of soil conditioning effects of organic amendments as 'healthy' soil does not necessarily equate directly to increased yield. However, in this experiment, since equivalent units of N were used and there was no indication of P limitation, this extra value can be attributed to soil quality attributes.

Wendy said if farmers on the red-brown soils in the Riverina are able to have litter delivered and spread for less than $24/m3, it would seem to make economic sense on a two-year rotation.

"It is worth farmers considering using chicken litter to supplement annual N and P budgets," she says.

"Farmers who are in favour of sustaining soil with organic amendments regardless as well as a full mineral N fertiliser program to reduce risk, should not need to apply mineral P."

The full results of Wendy's research can be found at CRDC's online research library, Inside Cotton: www.insidecotton.com.au.

For more

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PLANT HEALTH AUSTRALIA

Exercise Blueprint gave the industry the opportunity to test its preparedness for a biosecurity emergency.

Biosecurity: it's everybody's business

Exercise Blueprint has shown the cotton industry has a clear understanding of the roles and responsibilities of individuals and organisations in the event of a biosecurity incident.

Run by Plant Health Australia (PHA) with support from CRDC, Exercise Blueprint was held in August in Toowoomba, Queensland. It simulated an incursion of cotton blue disease, caused by cotton leafroll dwarf virus (CLRDV).

Susan Maas heads biosecurity R&D for CRDC and says the main aims of the exercise were to raise awareness of biosecurity issues and roles within the industry; test industry-wide response structures and processes; and investigate the ability to develop appropriate response strategies for the industry's priority pests.

Cotton blue disease was chosen as the target for the scenario as it is a priority pest for Australia and could have significant impacts should it arrive here. CRDC-supported research undertaken by QDAF Virologist Dr Murray Sharman has already confirmed its presence in Timor Leste, north of Australia. It has led to severe damage in cotton in other countries, most recently USA. Transmission is via a vector endemic to Australia – the cotton aphid (*Aphis gossypii*) – a major pest of cotton with a host range that includes other commonly grown crops.

Exercise Blueprint involved farmers, agronomists, ginners, CottonInfo, Cotton Australia, the Department of Agriculture, NSW DPI, QDAF and CSD.

"We were really pleased with what came out of the exercise," Susan said.

"It highlighted our industry is in a really good position for communication with our strong collaborative networks such as CottonInfo and CSD, which have extensive data bases and reach to support Cotton Australia, who represent the industry under the terms of the Emergency Plant Pest Response Deed (EPPRD).

"We also have a strong advocate in Cotton Australia and robust R&D ongoing into priority pests.

"The scenario helped clarify how these organisations would work together and interact with the State Department, who under the deed leads the incursion response."

Should cotton blue disease arrive in Australia, Susan said eradication would be complex, due to being aphid-vectored and a virus with a range of hosts.

"There was some interesting thinking about eradication in terms of managing the vector as opposed to just the virus directly, with thinking around minimising impact on industry," she said.

"The importance of early detection and isolation of an exotic threat cannot be understated, along with the importance of on-farm management biosecurity measures, such as Come Clean Go Clean, managing weeds (hosts) between seasons and on-farm day-to-day farm cleanliness measures – which we know should be a natural part of any farm business.

"If these measures are already in place it can have a huge effect on isolating and hopefully eradicating a pest."

Part of the plan

Australia is no stranger to incursions of exotics pests and diseases. Silverleaf whitefly, mealybug and cotton aphid are all imports. CRDC investment in biosecurity preparedness has been ongoing

and is a key part of CRDC's current (2018-2023) strategic plan. Exercise Blueprint is a result of this investment and builds on from a similar CRDC supported exercise held July 2017, that focused on boll weevil and highlighted the need for industry communication roles and responsibilities to be better defined.

"What we've learned from these scenarios is that during an incursion, decisions need to be made with imperfect information – for example we don't necessarily know all the domestic hosts of blue disease because we haven't had it here," Susan said.

CRDC RD&E looks to develop tools to support an incursion response as well as capacity. Investment has included travel exchanges, modelling and research to assess potential impact, pest ecology, diagnostics and surveillance research, as well as investigating potential controls for critical threats where eradication is less likely.

Several industry researchers have studied exotic threats overseas and in laboratories in Australia.

Dr Murray Sharman of QDAF has been investigating blue disease in Timor since 2013 with support from CRDC. Earlier this year, CRDC support enabled Murray and QDAF Pathologist Dr Linda Smith to travel to the US to participate in meetings with US counterparts, to share their research and see first-hand how the virus rolled out.

CottonInfo IPM Technical Lead, QDAF's Paul Grundy with QDAF Plant Pathologist and cotton blue disease researcher Dr Murray Sharman.

"Probably the biggest thing we can learn from the US experience, is that each incursion is likely to be very different," Murray says.

Dr Dean Brookes of the University of Queensland is also looking at boll weevil and pheromone trapping as part of the iMapPESTS: Sentinel Surveillance for Agriculture, a project supported under the Australian Government Department of Agriculture's Rural R&D for Profit Program. He's also using a technique which examines gut content to determine hosts of exotic invertebrate pests. A recently announced Rural R&D for Profit Program project CRDC is involved in will boost diagnostic capacity for plant production industries.

Cotton Australia's leading role

Cotton Australia works with the Australian Government as the signatory under the Emergency Plant Pest Response Deed, which is very clear about the process and the type of information needed to make a decision in an attempt to eradicate a pest.

The National Cotton Industry Biosecurity Plan was launched in 2006 and reviewed in 2015 with CRDC funding to PHA. Cotton Australia's Sally Ceeney said Exercise Blueprint reiterated that "planning and more planning, along with training for industry personnel – such as the Blueprint scenario" would be essential.

"Stakeholder engagement is crucial during a response plan," she said.

"We've developed and revised a communication strategy during a response that helps ensure stakeholder engagement is done successfully, and that all industry personnel are aware of their roles and responsibilities.

"All response plans are different with many variable factors. While being prepared is crucial, it is also important to be flexible and stay responsive as no two responses will ever be the same."

Cotton Australia also works with CRDC to convene the cotton industry biosecurity reference group (BRG) which meets annually to review the biosecurity plan, high priority pests and prioritise RD&E. The BRG provides technical advice in any potential incursions and identifies gaps in research and policy.

Best management practice

While Cotton Australia is leading biosecurity steward-ship, everyone in the industry has a role to play.

The *my*BMP program includes a farm biosecurity module which was reviewed this year to reflect the responsibilites growers have under changed biosecurity legislation. The module provides linkages to resources including the Animal Health Australia/Plant Health Australia Farm Biosecurity website, and CottonInfo. Links have been added to guide growers to Northern Territory and Western Australia biosecurity resources.

There are avenues for farm managers to raise awareness:

- Include a biosecurity component in workplace inductions and tool shed meetings so employees are aware of on-farm biosecurity practices as well as what to do if they see something unusual.
- Include Exotic Cotton Pests biosecurity posters in the shed or office to act as a reminder to staff and visitors (available from CottonInfo).
- Report suspected pests, diseases or unusual symptoms to the Exotic Plant Pest Hotline immediately on 1800 084 881.

For more

***my*BMP**

www.mybmp.com.au

Know the rules when moving north

Recent successful harvests of commercial crops in the Northern Territory, Western Australia and Far North Queensland has seen increasing movement of people and machinery to and from the areas.

With this movement comes a reminder to make sure no unwanted pests and diseases are hitching rides to new cotton growing areas, and vice versa. Adhering to respective state and territory guidelines as well as Come Clean Go Clean is imperative.

"Industry expansion in the North has seen many people drive and fly up to look for themselves, along with southern growers moving their operations north," CottonInfo Biosecurity Technical Lead Sharna Holman of QDAF said.

"We don't want unwanted pests and pathogens spread to these relatively disease-free areas – conversely, we don't want northern pests carted south."

Northern Australia is currently free of pests and disease issues found in established areas including soil-borne pathogens black root rot, Verticillium wilt, Fusarium wilt and reniform nematode, which can have a significant impact on land management and crop yield.

"The easiest way to avoid this is to Come Clean Go Clean including ensuring you are meeting your legislative requirements, as each State and Territory has different requirements based on its respective pests of concern," Sharna said.

Northern cotton growers are instigating practices to reduce the risk of pests heading south, such as pink boll worm, by sending their cotton to be ginned in St George or the Darling Downs instead of closer gins in Central Queensland.

"While the risk is considered very low, particularly given crop scouting for pink boll worm is undertaken, it is unlikely a rare survivor could find a suitable host during winter in these cooler regions, and we also have pheromone trapping in place," Sharna said.

Some key biosecurity requirements:

- Ensure shoes, luggage, machinery is free of soil, plant or other organic material.
- Pressure clean with high volume water and agricultural detergent and disinfect with an agricultural decontaminant.
- Be aware that extra conditions may apply for machinery coming from regions with high-risk plant pest status including Russian wheat aphid's zones.

CottonInfo has developed a factsheet with guidelines for moving machinery and equipment into different States and Territories.

For more
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www.cottoninfo.com.au/biosecurity

Grower reimbursement for eradication

Without early reporting, eradication efforts of exotic pests or disease can be futile as they can become too widespread and established in the environment.

In these cases, growers face the task to manage the pest or disease, potentially leading to permanent increases in production costs, impact on quality and yield or reduced industry social licence due to possible additional pesticide requirements.

To reduce the financial impact of an eradication response on the grower and encourage early reporting to improve the chance of successful eradication, the Plant Health Australia Emergency Plant Pest Response Deed (EPPRD) allows for Owner Reimbursement Costs (ORCs).

ORCs are payments to growers who can demonstrate financial losses or costs incurred as a result of an effort to eradicate or contain an emergency plant pest (EPP).

ORCs apply when a response plan to eradicate an EPP has been approved.

Considerations for calculating reimbursement include:

- Direct eradication costs incurred by the owner.
- Additional costs to ordinary operation costs resulting from implementation of the response plan.
- Estimated farm gate value of a crop that's destroyed, or economic value loss as a consequence of the response plan.
- The loss of estimated farm gate value of foregone crops, less production costs, if land is required to be fallowed for a specific period under the response plan.

Calculating reimbursement

Cotton Australia and the industry's cotton industry Biosecurity Reference Panel have worked with Plant Health Australia to translate the ORC guidelines into a cotton-specific framework to calculate payments to affected growers. The figures for calculating ORC are determined according to a hierarchy of evidence, with specific, local and certifiable information where available and where not available or appropriate, using increasingly generalised averages and estimates. This is where good reporting and record keeping is crucial.

"The aim of ORC are to provide natural justice to those affected by an exotic pest response plan and under the principle of growers and landowners being no worse off or better following an incursion," says QDAF's Sharna Holman, CottonInfo's Biosecurity Technical Lead.

"It is important to have certifiable data and records to assist in providing evidence that allows for specific and local information to be used in calculating reimbursements. This includes accurate property maps, yield data, bale contracts – or for cotton non-contracted, auditable records.

"Auditable individual gross margins are particularly important where you may have costs or systems that differ from regional gross margins."

Examples of what is not covered:

- The cost of replanting a replacement crop, except for perennial crops.
- The difference in farm gate price between the owners preferred crop and an alternative crop.
- Lost consequential income.
- Emotional stress, legal fees and valuation costs incurred by an owner seeking to appeal against their ORC assessment.

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Plant industries join forces to strengthen biosecurity

Incursions of exotic pests – diseases, vertebrates and invertebrates – are often detrimental to several industries and history tells us it's not a case of 'if' they will arrive, but 'when'.

By pooling knowledge and resources, Australia's plant industries can better prepare for common threats and learn from each other's biosecurity strategies and preparedness techniques.

The Plant Biosecurity Research Initiative (PBRI) held a two-day symposium in Brisbane in August showcasing current plant biosecurity research, supported by members including CRDC. It was the first meeting of its kind in Australia to address biosecurity in this way.

Research teams from across the country presented findings around pests, diseases and weeds. The program included keynote speakers and panel discussions on future priorities for RD&E.

Importantly the event provided a forum for plant biosecurity networking and collaboration across industries as well as borders. Under a recently signed MOU between PBRI and Better Border Biosecurity NZ, teams are looking to work together on common biosecurity issues; presenting their research with the intention of future collaboration.

The symposium also aimed to help avoid duplication of research on common biosecurity themes. It was the first time biosecurity research, supported by seven plant RDCs and Better Border Biosecurity (B3) New Zealand, had been discussed in one forum.

Biosecurity is a key issue for all Australian industries involved in producing crops of any kind. CRDC's Susan Maas chaired the panel session on future RD&E priorities. She said the symposium created synergy and a successful outcome for the RDCs working together on biosecurity.

"Even if the pests weren't relevant to cotton, I found there were aspects of the RD&E and lessons we could take away, highlighting the benefits of the concept of PBRI," Susan said.

General Manager of Research Funding at Sugar Research Australia Dr Harjeet Khanna, said "looking at what cotton is doing as part of the Exercise Blueprint project and being a part of the PBRI has exposed us to a great learning in that suppose we have an incursion tomorrow: this is how we are going to deal with it".

"Pooling experience is a great thing because it doesn't matter what crop you're dealing with biosecurity is a huge risk – there are fungi, bacteria, insects and weeds – we all live in the same environment and there are a lot of crops that share the same space.

"The demographics and the culture and the climate are often the same, so it's a great opportunity to learn from each other."

Dr Liz Water, Wine Australia's General Manager of R&D and Extension reiterated the sentiment.

"Cotton and wine share some priority pests such as brown marmorated stink bug.

"We accept that it's not a case of if they come but when they come," she said.

Several cotton industry researchers, including virologist Dr Murray Sharman, entomologist Dr Dean Brookes and pathologist Dr John Webster presented on issues such as cotton blue disease, new biosecurity pest techniques and disease diagnostics. Cotton Australia's Sally Ceeney reported on the success of the industry biosecurity preparedness activity Exercise Blueprint (see page 25).

Panama disease

Panama disease is actually a form of Fusarium wilt, a disease which had a major impact on the cotton industry when it was first detected in the early 1990s. The earliest known discovery of Panama disease was actually in Australia in 1874. In 1890, the disease was found in its namesake country and over the next 30 years spread to most Caribbean and Central American countries.

The Cavendish variety of banana (named after the Englishman Lord Cavendish as he had this unnamed variety growing in his extensive arboretum on his estate) rescued the industry due to its inherent resistance properties, and for five decades the variety's seedstock spread around the world.

Today, 99 per cent of exported bananas and nearly half of total production worldwide is the Cavendish variety. However this strength became the banana industry's greatest vulnerability when Panama disease returned, and this time the Cavendish was no longer resistant.

Bringing plant industries together created a valuable opportunity to understand commonalities and experiences in biosecurity, preparedness, research and grower stories. CRDC's Susan Maas chaired a panel session at the symposium.

A highlight was the presentation by growers.

A warning to all industries on the importance of biosecurity was the first-hand experience of past president of the Australian Banana Growers' Council Doug Phillips. Doug's keynote speech 'Biosecurity lessons learned – a grower's perspective' outlined the outbreak of the devastating Panama disease on the Australian banana growers in North Queensland. The scenario holds some important lessons for all plant industries on how quickly an industry can be threatened and the reliance on variety for resistance to disease and pests.

Doug spoke about the impact of the disease on growers' businesses, such as their loss of trade and income and the need to consider the social isolation of having an infected property in a regional community.

The grower presentations reflected discussions at the Exercise Blueprint scenario about the impact a biosecurity incident can have on individual growers as well as communities.

"Cotton had a similar scenario in the cotton industry when Fusarium wilt was first detected on the Darling Downs in Queensland in 1992," Susan said.

"We can't forget that there is the social impact of an incursion, and this should be factored in to the planning."

Susan's favourite quote of the day came from Shane Templeton, from Templeton Ginger on the Sunshine Coast, who described his experience with pythium rot and the strict on-farm biosecurity measures he implemented. Shane highlighted how biosecurity has become part of his everyday business and these better biosecurity systems have also improved his production systems.

"It is not the cost on production of doing better biosecurity that we need to focus on, it is the cost of not doing it," Shane said.

From a forestry perspective, Andrew Islay Robertson from HQ Plantations spoke about the giant pine scale response and the importance of working closely with government to ensure systems and processes are in place before an emergency response.

"These farmers brought home the salient points around being ready for an incursion – from an industry and individual standpoint – because it is not if but when.

"Early detection of exotics is key, and disseminating that information throughout industry, along with pre-emptive control through our on-farm biosecurity protocols under Come Clean Go Clean," Susan said.

"For growers, protecting the biggest asset – your farm – with a biosecurity plan is a no-brainer and this symposium made that aspect glaringly obvious.

"If you can keep a pest, weed or disease off your farm (especially soil-borne diseases) that is the greatest weapon in your arsenal."

For more

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Overcoming an incursion

Nearly 30 years ago, Graham Clapham noticed a patch of poor looking cotton on his farm near Norwin on the Darling Downs. What ensued was a roller-coaster ride of emotions, from anguish to finally acceptance and a new way of thinking.

It was 1990 and what turned out to be the exotic Fusarium wilt started with a small patch of damage.

"The first small patch was about 600 metres from my house and ran down to Clapham Road which I went up and down several times a day, so we saw it immediately," Graham said.

"At first there was only in one spot in one field and I didn't think it was anything new because I knew about Verticillium and thought that's what it may be.

"We fallowed that field the next year, followed by cotton and it appeared right across the whole bottom of the field and seedlings were dying in strips.

"I recognised that this was a serious problem and contacted people in the industry.

"Plant pathologist Dr Joe Kochman (from the then Queensland DPI Farming Systems Institute) in Toowoomba came out and said 'this is Fusarium wilt...'"

That's when farming as they knew it changed for the Claphams. It took another two years to officially confirm the diagnosis, and in the 1992-93 season it was communicated to the industry that Fusarium wilt had been found for the first time in cotton in Australia.

Manifesting uniquely

Exotic disease incursions occur, manifest and spread in their own unique way across the world. Blue disease manifested differently in the US to other countries, and Fusarium was no different.

"In the US Fusarium was always associated with nematodes but what we were seeing was different and unique to Queensland," Graham said.

Initial efforts centred around trying to identify it, ascertain where it had come from and how it was spread.

"We really don't when it actually turned up or how long it was in the soil, but we didn't see it until we grew the Siokra 1-4 variety," Graham said.

"Siokra 1-4 was a marvellous variety, but we quickly identified that it was our enemy as it was not only susceptible but where it was planted it rapidly built up spores in the soil.

"It was being spread on our farm through our tail water return system and every field watered from the storage tank got it – some worse than others, but early on we weren't seeing patterns.

"There were other growers who irrigated out of bores with no return water who had it spread across their farms and first-time cotton fields got it as well."

Graham said this was baffling. He and other affected growers worked with University of Queensland Gatton who ran an exercise with them to set out a questionnaire for growers and interview them.

"The survey asked everything and anything, with the aim to look for commonalities: what was responsible and what propagated and spread it.

"They never found any, so where it came from and how it was initially spread remains a mystery."

Breaking point

"I remember in the early 2000s – we had our cotton off to a flying start, we had water and seasonal conditions were good.

"Then just before Christmas we had a major rain event, triggering the Fusarium and we ended up losing a major part of that crop.

"That was the low point for me.

"We had ordered some new equipment to go into no till and I remember sitting on the tractor destroying the affected crop and thinking that now I would have to cancel the order.

"That was the low point. I was going to let the local machinery dealer down, and wouldn't be in a position to go into other crops using minimum or no till.

"To get the crop to pre-flower then lose it through one adverse weather event was devastating.

"After that we decided we couldn't take the risk anymore – so we grew sweet corn, sorghum and chickpeas.

"The risk was too great to grow cotton. It wasn't just the loss of income but the mental anguish, it was too demoralising."

Graham says getting to this point however, allowed him to accept the situation he was in and move onto alternatives.

"Don't think today where it is at its darkest is where it is always going to be," he says.

Famous for the wrong reasons

How farmers personally deal with an exotic incursion was discussed at the Plant Industries Biosecurity Symposium this year by banana and ginger growers. The personal costs both economically and mentally can be high, yet can be overcome.

Today under Owner Reimbursement Costs, growers can recoup some of the initial costs of destruction and mitigation, but there are other tolls the cotton industry is keen to address, known all too well by Graham and his family.

Firstly, it's dealing with the attention. After the identification of Fusarium on his farm, all eyes were on Graham.

"During the mid-90s and early 2000s there were so many interviews and articles, people coming and going, but it is not something you want to be famous for," Graham said.

"To start with there was nobody in the immediate community who didn't know about it because the damage was quite visual.

"There was no hiding it, nor would we have tried to.

"I recognised it was a serious issue and I'm never one to ignore a problem and hope it will go away and fix itself. I've never seen that work.

"The sooner you face up to it the sooner you can get over it."

Further to unwanted attention is the quarantine necessity, which has changed since the 90s.

"I didn't get too hung up on these things, we worked around it.

"Our agronomist came to our farm last, and when we still had some

relatively clean fields we used to clean the implements down and disinfect them before moving paddocks.

"Some people did try using two sets of gear – but I don't think there was a documented case of this preventing spread."

Dealing with forced change

More of an issue for Graham was what he says is the psychology of dealing with 'unchosen change' in life. The philosophy is generally based on a sequence of emotions: shock; denial; anger; depression; acceptance and integration.

"The first time I learned about it was when coal seam gas turned up – I was basically told what was going to happen on my farm, with or without it, which made me angry," he says.

"I got stuck in the anger stage for the first three years and it burned me up.

"Then came depression, but finally acceptance: and the quicker you get there the quicker you can resolve and can get on with your life.

"I was turning into someone I didn't want to be – and I had to deal with in a different way.

"That journey fitted the unchosen change that the discovery of Fusarium had on me. Looking back I wish I had have known about it as it would have helped a lot.

"The human aspect of it is that we contend with a lot of things and you get swallowed up by the injustice of it all and it can take a long time to get to the acceptance stage and start to look for a solution.

"This is a very important aspect and it's great to hear coming out of these biosecurity exercises that it's one that the cotton industry is aware of and looking to help us through."

Outrunning the disease

Managing exotic diseases is a long-term prospect for researchers and farmers.

Many of the current strategies to manage the disease have been developed as a result of the project work carried out at Graham's property 'Cowan'. Specifically this includes the development of the 'F.rank' system to allow growers to compare resistance of varieties to Fusarium and the identification of germplasm with resistance to the pathogen. This led to the breeding and release by CSIRO of varieties with significantly improved resistance to Fusarium and with acceptable yield and quality characteristics. Graham's willingness to offer his farm for trials, often at personal economic cost, has led to the identification of some agricultural practices, such as planting date and crop rotations, that reduce disease incidence.

This 2019-20 season will be the first since 1995 that screening trials for Fusarium won't occur on the Clapham's farms, due to lack of water for the trial crop. The first screening trial was undertaken right in the initial hot spot of about one hectare. Every year since there has been screening and other research of some sort.

"These trials have been a major part of our farm operation since 1995," Graham said.

"In the very early days I was on speed dial to and from every nutritionist and snake oil salesman around – everything you know and things you don't know about ... they came to my door.

"We tried all manner of things that didn't work, but what we learned was that if you have a nutrition problem that your plants are far more susceptible."

Eventually Graham had to scale their cotton growing operations back as the disease became very severe in all their fields. Scaling back up resumed with the release of F-ranked varieties and management knowledge from the trials.

"We've still got Fusarium, it never goes away, but we now have the varieties to overcome it.

"We still see the odd affected plant, it still lurks and we can't go back to growing things that are susceptible, that's why we need to keep screening."

So with more experience than most in dealing with an exotic disease, what is Graham's advice?

"You have a responsibility to the industry to tell someone if you suspect something out of the ordinary, so industry knows and can halt the spread," he says.

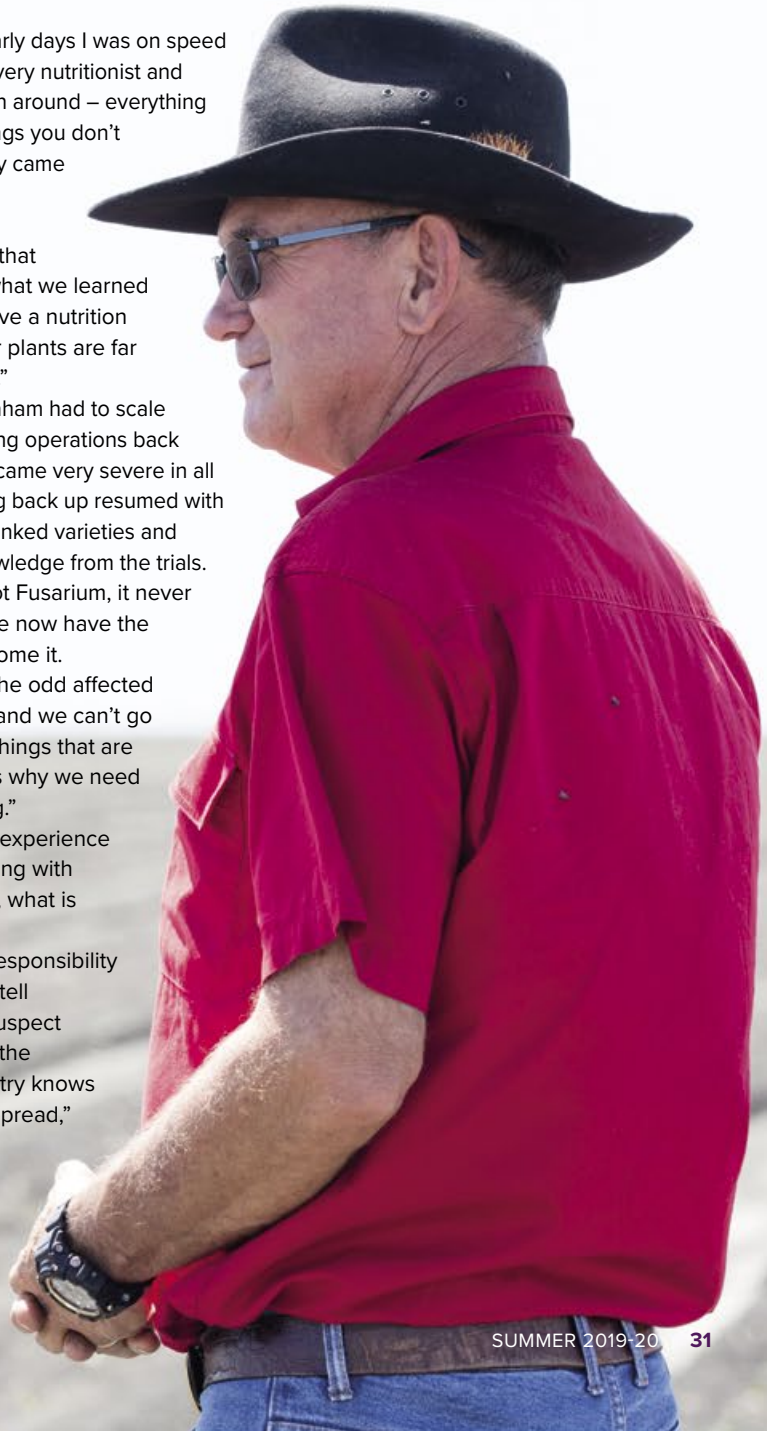
"You will go through a range of emotions, but the sooner they can be dealt with, the sooner we can get to solutions to deal with the issue and move on.

"It's a funny thing to say but I have met the most fantastic people in this journey I wouldn't have otherwise.

"Sometimes in adversity we meet people who change our lives and I have the utmost respect for them and what they have done.

"I actually look back on some of the experience with gratitude."

If you find something suspicious in your cotton, call the Exotic Pest Plant Hotline: 1800 084 881.



Investment, Innovation, Impact. 2018-19 in review

STEVE YEATES

These three words capture the very core of CRDC – investing in innovation to deliver impact for cotton growers, the cotton industry, the wider community and the Australian Government, says Executive Director Ian Taylor.

CRDC RD&E supporting continued industry expansion into areas such as the Kimberley region of Western Australia. Image by Steve Yeates, 2017 Researcher of the Year and cotton development and coordination leader for northern cotton.

The 2018–19 year was the first year of investment under our Strategic RD&E Plan 2018–23.

During the 2018–19 year, we took a renewed look at our investments, and sharpened our focus around our five new strategic priorities – increasing productivity and profitability on Australian cotton farms; improving cotton farming sustainability and value chain competitiveness; building the adaptive capacity of the Australian cotton industry; strengthening partnerships and adoption; and driving RD&E impact.

We invest in these areas to ensure our cotton growers, our communities, and the wider industry are all prepared to capitalise on the opportunities and overcome the challenges ahead.

CRDC plays a critical role in ensuring a strong future for Australia's cotton industry and the cotton innovation system, particularly in light of the current social licence challenges facing the industry and the commentary about the future of Australia's innovation system.

We deliver strength and stability, driving the RD&E agenda with a strong focus on the cotton industry: an industry that embraces RD&E and has a long-standing culture of innovation.

MELANIE JENSON

CRDC Director Liz Alexander was one of the 46 percent of speakers supported in some way by CRDC – be it as a Director, team member or supported researcher.

We pride ourselves on our strong relationships with cotton growers, research providers, government and other core partners. Collaboration is at the very heart of everything we do. There isn't a single research project we invest in that isn't delivered in partnership with our growers, researchers and partners. Of all the RD&E projects conducted in cotton, we are partners in over 80 per cent of them.

We also partner with those outside our sector, as we recognise the importance of cross-sectoral collaboration in solving issues that are bigger than the cotton industry alone.

In 2018–19, 24 per cent of CRDC's investments were in cross-sectoral RD&E, tackling issues like climate variability, soil health and nutrition, irrigation, plant biosecurity, crop protection, farm safety, and human capacity.

Importantly, we recognise that for the industry to benefit from our research investments, the outcomes need to be rapidly extended and adopted, and where relevant, commercialised.

In this special *Spotlight* feature, we take a look at some of the highlights of the 2018–19 year.

You can find more detail in our 2018–19 Annual Report and Performance Report, both of which are 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.

For more
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YEAR IN REVIEW

CRDC RD&E achievements 2018–19

Ambitious new Strategic RD&E Plan

Our new strategic plan, the CRDC Strategic RD&E Plan 2018–23, began on 1 July 2018, following 15 months of development in close collaboration with the industry. The Strategic Plan provides a high-level overview of our strategic direction for the five years, and will guide all of CRDC's investments during this time. The aim of the plan is to contribute to creating $2 billion in additional gross value of cotton production through our investments in RD&E.

Delivering impacts for cotton growers

We conducted an analysis of the benefits delivered to cotton growers and the wider sector under our previous strategic plan, which ran from 2013 to 2018. Major impacts of our investment during this time included: the achievement of our target – a three per cent average growth in yield per hectare over the five years; the commercialisation of four new products (Sero X,CottonSpec, cotton contamination sensors for gins, and algorithms for stress-time thresholds); an increase in the number of growers participating in myBMP from 40 to 78 per cent; and a benefit-cost ratio of 8.3:1 for our investment in water-use efficiency RD&E – $8.30 in benefit to growers for every $1 invested in RD&E.

CRDC-supported innovation commercialised: algorithm for canopy temperature sensors

In 2017–18, CRDC successfully commercialised three new products, including algorithms for stress-time thresholds, with research partner CSIRO. At the time, we reported that using these algorithms with canopy temperature sensors could result in a 5–10 per cent benefit in water-use efficiency in climatically challenging seasons. In 2018–19, the canopy temperature sensors became commercially available through Goanna Ag, allowing cotton growers to refine irrigation scheduling, saving water while maintaining yields. The sensors monitor cotton plants in real time, allowing growers to make decisions in real time about irrigation scheduling before stress levels affect yield.

New leadership team to drive CRDC forward

The CRDC team said farewell to longstanding

Executive Director (ED), Bruce Finney, during 2018-19, as he stepped down from the role in January 2019 following 14 years at the helm. Then CRDC General Manager, R&D Investment, Dr Ian Taylor (pictured right), was appointed Acting ED in January, and was formally appointed to the ED role in March. His previous position was subsequently filled by CRDC R&D Manager Allan Williams, who officially took up the General Manager, R&D Investment role in June.

Delivery of three major CRDC-led collaborative projects

We have led three major collaborative projects this year – one under the Rural R&D for Profit program More Profit from Nitrogen; one under the National Landcare Program Smart Farming Partnership Cotton Landcare Tech-Innovations 2021; and one collaborative project born out of Rural R&D for Profit but continuing on as an RDC-led collaboration, Australian Agriculture: Growing a Digital Future – a follow-on project to Accelerating Precision Agriculture to Decision Agriculture.

Research on the agenda at the industry's major event: the Australian Cotton Conference

The 2018 Australian Cotton Conference – proudly supported by CRDC as a founding sponsor – provided a platform to showcase CRDC-supported cotton RD&E to the industry. At the conference, 46 per cent of speakers were supported in some way by CRDC – be it as a Director, team member, or supported researcher. The conference broke attendance records, with 2460 delegates, the largest gathering of industry participants since the event began.

CRDC-supported researchers recognised for contributions

CRDC-supported researchers Dr Joseph Foley, Dr Malcolm Gillies and Dr Alison McCarthy, all of the University of Southern Qld (pictured below), were recognised for their major contributions to cotton

MELANIE JENSON

MELANIE JENSON

RD&E as co-recipients of the 2018 CSD Researcher of the Year Award, presented at the 2018 Cotton Conference. Drs Foley, Gillies and McCarthy were all integral members of the CRDC-led Smarter Irrigation for Profit project team, which found that participating farmers from the dairy, cotton, sugarcane and rice industries could achieve a 10 to 20 per cent improvement in water productivity through adoption of new and existing precision irrigation technologies.

Tracking our water productivity

Early indications from the latest water productivity benchmarking study – supported by CRDC and led by NSW DPI – indicate continual improvement in water-use efficiency in the Australian cotton industry. Early indications have identified that water productivity appears to have slowly increased over the past 10 years, indicating that the industry has achieved steady improvement in yield with less water. On-farm Gross Production Water Use Index (GPWUI) was 1.174 in 2006–07; 1.139 in 2007–08; 1.120 in 2012–13, and is tracking around 1.2 bales/ML for 2017–18.

RD&E supporting continued industry expansion

Despite this season's challenging seasonal conditions, the Australian cotton industry continues to grow sustainably into both the north and south. In 2018–19, a new CRDC supported pathologist was appointed to southern NSW, to further strengthen the research effort in the south. Meanwhile, in the north, 2017 Researcher of the Year, Steve Yeates, continues his role as cotton development and coordination leader for northern cotton; growers in the Ord (including CRDC- and Cotton Australia–supported Nuffield scholar Luke McKay) are into their second cotton season; and NT growers have harvested their first commercial cotton trial in 15 years.

Building adaptive capacity: support for industry leaders

In addition to 2018 Nuffield scholar Luke McKay, (pictured right) CRDC has also invested in other industry leaders during 2018–19, under the Strategic Plan goal of building adaptive capacity.

These include 2019 Nuffield scholar, Emerald cotton grower and Cotton Australia regional manager Renee Anderson (co-supported by Cotton Australia); the CRDC supported ABARES 2019 Science and Innovation Award winner, UQ researcher scientist Dr Dean Brookes; and the latest cohort of Australian Rural Leadership Program participants: Richard Malone and Tim Chaffey (course 24) and Fleur Anderson and John Durham (course 25), in conjunction with Cotton Australia and Auscott Ltd.

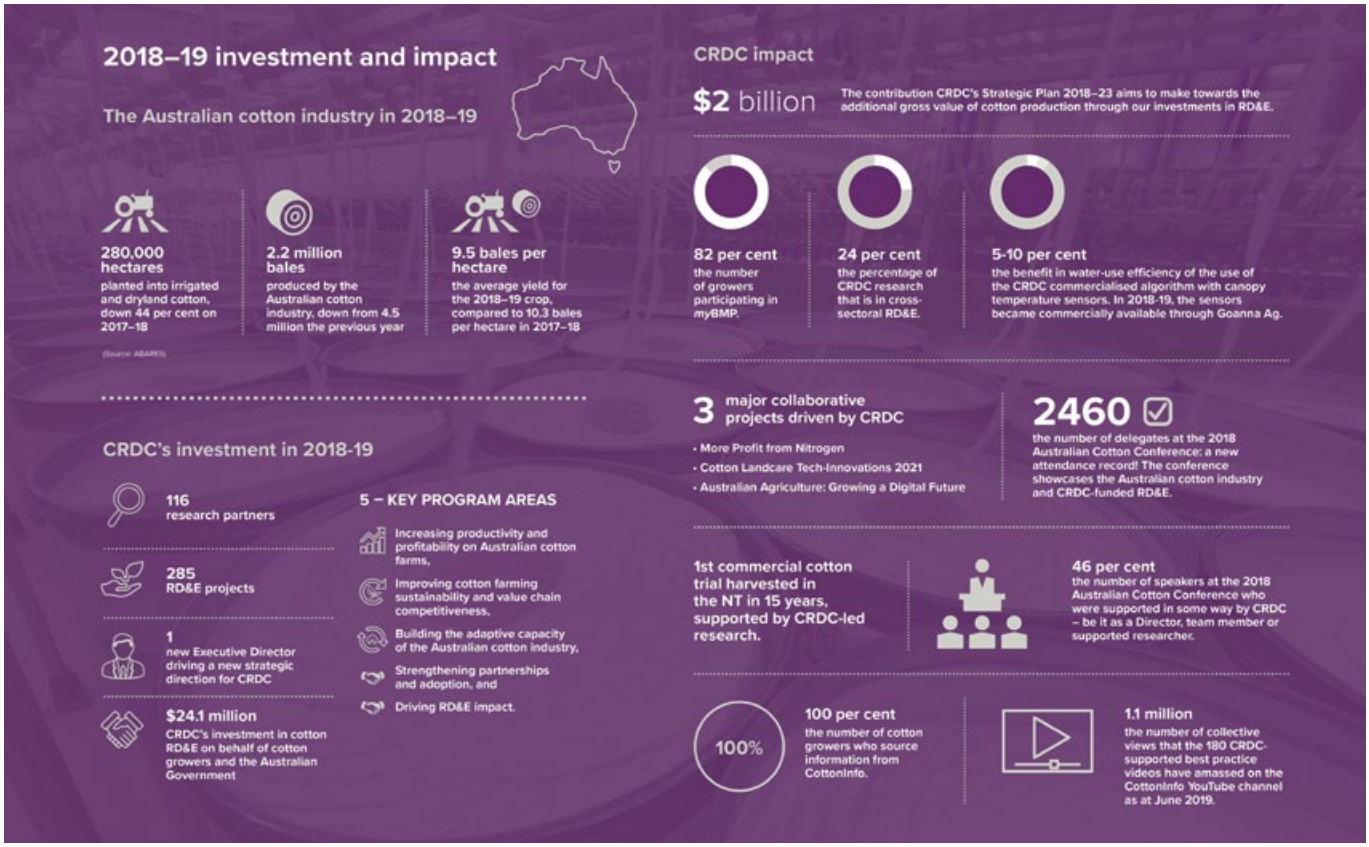
Extending R&D outcomes to growers: CottonInfo connecting growers with research

The industry's extension program, CottonInfo, undertook a review in 2018–19, capturing key highlights and achievements from its first six years of operation. The review found that CottonInfo has grown to become a trusted source of information for growers and consultants, with 100 per cent of growers now sourcing information from CottonInfo. Over the past six years, CottonInfo has run nearly 1000 extension activities, with a total 14,000 participants. Of 126 events where intention to change was evaluated, 1600 growers indicated they would change practices as a result of increased awareness or knowledge facilitated by CottonInfo.

ROURKE WALSH

Weed management app

A new weed identification mobile app was released in 2018–19, designed to assist growers and advisers in identifying 50 key weed species. Weeds of Australian Cotton was developed as part of a CRDC-supported project led by Dr David Thornby, with input from fellow weeds experts Graham Charles, Jeff Werth and Dr Ian Taylor. The app specifically includes cotyledon shapes as an important diagnostic characteristic, because weed identification in early growth stages is critical. The app is available to download from the Apple store and Google Play.



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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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