Spotlight
ON COTTON R&D

WINTER 2020

Industry's sustainability report card released

Creating disease suppressive soils

CCA survey shows species shifts

CRDC

Ian Taylor

In the Spotlight

Welcome to the Winter edition of *Spotlight*.

This year has thrown some unforeseen challenges at us, yet agriculture is one industry that has remained constant, as primary producers continue to do what they do best. There are crops to be harvested and planted, with some promising rainfall across a lot of drought-affected regions. Also continuing is the research being undertaken by our world-leading team of scientists in the Australian cotton industry. CRDC has worked to support researchers in their projects as travel and social restrictions came into place. Our office in Narrabri has been temporarily closed, with our team still working for the industry, albeit from home.

A part of our work has been the completion and release of the industry's second Sustainability Report, which has been five years in the making. The report represents how important we as an industry view the impact and imprint we have on the land and society.

The Australian industry continues to improve its record of stewardship of natural resources and takes this responsibility seriously, as evidenced by the production of the report, which shows we have made great improvements. Now is the time for the industry to seek more ways to continually improve.

The task now is to use the report data to set five-year targets for 2024 and 2029, along with plans to achieve those targets. The industry's new PLANET. PEOPLE. PADDOCK. sustainability framework will guide the industry to set these ambitious targets, coordinate a whole-of-industry strategy to achieve them, and engage effectively with stakeholders on actions and progress.

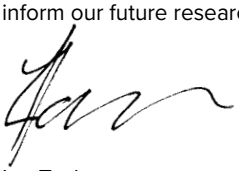
If the COVID-19 pandemic has shown us anything, it is how prepared we are to adapt to change, challenges and uncertainty. Building adaptive capacity is a core part of our Strategic Plan 2018-23, as we recognise our environment is dynamic, and we must be also. Through sound research and support for our research community, growers and industry, we aim to secure the future of our industry.

In this spirit, CRDC has been supporting research into how we manage diseases of cotton, looking to create natural suppressiveness in our soils, and treating the cause rather than the symptom. New research, some of it using many years of data collected in annual disease surveys, is building on what we already know to help growers alleviate the negative impact of disease by creating healthier soils. It all starts with the soil and we hope you enjoy reading our feature on disease suppressive soils research.

Likewise, we are looking at ways to harness the natural ability of insects to control pests of cotton. The development of systems to protect natural biodiversity in our cotton fields and on farms is creating new methods of managing pests, and in this edition we look at how silverleaf whitefly research is making impressive inroads.

In this edition we have also included our 2020-21 projects list, which shows the depth and breadth of research underway with our more than 100 partners. If you would like any more information about these or other CRDC-supported research, please contact one our R&D Managers, or go to the industry's online library, Inside Cotton (www.insidecotton.com.au) which holds outcomes of all our past CRDC-supported research.

We haven't seen many industry faces of late, other than via a computer screen, however we look forward to getting back to catching up at meetings, field days and conferences when it is safe and healthy to do so. In the meantime, we encourage you to participate in the annual CRDC cotton grower survey. This year the survey will be conducted by the research team via phone, providing some much needed social connection while collecting important information to help inform our future research.



Ian Taylor
CRDC Executive Director

Winter 2020

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CRDC
COTTON RESEARCH AND DEVELOPMENT CORPORATION

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

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ON THE COVER: CRDC is working towards the industry vision of being a global leader in sustainable cotton production.

Want to see more of Spotlight?

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

COTTON NEWS

FEATURES

In this edition of *Spotlight,* you will see two QR codes accompanying our feature stories. Simply scan the QR codes using your smartphone camera and follow the link to tell us if: a/ the feature story topic is an issue on your farm, b/ you'd like further information from the research team, or c/ you'd like your local CottonInfo REO to include the topic in your next cotton catchup meeting – or all three!

My science

Amanda Padovan and fellow scientists at CSIRO are investigating molecular resistance monitoring in pests of cotton.

CRDC, Bayer and CSIRO have collaborated on this project that uses molecular testing to identify the diversity and relative frequencies of Bt resistance alleles in *Helicoverpa armigera* and *Helicoverpa punctigera*, to develop a cost effective, faster technique for monitoring.

From egg in the field to resistance status using the molecular tool could be as fast as a month. Growers can use the local and up-to-date resistance information to make management decisions mid-season.

"In the next phase of the projects we will expand the molecular resistance monitoring tool to include many pests in many crops on a global scale," Amanda said.

The tool may also be used to answer questions about the ecology of the pest system to better inform some aspects of how the industry manages resistance.

CRDC Executive Director Dr Ian Taylor, Acting Agriculture Chief Scientist and Chief Plant Protection Officer Dr Gabrielle Vivian-Smith, Federal Minister for Agriculture David Littleproud, Dr Dinesh Kafle and CRDC Board Director Dr Jeremy Burdon.

ABARES and CRDC reward disease research

Research into new methods to manage Fusarium wilt and Reniform nematode will be boosted through the 2020 CRDC-supported ABARES Science and Innovation Award.

QLD DAF agricultural scientist Dr Dinesh Kafle was presented with his award at the ABARES Outlook Conference dinner in Canberra earlier this year, attended by CRDC's Executive Director Ian Taylor and Board Director Jeremy Burdon.

Dinesh's innovative research project will investigate whether cotton plants can be primed with silicon to boost defence against fusarium wilt and reniform nematode. This involves germinating cotton seeds in soil with added silicon, before infecting them with the diseases.

"Very little work has been done on silicon in the past," Dinesh said.

"It's a novel approach, and if successful, it's going to be really a great tool in managing disease."

While silica is naturally present in the soil, it is difficult for crops to absorb. Therefore, Dinesh plans to examine if there is any priming effect when seedlings are given silicon in a readily available form.

"The concept of priming itself is also relatively new, having been studied mostly in ecological settings," he says.

"I'm trying to see if the priming has any implications in agriculture, so it's really exciting."

Dinesh grew up in a small village in Nepal, living next to an agricultural research station whose field trials would inspire him for life. He trained in Germany and Israel, before turning his attention to Australian cotton in 2018. Dinesh says it's been amazing to work in such as large, profitable and interesting industry.

Now based in Brisbane, Dinesh is a member of cotton pathology research group at DAF, led by Dr Linda Smith. He is involved in several CRDC projects.

"I started my research on the CRDC project Understanding the ecology of reniform nematodes in cotton and worked on this project until the end of 2019," he says.

"Currently, I am working on the project Characteristics of disease suppressive cotton farming systems and soils. (See page 20)

"The cotton industry offers a lot of opportunities," he says. "I'm still learning so many things, and it's an exciting field of agriculture."

For more

dinesh.kafle@daf.qld.gov.au

Transforming Australia's cotton industry

THE cotton industry has released its highly anticipated Australian Cotton Sustainability Report 2019, following on from the inaugural report published in 2014.

The report, co-produced by CRDC and Cotton Australia, tells a positive story of increasing efficiency in the use of resources including water and land. It reveals long term trends that producing a bale of cotton now takes 48 per cent less water, 34 per cent less land, and 97 per cent less insecticide than it did in 1992.

By comparing performance over five-year periods in the industry's most important sustainability areas, the report also highlights areas for improvement, including nitrogen use efficiency and the closely associated increase in greenhouse gas emissions per bale.

"Sustainability for the Australian cotton industry means running profitable and efficient businesses while creating environmental, economic and social value. It also means being accountable to stakeholders for the industry's actions and impacts," CRDC General Manager, R&D Investment, Allan Williams said.

"The Australian cotton industry has been actively working to do this for over 30 years.

"Now, the industry is seeking to improve even more as it works towards its vision of being a global leader in sustainable cotton production."

The report is focused on eight sustainability topics most important to the industry and its stakeholders. These topics were decided through a process involving a technical review, industry input and external stakeholder consultations.

The report is part of the industry's new PLANET. PEOPLE. PADDOCK. sustainability framework which guides the industry to set ambitious targets, coordinate a whole-of-industry strategy to achieve these targets, and engage effectively with stakeholders on actions and progress.

Allan said the industry will now use report data to set five-year targets for 2024 and 2029, along with plans to achieve those targets.

"We need to set bold targets, ensure our research and adoption program can get us to those targets, and frequently and transparently share progress with our stakeholders," Allan said.

"We will be consulting with growers and other stakeholders inside and outside the industry on setting the right level of ambition in our sustainability targets.

"The industry can point to long-term trends of significant improvement in areas it has focused on in the past, and we will draw on this experience to transform our performance in other areas in the future."

Carbon positive cotton farmers

The Statham family has invested in constant research, trials and innovation for many years to achieve their sustainability results and a carbon positive farm. They've made significant improvements in water use, fertiliser efficiency, soil health and biodiversity enhancement.

David and Danielle Statham requested a full sustainability report to be undertaken by the University of Queensland (USQ) in 2018, which showed the carbon footprint (carbon emissions minus carbon stored in soil and vegetation) per bale of irrigated cotton produced, ginned and delivered to port of a high-yielding crop of 14 bales per hectare was -412kg CO_2e per bale. This means the Statham's 20,000 hectares of black alluvial soils are a carbon sink, storing more carbon than is emitted to grow cotton. This has largely been achieved through practices such as using composted waste matter, crop rotation, and minimum or zero tillage.

Together, these have seen soil carbon levels rise from 0.5 per cent in 2013 to 0.74 per cent in 2017.

The USQ study showed the carbon footprint for the entire farm, including cattle, was -26,682 T CO_2e. That means the Stathams are running a productive food and fibre business – and storing enough extra carbon to offset the total annual emissions of about 1800 Australians.
Find the full report at www.crdc.com.au/publications/australian-cotton-sustainability-report

Measure to value

DANIELLE Statham says, first and foremost "you cannot value what you cannot measure".

"Cotton is the fibre of choice by the majority of consumers – this is proven, but with that said, today's brand and consumer behaviour towards sustainability has given other fibres more of our market share," she said.

"Brands have pivoted from public statements of responsible sourcing and proving environmental footprint reductions, to now understanding deeper levels of sourcing, which emphasises transparency and traceability.

"The Sustainability Report is vital because it provides a measure of our industry, and neither the industry nor consumers can value what they can't measure.

"We need data behind our claims and credentials as a sustainable industry, so we as individuals can continue to improve our operations for future farming, as well as telling our story to customers and consumers.

"The growth in scientific measurement of sustainability must grow exponentially in the next five years, as without verified data attached to transparency and traceability, we are wasting our time in the debate to educate anyone on the sustainability attributes we are bringing to the conversation."

Danielle says it's important for cotton growers to value their role.

"You're not just a farmer, you're a massive part of the supply chain," she said.

"We really want to tell truthful and powerful stories that debunk the myths and misconceptions of cotton farmers, or what is perceived as poor management practice.

"We must provide accurate farm data attached to individual stories for traceability, which proves the transparency of sustainability claims."

Looking to broaden acres in Northern Australia

A $1.4 million research program for Northern Australia supported by CRDC was announced earlier this year, to trial high-value crops such as cotton with potential rotation crops.

Cotton at Tipperary Station: one of the grower partners in the new CRCNA collaborative project.

The two-year, $2.1 million Potential for broadacre cropping in the Northern Territory project is being co-funded by the Cooperative Research Centre for Developing Northern Australia (CRCNA), CRDC, GRDC and 14 industry partners. It's the largest collaboration to date for the CRCNA.

Researchers from the Northern Territory Department of Primary Industry and Resources (DPIR) will lead a project team from the Queensland Department of Agriculture and Fisheries (DAF), CSIRO, universities, natural resource groups, industry associations, seed distributors and producers from across the Territory.

This project will collate historical broadacre cropping data, natural resource information and an understanding of market opportunities to support the development of viable broadacre cropping systems in the NT.

This will be achieved by project participants who each bring unique expertise to develop crop management strategies which will help to de-risk broadacre agriculture in the Top End.

The Northern Territory Farmers Association believes if the NT realises its potential, by 2029 the area under broadacre cropping would be extensively expanded. The cotton industry alone is projected to grow to 35,000 hectares from just 80 hectares currently, generating 300 jobs.

The project will identify potential crops, the timing and length of the potential cropping windows, and the impacts of climate and soil conditions on yield and quality. These factors ultimately determine the productivity of broadacre cropping systems. For those crops which will technically grow based on available resources and environmental conditions, there must also an analysis of their market opportunities to support their successful adoption. The initial focus will be on rain-fed and irrigated systems growing cotton and peanut crops, while maize, sorghum, rice and pulse crops will also be investigated as possible 'break crop' options for cotton and peanut producers.

A mixture of on-field and simulation techniques will be used throughout this project. Small-scale trials will be complemented by larger, commercial demonstration trials and supported by crop simulation tools like OZCOT.

"Advances in these crop simulation models provide a powerful tool which can be used to extend learnings from past and current field research, build an understanding of the short and long term risk profiles, identify key management decisions, determine irrigation water demands and incorporate producer experience while developing an overall picture of the cropping potential of a region," DPIR senior research agronomist Dr Ian Biggs said.

Data collected as part of the trials will be used to validate OZCOT under Northern Australian conditions, while the University of Southern Queensland (USQ) will contribute its cropping system modelling expertise to the project. The USQ Centre for Sustainable Agricultural Systems assists decision-makers to identify system constraints and make informed, science-based decisions that improve the productivity, profitability and environmental sustainability of agricultural systems.

CRCNA CEO Jed Matz said this information will help producers decide which crops to grow and when and where to grow them.

"This collaboration is about gathering the brightest minds in northern Australian cropping systems. It's about setting the starting points for the development of broadacre cropping systems by giving producers, investors and development decision-makers the information they need to realise the region's potential and all the economic benefits that flow from realising that potential," he said.

For more
www.crcna.com.au

The grower delegation at evokeAG: 'It was a great opportunity to meet motivated and innovative people...'

Evoking new ways of thinking and innovating

COVERING three main themes – Food, Farm, Future – the evokeAG conference allows delegates to explore what's next in the agri-tech space.

This relatively new event, in its second year, is a game-changer in terms of the ability to immerse attendees in a futuristic experience delivering diverse topics and cutting-edge innovation from across the region and around the world. It is the only event of its type where people come together to connect, collaborate and evolve all things agriculture.

Held by CRDC's fellow research and development corporation, AgriFutures Australia, Managing Director John Harvey said evokeAG aims to inspire and challenge new ways of thinking.

This international event has grown in size and popularity, with 1300 delegates attending each day to hear national and international speakers take to the stage and highlight new technologies, food markets, lessons on launching into international markets, and investment opportunities. Speakers ranged from growers and producers with big ideas to venture capitalists, corporate heads and startup wizards.

"...it gives you a chance to take a fresh look at how technology and innovation can improve your current operations."

CRDC supported cotton growers to attend the event, held in Melbourne in February this year.

Riverina Agriculture's Managing Director Lachlan Danckert was one of the growers CRDC supported to attend, taking the number of farmers across all commodities to more than 100.

Lachlan's business entails growing cotton, winter crops like barley and wheat, and a lamb feedlot, as well as an earthworks business at Deniliquin in the Riverina district of NSW.

Lachlan says a highlight was to hear Hungry Jacks founder Jack Cowin discuss the 2030 vision of achieving a $100 billion agricultural industry in Australia.

Jack told the evokeAG attendees that a long-term strategy is needed in Australia to drive innovation in agriculture.

"The DNA of Australia is entrepreneurial, we are early tech adopters in this country and we're well equipped in this regard," he said.

"My concern is the big stuff, what are the building blocks that this country needs to use to make us successful over the next 40 and 50 years."

Lachlan agrees, saying "We have the technology and the skills, and corporate investors are looking for ways to become involved, but we need an organisation that is not tied to any short term political constraints, which can harness the opportunity which our country has to put into place nation building projects for agriculture".

There is a lot to see at evokeAG in terms of technology, start-ups and research, with on-farm application a reality.

"I learned a fair amount about the new tech start-up businesses which are doing really well," Lachlan said.

"One which stood out for me is the Zetifi WiFi connectivity repeater for farms with poor phone and internet service.

"We could be looking at installing this system on our farm to improve our productivity.

"I would certainly recommend others attend because it gives you a chance to get away from your everyday work environment and take a fresh look at how technology and innovation can improve your current operations.

"The evokeAG conference was a great opportunity to meet motivated and innovative people who have been successful in building businesses."

evokeAG 2021 will be held February 16-17 in Perth, Western Australia.

For more
www.evokeag.com

Strengthening partnerships creates unity

CRDC, as an investment organisation, relies on high-quality partnerships with research providers to deliver findings and innovations that address new and existing challenges for the benefit of the industry in the long term.

For the Australian cotton industry to benefit from research investments, the outcomes need to be rapidly extended and adopted, and as applicable, commercialised. To achieve these outcomes CRDC works with many partners: research institutions, industry groups, individual researchers, fellow research and development corporations and state bodies of agriculture. CRDC works with around 100 different research organisations each year.

"We pride ourselves on our strong relationships with cotton growers, research providers, government and other core partners," CRDC Executive Director Dr Ian Taylor said.

"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 other collaborators.

"Of all the RD&E projects in cotton, we are partners in over 80 per cent of them."

CRDC also recognises the importance of cross-sectoral collaboration in solving issues bigger than the cotton industry alone. In 2019-20, 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. In 2020-21, this number is set to rise to 48 per cent.

To assess the health of its partnerships, CRDC invited its key partners to provide feedback on the health of the partnership, to identify what was working effectively, and also highlight what the opportunities were for strengthening the partnership. This was undertaken in late 2019 and early 2020, replicating a similar study by CRDC in 2016.

The feedback has demonstrated strong results across each of the three headline organisational performance metrics and improvement in the partner ratings across a large number of measures from 2016.

"This was particularly encouraging given the already high benchmarks achieved in 2016, the significant organisational changes at CRDC over the past few years along with the increasingly difficult operating conditions now faced by the industry," Ian said.

"Trust is also integral to partnerships, and with a collective rating of 8.9 out of 10 for trust (up 0.2, with no partner rating this at less than a five out of 10) points to a strong foundation for a successful partnership."

Overall satisfaction with the partnership across all partners was again strong. The ratings and feedback provided highlighted a number of perceived strengths of the current engagement and relationship with partners.

"It is very pleasing for us to receive acknowledgment that our motivation is driven by our role as an 'industry custodian'," Ian said.

"Our partners value our commitment to invest in, develop and improve relationships with them.

"A number of partners identified a more proactive approach in recent times from CRDC to build, nurture and sustain open, frank and robust relationships with its industry partners.

"The personal connections that underpin our engagement processes provide strong threads for engagement to build on, and within a small industry, these types of relationship are possible and productive."

The review found that the ongoing investment in establishing and nurturing these one-to-one relationships will deliver dividends for CRDC.

A number of partners characterised the industry as being more united with shared goals and objectives through the discussions and survey feedback.

While drought results in a reduction in investment funding, partners felt CRDC provided effective management of changing industry conditions and the resultant reduction in available R&D investment funds. Partners, while concerned about the changes, acknowledged CRDC for being proactive, transparent in their planning, clear in their communications and cognisant of the ramifications of budget tightening of its effect on partner organisations.

For more
www.crdc.com.au/publications/crdc-partner-relationship-review

Giving back to growers through Grassroots

THE grassroots of the cotton industry are the growers, and CRDC is keen to support projects devised and run by them.

The Grassroots Grants program is open to cotton grower associations (CGAs) to support local projects, with grants of up to $10,000 available. This scheme continues as CRDC sees much value in this investment, as do those undertaking projects. To date, 77 projects have been supported, which has seen nearly $670,000 going back to local grower organisations.

Applications for this year open July 1, and as usual, work on a first-in best dressed basis, so if you or your CGA has a great idea, program, infrastructure or research angle you've been sitting on, contact CRDC to find out how to apply.

These small grants can be just what is needed to get on-farm trials, demonstrations or workshops off the ground. They've been used to help growers with agtech queries, address emerging issues such as pests or disease, start on-farm trials and build weather stations. They've even been used to write a book! *A Dam Good Story: 40 years of Irrigation from the Fairbairn Dam*, captured the facts and stories of those involved in the construction of the Fairbairn Dam and the first 40 years of the enormous benefits it has provided irrigators, industries and the community of the Central Highlands, Queensland. The stories within this book are a precious history of the farming families and the community.

CRDC's Allan Williams says the opportunities offered through the grants include more intrinsic value too, such as fostering collaboration, improving research skills for non-researchers through on-farm and grower-led research and peer-to-peer learning.

A group of farmers from the Northern Territory and Western Australia got their first look at a cotton crop on a tour down south through a Grassroots Grant. "Not only did we learn more about the way the crop is grown; but how the industry operates. The biggest thing is that it's given us confidence that in the future we can go down south and learn even more."

"These grants are always really popular and the scope and quality of projects we see is very broad.

"If you have an idea, please don't hesitate to contact us through your CGA to discuss and potentially refine or expand the idea before applying."

Applications should include a timeline, accurate costings, the likely learning outcomes, and the overall benefits of the project for the industry.

For more
www.crdc.com.au/for-growers/community-grower-support

Time running out for AgSkilled funding

THE AgSkilled strategy has provided funding for training to many in the NSW cotton and grains industries since 2017. Applications for funding will conclude on June 30, 2020, so if upskilling personally or for staff is on your agenda, be quick!

AgSkilled is an industry-led direct partnership between Cotton Australia, the Grains Research and Development Corporation (GRDC) and the NSW Government. AgSkilled can deliver flexible training from single units up to Advanced Diploma qualifications.

While COVID-19 has impacted some training, training providers have made adjustments including moving some delivery online to ensure everybody has the opportunity to access this funded training while it's available.

AgSkilled-endorsed training providers (found on the AgSkilled website) should be contacted directly to discuss training needs and to secure funding before June 30. Courses are available in agronomy, machinery operation, business management, personal development, first aid and work health & safety, to name a few.

For more
www.agskilled.org.au

What are you reading during lockdown?

IF you're looking for some reading material and keen to grow world class cotton crops, CRDC and CottonInfo have the book for you!

The 2020 Australian Cotton Production Manual is fresh off the press and is included with this edition of *Spotlight* for our subscribers. If the *Spotlight* magazine you're reading right now isn't yours, never fear, the Manual can also be downloaded from the CRDC website. While you're there, why not subscribe to *Spotlight* as well!

The manual is a must for crop managers, as it is updated annually to include the latest information and science around cotton growing. Research moves rapidly at times and the manual moves with these changes and as such is reworked each year so crop managers can be sure they are getting the latest advice from researchers and the hundreds of projects CRDC invests in on behalf of growers.

For more
www.crdc.com.au/publications/australian-cotton-production-manual

Save the date in 2021!

WELCOME news for the cotton industry is that the number one event on the calendar will be on next year.

The Australian Cotton Conference committee was forced to postpone this year's Conference and associated events including the Australian Cotton Industry Awards and the joint Cotton Australia and CRDC Future Cotton Leaders program due to coronavirus. The new date is August 3-5, 2021 .

Due to uncertainty and safety created by COVID-19, the committee made the call in April, and was able to negotiate this date change with the Gold Coast Convention and Exhibition Centre. As the event is held every two years, a new Conference cycle will now commence, with the event to be held in 2021 then 2023. This also impacts the Cotton Collective and the Association of Australian Cotton Scientists cotton research conference and it is envisaged these events will be held every two years starting in 2022.

The Cotton Industry Awards will return with Conference in 2021, with a new call for nominations going out in early 2021. Any nominations already received will be included for consideration in next year's Awards (with the nominee's consent). A new open call for three-minute theses will be issued around February 2021 also.

All registered delegates are eligible for a full refund for registrations, accommodation and awards dinner tickets. Sponsors and exhibitors who committed to the 2020 Cotton Conference will retain the sponsorships and sites.

For any questions or concerns, please contact the Conference Secretariat Tracey Byrne-Morrison.

For more
secretariat@australiancottonconference.com.au

How you grow is important to CRDC

THE CRDC Grower Practices Survey opens on June 1, giving growers and crop managers the opportunity to compare their practices to others and gain a greater insight into all aspects of how others view the industry and manage their farms. The survey report also allows growers to compare regional data and the results provide CRDC and Cotton Australia with important information about what's happening on Australian cotton farms.

The survey includes core questions and focus areas to investigate specific aspects of the farming system and for the first time, will be conducted via a quick telephone call.

The survey is conducted by a professional researcher team, Intuitive Solutions, who have many years of experience. Importantly, the information collected remains confidential, and only aggregated, anonymous information is passed on to CRDC.

The results of the survey are published annually via both a user-friendly PDF report, and an interactive digital dashboard, enabling you to explore the data in more depth.

"We want to highlight that this survey is an opportunity to build a picture of the industry which in turn influences research and extension direction and focus," CRDC Executive Director Dr Ian Taylor said.

"Growers invest in R&D through their levies: the survey information helps to inform CRDC about the benefits of the research it invests in on their behalf.

"With just over 20 years of surveys, we also have a record of practice change over quite a long period.

"We understand that surveys are often approached with a sigh and survey fatigue can set in, however the data is enormously valuable to the industry, so we do ask growers to put aside 15-20 minutes to participate."

Last year's survey results and the interactive digital dashboard are available via the CRDC website.

For more
www.crdc.com.au/publications/growersurvey

Smarter irrigation goes into phase 2

Irrigation efficiency is set to take another leap forward through Phase 2 of the Smarter Irrigation for Profit project.

Phase 2, led by CRDC, kicked off in late 2019. The project is a partnership between the major irrigation industries of cotton, dairy, sugar, rice and grains, plus research organisations and farmer groups. It is building on the success of on the initial Smarter Irrigation for Profit project, which wound up in 2018. Phase 2 is addressing the challenges of reduced water availability by improving the water productivity of crop and pasture irrigators, through developing new precision irrigation technologies, improving existing technologies and facilitating faster uptake through producer-led demonstration sites.

Day-to-day project activities are being overseen by Cathy Phelps, who has worked extensively in both the dairy and cotton industries.

"There are more than 4000 cotton, dairy, rice, grains and sugar irrigators set to benefit from this project, along with the sustainability and efficiency of those industries," she said.

"We've started the 14 sub-projects with our partners, covering three key components."

These components are:

- development of new irrigation technologies including new sensors, advanced analytics to improve irrigation scheduling and strategies to reduce water storage evaporation;
- cost effective, practical automated irrigation systems for cotton, rice, sugar and dairy; and
- a network of 36 farmer-led optimised irrigation sites on commercial farms across Australia.

While the learning and research undertaken across the 14 sub-projects can be shared across industries, which is a feature of the projects, there are also cotton-specific projects. These will cover areas such as:

- utilising plant-based sensing to optimise for irrigation strategies;
- development of solutions to reduce evaporation from water storages;
- increasing the adoption of automated irrigation technologies;
- precise real-time automated cotton irrigation for improved water productivity;
- development of a whole-of-farm scale gravity fed irrigation management system with the aim of increasing on farm water use efficiency;
- demonstration of the application of the latest digital technologies for precise automated irrigation in the Gwydir Valley; and
- improving the science of water footprinting methods to make them more applicable for Australian agriculture.

Smarter Irrigation for Profit Phase 2 is building on the success of Phase 1, which led to improved dry matter productivity on dairy farms, increased water use efficiency on cotton and sugar farms and cropping options for rice farmers. Cane farmers from North Queensland visited cotton farms in NW NSW to see the latest in irrigation technology as part of the project.

Smarter Irrigation for Profit Phase 2 is funded by the Australian Government Department of Agriculture, Water and the Environment, as part of its Rural R&D for Profit program, round four, in conjunction with CRDC, Dairy Australia, Sugar Research Australia, Grains Research and Development Corporation, AgriFutures Australia, CSIRO, University of Melbourne, University of Southern Queensland, Deakin University, Tasmanian Institute of Agriculture, NSW DPI, Agriculture Victoria and the Gwydir Valley Irrigators Association. Supporting partners include farmer groups and commercial irrigation providers.

For more
www.crdc.com.au/smarter-irrigation-phase-2

Seeking commercial partners

CRDC and the University of Southern Queensland are collaborating to develop and deploy irrigation technologies produced through the Smarter Irrigation for Profit – Phase 1 suite of projects. Expressions of interest are being sought from commercial partners who wish to access these technologies to further develop them and provide commercial context/deployment options.

Expression of interest close June 15. For further information, please download the information, terms and conditions, from www.crdc.com.au/smarter-irrigation-phase-2

Soil biology holds key to disease management

Creating disease-suppressive soils is one step closer for cotton growers.

CRDC has been supporting a ground-breaking project analysing the annual disease surveys, looking for correlations between field management and disease incidence. The Disease suppressive systems and surveillance project is aiming to help growers avoid and manage disease by understanding how to develop disease-suppressive soils. CRDC R&D Manager Susan Maas said CRDC's goal, with the information provided by the project, is to reduce the impact of disease by 40 per cent over the next five years.

This project builds off the approach developed as part of the Digital technologies for dynamic management of disease, stress and yield project, through funding from the Australian Government Department of Agriculture as part of its Rural R&D for Profit program.

"We identified that there was an opportunity to do more with data collected as part of the disease survey and a collaboration with Wine Australia, through the earlier project, provided an opportunity to establish a framework with cotton as a case study," Susan says.

"Given the positive outcomes from the earlier project CRDC has continued to support this initiative through the Disease suppressive systems and surveillance project."

The new approach to disease surveillance initially required developing a geospatial database. Three years of field assessed cotton pathology data

Scan this QR code using your smartphone camera and tell us if: a/ this is an issue on your farm, b/ you'd like further information from the research team, or c/ you'd like your local CottonInfo REO to include this topic in your next cotton catchup meeting – or all three!

and management practices were collected with analysis of survey data performed by Associate Professor Adam Sparks of the University of Southern Queensland. This tested for any effect of previous crop and cotton trash present on early and late season diseases.

Key findings included the impact of previous cropping on disease in the subsequent cotton crop. For example, Verticillium wilt was significantly higher following winter cereal crops than cotton. Seed rot was significantly lower following a fallow or winter cereals, boll rot was significantly higher following summer grains, and tight-lock was significantly lower following fallow and winter cereals, than cotton. Tight-lock had the strongest negative relationship with yield in the data set, providing statistical support of anecdotal findings.

Correlation network analyses were performed on the disease survey data to identify relationships between diseases and yield and diseases themselves in the whole data set and in each state.

The amount of cotton trash present in the field did not have any significantly detectable effect on disease in the analyses performed on these data.

"Given the impact of the previous crop on disease incidence, an estimation of crop residues other than cotton may provide insight to how other crops influence disease, such as maintaining inoculum levels through asymptomatic colonisation or providing a suitable carbon source for saprophytic growth," says QLD DAF pathologist Dr Linda Smith, who is leading the research.

"Hence, these findings provide direction for research to investigate cropping rotations that potentially will decrease/increase disease incidence of important diseases of cotton."

The disease ring is indicative of cotton infected with Verticillium wilt.

"Using several data sets creates a clearer picture of what drivers or conditions are causing disease."

The groundwork has provided the foundation knowledge and critical directions to improve the collection and storage of data, and to build on the analyses already conducted.

Verticillium wilt research

The management of Verticillium wilt requires an integrated approach that ultimately reduces soil inoculum levels without deleterious effects on overall soil biological health. Field trials conducted in this project have shown that rotation can reduce disease but needs to be longer than one year out of cotton where Verticillium levels are high.

Two years of rotation to either non-hosts (sorghum and corn) or a bare fallow significantly reduced Verticillium levels compared to growing three years of continuous cotton. One year of rotation (corn, sorghum or fallow) on the other hand was not long enough to significantly lower disease levels.

"The assessment of microbial changes in the soil under the different rotations sequences was conducted by CSIRO's Dr Gupta Vadakattu," Linda said.

"It suggests that managing *V. dahliae* by growing other non-host crops that may also promote disease suppressive microorganisms which may be a better option than fallow as these crops reduce disease incidence and also maintain overall soil biological health.

"A decline in overall microbial populations in the long term could potentially make soils more conducive to soil-borne diseases."

V. dahliae has one of the widest host ranges of any fungal pathogen, including over 400 susceptible crop and weed hosts. It may cause classic characteristic symptoms but also has the ability to develop asymptomatic, endophytic infections. The susceptibility of some rotation crops to Australian isolates of *V.dahliae* commonly grown in the Australian cotton farming system has been largely unknown to date.

Previous QLD DAF studies have shown that grain sorghum is a non-host and that faba bean and cultivars of chickpea, mungbean, wheat and barley are all susceptible symptomatic hosts with some differential cultivar and strain reactions observed in some of these crops. NSW DPI pathologist Dr Karen Kirkby has also confirmed biofumigant blends containing mustard and Ethiopian cabbage were hosts to *V. dahliae*, as was safflower.

"While the susceptibility of these crops has not been proven under natural field conditions there is clearly the potential for infection to occur and close monitoring of field plants of these alternative hosts should be carefully monitored and assessed when grown in fields known to have a history of Verticillium," Linda said.

"These analyses of laboratory and field-based research have provided a wealth of knowledge to address systems questions on disease management.

"Research to understand management strategies that promote microbial diversity, increase specific groups of beneficial microorganisms, and reduce pathogen capability to cause disease, is now required."

More, and better data on the way

Susan Maas says the key takeout for CRDC is that it is not straight forward cause and effect but the analysis shows where future research should focus in developing disease suppressive soils.

"Correlations aren't necessarily causations," Susan said.

"The project has highlighted future opportunities to use data from the disease surveys, for example spatial data and overlaying crop/soil management on disease incidence.

"We are collecting data on disease severity, raw information about yield, rotation crops and management practices and looking at microbial activity as part of the disease survey.

"Using several data sets creates a clearer picture of what drivers or conditions are causing disease and by using better data processes and analytics we can create a richer profile and conduct analysis to determine how to create disease suppressive systems."

Disease data collection on the rise

Associate Professor Adam Sparks has been working with Linda and the other researchers in the project to help enhance the information from previous and future surveys and to derive the most benefit from the data collected. This includes better data collection tools that will enhance the quality of the data collected in the paddock.

"I'm also developing methods to analyse the data that take advantage of the richness and completeness of the data that has been collected.

"The data reflects a wide range of situations but is not what research data typically consists of, where we usually have well defined trials and hypotheses about a treatment effect. These are observational and can link several types of data from the farming practices to weather data over several years."

The analyses Adam's undertaking enhance the understanding of the data, its meaning and direction for research, and ultimately, management guidelines for cotton growers to create disease suppressive soils and systems.

"We've already found some confirmation in the data of some anecdotal observations about some of the associated environmental factors that might drive disease development.

"For example, some previous crops appear to favour the development of some cotton diseases over others. These findings are useful in designing new research studies that we can do in the glasshouse or paddock so that we can study these relationships more closely."

Adam and the team will be working to collect more thorough and detailed data in the future.

"We'll be making more effort to work with growers and agronomists to fill in the gaps around farming practices where we can as well as just taking better notes in the paddock.

"This data is valuable in helping us to unravel how these factors affect disease development.

"We will also be gathering more data from other sources such as the Bureau of Meteorology to have weather records that we can use in these analyses.

"Using this data will help us to develop a more complete picture of what drives disease development from farming practices to weather conditions and recommend ways to implement control methods that help growers manage cotton diseases more effectively."

Regionally-specific research

Research undertaken by Gupta Vadakattu as part of the survey project has included analysing the composition and abundance of microbial communities of soils from different regions with different cropping histories and varying disease incidences.

"Knowing the factors that drive the soil fungal community in cotton soils across the regions and the potential link with disease will help identify management options to modify beneficial soil fungi," Gupta said.

A laboratory-based pathogen suppression potential assay is being developed which provides a quantitative measure of a cotton field soil's ability to support or inhibit soil-borne fungal pathogens such as *V. dahliae*.

Results from this study clearly indicate the presence of a genetically diverse fungal community in cotton soils and distinct variation in the community composition and diversity between fields in different cotton regions. Actinobacteria were the most dominant bacteria and bacterial community composition was significantly different in fields from some regions.

Research to understand microbial communities in suppressive soils complements the overall efforts to identify management practices that promote disease suppression capacity of cotton soils across different regions.

For more

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What are the key facets of a disease suppressive soil?

Using the soil's natural disease suppression abilities to protect crops would give cotton growers an extremely valuable biological management tool.

Disease suppressive soils are characterised by having the ability to cause a reduction of the incidence or severity of a plant disease in the soil, even with the presence of a pathogen, a susceptible host plant and favourable climatic conditions. All soils have an inherent level of suppressive activity, but this level can be significantly modified by farm management practices.

This type of suppression can be the result of either the suppression of the pathogen or the incidence of disease or both. Pathogen suppression occurs when soils become inhospitable to the pathogen itself, whereas lack of disease incidence can be the result of the inability of the pathogen to cause disease due to the pathogen-microbe-plant interactions and/or from changes to a plant's resistance to the pathogen.

It's about putting the soil's natural, microscopic army to work for you – the microbes.

Soils function as biological entities due to the microbial communities that exist within them. It is estimated that in one kilogram of soil, there are more than one billion bacteria and more than two kilometres of fungal hyphae.

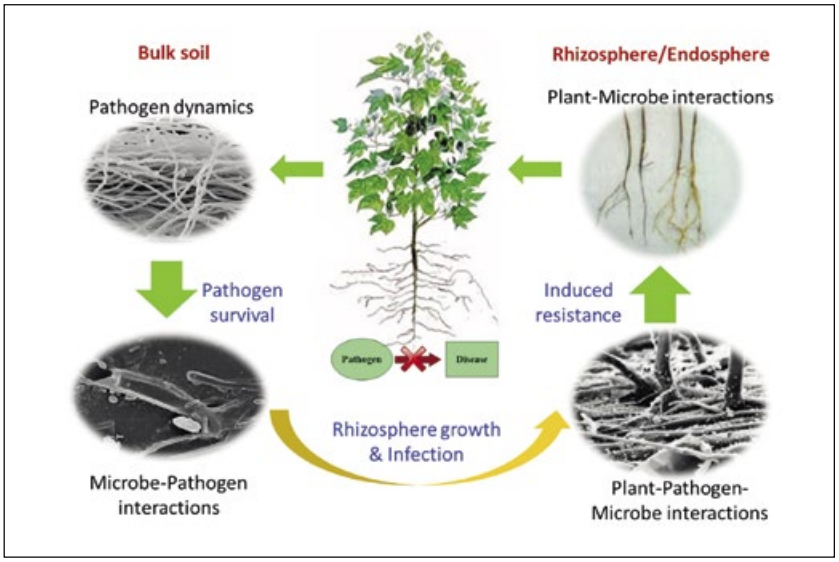

Figure 1. A conceptual diagram showing the different interactions between the pathogen, plant and soil microbial communities involved in disease incidence and suppression occurring during cotton season (near the cotton roots and inside plants) and non-crop periods in bulk soil. Rhizosphere = soil surrounding (2-3mm) root, Endosphere = inside the cotton root.

One of the industry's leading soil researchers, CSIRO's Gupta Vadakattu says microbial communities are often overlooked but are an integral part of natural ecosystems which seem to impact in managed/intensive agricultural systems.

"Disease suppression is a function of diverse microbial communities in our soil operating both in the presence and absence of the host plant and the level of suppression ability varies depending upon soil biological characteristics, physical and chemical properties," Gupta said.

"Soilborne diseases such as Fusarium wilt, black root rot and Verticillium wilt have significant impact on cotton production.

"Currently the management of disease impacts is through the selection of genetically resistant cultivars (where available), agrochemical application and rotation with non-host crops.

"However even in our current resistant cultivars significant losses can occur from soilborne diseases under the right environmental conditions."

While the research in the disease suppressiveness of cotton soils is in its initial phase, Gupta and other researchers are currently working to identify specific management practices (e.g. crop rotation, cover crops) that promote the disease suppressive potential in cotton systems.

"While a recipe specifically to manage the disease suppressive potential (DSP) in different regions/farmer fields is not readily available, there are some basic principles that promote microbial diversity and maintain its catabolic capacity in order to develop DSP," Gupta says.

Crop rotation, stubble retention and no-tillage can either reduce the levels of pathogen inoculum and/or modify pathogen-soil microbe interactions thereby influencing disease impacts. For example non-cereal crops have been shown to reduce Rhizoctonia solani AG8 inoculum levels in a cropping sequence. Changes in the microbial diversity and activity in the short-term clearly indicated the significant and important contribution of soil microbiome for the suppression of Verticillium wilt in cotton.

Gupta found that suitable crop rotation and stubble incorporation was the major driver of fungal community structure. Results of an initial crop rotation trial has shown that cotton following crops such as sorghum and corn exhibited lower

verticillium disease and had increased microbial activity; higher diversity of bacteria and fungi; increased abundances of specific groups of microorganisms involved in antibiosis, antifungal (cell-wall degradation) and plant growth promoting capabilities, along with lower pathogen levels.

Conversely, Gupta found that the fallow treatment caused a significant decline in the total microbial activity and catabolic diversity, genetic diversity of bacteria and fungi, resulting in lower pathogen suppression capacity.

Although the lower pathogen levels would help in the reduction of disease incidence, long-term adoption of such management practices would not benefit in maintaining or improving the overall soil biological health.

"The traditional continuous cotton system seems to promote the growth of pathogenic fungi such as *Verticillium dahliae* and result in lower microbial diversity and abundances of beneficial microorganisms," Gupta said.

The potential contribution of soil microbiome involving specific groups of bacteria, actinobacteria and fungi in disease suppression has been observed for a number of soilborne fungal pathogens including Verticillium wilt in vegetable crops. High levels of disease suppression, which can result in minimal or no disease constraints to plant growth and productivity, have been reported from a variety of cropping systems worldwide including in Australia.

Suppressive soils can be differentiated into two categories. 'General suppression' refers to the inhibition of pathogenic populations, and is related to either the activity of the total microflora or diverse microbial-faunal interactions. In contrast, 'specific suppression' refers to the activity of specific groups of microorganisms (antagonists).

Suppressive ability is a continuum and all soils have some potential for disease suppression. In the rainfed grain cropping systems in southern and western Australia, management practices that supply higher levels of biologically-available carbon over long periods (more than seven years) and maintain higher levels of microbial carbon turnover can result in changes to the composition and activity of the soil microbial community and consequently increase disease suppression capacity.

Results from the analysis of soils from long-term experiments at the Australian Cotton Research Institute indicated that the diversity and abundance of soil fungal communities varied significantly depending on crop/field management history.

Fungal communities in suppressive cotton soils were characterised by higher diversity and higher connectedness indicating resilience to change and would provide the cotton plant with a stable microbial reservoir across varied seasonal environmental conditions. For example, in a laboratory-based assay Gupta found higher growth of the pathogen *V. dahliae* in disease conducive soils (lower pathogen suppression potential) compared to that in the suppressive soil (higher pathogen suppression potential) (Figure 2). Management and biotic factors that can, in general, promote disease suppression include:

- Avoid monoculture of host crops that promote pathogens and can reduce microbial diversity;
- Implement rotations involving crop types that promote specific microbial communities such as antibiotic producing/antagonistic microflora and non-pathogenic variants, e.g. corn in rotation was found to promote potential disease suppressive groups of bacteria against Verticillium wilt in potato and in our initial experiments;
- Adopt crop residue retention and appropriate tillage treatments that generally promote total microbial biomass and activity;
- Avoid frequent fallows in a crop sequence that cause a significant decline in the microbial activity and diversity;
- Addition of composts or other organic manures to support higher levels of carbon turnover over multiple seasons.

In view of the field/region-based variation in soil microbial communities (especially fungi) in cotton soils, the specific groups of microbes that are influenced by rotation and other management practices need to be verified to determine the magnitude of benefit that could be harnessed from cotton soil biota to reduce disease impacts.

Suppressive ability is not a fixed property of a soil but can be acquired and maintained at a level beneficial to crops. This means that productivity losses from root diseases under conservation agricultural practices can be reduced, and high water and nutrient use efficiency attained without expensive and variable chemical controls.

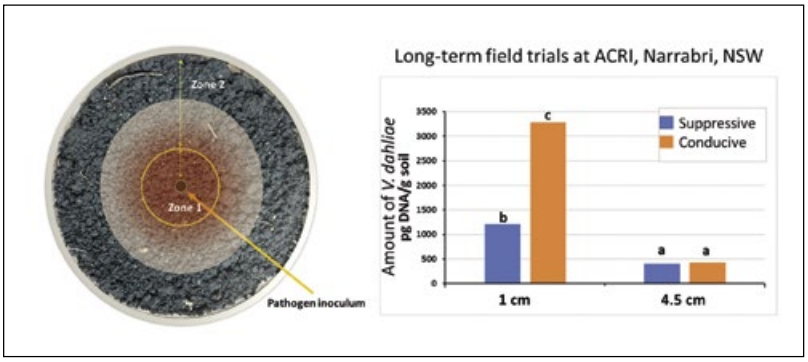

Figure 2. Pathogen suppression potential estimated based on the growth of *V. dahliae*-D strain in surface soils from the long-term cropping system experiments at ACRI (Suppressive – F6E, long-term crop rotation experiment of I. Rochester; Conducive – KK, disease block experiments maintained by K. Kirkby). Columns for each zone with different letters are significantly different at P<0.05.

For more
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Soil microbes offer disease protection

Cotton industry scientists have isolated microbial biocontrol agents with the potential to control Fusarium and Verticillium wilt.

ABOVE: Researchers from Western Sydney University hit the paddock with Andrew McKay from CottonInfo to learn more about microbial communities.

In line with CRDC's other projects investigating the use of biological agents to created disease suppressive soils, a Western Sydney University (WSU) project is showing promising results.

Upon pathogen invasion, in some cases, plants are able to recruit specific protective microbes and even modify their activity in order to suppress the disease.

Professor Brajesh Singh of WSU's Hawkesbury Institute for the Environment says there is an enormous microbial diversity associated with crops, comprising thousands of different microbial species. He said a plant's mechanism of recruiting protective microbes has received significant attention in recent years as it can be exploited for the development of biological-based products for plant protection.

"The aim of our project is to provide a customised, Australian, bio-based solution for Verticillium and Fusarium wilts, to optimise the capacity of native biological resources," Braj told *Spotlight*.

"This aim is compatible with management practices already used in Australian cotton farming systems.

"Our approach focuses on minimising cotton productivity loss from Verticillium and Fusarium, providing growers with a tool kit to better predict and manage these cotton diseases, in order to reduce future outbreaks."

Working alongside the CottonInfo team, the UWS team collected samples and obtained information from 35 cotton fields and 17 non-agricultural fields in four cotton-producing regions in NSW and Queensland: Narrabri, Macquarie, Moree and St George.

In each region, samples were collected from fields showing incidence of Verticillium and/or Fusarium wilts; fields with no disease history; and non-agricultural fields.

Using next-generation sequencing on more than 2000 samples, the researchers determined the core microbiome of cotton plants and how it changes under key management practices and in the presence of the disease. Dr Bruna Batista of WSU, the post-doctoral fellow on this project, said the preliminary data analysis using machine learning and modelling approaches has identified key microbial taxa which can predict microbial indicators that can distinguish healthy fields from fields with Verticillium wilt. The scientists are working to gather more data on Fusarium.

"These results provide pathways to harness some of these taxa to minimise productivity loss caused by wilt diseases," Bruna said.

"This information is also critical to identify best management practices for a healthy soil and increased farm productivity."

The researchers have also isolated microbial biocontrol candidates from healthy cotton plants of varying cultivars and tested their ability to control

Fusarium and Verticillium in controlled conditions. The project PhD student, Simranjit Kaur, said preliminary data analyses have shown promising results against Fusarium wilt where 75 per cent and 87 per cent suppression of disease were observed in Dp-16 and Sicot 71 BRF variety, respectively.

The project's final outcome will be tools using a consortium of microbial species that can have a direct beneficial effect on plant health and/or promote colonisation of a beneficial microbiome, protecting Australian cotton against fungal wilts. A number of other glasshouse experiments are ongoing with aim to bring a small-scale field trial in the 2021 season.

Research towards the development and implementation of efficient crop management practices that include biological solutions has been identified as a key goal by CRDC and will lead to what is considered the "next green revolution."

"However the successful implementation of these products will depend on multiple factors including identification and isolation of indigenous microbial communities, understanding mechanisms by which these communities improve plant fitness, and their ability to colonise plants when re-introduced in the field," Braj said.

"To achieve disease suppressive soils, there also needs to be a change in standard cotton farming practices which currently favour the survival and dispersal of these soil-borne pathogens.

"Management practices such as crop rotation that are recommended to minimise disease incidence are becoming less effective and require extended periods to reduce the pathogens' load in the affected areas.

"Current tillage practices increase pathogen survival, while furrow irrigation, machinery and vehicle movement help to disperse the pathogens within and between farms."

"There are currently no effective measures for controlling wilt diseases in Australia, however our research is closing this gap – the biological way which is the envy of most industries."

For more
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Never lose underwear in the paddock again!

In the name of building healthier soils, the CottonInfo team is once again inviting you to soil your undies! This fun soil science experiment lets you see how healthy your soil is and share your experiences through a new, although once soiled, old undie tracking map.

To participate simply contact your local CottonInfo REO to request a pair of cotton undies. Bury your undies in topsoil for two months and then check the level of decomposition. If there's not much left you have good biological activity, which indicates healthy soil.

"Little decomposition and you've got soil health problems," says soil scientist Dr Oliver Knox, who heads the University of New England's Cotton Hub and oversees the experiment as CottonInfo's soil health technical lead.

"If the undies are gone, that means that you have a good mix of organisms in your soil and they are active!"

Experiments at UNE show there are a range of cellulolytic enzymes involved in the breakdown of cotton and that these enzymes come from a range of soil microbial organisms.

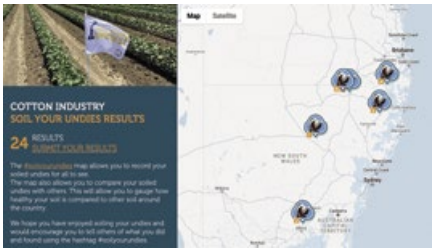
The #soilyourundies map allows you to record your soiled undies for all to see and compare results with others. It's found on the CottonInfo website, with further information about your experiments.

"Hopefully you enjoyed soiling your undies and now we would encourage you to share with others what you did and found using the hashtag #soilyourundies and the map," Oliver said.

"If land managers bury several pairs of pants around a farm they can start to consider if system management, soil types or land use areas show differences in their microbial activity."

What this work is also showing is the ability of cotton to break down ecologically in the soil.

"Little decomposition and you've got soil health problems"



The #soilyourundies map allows you to record your soiled undies for all to see and compare results with others.

Oliver highlighted this with an appearance on national television last year outlining the benefits of the first compostable (not to be confused with combustible!) cotton bra. *The Project* aired a story about Stephanie Devine, who designed a cotton bra after being advised for health reasons, to wear a natural fibre bra. Unable to find anything suitable on the market, she designed her own – the Very Good Bra. Steph pointed out that fifty per cent of the clothes that we own are polyester, and if they go into landfill they will last 200 years.

Oliver's segment focused on tests he ran on the bras' decomposition rates, which showed the bras were 'basically gone' in 61 days.

"The cotton bra Steph designed will decompose entirely, showing that by decisions we make about the clothing we buy, we play a part in reducing waste and changing our planet.

"It's important that what we look at how biodegradable our clothing is an also how healthy our soils are."

For more information about #soilyourundies, see the quick and dirty how to guide, or follow us on twitter @CottonInfoAust.

For more
www.cottoninfo.com.au/soilyourundies

Nematodes live on in Queensland soils

The reniform nematode *(Rotylenchulus reniformis)* is a growing threat to the cotton industry in central and south east Queensland, with the possibility it could spread further afield without control and farm biosecurity measures.

The first reniform nematodes were detected in 2012 in the Dawson/Callide area of Central Queensland and have become a serious concern for cotton growers and researchers. Since this first detection, CRDC has been supporting the QLD DAF pathology team to monitor the number and spread of reniform in the Theodore and wider Central Queensland area. Rotation trials have also been undertaken to determine non-host crops.

Cotton fields in NSW and Queensland were monitored over three seasons (2016-2019) to confirm the presence or absence of plant-parasitic nematodes and shed light on possible issues. Reniform nematode were confirmed as causing yield loss in the Theodore region. Early season soil sampling conducted during the annual disease survey also identified four fields in the Emerald region with reniform nematode. The researchers are returning to these fields after harvest to determine population numbers.

QLD DAF pathologist Dinesh Kafle says control methods in Australian cotton are limited. The US experience showed chemical control was never able to eradicate this pest meaning that cultural control methods were needed. Aldicarb was the only nematicide registered for use in Australia, but its registration has not been renewed.

"In the absence of chemical control strategies, crop rotations remain a potential damage-limitation option, but insufficient information on the reniform's host-pathogen-soil interactions and general ecology in our systems hampers our ability to design suppressive soils through rotations or implement additional cultural control methods," he said.

"By improving our epidemiology understanding of this pest in this project, we are helping to develop control mitigation strategies suitable for deployment in the Australian cotton industry."

Reniform nematode affects a wide range of crops including banana, pineapple, tomato, capsicum, melons, and sweet potato. While traditionally been considered a Northern pest, it has recently been detected as far south as the Lockyer Valley. Research undertaken in collaboration with Dr Dean Brookes of the University of Queensland has determined that reniform nematodes found in different crops across Queensland are genetically similar. They are also not different from the international population, therefore management practices from abroad should be applicable in Australia.

Dinesh has looked at the distribution of reniform through the soil profile, suggesting they can survive deep in the soil profile – to at least 100cm.

Growers at Theodore have reported up to 30 per cent yield loss and data suggests that reniform has potential to cause yield loss when populations exceed the estimated damage threshold of 1000 reniform nematode per 200ml of soil.

Early-season deep core samples from Theodore in 2018-2019 showed the variable abundance of reniform in the soil profile. In some fields they were most abundant in the top 30cm while others large populations in the 30-70cm zone below the surface.

"Interestingly, in some of the fields, the highest population was found at 70-100cm below the surface," Dinesh said.

"These results clearly show that the reniform can live and survive deep in the soil profile thereby providing a reservoir of nematodes that may reinfest the planting zone when cotton is sown, even following a non-host rotation crop.

"Pot trials confirmed reniform can move upward from a deeper soil profile in the presence of a suitable host (cotton) once seedlings start to grow."

Dr Dinesh Kafle says reniform nematode can move vertically through the soil profile, to infect susceptible crops such as cotton.

Testing of the host/non-host suitability of different crops to reniform and the effect of varied populations on growth and yield in several cotton varieties provided interesting results on varietal response. Reniform had a direct negative effect on growth and yield on one variety, while two others were unaffected. Field trials will need to be conducted to confirm these findings.

"Yield may be significantly reduced if the number of nematodes in the soil reaches a certain threshold and different cotton varieties may have different thresholds," Dinesh said.

"We've also found evidence that rotation crops such as corn, forage/grain sorghum and wheat were non-hosts, these crops were not infested by reniform nematode, and interestingly, the population in the soil dropped to almost zero."

The effectiveness of seed treatment products with nematicidal properties and a biological control agent were field-tested. Dinesh said commercial seed treatments had no effect on the reniform population. Similarly, a biological product containing Bacillus species showed no effect.

"Through our research we are closer to finding solutions through rotation crops, along with how the reniform moves through the soil," Dinesh said.

"We've identified suitable crops which significantly reduce populations in the glasshouse, now we need to replicate these trials at a commercial scale to see if they are a viable control option for growers."

For more

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Understanding the real nature of long fallow disorder

Coming off the back of drought, crop managers may have concerns that prolonged periods of fallow will cause a rise in the incidence of long fallow disorder.

Long fallow disorder is characterised as emerging crops growing poorly following periods of fallowing paddocks. In the 1970 and 80s, the disorder was associated with low densities of arbuscular mycorrhizal (AM) fungi. The theory was that propagules of the AM fungi decreased over time during long fallows and this caused the disorder. However a body of cotton industry research over 30 years tells a different story.

Research undertaken by Professor Peter McGee in the 1990s showed that AM persisted in soil columns that were not subjected to wetting and disturbance. Field trials undertaken over seven years in late 90s onward by many of the cotton industry's pre-eminent cotton researchers — Stephen Allen, David Nehl, Chris Anderson and Peter Lonergan — showed that AM persisted under drought over this period of time. The conclusion of all this work was that a lack of AM colonisation is a symptom of long fallow disorder and not a cause.

Long fallow disorder is likely due to all organisms that make up the soil biology competing for organic matter and nutrients after extended dry periods coupled with the fact that these microbes are better at consuming organic matter than plants. Long fallow disorder appears to be associated with a reduced colonisation of the roots by mycorrhizal fungi, but the exact cause remains elusive.

CottonInfo soil health technical lead, Dr Oliver Knox of the UNE School of Environmental Science says that when soils dry out, some of the biology can enter a survival stage. Some bacteria and fungi produce drought-resistant spores, while nematodes and other invertebrates undergo anhydrobiosis and 'sleep' until it becomes wet again.

"Some of the biology dies. This dead biology does not decay until the soil becomes wet again, at which point it decomposes rapidly, releasing nutrients that feed rapid growth in the surviving soil biology. The resultant feasting of the soil biology on this nutrient flush is accompanied by rapid growth and a reduction in available nutrients", Oliver said.

"Germinating seed with a pathetic root system in this environment will have slow growth (Figure 2).

"The good news though is that the feasting can't last forever.

Cotton industry researchers are looking to dispel some of the misnomers around long fallow disorder.

"Over time the soil biology will return to a more balanced system in which crops have a better chance of getting the nutrients they need and, hopefully, that slow start due to long fallow disorder becomes a distant memory.

"This is also important as these crops provide new sources of food and organic matter that the system needs."

In periods of wetting followed by drying, with no plant input to the system, the flush of biology does not get the new crop inputs it needs to survive. As a result, the soil biology reduces with each successive wet/dry cycle, as the organic matter pool is used up. In these instances, AM spores may well germinate, but die having not found a plant host, reducing the propagule load.

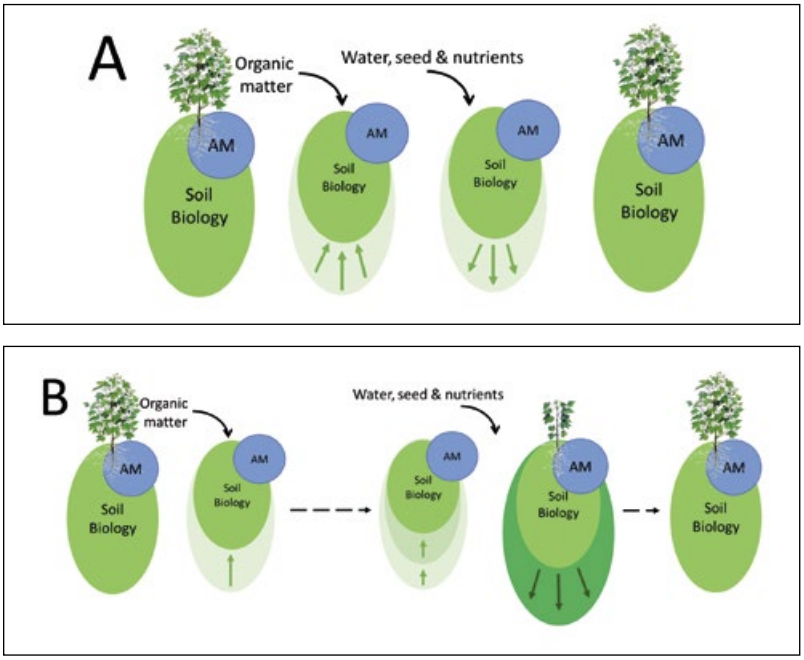
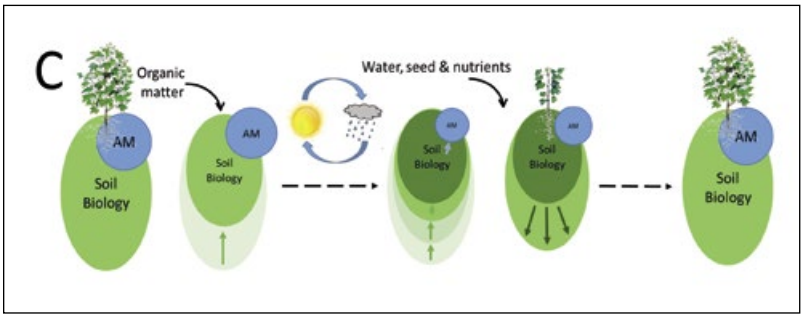


Figure 2. Schematic view of (A) the soil biology under a normal cropping cycle, where the biology might decrease and recover between crops. (B) Under drought, where the prolonged lack of water in the system leads to a further decline in the soil biology, whilst AM survive. Upon water returning to the system, the biology responds rapidly on the available flush of carbon and nutrients, to the detriment of the crop, but the system recovers.



During a drought with wetting and drying cycles (C), the biology is stimulated with each wetting event, living off the organic matter in the soil, but with each cycle this organic matter declines. With no new organic matter/plant inputs the overall biology declines, which includes the AM. When growing conditions return the system takes longer to return to normal and we see more pronounced long fallow disorder and AM colonisation issues as a symptom.

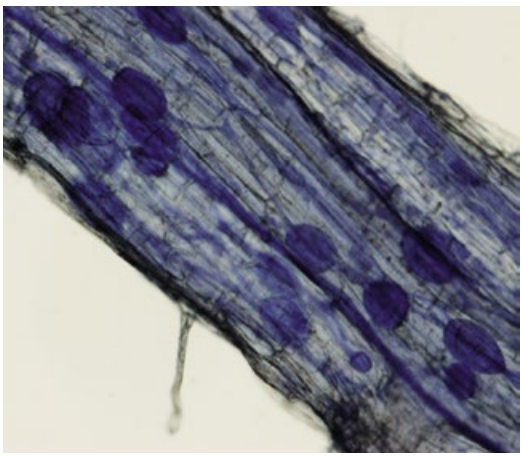


Figure 1. A cotton root that has been cleared and stained. The dark oval structures in the root are the vesicles of AM fungi that have colonised the cotton. Colonisation of cotton, like this, remained similar across seven years of sampling of a field that received no rain during the millennial drought.

What can growers do?

AM propagules survive well in soil, as long as there are no wetting and drying cycles.

"During this drought we barely saw a storm, so even cultivation is unlikely to affect your AM numbers," Oliver said.

"Weeds or cover crops could help your AM fungi, but they will also feed your other soil biology.

"Overcoming long fallow is likely to involve helping all members of the soil biology.

"Keeping fields clean in a drought is best management practice when it comes to weeds, but a cover crop planted on enough moisture to emerge and establish may assist with erosion, water infiltration and maintaining or improving your soil biology.

"On the back of this drought you may experience some signs of long fallow disorder, but the AM fungi, just like you, are a victim and not the cause, the real culprit is the incredible soil biology responding to favourable conditions.

"Only time or changes to field management will lessen long fallows effects."

For more

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CCA report brings weed control into focus

Managing herbicide-resistant weeds and the emergence of resistance in more species across more regions is a key issue for cotton consultants and their clients.

The Crop Consultants Australia (CCA) Qualitative Report has been released for the 2018-19 season, and is a must-read growers, researchers and consultants. Supported by CRDC, the report provides a comprehensive 'state of affairs' of what consultants are seeing on the ground.

CCA survey director Ben Dawson says what's unmissable this year is the issue of weed control, and in particular increasing herbicide resistance in feathertop Rhodes grass (FTR) and sowthistle.

"This was also highlighted in the 2017-18 season, which rated weeds as having the biggest impact on profitability, either through budgeted or unbudgeted costs or through yield loss, over disease and insects," he said.

The report on last season (2018-19) showed that in irrigated fields FTR was rated as the most challenging weed to manage, with resistance being the major contributing factor. Barnyard grass was assessed as less of an issue, but resistance rated as more of an issue in control. FTR also topped the list of species emerging as an issue or likely to become difficult to control due to resistance, followed by sowthistle.

In dryland systems, the biggest challenge was found to be fleabane and FTR, with resistance again playing a larger factor in FTR. Emerging weeds of concern were cited as FTR, windmill and barnyard grass.

"The report is a true reflection of what our consultants are seeing in the field," Ben said.

"FTR is definitely already a problem with the potential to be a bigger one – it could be the new fleabane.

ABOVE: A fallow field with the double up of problem weeds: sowthistle and feathertop Rhodes grass.

"Consultants and growers are seeing it across all our growing regions now and has made its way into paddocks.

"The situation with control is becoming serious – it's very hard to kill with glyphosate alone, so we are increasingly tank-mixing with Group A herbicides, or using alternatives to glyphosate, such as paraquat.

"Sowthistle also stands out, it is now germinating at any time and getting harder to kill," Ben said.

Ben says what consultants are witnessing is a change in weed ecology, which is backed up by cotton industry researchers, who have been monitoring weeds' ability to adapt to new regions and adjust germination time and conditions to thrive in new areas.

"Sowthistle was always a winter weed but now grows all year around, so it's a year-round issue for management," Ben said.

"Glyphosate is used most of the time, but we are losing efficacy against it.

"We need to be looking at more and varied options – we can't spray ourselves out of it."

This aligns with the annual weed surveys which reported a rise from 25 per cent in the 2015-16 surveys to 40 per cent glyphosate resistance in the plants tested. Samples came from across NSW and southern Queensland. A 25 per cent rate of glyphosate resistance was found in sowthistle samples. They have also detected some Group I resistance in sowthistle.

While consultants felt weed control was generally good, especially in irrigated cotton, controlling weeds in irrigation infrastructure and non-cropping areas such as fence lines and around buildings was generally less effective. In terms of modes of action, there was a rise in the area (hectares) where suspected Group A resistance was on the previous report. Group M (glyphosate) showed the largest area with resistance suspected.

Compaction is another issue highlighted in the survey.

More than half of the hectares surveyed (87,408) were thought to have been affected by compaction, with more than 20,000 hectares having an estimated impact of greater than one bale/ha. With the wet end to the season for many this season, this is a good reminder for growers and consultants to plan their strategies to remediate any damage that has occurred.

The consultants represented 494 cotton growers and covered 155,287 hectares: 41 per cent of the Australia cotton production area for the 2018-19 season (not adjusted for row spacing). This is based on the 2018-19 production figure of 379,310 hectares (Cotton Australia).

CRDC commissions this survey each year to provide current and longitudinal knowledge of on-farm practices and attitudes, to aid the research, development and extension effort and identify emerging issues within the Australian cotton industry. The full report is available at www.crdc.com.au/publications/cotton-consultants-survey

For more
www.cropconsultants.com.au

DAF's Jeff Werth says the temperature range of germination for fleabane appears to have increased in comparison to studies undertaken in 2007, where no germinations occurred at five and 35C. In his recent study, there was almost 30 per cent germination at 35C.

"This change supports anecdotal evidence that in the field, fleabane is emerging more in summer, as well as the main times of autumn and spring," he said.

"The ability of fleabane to produce a large amount of seed has more than likely facilitated this adaptation to warmer conditions."

Jeff found sowthistle germinations were consistently high over all the temperatures tested, with the lowest germination of 64 per cent occurring at 38C. Sowthistle was previously considered a winter weed, however, as is indicated by results from this experiment, now it is emerging in the field all year round. Older research also reported a wide range of temperatures at which sowthistle can germinate with above 80 per cent germination at both five and 35C.

Reviewing residuals as weeds evolve

Herbicide resistance and changing weed ecology is necessitating the re-incorporation of residual herbicides and tillage into our farming systems. However, since residuals have not had widespread use for a number of years, there is uncertainty as to their potential damaging effects on higher yielding cotton.

New CRDC-supported research from some of the industry's leading scientists will investigate how residual herbicides and other alternative tactics can be used in cotton, grains and fallow, developing a system to manage weeds, while limiting the negative effects of these tactics on cotton and alternate crops. The group also flagged the changes to pupae busting requirements which removes a late weed control cultivation. Anecdotal evidence suggests that late emerging weeds are surviving post-harvest and topping up the soil seedbank, an issue in the following cotton crop. The use of non-chemical options will be evaluated. The project team of NSW DPI's Dr Graham Charles and Eric Koetz and QLD DAF's Dr Jeff Werth will also contribute technical advice to cover-cropping and dryland cotton projects in terms of weed monitoring and management.

This approach builds on many years of research experience from the scientists involved and ensures soundness and clarity of research questions and methodology.

"Herbicide resistance and species shifts are ongoing concerns," said Eric, who is also the CottonInfo technical lead for weed management.

"This project incorporates a significant survey component in order to identify possible shifts and potential new problems with the aim to strengthen the crop management plan for herbicide-tolerant cotton and provide practical options for weed management which growers can apply directly to their farming systems."

The project includes field surveys, and experiments in the laboratory, glasshouse and field.

Residual herbicide work will be in a cotton-wheat cropping sequence and around eight residual herbicides and combinations will be used in each phase. Selected options will be used in grower fields as opportunity arises.

Targeted and random weed surveys will be conducted with the assistance of the CottonInfo regional extension officers and operate in conjunction with GRDC surveys. A selection of cotton growing valleys will be targeted in each growing season.

Seeds from problem and emerging weeds identified from ICAN workshops in 2016-17 will also be collected for herbicide resistance testing. Weeds will be screened for glyphosate, glufosinate, paraquat, dicamba and Group A tolerance. Localised weeds will also be considered for collection if they are suspected of developing resistance.

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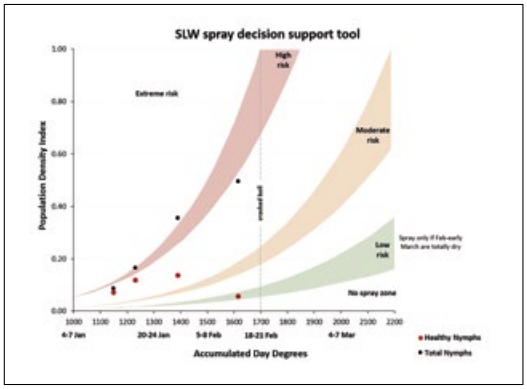
Understanding the SLW numbers game

Cotton industry silverleaf whitefly researcher Dr Richard Sequeira has been working on a new strategy for management decisions. *Spotlight* caught up with Richard to hear what the season looked like and the role parasitic wasps played in whitefly management.



Visualising data with the DST. The progression of red dots indicates very high natural mortality of whitefly which largely neutralised the lint contamination threat after cracked boll thereby helping to avoid intervention with chemical insecticides. The data was taken from a crop at Boggabri (see next story).

The hot and relatively dry 2020 cotton season was the smallest on record since 2007-8 with around 60,000 hectares planted in total across Queensland and NSW, a tenth of the area planted in 2011. While the economic impacts of very small cotton seasons are irrefutable, they provide unique learning opportunities for entomologists to study the behaviour and population dynamics of pest populations under conditions of severe food resource limitations. A case in point is the silverleaf whitefly (SLW), *Bemisia tabaci* MEAM1.

Based on industry reports, the population dynamics of SLW appeared to be more variable in 2020 than in previous years. Some crop managers reported seeing SLW adults in their crops as early as the middle of January whereas others reported seeing their first adults in early February which is more typical of the whitefly build-up in most seasons.

High levels of parasitism by the tiny wasps *Eretmocerus* and *Encarsia* were also evident, substantially more so than in previous years, with many cotton crops escaping a spray because of very high levels of SLW nymphal mortality from parasitism.

Many would be wondering why parasitism of SLW was so high this season and why the phenomenon does not occur at such levels every season. The answers to these and related questions on pest management require an understanding of the population dynamics of the pest within the context of the cropping system.

SLW population dynamics, like that of most other insects, is a numbers game. If the number of overwintering SLW adults moving into cotton is low and the crop acreage is high, the dilution effect is large. In such situations the population build up will be slow under moderate summer temperatures and rainfall conditions. However, dry and hot spring/summer conditions will almost certainly fuel faster population growth.

When the cotton acreage is extremely low, the small areas of green crop in an otherwise bare earth landscape become “magnets” for low numbers of dispersing whitefly from far and near, and populations can build up faster in some areas because of higher starting numbers in younger crops.

This magnet effect that attracts SLW adults also facilitates aggregation of the parasitoid wasps, the end result being earlier and very high rates of parasitism in small seasons, 2020 being a case in point.

New decision support for SLW management

Management strategies based on a sound understanding of the underlying pest population dynamics will give crop mangers more confidence in making intervention decisions and better outcomes.

The new SLW decision support tool (DST) and strategic framework for cotton developed by QLD DAF and CSIRO researchers promises a population dynamics-based approach to making spray decisions underpinned by validation data from crops across Southern Queensland and NSW.

The ability to incorporate natural enemies and the mortality they cause into pest management decisions has long been on the wish list of most entomologists and crop managers. Now, for the first time, the new DST offers crop managers a realistic and practical way of incorporating the SLW mortality contribution of parasitic wasps and other beneficials into their spray decisions. This will bring the industry closer to developing truly “integrated” (beneficials plus insecticides) approaches to pest control.

Scan this QR code using your smartphone camera and tell us if: a/ this is an issue on your farm, b/ you’d like further information from the research team, or c/ you’d like your local CottonInfo REO to include this topic in your next cotton catchup meeting – or all three!

Webinar to discuss new decision support tool

A Crop Consultants Australia webinar in July will include a detailed discussion with Richard about the DST, its practical operational requirements, functionality, and underpinning population dynamics parameters for SLW.
The webinar is for CCA members and will be held on July 22 at 7pm. An all-industry consultation workshop will be held in early August 2020 or as soon as is allowable. Details will be publicised through CottonInfo.

For more
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Building a clear picture of parasitism

Trialling of the new SLW management program has received positive feedback.

The SLW DST was used to quantify the effect of drone releases of beneficial insects into the Watson's crop.

The industry's leading entomologists have developed and are refining a new spray decision support tool (DST), which was trialled in a few crops this season (2019-20).

A major change is a new protocol for monitoring whitefly, by counting nymphs (juveniles) in the lower canopy (node 11 down from the terminal) and the activity of beneficial insects, such as *Eretmocerus hayati*, which are integral to whitefly control. The DST crunches the numbers to generate a real-time visualisation of whitefly population density in the crop in relation to the risk of lint contamination, and the imperative for spraying.

An advantage of the new protocol over the old is that at the end of the season one can use the DST visualisations in the form of graphs, to look back at how SLW progressed in different management units and compare seasonal SLW profiles among fields, farms and even across regions.

Historically, SLW have not been an issue for Boggabri grower Andrew Watson. While they've been around, he's only sprayed for them in the 2018-2019 season. However, after that difficult season, including the first-time detection of mealybug, this season he was keen to trial releasing beneficial predators green lacewing and the predatory wasp *Eretmocerus hayati*.

Andrew has always taken a soft approach to insect control, closely following industry guidelines and thresholds. He was the first cotton grower to grow 11 consecutive crops completely spray-free. However, the arrival of high numbers of SLW and mealybug into the mix required another tactic.

"After early detection of whitefly in December, and in an effort to try to build a defence against mirids, we decided to release beneficial insects by drone at the end of December with another release 10 days after that," Andrew said.

"We put out 20,000 bugs per hectare with two drone releases on 70-metre swathes across 10 fields, with one separate field kept as a control.

"We were looking for a way to assess the impact of these beneficials on pest numbers, and the new decision support tool turned out to be ideal."

CSIRO entomologist Tanya Smith and QLD DAF's Dr Richard Sequeira used the new DST to crunch the numbers from Andrew's farm. Tanya's sampling data from crops throughout the Gwydir, and lower and upper Namoi valleys allowed comparisons of population profiles generated using the DST across the region.

"The DST only requires that large nymphs, including the red-eyed nymphs to be classified as healthy or dead, but for Andrew's crops I also recorded levels of parasitism so that he could track the effectiveness of his wasp releases against predation and other causes of death," Tanya said.

"My observations lead me to believe that parasite activity was generally up across the region this season, and in Andrew's crops they were a step ahead of those in nearby cotton fields."

"Field inspections didn't see much activity from the green lacewing, but the wasps were really active – in whitefly we were seeing over 90 per cent parasitised or predated," Andrew said.

"From the graph produced by the DST we could see, in relatively real time, where we were headed – and to see the trend of insect pests dying was great, it gave us confidence in what we were doing and the ability to quantify the effect of drone beneficial release."

A phone app for whitefly sampling is in the final stages of development, with support from CRDC. The exciting technology accurately detects the number of healthy large nymphs on a leaf. It will eventually incorporate the whitefly DST and 'automate' whitefly management in cotton. The phone app should minimise human error and the need for consultants to develop skill in identifying whitefly nymphs in different states (healthy, parasitised, predated). Due to low numbers this season, limited trials of the app were undertaken, however developer Derek Long from the University of Southern Queensland says it will be ready for use next season.

For more

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Annual resistance testing has shown continued resistance to key insecticides used to control silverleaf whitefly (SLW), highlighting the need for strict adherence to Insecticide Resistance Management Plan (IRMS) guidelines and the importance of implementing integrated pest management (IPM).

SLW resistance remains

Undertaken by QLD DAF's Dr Jamie Hopkinson, SLW samples are tested for resistance to a range of registered insecticides including pyriproxyfen, spirotetramat and the pyrethroid bifenthrin.

Bioassay results from SLW populations collected during the 2018-19 season showed resistance to pyriproxyfen at six localities from 19 tested, primarily in the Gwydir and Namoi. A single site tested at Mungindi also showed resistance.

SLW populations from Emerald and Theodore regions showed no evidence of pyriproxyfen resistance, however resistance to bifenthrin was detected. In bioassays of SLW from these regions, survivors were found at the discriminating dose of bifenthrin; indicative of low-level pyrethroid resistance. This appears to be a continued trend.

"Over the past three years we have detected low frequency resistance to the pyrethroid bifenthrin in many different localities," Jamie told *Spotlight*.

"Resistance to spirotetramat was also detected at very low frequencies in the Emerald irrigation area in 2018-19 and 2019-20."

The detection of resistance to spirotetramat reinforces the importance of adopting IPM.

"Practices that enhance or preserve natural enemies are valuable for in-field suppression of pests including those carrying resistance," Jamie says.

"For example: the parasitism of SLW surviving insecticide application is a way of removing potentially resistant individuals from the population."

One of the recent changes to the IRMS was to reduce the number of applications of spirotetramat from two to one (except where mealybug control requires a double application to be effective).

"This was a forward-thinking action to reduce the selection pressure on this insecticide," Jamie said.

"There are now several mode of action groups available to control SLW, so a key principle of the IRMS is to rotate chemistry where multiple sprays are required."

"Results this season demonstrated that Eretmocerus is capable of building up to large numbers."

JANELLE MONTGOMERY

Dr Jamie Hopkinson (right) with Jacob Balzer collecting SLW samples.

Eretmocerus in abundance

Jamie and his team have also been monitoring SLW parasitism levels by the wasp *Eretmocerus hayati* with CottonInfo Regional Extension Officers Andrew McKay (Border Rivers), Janelle Montgomery (Gwydir Valley and Mungindi) and Amanda Thomas (Macquarie). They've been collecting samples on leaves, learning how to identify parasitised nymphs and reporting the levels to Jamie.

"Results this season demonstrated that *Eretmocerus* is capable of building up to large numbers. For example in the Macquarie, Amanda found parasitism was already at 50 per cent in early February and maintained this level of abundance over the next few weeks," Jamie said.

In Moree, Janelle reported around 70 per cent in mid-February, which continued to increase to over 90 per cent within a month, while Andrew tracked an incremental increase in parasitism over four weeks at St George.

As part of a CRDC project led by QLD DAF's Richard Sequeira, parasitism data from North Star and Boggabilla was collected by the entomology team in Toowoomba and CSIRO's Tanya Smith in the Namoi Valley. At North Star, parasitism steadily increased to between 50 and 70 per cent, while at Boggabilla, in one field parasitism steadily increased

Silverleaf whitefly parasitism mapped at St George, with data supplied by CottonInfo REO Andrew McKay.

from eight to 50 per cent over six-weeks from late January. This data has been used to enhance the functionality of the new spray decision support tool (DST) for whitefly. The DST will allow users to quantify and factor in the mortality caused by natural enemies into their decisions. (See article on page 26)

New tech on the table

The physical distance between the REOs and Jamie who is based in Toowoomba, created some challenges in comparing results and images, which required a new way of operating.

"Microscopes with photographic capability purchased by CottonInfo has made the experience much easier," Jamie said.

"For the most part it's fairly easy to tell if SLW are parasitised, but there are always one or two that it can be difficult to tell, even with many years of experience, so the REOs could send images that were tricky."

Jamie and team travelled to Narrabri, Moree and St George in March to collect more samples to test for changes in resistance levels.

"It wasn't an easy task given the high levels of parasitism, but we managed to collect enough, with help from Upper Namoi REO Elsie Hudson, Janelle and Andrew," Jamie said.

"Our most recent collections for testing came through in April from Amanda and also CRDC's Elle Storrier from Narromine and Hillston."

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Scouting whitefly like CSI

The CottonInfo REOs involved in the sampling, Amanda Thomas, Andrew McKay and Janelle Montgomery all highly rated the experience of being involved in Jamie Hopkinson's silverleaf whitefly monitoring project to track levels of parasitism by the wasp *Eretmocerus hayati*.

Learning methods of sampling and accurate identification of whitefly nymph from Jamie was first up. The team used microscopes to classify each nymph as either healthy, parasitised, dead or unknown. Over four weeks the team then collected nymphs for classification and forwarded the data to Jamie.

The microscopes, with photo and video capability, have been a worthwhile addition to the REO toolkit, and were vital for sharing information and images from fields far away.

"This worked really well and in no time we improved our skills in this area," Amanda said.

"I am sure it also gave Jamie useful information about what is happening out in the regions."

Andrew said over the four weeks he examined and classified more than 1300 nymphs.

"Any that I was unsure about, I was able to capture an image and send to Jamie for confirmation," he said.

"We learned so much, and one aspect I found particularly interesting was the changes in the look of parasitised nymphs over the sampling period.

"SLW nymphs have a stage where they have obvious red eyes and are referred to as red eye nymphs, however I found that some parasitised nymphs also developed red eyes so this obvious feature could not be relied upon for correct classification."

Amanda also learned a lot throughout the project and enjoyed being able to share this knowledge and knowhow with growers, consultants, fellow REOs and researchers.

"I found this a very worthwhile collaboration, we didn't have high SLW pressure this season so it was difficult to find populations, however that is a big benefit as this means researchers don't have travel lots of kilometres to find out there is little whitefly about," Amanda says.

"I think this project is a good example of how CottonInfo can be ears, eyes and boots on the ground to make sure we can complement and enhance research projects.

"It also ties in with CottonInfo Regional Crop Check Reports that are produced monthly in each growing region and e-mailed out.

"As we collate these reports we find out where the pest populations are meaning we can sample more effectively."

Amanda says SLW is one of the more difficult pests to scout as the nymphs are very small and "really need magnification to be able to tell if it is a viable nymph" – and she has some good advice.

"If you are counting presence or absence of SLW, keep in mind that time of day and level of disturbance play a big part in sampling the population correctly.

"The great thing about this project this season was to see first-hand the high levels of parasitism.

"It was definitely hard to find viable nymphs at the end of the season.

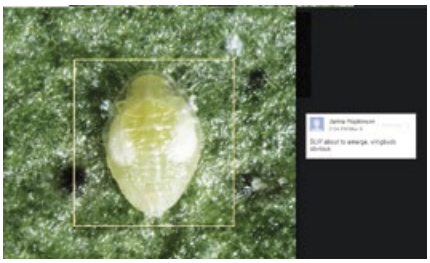
"This is proof we have the sought-after parasitoid wasps such as *Eretmocerus hayati* and they are busy fighting SLW populations in our fields.

"When you pair this up with the high numbers of spiders and ladybeetles I think our friends in the field did a great job this season.

"We would love more consultants to take advantage of this collaboration and develop a system for utilising our skills

ABOVE: An early parasitised nymph under the CottonInfo microscope: REOs were able to send images to entomologist Dr Jamie Hopkinson for clarification.

RIGHT: A healthy SLW nymph about to emerge.



and microscopes.

"We can assist with the evaluation of viable nymphs, if consultants want to collect leaves and drop them off, we would be happy to assist."

Andrew said he found a great sampling site in his Macintyre region through local consultants. The field had low levels of SLW and had not been treated for SLW.

"The site provided an excellent example of an SLW nymph population in which the proportion of healthy SLW nymphs declined as the proportion of parasitised nymphs increased, demonstrating effective control of the pest by natural enemies," he said.

"It also reinforced how important it is not to disrupt natural enemies (the block had been sprayed twice for other pests) and allow them to be effective as control agents."

Andrew also witnessed first-hand the effect of rain on SLW numbers.

Sampling weekly, heavy rain occurred between Andrew's third and fourth weeks of sampling. He had observed total SLW nymph numbers rise for the first three weeks (in a rough exponential pattern) then drop sharply after the rain event.

"My sampling put some numbers to the consultant's experience that adult SLW numbers seem to be reduced by rain events (at least on a temporary basis).

"However, irrespective of total numbers, the trends in proportions of healthy and parasitised nymphs were maintained."

Janelle said in the Gwydir, over the season some consultants had taken advantage of being able to look at SLW nymphs to monitor parasitism.

"It was a great opportunity to connect researchers with growers, with Jamie available to confirm any IDs that they were unsure of," Janelle said.

"It can be time consuming, so the CottonInfo REO team can help monitor SLW parasitism over time and share the results with local consultants.

"I'd also like to highlight that the REO microscopes are available for our local growers and consultants to use, I really recommend taking advantage of having a look through one!"

All REOs agreed it was valuable to become more proficient in the use of the microscopes. Images captured by the camera can be fed to a computer screen allowing others to view what is under the microscope, which is useful at meetings or via web hook-ups.

"It also has the ability to connect via wi-fi meaning an image can be broadcast to tablets and the like for training/demonstration to larger audiences," Andrew said.

"Some unexpected highlights under the microscope for me were seeing a predator (lady beetle larvae) devour a whitefly nymph which I was able to capture with the scope's video capability."

Andrew also filmed an SLW nymph hatching. The actual event which lasted 25 minutes was edited down to a 60-second video, which makes fascinating viewing. Both videos are available on the CottonInfo website.

Over the course of the season the three REOs developed a system where they created a shared image folder with Jamie of nymphs they needed help to classify. This folder was then made accessible to other REOs and has turned into a valuable resource and the images are now available on the CottonInfo website for general viewing.

For more information, including the videos and photos, read the REO's entertaining blog – Scouting for silverleaf whitefly (it's like an episode of CSI).

For more
www.cottoninfo.com.au/blog/scouting-silverleaf-whitefly-like-csi

Farm hygiene and green bridges

With flourishing weed and pasture growth with our recent rainfall, it is likely that crop managers will see a future resurgence of pest activity, particularly from species such as *Helicoverpa*, mirids and aphids after what has been a relatively quiet season for these pests in cotton fields.

In pasture and rangeland areas, large numbers of *Helicoverpa spp.* are being observed flourishing on weeds and pasture that has grown after recent rainfall. Many of these larvae will diapause in cooler regions and re-appear in spring when large influxes of emerging moths are likely to challenge legumes such as chickpeas and newly sown cotton.

With some regions now having adequate soil moisture to support a winter crop it will be important to keep fallow areas free of weeds and importantly ensure that this season's crop destruction is 100 per cent effective. This is critical for minimising the opportunity for pests such as mealybugs to overwinter in fields and re-emerge in 2020-21.

Agronomy during COVID-19

Pubs closed, toilet paper an aspirational item, roadblocks on state borders, limited social gatherings: COVID-19 turned day-to-day life on its head – but what about life for agronomists?

It's widely agreed that agronomists started social distancing before it had a name – long days in a vehicle mainly communicating with clients by phone. So, for many it's been business as usual, but with some changes. As would be expected, the magnitude of these changes varies a lot depending on the size and nature of the agronomy business.

Damien Erbacher runs Dawson Ag Consulting at Theodore in Central Queensland, a one-man operation. With the continuity of his business heavily dependent on his health, he's taken extra steps to ensure good hygiene and social distancing.

"I've had a discussion with all my clients about how we communicate with minimal face-to-face contact and they've all been pretty responsive," he said.

"It hasn't changed what we do that much – a lot of communication was on the phone and if we need to catch up in the paddock, we exercise social distancing."

Damien has also been diligent in using sanitised wipes when having external contact such as fuel stations and the supermarket.

Ben Dawson is an agronomist with B&W Rural at Moree, NSW – a branch with 13 staff, including six agronomists. B&W have taken the approach of minimising contact between staff and between clients.

"We've split our merchandise and administration team in our Moree office – so one team works one week and the other team the next so if we did have an infection the whole team is not at risk," he said, "and our agronomists work from home, not going into the branch at all."

On-farm, Ben said most work is business as usual with communication by phone but avoiding people travelling together in vehicles. While everything keeps functioning adequately Ben concedes he misses the face-to face contact with colleagues and clients.

MCA agronomist Tim Richards says the COVID-19 restrictions have fast-tracked some innovations in communication MCA had been seeking to implement anyway.

"It's useful being in the office, talking to the merchandise guys and other agronomists about what's going on.

"A lot of decisions are made on farm around a kitchen table or in the front seat of a ute with a farmer."

The COVID-19 rules saw an end to the popular breakfast meetings for B&W Rural clients. Not deterred, they started using Zoom – streaming meetings live, with the option to watch later. Ben was amazed with the response with more than 200 farmers taking part across several branches.

"We had some farmers on their PC and some on their phones while they were in the field," he says.

"Going forward, we'll probably still stream some meetings on Zoom as a lot of people find it convenient."

Keeping clear channels of communication functioning is a bigger challenge than most for the team at Michael Castor and Associates (MCA).

Michael's team comprises 16 agronomists across three offices, servicing clients from Bellata in North West NSW to Dulacca in Central Queensland, thus straddling the closed state border.

MCA agronomist Tim Richards said while the restrictions hampered many aspects of their operation – it has also fast-tracked some innovations in communication they had been seeking to implement anyway. Zoom conferencing within their team and with clients has been heavily relied on.

"We've shut down our offices with everyone working from home so Zoom has replaced our normal Monday staff meetings around the coffee table in the office."

"We're utilising Zoom on-farm also – allowing us to have a discussion and screen-share spreadsheets so we're looking at the same thing.

"We'd hoped to use this technology more anyway, and the restrictions have sped it up and made it happen."

Tim said the biggest challenge of COVID-19 restrictions has been training young agronomists.

"While the young agronomists are the most tech-savvy, you can't replace time in the paddock, over a beat-sheet or in a ute with an experienced agronomist," he admits.

So, when the restrictions are finished, pubs are open and toilet paper freely available – will the lives of agronomists return to 'normal'?

The way consultants and their clients have embraced technology during COVID-19 has clearly broken down some psychological barriers to adoption. It has also given us the opportunity to experiment and consider how it might enhance service delivery in the future: some changes might be with us to stay.

Most agree however, technology will never replace showing a young agronomist a rare leaf disease, a counter-meal catch-up on a wet day, a face-to-face chat, a walk through a crop or a cuppa at the kitchen table with our clients.

For more

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CRDC 2020-21 Projects List

The 2020-21 year marks the third year under CRDC's five-year plan: the 2018-23 CRDC RD&E Strategic Plan. Under this Plan, during 2020-21, CRDC will invest $18.7 million into RD&E projects across five key areas, in collaboration with around 100 researcher partners, and on behalf of Australia's cotton growers and the Australian Government. This table outlines the projects that CRDC will invest in, along with the lead researcher, their research organisation, and the commencement and completion dates for the projects. *Please note that this table is current as of 13 May 2020, and may be subject to change.*

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
Goal 1: Increased productivity and profitability on cotton farms							
1.1 Optimised farming systems	1.1.1 Improved yield and quality	Improving crop establishment, termination and weed control in dryland cotton farming systems	CRDC1937	Annabelle Guest	DCRA	Jan-19	Jun-22
		Increased yield through improved management of soil constraints in cotton farm	USQ1903	John Bennett	USQ	Jun-19	Jun-22
		Managing cotton quality to maintain Australia's premium status (includes CottonInfo technical lead and myBMP module lead)	CRDC1924	Rene van der Sluijs	Textile Technical Services	Oct-18	Sep-20
	1.1.2 Improved input efficiencies	Improving the nitrogen use efficiency of cotton crops through better understanding the role of dissolved organic N	CSP1904	Bennett Macdonald	CSIRO	Jul-18	Jun-21
		More Profit from Nitrogen – Enhancing nutrient use efficiency in cotton	RRDP1712	Graeme Schwenke	NSW DPI	Jul-16	Jun-21
		More Profit from Nitrogen – Final evaluation and economic case studies	RRDP2021	Jon Welsh	AgEcon	Mar-20	Jun-21
		More Profit from Nitrogen – New technologies and managements: transforming nitrogen use efficiency in cane production.	RRDP1719	Matt Redding	QDAF	Sep-16	Jun-21
		More Profit from Nitrogen – Optimising nutrient management for improved productivity and fruit quality in cherries	RRDP1721	Nigel Swarts	UTAS	Aug-16	Jun-21
		More Profit from Nitrogen – Optimising nutrient management for improved productivity and fruit quality in mangoes	RRDP1720	Constancio (Tony) Asis	NTDPIR	Aug-16	Jun-21
		More Profit from Nitrogen – Quantifying the whole farm systems impact of nitrogen best practice on dairy farms	RRDP1716	Richard Eckard	UMELB	Jul-16	Nov-20
		More Profit from Nitrogen – YourData platform	RRDP1727	Jeff Coutts	Coutts J&R	Feb-17	Jun-21
		Nitrogen fixing cotton	COMM			Jul-19	Jun-22
		Optimising the management of manures in southern NSW cotton production II	DU1903	Wendy Quayle	DU	Jul-18	Jun-21
		PhD: The impact of irrigation methods and management strategies on nitrogen fertiliser recovery in cotton in southern QLD	UQ1502	John Smith	UQ	Jul-14	Dec-20
		Professor of Soil Biology (includes CottonInfo technical lead and myBMP module lead)	UNE2001	Oliver Knox	UNE	Jul-19	Jun-24
		Towards carbon neutral cotton production	COMM			Jul-20	Jun-23
		Water use efficiency for irrigated and dryland cotton benchmarked	DAN2002	David Perovic	NSW DPI	Jul-19	Jun-22
	1.1.3 On-farm sustainable development is supported	Developing novel cotton farming systems	COMM			Jul-20	Jun-23
		Developing novel farming systems – Central QLD	COMM			Jul-20	Jun-23
		National Soils RD&E strategy	COMM			Jul-20	Jun-21
		National Water RD&E strategy	COMM			Jul-20	Jun-21
		Potential for broadacre cropping in the NT	CRCNA2001	Jed Matz	CRCNA	Jun-19	Dec-22
		Science leadership for cotton development in Northern Australia	CSP1903	Steve Yeates	CSIRO	Oct-18	Sep-21
	1.1.4 Improved reliability of cotton production	Minimising yield variability to maximise yield	DAN1801	Guna Nachimuthu	NSW DPI	Jul-17	Jun-22
		Quantifying the effectiveness of cover crops as a means of increased water infiltration and reduced evaporation in the northern region	GRDC1801	David Lawrence	QDAF/ GRDC	May-17	Oct-20
		Supporting southern cotton production systems: Cotton Research Officer	DAN2001	Hayden Petty	NSW DPI	Jul-19	Jun-22

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
1.2 Transformative technologies	1.2.1 New technologies are adapted for use in cotton	Identifying sensors for better Integrated Pest Management (IPM) in cotton	NEC1901	Alison McCarthy	USQ NCEA	Jul-18	Jun-21
		Future Farm (phase 2): Technology solutions for improved nitrogen application	QUT1902	Peter Grace	QUT	Jul-18	Jun-22
		Smarter Irrigation for Profit 2: Beyond water smart – advancing dairy irrigation system performance	RRDP2012	James Hills	UTAS	Jul-19	May-22
		Smarter Irrigation for Profit 2: Cross sectoral integration and extension	RRDP2005	Louise Gall	GVIA	Jul-19	May-22
		Smarter Irrigation for Profit 2: Evaporation mitigating solution for Australian cotton water storages	RRDP2007	Greg Qiao	UMELB	Jul-19	May-22
		Smarter Irrigation for Profit 2: Gwydir Valley demonstration of the application of the latest digital technologies for precise automated irrigation	RRDP2004	Louise Gall	GVIA	Jul-19	May-22
		Smarter Irrigation for Profit 2: Improved irrigation system selection and operation for increased sugarcane productivity and profitability	RRDP2013	Michael Scobie	USQ	Jul-19	May-22
		Smarter Irrigation for Profit 2: Improving the science of water footprinting	RRDP2018	Guy Roth	USYD	Feb-20	Feb-22
		Smarter Irrigation for Profit 2: Key learning sites southern (making the most of water)	RRDP2014	Alex Schultz	NSW DPI	Jul-19	May-22
		Smarter Irrigation for Profit 2: New tech cotton irrigation key learning sites	RRDP2003	John Hornbuckle	DU	Jul-19	May-22
		Smarter Irrigation for Profit 2: Plant-based sensing for cotton irrigation	RRDP2006	Hizbullah Jamali	CSIRO	Jul-19	May-22
		Smarter Irrigation for Profit 2: Precise real-time automated cotton and dairy irrigation for improved water productivity	RRDP2002	Joseph Foley	USQ NCEA	Jul-19	May-22
		Smarter Irrigation for Profit 2: Project Management Committee meetings	RRDP2015	Cathy Phelps	C&J Phelps Consulting	Nov-19	May-22
		Smarter Irrigation for Profit 2: Precision automated furrow irrigation for the Australian sugar industry	RRDP2009	Malcolm Gillies	USQ	Jul-19	Jun-21
		Smarter Irrigation for Profit 2: Project leadership and coordination	RRDP2001	Cathy Phelps	C&J Phelps Consulting	Jul-19	Jun-22
		Smarter Irrigation for Profit 2: Scaling irrigation management to support whole farm operations	RRDP2011	Andy McAllister	DJPR	Jul-19	May-22
		Smarter Irrigation for Profit 2: Smart irrigation control for water and labour savings in rice growing systems	RRDP2008	John Hornbuckle	DU	Jul-19	May-22
		Smarter Irrigation for Profit 2: What is my yield gap? Maximising water productivity	RRDP2010	Cath Lescun	Dairy Australia	Jul-19	May-22
		Smarter Irrigation for Profit 2: YourDATA Monitoring & Evaluation Database	RRDP2017	Jeff Coutts	Coutts J&R	Nov-19	May-22
	1.2.2 Cotton farms are digitally enabled	Capital: Sundown Smart Farm Development	CRDC1928	Nick Gillingham	Sundown Pastoral	Nov-18	Oct-20
1.3 Protection from biotic threats and environmental stresses	1.3.1 Increased understanding of the impact of pests, diseases and weeds, and environmental stresses	IPM to support the management of emerging pests	CSP1905	Simone Heimoana	CSIRO	Jul-18	Jun-21
		Using DNA diagnostics to monitor disease suppressive cotton farming systems	COMM			Jul-20	Jun-23
	1.3.2 Improved identification, surveillance and management systems for pests, diseases and weeds and environmental stresses	ARC Research Hub for Sustainable Crop Protection	UQ2001	Neena Mitter	HIA/UQ	Jul-19	Jun-22
		Area Wide Management for cropping systems weeds, investigating the weed management, social and economic opportunity	GRDC2002	Rick Llewellyn	GRDC	Aug-19	Jun-22
		Biological based products for improved cotton production	UWS1901	Brajesh K Singh	UWS	Jul-18	Mar-22
		Characteristics of disease suppressive cotton farming systems and soils	DAQ2002	Linda Smith	QDAF	Jul-19	Jun-22
		CottonInfo IPM Technical Lead and pest management for high yield research (including myBMP module lead)	DAQ1902	Paul Grundy	QDAF	Jul-18	Jun-21
		Evaluate efficacy of novel chemistries, biocontrol agents and management practices to control Alternaria and Black Root Rot disease in cotton	2021FRP003	Duy Le	NSW DPI	Jul-20	Jun-22
		iMapPESTS: Sentinel surveillance for agriculture	HIA1802	Wee tek Tay Dean Brooks	HIA	Feb-18	May-22

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
		Improved management of silverleaf whitefly on cotton farms	DAQ1903	Richard Sequeira	QDAF	Jul-18	Jun-21
		Improved management of weeds in cotton and grains farming systems	DAN2004	Graham Charles	NSW DPI	Jul-19	Jun-22
		Innovative solutions to cotton diseases	DAN1703	Duy Le	NSW DPI	Jul-16	Dec-20
		Managing Climate Variability Program – Phase 5	MLA1701	Doug McNicholl	MLA	Jul-16	Jun-21
		Modern systems agronomy for resilient cotton production	CSP2001	Claire Welsh	CSIRO	Jan-20	Jun-22
		PhD: Building climate change resilience in cotton through translational physiology	ANU1704	Demi Gamble	ANU	Feb-17	Aug-20
		Reducing the impact of weather, insects and microbes on cotton colour	CSP1901	Simone Heimoana	CSIRO	Jul-18	Jun-21
		Southern Cotton Crop Protection (including CottonInfo Disease Technical Lead and myBMP module lead)	DAN1903	Tim Green	NSW DPI	Jul-18	Oct-21
		Sustainable insect management through improved insect resistance monitoring	DAN2003	Lisa Bird	NSW DPI	Jul-19	Jun-22
		Sustainable SLW management through improved insect resistance monitoring	DAQ2001	Jamie Hopkinson	QDAF	Jul-19	Jun-22
	1.3.3 Industry is prepared for a biosecurity incursion	2020 International Year of Plant Health (IYPH)	HIA2001	Jo Luck	HIA	Sep-19	Sep-20
		Boosting Diagnostic Capacity for Plant Production Industries	GRDC2001	K'trie Coster	GRDC	Jul-19	Jun-22
		Plant Biosecurity Research Initiative (PBRI) – Phase 2	COMM	Jo Luck	HIA		

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
Goal 2: Improve cotton farming sustainability and value chain competitiveness							
2.1 Sustainability of cotton farming	2.1.1 Improved environmental footprint for cotton farms	Cotton Landcare Tech Innovations: Communications Support	NLP1903	Bernadette Pilling	HOC	Nov-18	Mar-22
		Cotton Landcare Tech Innovations: Improved natural capital (biodiversity) on Australian cotton farms	NLP1901	Erin Peterson	QUT	Jan-19	Nov-21
		Cotton Landcare Tech Innovations: Improved natural capital (biodiversity) on Australian cotton farms.	NLP1902	Rhiannon Smith	UNE	Jul-18	Nov-21
		Cotton Landcare Tech Innovations: Spotlight evenings, demonstration field days & FloraBank training	COMM	Stacey Vogel	Consultant	Jul-18	Jun-21
		Feasibility study of managed aquifer recharge for improved water productivity	ANU1901	Anthony Jakeman	ANU	Aug-18	Aug-21
		Mitigating irrigation infrastructure impacts on aquatic biodiversity	2021FRP006	Michael Hutchison	QDAF	Jul-20	Jun-22
		PhD: Alternative energy technologies and policy solutions for the Australian cotton	UTS1901	Yunfeng (Forrest) Lin	UTS	Aug-18	Jun-21
		PhD: Sustainable water extractions: Low flow regia and critical flow thresholds	UNE1406	Marita Pearson	UNE	Jan-14	Aug-20
2.2 Create higher value uses for cotton	2.2.1 Increased value for Australian cotton	Developing renewable fine chemicals from cotton biomass (Biorefineries for higher-value animal feeds, chemicals and fuels phase 2)	SRA2001	William Doherty	QUT	Jul-19	Dec-20
	2.2.2 Increased understanding of market requirements and opportunities throughout the value chain	Joint RDC community trust project	RIRDC1903	Jennifer Medway	AgriFutures	Jun-19	May-21
		Strategies for improving labour conditions within the Australian cotton value	QUT1903	Alice Payne	QUT	Jun-19	Jun-22
2.3 Measurement and reporting throughout the value chain	2.3.1 CRDC collaborates in global leadership for sustainability initiatives	Cotton industry report on social capital wellbeing sustainability indicators	1920FRP037	Jacki Schirmer	University of Canberra	Jun-19	Jun-22

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
		Membership of the Sustainable Agriculture Initiative (SAI) – Australian chapter	CRDC1902	Selwyn Heilbron	SAI Platform (Aust) Inc	Jul-18	Jun-20
		PhD: Textile supply chain transparency and accountability	UL1901	Mark Sumner	UL	Oct-18	Sep-21
		Supporting the development of common impact metrics across cotton sustainability	CRDC2008	Angus Ireland	AWI	Oct-19	Dec-22
		Sustainability metrics for the cotton industry	CRDC1944	Chris Cosgrove	Sustenance Asia	Jun-19	Jun-22
		Sustainable Apparel Coalition membership	CRDC1817	Glenn Robinson	SAC	Aug-17	Jun-21
	2.3.2 The value chain is transparent and understood by participants	Australian Cotton Industry Fourth Environmental Audit	COMM			Apr-21	Dec-22
		PhD: Sustainable value chain analysis of the Australian cotton industry	QUT1901	Zoe Mellick	QUT	Jul-18	Jul-21

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
Goal 3: Build adaptive capacity of the cotton industry							
3.1 Science and innovation capability, and new knowledge	3.1.1 Science and innovation capacity is strengthened and strategically fit for a digital future	2021 and 2022 Science and Innovation Awards for young people in Agriculture, Fisheries and Forestry	COMM		ABARES	Jul-20	Jun-22
		Australian cotton industry digital strategy				Jul-19	Jun-21
		Australian Rural Leadership Program Course 26, Course 27, Trail 2019, Trail 2020	RIR1903	Matt Linnegar	ARLF	May-19	Dec-20
		Building digital capability in the Australian cotton industry	COMM			Jul-20	Jun-23
		CRDC and Cotton Australia Future Cotton Leaders Program	COMM		Cotton Australia	Jul-20	Jun-21
		CRDC summer & honours scholarships	COMM			Jul-20	Jun-21
		Graduate tour – Careers in cotton industry	COMM			Jul-20	Jun-21
		Improving grower decision in complex systems: A targeted tool to assist cotton growers in appropriate technology adoption	QUT2001	Geraldine Wunsch	QUT	Jul-19	Mar-22
	3.1.2 Increased understanding of the diverse human capital in regional communities	People in Agriculture	DA1502	Shane Hellwege	Dairy Australia	Jul-14	Mar-21
		Post Doc: Understanding and planning for the future cotton workforce	USQ1801	Nicole McDonald	USQ	Oct-17	Oct-20
3.2 Futures thinking	3.2.1 Australian cotton growers are able to adapt to change	2018-2021 Joint-RDC Health and Safety Farming Alliance	RIRDC1901	Jennifer Medway	Agrifutures	Jul-18	Jun-21
		CRDC Grassroots grants 2020-21			CGAs	Jul-20	Jun-21
		Grassroots Grant: Climate Change: Planting times, Pests and Spray Drift	CGA2003	Alec Macintosh	Walgett CGA	Dec-19	Jan-21
		Grassroots Grant: On-farm evaluation of pumping telemetry	CGA2002	Amanda Thomas	Macquarie CGA	Sep-17	Aug-21
		Grower RD&E advisory panels			Cotton Australia	Jul-20	Jun-21
		Nuffield Australia Farming Scholarship 2019: Renee Anderson	CRDC1901	Renee Anderson	Nuffield	Apr-18	Sep-20
		Nuffield Australia Farming Scholarship 2020: Richard Quigley		Richard Quigley	Nuffield	Apr-19	Sep-21
		Thresholds for resilience in regional communities	UM1902	Ruth Nettle	UMELB	Sep-18	Jul-20

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
Goal 4 (Enabling Strategy 1): Strengthening partnerships and adoption							
4.1. Partnerships and collaboration	4.1.1 Growers/ consultants value CRDC farming systems research outcomes	20th Australian Cotton Conference Foundation Sponsorship	CA2004	Tracey Byrne-Morrison	Cotton Australia	Dec-19	Nov-20
		Cotton Production Course	UNE2002	Oliver Knox	UNE	Jan-20	Jun-23

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
	4.1.2 CottonInfo partnership is maintained and practice change improved	Climate, energy and business analysis for cotton growers (including CottonInfo technical lead and myBMP project lead)	2021FRP004	Jon Welsh	AgEcon	Jul-20	Jun-23
		Communicating cotton best production practices with video	DAQ1901	Tonia Grundy	QDAF	Jul-18	Jun-21
		Cotton industry database management		Lee Armson	Consultant	Jul-21	Jun-23
		CottonInfo Field Demonstration Trial: Investigation of the impact of last irrigations on profit and quality in the Murrumbidgee Irrigation Area region	CGA2006	Emma Ayliffe	Southern Valleys CGA	Jan-20	Aug-20
		CottonInfo NRM Technical Lead (including myBMP module lead)	2021FRP005	Stacey Vogel	Consultant	Jul-20	Jun-23
		CottonInfo Technical Lead – Nutrition (includes myBMP module lead)	DAN1906	Jon Baird	NSW DPI	Jan-19	Jun-21
		Identifying key issues to maintain and improve Australian cotton fibre quality (including CottonInfo Technical Lead and myBMP module lead)	2021FRP001	Rene van der Sluijs	Textile Technical Services	Jul-20	Jun-23
		Proofreading 2020 Australian Cotton Production Manual and Cotton Pest Management Guide	CRDC2010	Helen Dugdale	Consultant	Apr-20	Jul-20
		Spray Hazard Tower Network	COMM			Jul-19	Jun-22
4.2 Best practice (myBMP)	4.2.1 Best practice is based on science and measured impact	Cotton industry injury and safety statistics	COMM			Jul-20	Jun-21
		CRDC data collection	COMM			Jul-20	Jun-21

Key focus area	Outcome	Project title	Project code	Researcher	Organisation	Commenced in:	To be completed in:
Goal 5 (Enabling Strategy 2): Driving RD&E impact							
5.1 Impact and effectiveness	5.1.2 CRDC monitors and evaluates RD&E impact	Annual consultant qualitative and quantitative surveys	CCA1901	Fiona Anderson	CCA	Mar-18	Dec-20
		Collaboration: Evaluation and Measuring impact	SRA2002	Leigh Clement	SRA	Oct-19	Sep-20
		CRDC Cotton Grower Survey 2020-22	CRDC2014	Michael Sparks	Intuitive Solutions	Jul-20	Nov-22
		Summaries of CRDC Research	CRDC1945	Bernadette Pilling	HOC	Jun-19	Jun-21
	5.1.3 CRDC funded projects demonstrate value and return on investment	Impact assessment of projects	COMM			Jul-20	Jun-21

Key

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AgriFutures	AgriFutures Australia (formerly the Rural Industries Research & Development Corporation)
ANU	Australian National University
ARLF	Australian Rural Leadership Foundation
AWI	Australian Wool Innovation
CCA	Crop Consultants Australia
CRCNA	Cooperative Research Centre for Developing Northern Australia
CGA	Cotton Grower Association
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCRA	Dryland Cotton Research Association
DJPR	Victorian Department of Jobs, Precincts and Regions
DU	Deakin University
GRDC	Grains Research and Development Corporation
GVIA	Gwydir Valley Irrigators Association
HIA	Hort Innovation
HOC	House of Communication
MLA	Meat and Livestock Australia
NSW DPI	NSW Department of Primary Industries
NTDPIR	Northern Territory Department of Primary Industries and Resources
QDAF	Queensland Department of Agriculture and Fisheries
QUT	Queensland University of Technology
SAC	Sustainable Apparel Coalition
SAI	Sustainable Agriculture Initiative
SRA	Sugar Research Australia
UL	University of Leeds
UMELB	University of Melbourne
UNE	University of New England
UQ	University of Queensland
USQ	University of Southern Queensland
USQ NCEA	University of Southern Queensland National Centre for Engineering in Agriculture
USYD	University of Sydney
UTAS	University of Tasmania
UTS	University of Technology, Sydney
UWS	University of Western Sydney

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MELANIE JENSON