Spotlight
ON COTTON R&D

SPRING 2020

Identifying key sustainability indicators

Cotton and Landcare a natural fit

Industry takes new approaches to drift

CRDC

Ian Taylor

In the Spotlight

Welcome to the Spring edition of *Spotlight*.

Spring marks new beginnings and in this light, this edition has a focus on setting new sustainability targets for the Australian cotton industry. This is a time of opportunity for the industry, on the back of the *Australian Cotton Sustainability Report 2019* to focus on what sustainability really means for the Australian cotton industry and the benefit this can bring to Australian cotton in the global market place.

CRDC's mantra of creating, maintaining and improving a sustainable industry is evident through the articles we bring you this edition. Some of these issues are highlighted in the sustainability report and the development of the draft sustainability targets, which you can read more about in this edition. The sustainability issues identified include off-target spray drift, nitrogen use and soil health.

CRDC is collaborating on many levels, including with other research and development corporations (RDCs) to address issues which have cross-industry implications. Addressing spray drift is one of these. We have included several articles showcasing how we are finding novel methods to address this issue in partnership with GRDC, and with the Australian Government's BRII initiative, and how behavioural psychology has been used to understand more about why it happens.

Biosecurity is another successful collaboration through the Plant Biosecurity Research Initiative. Along with the other plant RDCs, CRDC has joined to support this initiative for a second time. As a result of PBRI and through networks of collaboration, a new international project addressing the recently arrived fall armyworm has begun.

We have a deep focus on nitrogen and soil in this edition. Nitrogen use efficiency must be improved, and the industry has a wealth of information available through previous CRDC-supported research to help understand the processes involved in nitrogen uptake and use by cotton. In this edition, we've included a section of current research, to showcase the quality and breadth of the work underway – helping us to reach our sustainability target of improving nitrogen use efficiency and emissions reductions.

CRDC is also looking to the future in terms of pesticide use, taking into account developments around the world in pesticide use and approval. Preparedness for any changes to licencing of pesticides that are cornerstone products of cotton growing is imperative. As a result, we're working with the industry around potential 'loss of pesticides' scenarios: asking and considering some serious questions, which are outlined in this edition.

Despite the unpredictability that this year has thrown our way, progress continues. In this edition we highlight the importance of research undertaken in tropical regions and the impact it has had on growing cotton in new areas, and growing it better in existing northern regions. It is also encouraging to see plans underway for more research in the region and work underway to build a ginning facility in the Ord.

We wish everyone all the best for the coming season, with hopes for more rain to replenish dams and river systems.

Ian Taylor
CRDC Executive Director

Spring 2020

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

CRDC
COTTON RESEARCH AND DEVELOPMENT CORPORATION

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Our vision: A globally competitive and responsible cotton industry.
Our mission: To invest in RD&E for the world-leading Australian cotton industry.

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ON THE COVER: University of New England's Eldon Sanderson and Dr Rhiannon Smith choosing a new crop of river red gums for planting.

Want to see more of Spotlight?

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

COTTON NEWS

FEATURES

Innovation awards open

The 2021 ABARES Science and Innovation Awards for Young People in Agriculture – supported by CRDC – are now open. CRDC is encouraging young researchers aged 18-35 to apply for a grant valued at up to $22,000 to fund an innovative research project that will benefit Australia's cotton industry.

As a sponsor of the Awards program, run by the Department of Agriculture, Water and the Environment, CRDC supports and rewards young scientists for their exploration of concepts and the creation of new knowledge in the pursuit of scientific breakthroughs.

Recent recipients of the cotton award are Dean Brooks of the University of Queensland (2019) and Dr Dinesh Kafle (pictured) of QLD DAF (2020). Dean's innovative research project focused on scanning irrigation water for trace amounts of DNA left behind by pests and pathogens, as a potential new way to quickly identify the presence of difficult to find cotton pests. Dinesh's novel project investigates whether cotton plants can be primed with silicone to boost their defences against fusarium wilt and reniform nematode.

Further information and application forms are available from the Department's website: www.agriculture.gov.au/scienceawards. Applications close 5pm, Friday 2 October.

Soil respirators are used to measure in-field biological activity.

DR JACKIE WEBB

Seeking southern soil health sites

With the aim of improving soil health, researchers are putting a call out to cotton growers in the Murrumbidgee and Lachlan valleys.

Dr Wendy Quayle and Dr Jackie Webb from the Deakin University Centre for Regional and Rural Futures (CeRRF) are seeking volunteers to share their farms and knowledge as part of a broad-scale test of soil health in cotton production.

"All we need is one-off access to your site to do a spot measurement of soil respiration, take a sample of soil and half an hour of your time to get some basic information on field history, including litter and fertiliser application rates," Jackie said.

"We are working to collect large number of sites to kickstart this study and need your help!"

This research is funded by the CRDC, as part of a larger project looking at optimising manure management for soil fertility and plant nutrition in the southern cotton growing region, so the focus will be on cotton farms utilising organic amendments. Farms with other practices for soil management are welcome for comparison.

The project aims to provide a region-scale assessment of soil microorganisms activity and nutrient potentials in a variety of farming systems using different practices in the Riverina. Findings from this study will be used to inform soil health targets in the cotton industry and help identify ways to enhance soil fertility.

"We would also like to know the baseline soil biological health of cotton production systems in the area," Wendy said.

Jackie says that with this data, they will be able to directly assess the potential for improving soil biological health in intensive irrigated farming systems.

"Importantly, this data will help develop sustainability targets within the Australian cotton industry," she said.

Soil health underpins cotton production, but targets were not previously developed because of the difficulty of collecting meaningful data at the industry scale.

"Collecting meaningful data at the industry scale can be difficult, so we'd encourage growers to get on board with this study," CRDC R&D Manager Merry Conaty said.

"When indicators for the Cotton Industry Sustainability Targets are finalised, the cotton industry will review baseline data and consult with stakeholders on appropriate targets.

"CRDC aims to release soil health targets at the same time carbon targets are released, in 2021."

For more

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New achievements driving constant improvement

CRDC is committed to creating an increasingly sustainable Australian cotton industry, for its people and the planet.

Following the release earlier this year of the *Australian Cotton Sustainability Report 2019*, the next step is to develop sustainability targets and indicators for the industry, to guide the continuous process of reflection, evaluation, implementation and improvement over the next five years. The development of a new set of targets and indicators, called the *PLANET. PEOPLE. PADDOCK sustainability framework* is guided by the industry's Sustainability Working Group.

There are nine core focus areas under the framework, with draft targets now in development: water, carbon, biodiversity, pesticides, soil health, quality of work life, wellbeing and social capital, efficiency and profitability.

Feedback on the draft targets will inform setting sustainability targets in the areas most important to industry and stakeholders, help coordinate a whole-of-industry strategy to achieve these targets, and 'walks the talk' on engagement with stakeholders on actions and progress. The public consultation process on draft targets and indicators ended in July with more than 340 respondents from inside and outside the industry.

"Responses were constructive and thoughtful, and we're very grateful to the many people who took the time to share their views," CRDC's Executive Director Ian Taylor said.

"Stakeholder feedback on targets and indicators will be considered by experts and the Sustainability Working Group, a group of industry representatives guiding the development and implementation of *PLANET. PEOPLE. PADDOCK*, to finalise targets and indicators."

A report of stakeholder feedback will be published when targets are finalised at the end of 2020.

The Australian cotton industry, via its growers and powered by research, has been actively working to run efficient cotton farms while creating environmental, economic and social value for more than 30 years.

MELANIE JENSON

Sustainability includes re-establishing and maintaining balance: on farms, in the environment and within our people.

"These targets have been designed to stretch the industry to achieve them, especially in areas where dramatic gains have already been made over the past 30 years or where factors outside the industry's control may affect our ability to achieve targets," says CRDC General Manager R&D, Allan Williams, who has been involved in research and improving the cotton industry's sustainability since authoring the first BMP Manual in 1997.

"We understand growers and the industry may face criticism for falling short of difficult targets, however external stakeholders don't want easily achievable targets that require no more than business-as-usual practices.

"Some of the focus areas such as water and pesticides have never been out of our focus, and while these are two of our biggest improvement areas, they were also identified as still needing on-going improvement.

"Efficiency and profitability are also a constant focus for industry.

"While we've achieved huge gains in practice change and sustainability in these areas, we won't rest on our laurels: continuous improvement is imperative."

It's inherent through its work that CRDC is committed to a sustainable cotton industry so that we continue to have a cotton industry in Australia that is managed to the highest standards: that is, it is sustainable. An unsustainable industry is just that: a short-term proposition."

"As cotton is a relative 'latecomer' to broadacre farming in Australia, its been working to lessen the impact of the farming system on the environment and other farming systems, while concurrently addressing and overcoming both foreseen and unforeseen challenges of varying degrees of seriousness and impact," Allan said.

"As in any 'new' industry, overcoming challenges is inherent, and is achieved through research, innovation, creation and a group of participants willing to embrace it.

"We don't know how a new crop is going to impact an environment it is new to, its ecosystems and soils, people, towns and communities and local industries."

This is the role of CRDC – to both invest in research to provide answers to questions that haven't been asked, and to

provide solutions to questions and issues that have been raised.

Research helps identify potential risks, from pesticides to workforce shortages, herbicide resistance to exotic pests.

The job of the Sustainability Report and Framework is three-fold: to restore, maintain and improve balance.

For an industry, this balance may be the intricate web of biodiversity that is affected by farming, and going above and beyond to reduce the impact of our actions, based on insightful research. How has the R&D worked to restore this over recent years? Innovation and technology have been key, from sensors in irrigation to Bt cotton.

The industry also continues to face issues, despite the quality and quantity of research available to overcome them. Spray drift is a case in point, as is the decreasing efficiency being seen in nitrogen use, which is linked to emissions and the industry's carbon footprint.

Helping maintain and or restore balance to ecosystems and biodiversity, along with soils is both an ethical and sustainability issue. Research has shown the benefit of a healthy, diverse and abundant population of insects and other vertebrates on cotton farms, which are capable of bringing balance to farming systems.

This balance also includes people and work-life balance. At every intersection of the cotton community you will meet people. People are the industry. It's no secret then that healthy people make healthy families, communities and industries. Health can be mental and physical, or even economic in terms of a town. It's the quality of work life, sense of wellbeing and amount of 'social capital' we experience that dictates the health of our industry, and is why it is a key focus area for this Sustainability Framework.

The Sustainability Reports will be released every five years, and the Sustainability Framework will be monitored and kept up to date by the Sustainability Working Group.

Cotton taking land care to the tech level

AFTER prolonged drought conditions, recent rainfall throughout NSW has allowed researchers from the Cotton Landcare Tech-Innovations 2021 project to start establishing new trial sites.

Led by Dr Rhiannon Smith from the University of New England, a trial site was recently set up near Wallah, east of Narrabri in North West NSW to investigate the success of tube stock plantings against direct seeding for river red gum.

Rhiannon's research aims to improve the capacity for cost-effective revegetation on cotton farms by trialling new and improved revegetation methods using drone and tractor technology.

"The tube stock plantings were done at two depths, one being long-stem plantings at 40cm deep where up to two-thirds of the tree is buried in a large, deep hole," Rhiannon said.

"The other at regular surface planting of around 10cm deep.

"We know that long-stem plantings have been successful in clay soils, generally in riparian zones, so we are confident that placing more river red gum nodes underground should result in a stronger root system, and better growth earlier in the life of the plant.

"Having the root ball of the plant sitting deeper in the soil should also give the plant greater access to moisture.

"Two planting depths were also trialled for the direct seeding plots, and a microbial amendment was applied to half of the trial plots also."

Trialling innovations for cotton landscape revegetation

A second trial plot has also been established near Coleambally in southern NSW, with half of the plot direct seeded by tractor in autumn and the other half to be direct seeded by tractor in spring.

The aim of this planting is to investigate success rates in relation to planting time.

"Being a winter-dominant rainfall area, should we plant seeds in autumn and hope the rain comes, or should we plant in spring when there is already stored moisture in the soil profile?" Rhiannon said.

This Coleambally trial site focused on management actions are providing the desired biodiversity outcomes as new revegetation projects take place.

"The work has the potential to provide significant positive outcomes for growers, as insectivorous birds and bats play an important role in cotton crops because they eat insect pests.

"Therefore, caring for the health of the local bird and bat populations could save growers lots of money and reduce pesticide use."

One project focusing on biodiversity is concentrating on the development and deployment of innovative technologies to actively monitor bird and bat bioindicator species, to manage and report on biodiversity sustainability targets.

Professor Stuart Parsons and the team from Queensland University of Technology have recently returned from Narrabri and surrounding areas where bat diversity and their foraging activity at night was monitored on cotton growing properties.

"Our team also recorded the echolocation calls of bats to add to our library," Stuart said.

"We're aiming to develop automated species identification algorithms to automatically detect and identify bats and birds within the cotton landscape.

"The algorithms will then be used as part of automated acoustic sensors on farms to allow growers to answer the question, 'what's on my farm?'.

"These tools will test whether on-farm

PHIL SPARK

A rare white Southern Free-tailed bat or white microbat *(Mormopterus planiceps)* which are found on cotton farms.

Among the river reds: Field Environmental Services' Eldon Sanderson and Dr Rhiannon Smith on site at Walla near Maules Creek, choosing the next crop of river red gums to be planted.

MELANIE JENSON

larger seeded species such as butterbush, quandong and a variety of wattles that tend to respond well in direct seeding trials.

"These species are widely distributed across the landscape, but with few individuals in any one site, so seed collection is difficult," Rhiannon said.

"By incorporating seed from a variety of sites around the landscape in one place, it is hoped that this site may act as a seed nursery for future plantings."

Sites are currently being established in the Coleambally district to trial a range of planting methods and potential interventions, such as seed coating and mulches, to increase revegetation success.

Under the National Landcare Program's Smart Farming Partnerships initiative, CRDC secured a grant to bring Cotton Landcare Tech-Innovations 2021 onto Australian cotton farms to enhance natural resources and biodiversity.

The projects build on international best practice to implement and develop cutting-edge technologies, such as drone mapping and aerial seeding, acoustic monitoring and big data, to help Australian cotton better report on and improve on-farm biodiversity.

New interactive biodiversity management guides for growers

Another initiative under the Cotton Landcare Tech Innovations 2021 project has recently delivered biodiversity management guidelines for all Australian cotton catchments, available through an interactive map on the CottonInfo website.

Building on previous research funded by CRDC, Forest Wood Products Australia, CSIRO and the Australian Government's Rural R&D for Profit Program the guides recommend management actions to best suit the habitats of the particular species represented in each of the shires.

CRDC R&D Manager Stacey Vogel said the maps are based on comprehensive research and will support 'boots on the ground' action to improve conditions for the rich diversity of species contained in cotton landscapes.

"Cotton landscapes of Australia contain an abundant diversity of native plant and animal species that occur in a mosaic of forest, woodland, wetland, grassland and cropland systems," she said.

"Protecting biodiversity is important for all Australian cotton-growing communities: biodiversity delivers ecosystem services on which businesses and communities enjoy and are dependent. These new maps are another useful addition to the cotton grower's toolbox for improving biodiversity."

For more information on CRDC's Cotton Landcare Tech-Innovations 2021 and its goal to strengthen Australian cotton farm biodiversity and sustainability management visit www.crdc.com.au/cotton-landcare-tech-innovations.

MELANIE JENSON

University New England Technical Officer Trevor Stace is a part of Rhiannon's team, trialing planting methods to determine cost-effective revegetation strategies.

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Meeting industry biodiversity targets

A new resource for growers has been developed to manage biodiversity and meet industry sustainability targets.

SNAPSHOT OF BIODIVERSITY ASSETS:

- **136,117 km^2 of cotton landscapes and 45,070 km^2 of cotton properties mapped.**
- **490 vegetation types across cotton landscapes mapped, 348 occurring on cotton properties.**
- **Approximately 26 per cent of the cotton landscape retains a cover of remnant native vegetation.**
- **50 per cent of cotton landscapes and 40 per cent of cotton properties have native vegetation in 'high' or 'moderate' condition.**
- **7300km of major rivers and creeks and 10,480km of minor creeks flow through cotton properties.**

Following the release of the *Australian Cotton Sustainability Report 2019*, the cotton industry's Sustainability Working Group is developing draft sustainability targets and indicators for the industry. One of the core focus areas is biodiversity.

The area of land managed for conservation outcomes, as reported in the Sustainability Report, is one simple indicator of biodiversity. However, it doesn't tell us what condition this land is, or if the land has relatively high ecological value. Outcomes-based indicators can do this, but they are more challenging to measure due to the time, cost and technical expertise. As a result, the industry is proposing to use a mix of area and outcome-based indicators.

In line with these aims, the industry has mapped cotton-growing regions to identify and manage biologically diverse and threatened environments.

CottonInfo has launched the new online resource to provide cotton growers with biodiversity information for every cotton growing shire/Local Government Area (LGA). The information gathered further provides a resource for forming collaborative partnerships with regional natural resource management groups, environmental non government organisations and retail brands similarly interested in improving the environmental footprint in agricultural landscapes such as cotton.

The project identified 315 threatened and iconic plant and animal species in cotton landscapes. The biodiversity data presented in the maps was collated through CRDC research projects to help the cotton community to understand and prioritise the conservation value of areas of native vegetation within cotton landscapes. Priority areas for restoration and management actions were identified to help restore these areas for the benefit of threatened and iconic species.

This was achieved using overlapping spatial factors important for persistence of biodiversity, for example land adjacent to rivers and streams, vegetation cover, landscape corridors and high overlap of threatened species.

How to use the maps

Using CottonInfo's clickable map, select an LGA to see a snapshot of biodiversity assets and priority management actions for threatened and iconic species.

"This information can be used by land managers to make decisions to support biodiversity on our cotton farms," CRDC R&D Manager Stacey Vogel said.

"Each LGA's priority management actions are based on the specific species likely to occur in that region and the actions needed to best protect them.

"There are also several general management actions, that taken collectively across all LGAs, will benefit ecological function and biodiversity resilience across the cotton landscape."

A 'Priority areas for restoration map' was produced at an industry scale as a guide for where restoration activities might best be undertaken and further ground truthing is required. This map has not been included on the website, but growers interested in finding out if their farm has areas identified as priority zones for restoration should contact Stacey.

CottonInfo is currently developing a collaborative partnership to support cotton growers in priority areas to restore biodiversity on farm; more information will be available in the coming months.

The mapping was part of the Cotton Landcare Tech Innovations 2021 project funded by CRDC in partnership with the Australian Government's National Landcare Smart Farming Partnership Initiative, and the Australian Government Department of Agriculture, Water and Environment, through its Rural R&D for Profit Program with partners CRDC, CSIRO, Forest and Wood Products Australia and the Fisheries RDC.

For more
www.cottoninfo.com.au/managing-biodiversity-cotton-landscapes

Help us assess our wellbeing

THE Regional Wellbeing Survey (RWS) is an annual survey that measures the subjective wellbeing of people living in rural and regional Australia. It also includes measures of resilience of rural and regional residents and the liveability of their communities. It aims to provide data that can be used by CRDC and others to explore how rural and regional Australians are experiencing a wide range of changes occurring in their communities. CRDC is encouraging all those in the cotton community who live rurally and regionally to take part in the survey.

The Australian cotton industry reported on wellbeing for the first time in its *Australian Cotton Industry Sustainability Report 2019,* using data from the RWS. This is a starting point in more thoroughly addressing the wellbeing issue, and more work is needed to understand the context, the impact of drought, and other factors on these baseline numbers. Indicators need to help the industry understand if and how it can do more to work with government, communities, other industries and individuals to improve the welling and social capital of people and communities where cotton is grown.

"Because measuring wellbeing is new to the industry, education and collaboration is needed to make these indicators understood and relevant in the cotton industry and in cotton growing communities," Rachel says.

"The wellbeing of people in the Australian cotton industry is integral to its success and level of sustainability.

"The cotton industry intends to work with the National Farmers Federation and other broadacre sectors towards a consistency of wellbeing indicators, and when they are confirmed, after the consultation process, the industry will set targets that ensure it contributes to national wellbeing aspirations.

"In the meantime, we'd like growers to complete the survey to provide an insight into regional cotton communities wellbeing, resilience and quality of life."

The survey will be available on-line and in hard copy form from September at www.regionalwellbeing.org.au.

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Raising the bar to make safety part of cotton culture

THE Rural Safety & Health Alliance, of which CRDC is a partner, is delivering work health and safety (WHS) research across nine rural development corporations (RDCs).

The *Work Health and Safety Communications Guidelines* have been created under the alliance to guide how WHS is delivered to industries by RDCs and industry organisations including Cotton Australia, *my*BMP and CottonInfo.

Consistently high rates of death, injury and illness in agriculture reinforce in stark terms that WHS uptake is a priority for the entire sector. Communication is a key priority in the RSHA's RD&E Strategy. This sits within the broader objective to build capacity, but it also draws on other strategic priorities such as improving risk management, stimulating learning, enabling leadership, and tackling barriers and leveraging enablers for change.

"We need to raise the profile of work health and safety culture in the cotton industry and in cotton farm businesses," CRDC R&D Manager Rachel Holloway says.

"Ensuring your business culture, from RDCs to the farm, has a culture of talking and acting about safety is critical to ensuring the safety of the farm families, employees and attracting people into the cotton industry workforce."

MELANIE JENSON

The cotton industry has always regarded safety as a part of its remit to the workforce. At the 2018 Australian Cotton Conference, a panel session was dedicated to WHS, with well-known rugby league player and safety ambassador Shane Webcke, who is passionate about the issue after losing his father in a workplace accident.

Rachel said the project has raised the importance of leadership of WHS in the cotton industry and initiated a collaborative industry group, the Australian cotton industry WHS committee.

"This ensures the various industry roles are working collaboratively on WHS initiatives including research, WHS data, policy, best practice, training, workshop and identifying barriers and gaps in WHS," she says.

The guidelines also include a WHS Communications Checklist, recommendations on the use of imagery and statistics, and how to segment an audience. The checklist and a webinar are available at www.rsha.com.au/projects.

RSHA is a partnership between AgriFutures Australia, Australian Eggs, Australian Pork Limited, Australian Wool Innovation, CRDC, Dairy Australia, Fisheries RDC, GRDC, and Meat and Livestock Australia.

Fall armyworm a new addition to Pest Guide

LYLE J BUSS UNIVERSITY OF FLORIDA

THE incursion of fall armyworm (*Spodoptera frugiperda*) in Northern Queensland in February put the cotton industry on high alert.

Since the detection in the Torres Strait, fall armyworm has been confirmed in WA, in the Darwin, Doulgas/Daly and Katherine regions of the Northern Territory, and as far south as Bundaberg in Queensland. Producers in Central Queensland are on the lookout too, with recent detections in Emerald and Biloela.

The CRDC and CottonInfo *Cotton Pest Management Guide 2020-21*, included with this edition of *Spotlight*, includes a fall armyworm identification guide and information.

There are species of *Spodoptera* in Australia which can look similar to fall armyworm. *Spodoptera litura* (cluster caterpillar) is native to Australia and can be a pest of cotton in Northern Australia. Other species not harmful to cotton include lawn and dayfeeding armyworm.

"So far we have had no detections of fall armyworm in any cotton crops throughout Northern Australia this season, despite the pest being active in nearby crops of sorghum and maize," CottonInfo Integrated Pest Management (IPM) Technical Lead Paul Grundy said.

"As the pest status of fall armyworm becomes clearer, consideration for how insecticides are used across different crops will require a strategic approach to limit the chance of resistance developing not just in fall armyworm but also in our key pest *Helicoverpa armigera*.

"The management of the pest in maize has seen an increase in the use of a range of insecticides, that if continued over the long term in an unstructured way is likely to increase selection pressure on *H. armigera*.

"Increased resistance in this species would have dire consequences not only for cotton but for grains, pulses and some vegetable crops.

"It will be important to consider the management of fall armyworm through a lens that takes into account other key pests.

"Just as we depend on IPM for other pests, the longer term management of this new pest has the greatest chance of success when we better understand and use information on its host range, seasonal abundance, damage potential, resistance risk factors and the role that natural enemies might play to our advantage."

Where control may be required in cotton, emergency use permits have been obtained for spinetoram and chlorantraniliprole. Other products are being considered so refer to APVMA (www.portal.apvma.gov.au/permits) for the current list. These products were chosen because of their likely efficacy and ability to be used within an IPM program that seeks to preserve natural enemies of fall armyworm and other key pest species.

Silverleaf whitefly

Whilst an updated threshold strategy is under development, silverleaf whitefly (SLW) sampling information will remain the same for 2020-21, with an updated strategy due next season.

Paul highlighted the resistance results for SLW (see Winter 2020 *Spotlight* for more) and the need for crop managers to be aware of guidelines. Key factors are that pyriproxyfen (Admiral) resistance has remained in check. QLD DAF entomologist Dr Jamie Hopkinson explains that this "tells us that the changes that were put in place three years ago are working and importantly will need to be continued".

"Detection of resistance at very low levels to spirotetramat (Movento) at Emerald and elsewhere in horticulture have shown the need for a considered approach for using this product, hence it is restricted to one use per season," Jamie said.

The resistance that has been detected is likely to be widespread and while at very low levels, the mutation that confers resistance has a dominant mode of inheritance (heterozygotes are resistant) meaning resistance has the potential to develop rapidly and would be very difficult to reverse, hence the best strategy is to avoid selecting for it in the first instance.

"Rotation of chemistry is a valuable approach to reducing selection pressure," Jamie said.

Don't disrupt the good guys

The beneficial disruption table will also be printed as a pull-out ready reckoner this season.

"This is a great new feature with the idea coming from a survey of the pest management guide readers," Paul said.

"This table provides important information on the selectivity of insecticides, and their likely impact on key beneficials.

"Keeping our beneficial populations healthy and abundant is a cornerstone of the industry's IPM system."

For more
www.cottoninfo.com.au/publications/cotton-pest-management-guide

Sensing change at St George: IoT and LoRaWAN

WHETHER you're still trying to wrap your head around the 'internet of things', on-farm sensors and data transfer technology, or are confident enough to start dipping your toe in the water, a new series of videos from CottonInfo and the St George Cotton Growers Association (CGA) give a grower's perspective of what you need to know.

Join cotton growers Andrew Sevil and Glenn Rogan, along with experts in the field, GoannaAg's Tom Dowling and Dan McNulty, and QLD DAF's ag systems mechatronic engineer Paul Stewart for first-hand experience and knowledge through this collection of 19 concise and insightful videos.

The St George CGA has been looking into internet of things (IoT) sensor technology and transmission of sensor output data via low power, long range (LoRaWAN) networks. Sensors can be used to measure everything from flow rates, soil moisture, channel water heights and even the whereabouts of the family dog.

Supported by CRDC's Grassroots Grants program, the CGA's initiative investigated two approaches to the technology to share with industry:

- a 'build-your-own' approach, by local cotton grower Andrew Sevil; and
- a commercially-supplied, supported and serviced technology approach at Glenn's farm, which has been set up as a demonstration site (how it was done is all in the videos!).

Initially, the grant was to be used to support the purchase of some of the technology to be showcased at a field day on Glenn's farm. However, these plans were halted by COVID-19. This called for another approach and the videos were instead created, for a 'virtual field day'.

CottonInfo's Regional Extension Officer for the St George area, Andrew McKay, produced the videos and said he believes there are operational and efficiency gains to be had from any technology that can monitor, record and be viewed remotely. Firstly, he says, growers needed to understand how it works, what's involved in installation, what it costs and what it can do.

"One thing most growers comment on is the time and travel savings made by remotely monitoring an irrigation system, that translates to more productivity elsewhere (doing other tasks)," Andrew said.

"From the efficiency perspective, the range of monitors will allow growers to get a more accurate estimate of their water use efficiency and get this figure more easily in the future.

"A LoRaWAN system is one solution to the issues facing growers in more remote areas where cellular coverage can be poor, it is not a major capital investment, has good range and is quite reactive/responsive in term of updating/refreshing screens."

Andrew Sevil says the initiative and videos have given a comprehensive overview of the options available not only in off the shelf systems, but also for those keen to build their own.

"It was a great thing the CGA did as it shows growers where this technology is going and what can be measured," he said.

"I set some sensors up on other farms and have seen the positive effect they can have on efficiency and profitability, through improved water use and labour savings.

"I put a channel sensor on one of ours last season and didn't have to get up at all during the night to check levels, I could do that within seconds, by checking my phone or computer, so that in itself is a great outcome."

Andrew Sevil has learned to build his own network and is now helping other growers get on board with sensor technology and on-farm data collection.

Grassroots Grants

CRDC's annual Grassroots Grants program is now open, with grants of up to $10,000 available to cotton grower associations (CGAs) to support local projects. To date, 77 projects have been supported, which has seen $670,000 going back to local grower organisations.
If you or your CGA has a great idea, program, infrastructure or research angle you've been sitting on, apply today at www.crdc.com.au/for-growers/community-grower-support

Plant RDCs make biosecurity a priority

THE Plant Biosecurity Research Initiative (PBRI) is a cross-industry research initiative across a number of groups including the Australian Government Department of Agriculture, Water and the Environment, Plant Health Australia and the seven plant Research and Development Corporations, including CRDC. It was established in 2017 to ensure the efficient co-ordination of research, development and extension (RD&E) efforts for plant biosecurity

Under the initiative, 10 collaborative projects have been funded with a total value of $50 million to support plant biosecurity research. These projects are investing in RD&E for risks such as xylella, and cotton pests brown marmorated stink bug and fall armyworm, all of which are high priority threats for Australian agriculture and the environment. The PBRI is also playing an important role in supporting the national efforts on the UN-declared 2020 International Year of Plant Health.

Given the success of PBRI, partners have recently agreed to continue the collaboration. Minister for Agriculture, Drought and Emergency Management, the Hon. David Littleproud MP made the announcement, saying the agreement strengthens collaboration and coordination across the Australian plant industry sector on biosecurity research, while building and maintaining critical plant biosecurity expertise for Australia.

"Detections of fall armyworm in northern Australia and repeated detections of brown marmorated stink bug at our borders are a reminder of the importance of biosecurity for our plant health," he said.

"Our biosecurity system relies on partnerships between the Australian and state, territory and local governments, industry, environmental bodies, land managers and the broader community."

The PBRI coordinates investment in cross-sectoral biosecurity issues, to optimise impact for Australian industry and to better align to broader national goals. The PBRI has established a successful collaboration model aiming to minimise duplication in RD&E investment.

CRDC's Susan Maas said a direct benefit of PBRI was the joint R&D project with the Grains Research and Development Corporation to address fall armyworm (see next page).

"The PBRI provides a framework, and strong cross-RDC relationships that have led to collaborative investments in pests of common interest, such as fall armyworm, as well as research that addresses strategic national plant biosecurity needs such as diagnostics and surveillance.

"PBRI helps to connect CRDC to broader networks in Australia and overseas.

"Importantly this network also helps avoid unnecessary investment of concepts/ideas where there could have been duplication and enables co-ordination of biosecurity activities as well as investment."

For more:
www.pbri.com.au

MELANIE JENSON

Combining forces to control exotic pests: The grains and cotton industry are working together with other plant research and development corporations through the PBRI.

International, to combat fall

CSIRO is leading a new collaborative research project to understand and manage fall armyworm (FAW).

FAW is a global pest threatening crop production across South East Asia and Oceania, including Australia, after its detection here in February.

The project will provide a greater understanding of the pest's genetic make-up and insecticide sensitivities to inform the most effective management strategies. This knowledge will help countries including Australia develop effective pest management plans across industries such as cotton and grains.

CSIRO researcher and project leader Dr Wee Tek Tay said FAW is capable of damaging various crops, including cotton, maize, sorghum, ginger and sugarcane.

Historically, this pest has been classified as either rice-preferred or corn-preferred fall armyworm. However, recent genomic studies confirmed the presence of hybrids in both native and invasive ranges, highlighting significant knowledge gaps in our understanding

DR PAUL GRUNDY

The strain of Fall armyworm that has entered Australia has not yet been found to attack cotton, but has caused damage in maize crops, as documented by QLD DAF's Dr Paul Grundy.

cross-industry project armyworm

of host crop preferences, especially in invasive populations.

"This particular species of armyworm has developed resistance to commonly used insecticides in other parts of the world, making management more difficult," Tek said.

"It has spread rapidly since the first reported detection in Africa in 2016, across Asia and Africa and to Australia in early 2020, potentially carrying new insecticide resistance or feeding traits.

"The resistance status of the current incursion, potential for resistance to develop over time and the ongoing migration of FAW into Australia and the region may present significant challenges to agricultural industries.

"The more we know about this armyworm, its genetics and its response to insecticides, the better we can plan for effective management strategies."

The project is co-invested by CRDC, Australian Centre for International Agricultural Research, the Grains Research and Development Corporation, FMC Australasia and Corteva Agriscience. It involves partner organisations in Indonesia, Vietnam, Lao PDR, Myanmar, Cambodia, Philippines, Malaysia and Uganda.

Dr Sarina Macfadyen, ACIAR's Associated Research Program Manager for Farming Systems Analysis, said it was hoped the research activity will help develop the knowledge needed to guide individual country responses and facilitate co-ordinated actions.

"The team will focus on developing new knowledge in two areas; firstly, conducting a genetic characterisation of the similarities and differences in the populations found in Australia and South East Asia," Sarina said.

"The second area of research involves testing the insecticide sensitivities of these populations that may already show some level of resistance to commonly used products.

"The team will look for genetic markers that, if present, may suggest some populations already carry mutations that make them able to withstand specific insecticides, and will conduct bioassays on live caterpillars exposed to different insecticide modes of action.

"This knowledge will feed into the development of resistance management plans by individual countries and inform insecticide recommendations to farmers."

"This knowledge will feed into the development of resistance management plans by individual countries and inform insecticide recommendations to farmers."

The spread of pests such as FAW through multiple countries and continents has increased dramatically in recent years. Globalisation, trade and climate change, as well as reduced resilience in production systems due to decades of agricultural intensification, may all have played a part.

"This co-investment brings together partners in government, RDCs, the private sector and the research community to address an immediate priority – the characterisation of FAW in Australia and South East Asia," said Dr Jeevan Khurana, GRDC's Manager Biosecurity who is co-ordinating the partnership.

"The information generated will be an important component in the development of sustainable management strategies."

CRDC R&D Manager Susan Maas said while there haven't been any reports of impact on cotton to date, it is not yet known how the pest will behave in Australia.

"Given the genetic diversity of this pest and risk of future incursions, working with near neighbour countries will also provide insights into the risk of further incursions introducing change in host preference or different resistance profiles," Susan said.

"This collaboration is a great opportunity to be on the front foot in terms of understanding baseline Bt and insecticide resistance as well as genetic characterisation."

The research is due to run until the middle of 2021 with a final report of the findings to be published by CSIRO and ACIAR.

For more

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susan.maas@crdc.com.au

Is it possible to revolutionise agricultural spray application?

The Australian Government's Business Research and Innovation Initiative (BRII) is providing $12 million funding for small and medium sized enterprises to solve five important environmental challenges.

One of these challenges, submitted and now managed by CRDC is 'Is it possible to revolutionise agricultural spray application?'

BRII aims to find effective ways of dealing with challenges that affect the environment, while providing opportunities for start-ups and businesses to develop new products and technologies for the global market by offering competitive grants to encourage the development of innovative solutions to public policy and service delivery challenges as nominated by government. The challenge submitted by CRDC – to revolutionise agricultural spray application to reduce spray drift – was one of five chosen by the government to support, and challenges applicants to find new approaches with innovative technology solutions to improve applicator capacity and reduce spray drift.

CRDC R&D Manager Susan Maas developed the successful application to BRII.

"Pesticides help ensure Australian farming remains productive and maintains its reputation for high quality, but spray drift, or movement beyond the original target, is an ongoing, global issue," she said.

"Spray drift onto sensitive crops results in environmental contamination and significant financial loss.

"Spray application is complex, with many factors needing to be considered including chemical composition, application equipment, training and legal requirements.

"The solution could address one or many of these factors, reduce complexity or could involve the use of a lateral-thinking technological solution that brings increased automation and insight to the process.

"The successful grant applicant will have the chance to work closely with government to create a product that could be commercialised locally and even globally."

The challenges are examples of how RDCs are trying new approaches to address the big issues facing agriculture.

CRDC's successful project has benefits beyond the cotton industry. Spray drift is a concern for all agriculture and in particular, the grains industry is also looking on with interest as it seeks improved targeting of spray droplets, thereby increasing spray efficiency and more economical use of chemical inputs. The BRII challenge will build on existing cross-industry collaboration addressing the issue of spray drift.

Conversely, CRDC is looking forward to seeing responses to the Grains Research and Development Corporation's (GRDC) challenge, 'Turning farm crops into a renewable hydrogen source'.

GRDC Head of Industry and Government Relations, Justin Crosby, says the GRDC's challenge through BRII has the potential to generate significant advantages for the nation's grains industry.

"We are seeking innovations that will complement an existing GRDC investment that is looking to develop new processes for fertiliser production that are more energy efficient and environmentally sustainable," Justin says.

"If this BRII challenge can produce an innovative means of generating hydrogen for renewable fertiliser production through recycling farm biomass, then it's a win-win for grain growers and the broader industry.

"And the benefits will flow to the general public, the environment and the economy."

Australian startups and small and medium businesses can submit proposals for ideas that address the challenges. Successful applicants will receive grants of up to $100,000 to further develop ideas and test feasibility over three months. The most successful of these ideas may then be eligible for a grant of up to $1 million to develop a prototype or proof of concept over a maximum of 18 months. Relevant government agencies will have the option to purchase these solutions at the end of the proof of concept stage.

Applications close on September 10, 2020. To find out more, including how to apply for a grant, visit www.business.gov.au/BRII

For more
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Spray drift warning system a step closer to implementation

Minimising spray drift is a high priority for Australian agriculture, with the grains and cotton industries joining to develop a hazardous weather warning system to provide real-time weather data and alerts to growers and spray operators.

The Grains Research and Development Corporation (GRDC) and CRDC are currently working to identify partner/s to develop and deploy the Spray Drift Hazard Alert and Warning System in NSW, southern and Central Queensland, with potential to expand to other states and industries.

GRDC Manager Chemical Regulation, Gordon Cumming said the aim of the investment was to create a system that would improve on-farm decision making, by accurately identifying and forecasting hazardous spray conditions.

"Reducing the risk of spray drift is imperative for social, environmental and financial reasons for Australian agriculture and the wider community," Gordon said.

"As research leaders, GRDC and CRDC are committed to investing in research that supports improved on-farm practices, the sustainability of agriculture and more specifically the enduring profitability of Australian farmers.

"Until recently, there has been no reliable and accurate method to determine when inversion conditions are hazardous for agricultural spraying using real time data."

IMAGE: MELANIE JENSON

"This work will be a significant venture into an innovative new space that will see the development of a continuous network to mitigate spray drift across the cropping areas of eastern Australia."

Regulations currently provide strict guidelines for the application of agricultural chemicals, which do not permit spraying when hazardous surface temperature inversions are present. In this situation droplets can remain suspended in the inversion layer in concentrated form and be carried significant distances. Until recently, there has been no reliable and accurate method to determine when inversion conditions are hazardous for agricultural spraying using real time data.

"These (hazardous inversion) conditions exist most nights of the year for undefined periods," Gordon said, "so we need to have the ability to know exactly when they are occurring and stop spraying."

This collaborative, potential new investment will build on research by the GRDC, CRDC and the West Australian Department of Primary Industries and Regional Development, who investigated the effect of near-surface temperature on spray operations. The research produced methodology and algorithms that allow for the accurate real time identification and forecasting of hazardous inversion conditions.

After the recent expression of interest (EOI) process, CRDC and GRDC are now considering proposals for the building of a tower network, and the development of software with remote sensing capability to provide information back to growers and spray contractors about weather conditions. This work involves establishing, operating and maintaining a network of Profiling Automatic Weather Stations (PAWS), initially across the grain and cotton regions of NSW, southern and Central Queensland, with the potential to expand nationally.

Once developed and deployed this spray drift hazard alert and warning system will consist of PAWS which collect and process local weather data and provide accurate real time information as well as short-term forecasting about surface inversions to growers or spray contractors. Preferably this information would be presented alongside other relevant weather information that affects decision making by spray operators.

The GRDC and CRDC are equal investment partners in this project to develop the technology for this spray drift hazard alert and warning system.

CRDC's Executive Director Dr Ian Taylor said the EOI and subsequent submissions represented the next step in the process of improving spray drift hazard detection by creating an effective warning system for growers.

"Spray drift is a significant issue for agriculture and this investment represents a vital cross industry collaboration to improve information and outcomes at a farm level," he said.

Creating behavioural change key to eliminating spray drift

Solving the issue of off target spray drift is crucial to not only the cotton industry, but all of agriculture, for several reasons.

IVA QUARISA

The cotton industry is looking at how current training and information measures can be improved to further increase awareness and uptake of best practice to curb off-target spray drift. Farmer and community-led groups such as SOS are seeing high levels of community engagement from various industries and sectors.

Spray drift is costly in terms of economic crop losses, but also impacts the environment, regional social fabric, and broader public perception of agriculture. This raises the question, 'why is it still happening?'.

In an attempt to help answer this, CRDC supported a project using theory and methods from behavioural sciences to identify the main drivers and barriers to engagement in best-practice spray application.

Dr Lynette McLeod from the University of New England undertook the study and says changing human behaviour, and sustaining these changes over time, is a difficult process.

"Our study found that educating people about the negative impacts of spray drift and providing detailed instructions is rarely enough to initiate and sustain practice change," she said.

"Social research has shown that these proposed solutions will fail unless people are sufficiently motivated and empowered to change behaviours and adopt new approaches."

Acceptance and implementation of best-practice spray application ranges across a continuum. The survey found more than half (60 per cent) of the survey respondents had not adopted or only occasionally adopted these beneficial best practice behaviours.

Lynette found that at one end there are 'adopters', those who always implement best practice spray application. At the other end are 'non-adopters' who, for a range of reasons, fail to implement best practice, often causing significant negative impacts on and beyond their own properties.

"The elimination of the negative impacts of spray drift is a complex process that requires on-going participation by a diverse set of people who often possess a range of values, enterprise-interests, and skill sets," Lynette said.

The study outlined factors why best practice management for spray application wasn't occurring, which were linked to lack of information, no desire for the information, lack of engagement and perceived lack of time.

Drivers and barriers

CRDC's R&D Manager Rachel Holloway said the research increased CRDC's understanding of the drivers of and barriers to best practice spray application behaviours across mixed cropping landscapes and quantified this through research data.

"This understanding will increase the capacity of the cotton and other cropping industries to develop targeted strategies for increasing participation in best practice spray application," she said.

"As an industry we should be clearer in developing more tailored and targeted engagement approaches for those who are not currently conducting best management spray application."

Behavioural models help understand these drivers and barriers, so solutions can be found to overcome them. According to one model, behavioural factors determining behaviour can be classified into three groups:

1) Capability – Do individuals have the relevant knowledge, skills, and physical capacity to engage in the

target behaviour? Do they know the best management strategies?

2) Opportunity – Are situational conditions present to support the behaviour? Are relevant laws and other support structures in place to support action? Are appropriate technologies readily available?

3) Motivation – Are individuals sufficiently motivated to take action? Are they aware there is a problem in their region? Do they possess the right combination of values, attitudes, and beliefs to inspire action?

Improving capability

Fellow CRDC R&D Manager Susan Maas has been involved in several projects CRDC is supporting to mitigate off-target drift, which includes the Spray Drift Hazard Alert and Warning System (a collaboration with GRDC) and the Business Research and Innovation Initiative challenge project 'Revolutionising agricultural spray application'.

She says when we look at the behaviours, we need to look at how we answer the questions they pose.

"Training is still needed, but it's only part of the solution," Susan said.

"There is clearly a group who are disengaged – who won't attend training or feel the need to, so our challenge is to reach this group.

"This report shows that lack of knowledge isn't the only barrier to driving adoption of best practice.

"We've had to ask 'Are there better ways to traditional training than field days?'.

"The study shows we need to employ behavioural change techniques to address capability, opportunity and motivation, and continue to find ways to reduce complexity in achieving best practice.

"The Stop Off-target Spraying groups are a case in point: as well as providing practical information to support operator capability, these groups are using a community approach to engage across networks and appealing to the motivation of individuals to take action." (See story page 18)

For more

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Reporting damage and poor practice

Stewardship of pesticide applications to prevent off-target spray damage is a priority across all of agriculture to ensure the safety of communities and environments.

Spray drift damage can have significant financial impact. Production losses from spray drift damage to cotton crops in 2018 was estimated at $18 million. Drift damage and poor spraying practice should be reported to Cotton Australia along with relevant state authorities.

It is critical that growers report any incident, or suspected incident, as soon as it occurs to their closest Cotton Australia regional manager and fill out a Cotton Australia Spray Drift Incident Report. It is essential that incidents are properly logged and investigated, and Cotton Australia has a straightforward process that is simple and confidential. Growers whose crops have been damaged by off-target spray drift should report it to the relevant authorities in their state (see below).

"It is important that we know if incidents occur in order to make representations on behalf of the industry," Cotton Australia's Sally Ceeney said.

"While Cotton Australia cannot take legal action or provide professional advice we can point growers in the right direction and tailor spray drift awareness initiatives into key areas based on feedback received by growers."

Spray drift reports for the 2019-20 season were down from previous years; only 1.2 per cent of the crop was officially reported as being damaged by spray drift, compared to two per cent in 2018-19 and 9.5 per cent in 2017-18.

"The extremely dry summer conditions and smaller cotton crop are expected to have had an impact on reducing overall spray incidence," Sally said.

State contacts

NSW: EPA Environment Line: 131-555
QLD: Biosecurity Queensland: 132-523
VIC: Chemical Standards Officer: (03) 5430-4463

CRDC signs on to SataCrop

CRDC has recently entered into an agreement to support SataCrop, the tool designed to mitigate the risk of spray drift by allowing operators to understand where sensitive crops are located in proximity to their spray operation. This industry initiative was developed by Cotton Australia and Precision Cropping Technologies.

SataCrop has the ability to map all crop types, including cotton, grains and tree crops and can be used all year round. Growers can log in and plot the location of fields they have planted with different crops each season. Other farmers and spray contractors can review the site when planning spray applications to see the location of potentially sensitive neighbouring crops. This, coupled with vigilance around spray conditions, wind directions, and application helps to reduce adverse effects of spray drift.

In its first year, 63 per cent of cotton crops were mapped on SataCrop. The range of crops mapped included cotton, cotton refuges, barley, wheat, chickpeas, citrus, corn, grapes, macadamia, sorghum and soybeans. One of the advantages of SataCrop is that once fields are entered they do not need to be re-entered each season; users can simply change their crop type to reflect what is happening on farm.

"Cotton Australia have been very encouraged by the rapid uptake and positive feedback from users following the first year of SataCrop," Sally said.

"The project partners will continue to review and enhance the usability of the program into the future."

For more

www.satacrop.com.au

Joining together to create impact

Creating community commitment to combating off-target spray drift is driving change.

Taking a close look at spray application at Coleambally in the Riverina.

IVA QUARISA

The Stop Off-target Spraying Riverina Valleys (SOS RV) group, formed in early 2019, is made up of representatives from all farming industries (including cotton, dryland cropping and grazing, rice, grains, apiarists and horticultural production systems), advisors, chemical suppliers/resellers, spray applicators, councils, government departments and water supply organisations across the Riverina region.

The group was formed after an initial meeting coordinated by Iva Quarisa from the Irrigation Research and Extension Committee (IREC) and the Southern Valleys Cotton Grower Association (CGA), with support from a CRDC Grassroots Grant. One of their objectives was to target all local industries within the Southern Valleys CGA to focus on the prevention and management of off-target spray drift.

"That was on the back of spray drift being number one issue reported at a range of breakfast meetings we held the year before, and through Southern Valleys CGA and the CRDC Grassroots Grants, we started the local SOS group," Iva said.

"Spray drift has been a significant issue for many businesses across our region.

"As a result we need to engage with the whole agricultural community to increase awareness of the risks of off-target spray drift and change practice to reduce the number of drift events."

Southern Valleys CGA Chair Paul Cleton says one of the main take home messages is that spray drift is not relevant to one industry only – it impacts the whole of the community/region.

"The formation of SOS RV and the expansion of the SOS model to other valleys is proof of this," he said. "A collabarative approach to dealing with spray drift will ensure success.

"The primary outcome/benefit to the cotton and wider ag industry of the spray drift program is the increased awareness of the risks of off target spray drift, and to ultimately reduce the incidence of drift events and associated extensive production and financial losses that occur in the southern growing region.

"It will also provide an opportunity for a unified approach across all local industries to discuss the potential risks and associated mitigation tactics to minimise these risks."

In late 2019 SOS RV ran two days of training events targeting advisors, agronomists and farmers in understanding and preventing spray drift. Spray drift prevention tips and reminders are also promoted through social media and video clips.

Another round of workshops are planned for spring 2020 across the southern valleys as well as bore water testing and a survey looking at the attitudes and practices of farmers and spray applicators. Paul says he thinks this approach has worked in his region because they are adaptive.

"I think we are all pretty adaptive – in terms of farmers, agronomists, corporates, resellers.

"We were all able to play a part in mitigating off-target drift.

"Cotton industry has information and technology that will make it easier to avoid, and it's good to see CGAs taking a proactive approach like in the Namoi, by sharing weather data."

Paul says spraying is taken very seriously on their family farms, and in fact, only he and his brother drive the spray rigs, even though they have staff who are capable.

"It's such an important operation to get right: it's not like if you have a stuff up when you're working country, you can fix that. You can't fix drift," he said.

"There are also so many factors and steps to be aware of to mitigate risk – from the planning, including checking weather, checking machinery/nozzle setups, label requirements, through to longer term considerations such as water quality and of course the immediate requirement to be aware of weather conditions you are spraying in and how you're spraying.

"Even now in winter, spraying conditions here can change in five minutes. Sometimes we have only a three or four-hour window in the day before it cools off and inversions are likely."

CRDC aims to help growers tackle these conditions with more confidence and reliability through its project with GRDC on a Spray Hazard Alert and Warning System, which particular focus on inversions and real-time warnings (see previous article Page 15).

For more

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Project 'to benefit whole community'

Growers in the Upper Namoi Valley of NSW are making important weather data publicly available to mitigate the risk of off-target spray drift.

Cotton grower and Upper Namoi Cotton Growers' Association (CGA) President Nick Beer said reducing the risk of spray drift was a priority across all of agriculture to ensure the safety of communities and environments.

"The Upper Namoi CGA is investing more than $26,000 to tackle the issue head-on by bringing the data from 13 private weather stations on cotton farms in the region online, for the benefit of the public and environment," Nick said.

"Everyone in the community will be able to access the information from the weather stations through a free app 'Goanna Telemetry', developed by Goanna Ag."

Nick says the local cotton industry wants the project to benefit the whole community.

"This is about farmers doing their bit to protect environmental systems, wildlife, bees, their neighbour's crops, plants and stock," he said.

"We will be distributing stickers to be placed in tractor cabs, spray rigs and vehicles reminding people to check the app for any relevant data when planning spraying activities."

Farmers, beekeepers, graziers, spray operators and contractors are encouraged to download the app to access the free weather station information.

Each season, Cotton Australia works to devise and implement strategic awareness campaigns around spray drift and best practice for spraying. They work closely with cotton growers, spray applicators, chemical registrants, resellers, regulators and other agricultural industries to develop and deliver the campaign.

Regional Manager Alec Macintosh said to see the landholders make the data publicly available is a positive step forward for the community.

"The growers involved have also agreed to cover the upkeep and maintenance costs, to ensure they provide as much use to the community as possible," Alec said.

"This is a great example of cotton growers working collaboratively with the community to understand, navigate and assist each other through the challenges when planning spraying activities."

COTTON AUSTRALIA

Jock and Dave Tudgey from Tudgey Farms, Breeza, inspecting a weather station.

Breeza farmer Dave Tudgey has a weather stations on his property, and said all the growers involved in the project are committed to mitigating the risk of spray drift.

"The inversion network gives everyone a valley wide view of what conditions are doing and what to expect as your progress through the day while conducting your spray operations – this is an invaluable tool for everybody to have at their disposal," Dave said.

For more

Landholders who are interested in being involved in the program are invited to register their details at www.goannaag.com.au and reference 'Upper Namoi Cotton Growers Weather Network.'

Pesticide loss scenarios informing future R&D needs

MELANIE JENSON

To manage animal and weed pests, the Australian cotton industry has strong proactive stewardship programs to both minimise the need for pesticides and to ensure their best practice use, such as resistance monitoring, *my*BMP, and integrated weed and pest management guidelines.

Pesticides (including insecticides, herbicides, fungicides and defoliants) are an important part of farming, yet globally, changes are occurring in the licensing and registration of some key products.

To help ensure R&D considers potential challenges from loss of access to key pesticides, CRDC has held a series of facilitated discussions to consider the implications, alternative management options and the RD&E needs under a series of 'loss of pesticide scenarios'. The objective is to begin to brief growers and advisors on the current and potential future changes and enable industry RD&E and planning to be informed by and prepared for the potential loss of key pesticides.

With COVID-19 derailing plans for a larger workshop, the team, including CRDC R&D managers Elle Storrier and Susan Maas, have been hosting small group videoconference meetings to work through six different scenarios where individual active ingredients or groups of actives are discussed with advisors across the industry as well as industry and researchers.

"We looked at three scenarios involving herbicides, two involving insecticides as well as a scenario where the key defoliation products were not available," Elle said.

"While we were focused on RD&E gaps and planning for cotton, we also asked participants to consider loss of pesticides in the context of the whole farming system: this includes in other rotation crops, fallow and non-cropping uses, as this has implications for profitability and management of entire cotton farming systems.

"As well as possible chemical substitutions we are also interested in broader farming systems cultural practices: soil management, frequency/type of cropping or changes that may be adopted or occur under these scenarios.

"We are seeking direction on what existing, new and developing technology can be incorporated to fill a gap left by any potential pesticide loss."

Some key and consistent messages highlight the risk of unintended consequences of removing certain products from our system, such as the potential for an increase in resistance due to reduced ability to rotate actives, increased cultivation and the erosion, moisture loss and soil constraints induced by reverting to old systems.

"We were able to identify which products we are heavily reliant on and where the greatest need for R&D exists," Susan Maas said.

"In cases where product substitution is available, there may be low impact, or it may result in inferior products being used (more expensive, more disruptive, or less efficacious).

"Where there isn't a suitable substitution, the economic impact may be greater.

"Farming systems impacts including frequency of cropping or rotation options may also be affected."

Outside factors

Changing demand around the world will be felt with countries changing internal policy on the use of certain chemicals and maximum residue limits (MRL). The Australian cotton industry will need to be abreast of MRL changes internationally in case there are implications for how we manage chemistries domestically.

"In some cases, a reduced residue limit may require Australian growers to remove use of the chemistry from our system to meet the requirement of the export market," Elle said.

"There is also the risk of products no longer being made; if more countries adopt policies restricting or banning the use of certain products, manufacturers may cease production due to the loss of markets and profitability.

"Glyphosate has come under particular scrutiny, with a number of European Union countries severely restricting or phasing out its use by 2023."

While the issue of glyphosate being a probable carcinogen is not yet fully resolved and may not be for some years to come, it is prudent for the industry to consider the implications of not having glyphosate available or not being able to use glyphosate in line with current use patterns.

CRDC commissioned a gross margin exercise to quantify the impact of losing glyphosate from irrigated and dryland farming systems.

The cost of weed control for the different scenarios would increase by:

- Irrigated Bollgard 3 – seven per cent ($239/ha)
- Mon88701 (XtendFlex) – four per cent ($155/ha)
- Dryland Bollgard 3 – 12 per cent ($173/ha)
- Dryland Mon88701 (XtendFlex) – seven per cent ($104/ha)

International decisions affect domestic use

Changing community standards about pesticide safety and tolerance for environmental impacts are also being reflected for products beyond glyphosate.

In early June the US Federal court banned the use of over-the-top Dicamba products (Xtend, FeXapan, and Engenia). Plaintiffs are also suing to cancel the registration of Enlist Duo (2,4-D and glyphosate).

In May 2020 India's government moved to ban 27 pesticides, including key insecticides, fungicides and weedicides such as 2,4-D, atrazine, chlorpyriphos, deltamethrin, dimethoate, diuron, mancozeb, pendimethalin and thiodicarb. A potential risk for Australia is that zero tolerance in MRL for these products for cotton lint could be applied. While India only accounted for 3.5 per cent cotton exports last year, in 2016 it accounted for 22 per cent, and could return as a significant trading partner.

Up for review

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has a formal reconsideration process that incorporates legislative, administrative and scientific elements that contribute to a final decision to affirm, vary, suspend or cancel an approval or registration. The APVMA prioritises agricultural and veterinary chemicals nominated for review according to the scientific evidence supporting the nomination. Chemicals currently under review include 2,4-D, chlorpyrifos, diquat, fipronil, neonicotinoids, and paraquat.

In addition to changes in pesticide policy, brands are responding to ethically and socially conscious consumer expectations about sustainability. As an example, the Better Cotton Initiative (BCI) has banned the use of certain pesticides (those listed in the Stockholm convention, Montreal protocol and Rotterdam convention) and have requirements for phasing out other products. Phorate is a product BCI requires be phased out by 2021.

"While the Australian cotton industry has been able to promote a significant improvement in insecticide usage (a 95 per cent reduction per hectare since 1993), local community and global expectations and sentiments about the impact of pesticides on the environment and human health will mean the industry needs to identify further reductions," Elle said.

"The downside of this success is that further reductions are much harder, or will have negative impacts in other areas.

"For example, herbicide hazard could be reduced by using less herbicide, but this would likely increase tillage, which would have negative impacts on soil carbon, soil moisture and fuel use."

Fostering a sustainable industry

The *Australian Cotton Sustainability Report 2019* is the Australian cotton industry's second five-year sustainability report, co-published by Cotton Australia and CRDC. Concurrent with this is the industry considering sustainability targets. Environmental Toxic Load (ETL) is an indicator created specifically to assess human health and environmental hazards associated with pesticides used in cotton. ETL monitors the hazard to four different ecological components.

For simplicity, the industry is using two of these as a public target – bees for insecticide hazard and algae for herbicide hazard.

Similarly to total usage of pesticides, the ETL for both bees and algae have decreased significantly since 2004, by 87 per cent and 75 per cent respectively. Ongoing improvements will likely require the industry to further reduce pesticide usage, especially those that contribute strongly to these ETLs.

For more

Australian Cotton Sustainability Report 2019
www.crdc.com.au/publications/australian-cotton-sustainability-report

Environmental Toxic Load for Australian Cotton, 2000-2018
www.insidecotton.com/xmlui/handle/1/4769

What's next for nitrogen research?

MELANIE JENSON

Over the past 30 years CRDC has invested in a broad suite of research aimed at understanding the use of nitrogen in cotton growing, specifically, how cotton plants use nitrogen (N) – when and where they need it, what form and how best to apply it and where applied N ends up.

There is still plenty to find out and more we can know, with many talented researchers delving deeper and deeper into these questions every year.

In the past five years the average nitrogen use efficiency (NUE) on cotton farms has decreased from around 10kg lint produced per kilogram of N applied, to around 8kg lint/kg N applied. As an industry we are using more and more N fertiliser and getting less lint back per unit of N applied than before.

CRDC R&D Manager Dr Meredith Conaty says it's therefore obvious that something isn't lining up in terms of putting research into practice.

"As outlined in the current research being undertaken on NUE, most research suggests that cotton plants don't need the very high rates of N being applied in some places – and that there is more N in the soil, and that it can be accessed more than we previously thought," Merry said.

"Likewise tracking the losses on farm has shown that a huge amount of N each year is volatilised or washed away, never reaching the plants for which it was intended.

"The decreasing NUE of the industry as a whole shows we aren't getting more efficient at using N, we are getting less efficient, and N fertiliser represents an additional cost to growers which isn't improving their bottom line."

Furthermore, the recent *Australian Cotton Sustainability Report 2019* released by the industry shows that 58 per cent of greenhouse gas emissions from the cotton industry come from N fertiliser use. Emissions per bale have gone up by 12.6 per cent in the last five years, which is largely due to the average NUE of the industry decreasing over this time.

So as an industry, Merry says, we are at an interesting point in time.

"We need to work out answers to the question of why research recommendations for N management aren't translating into improved NUE for the industry, and also what research should we do next to facilitate growers to be able to increase their efficiencies – and therefore their gross margin per bale.

"Working out answers to these questions will mean that we can increase the profitability and the sustainability of cotton farming, which is a good news story for everyone."

To this end CRDC will be conducting a review of N research, needs and practices on farm at the end of this year and wants to hear from and consult with as many people as possible across the industry, to learn what is driving N management practices.

"The pattern of decreasing NUE is happening for a reason, and the more we can match research direction with on farm needs and questions, the better chance we have of success," Merry said.

"CRDC will be holding review meetings around October, either online or in person depending on what is possible.

"We also strongly encourage people to learn about what research is happening now, as highlighted in the following articles, and to think about what is driving on farm NUE."

How to get involved:

Read through the following research summaries and head to www.insidecotton.com.au for all research reports.

Contact CRDC for more detail or a pack of summaries of the research being undertaken now and in the past.

Get involved in the discussion by joining in the October forums. Call Merry Conaty on 0422180583 or email meredith.conaty@crdc.com.au for details.

When it comes to choosing nitrogen, cotton goes organic

When cotton plants take up nitrogen from the soil, it isn't just in the form of nitrate and ammonium – they can also directly take up dissolved organic molecules.

Historical wisdom has told us that organic nitrogen (N) compounds in the soil need to be broken down and mineralised into inorganic compounds (nitrate and ammonium) before they can be taken up by plants. This has led many farmers to focus only on nitrate and ammonium when considering plant nutrition and soil health.

Current research from James Latimer (CSIRO A&F Sustainability/ANU Fenner School) and CSIRO's Mark Farrell and Ben Macdonald indicates that this assumption is incorrect, and that cotton can in fact rapidly take up dissolved organic nitrogen (DON) compounds like amino acids and urea.

The researchers fed cotton seedlings a mixture of inorganic and organic N molecules to see which they were able to take up, and which they preferred when given a choice. The results showed that cotton can take up N in both inorganic and organic forms, and that there is no overwhelming preference for either of the two N pools.

For crop managers, this means an N management program needs to also include the management of soil organic matter. Soil organic matter is the primary source of DON, and 40 to 50 per cent of the plant N uptake is derived from soil N.

"At present, most N management decisions tend to focus solely on the standing pool of extractable nitrate present in the soil," James says.

"Our research findings – that cotton can and does take up organic nitrogen when presented with a choice – suggest that this nitrate-centric approach to N management underestimates N availability in cotton growing soils.

"They also highlight a mechanism by which cotton can access nitrogen efficiently from the soil organic matter."

This nitrogen 'bank' can be exploited to potentially improve yields in good years, but such exploitation must be carefully managed in much the same way as cash withdrawals at the bank. Ways to increase the size of the soil N bank are identical to those seeking to increase soil carbon levels, as they are both part of the soil organic matter. These may include legume rotations, additions of organic matter (manures) where available, and careful management of stubble.

"The conventional nutrient uptake paradigm suggests that cultivation of organic nitrogen (and carbon) in your soils is done so at the expense of plant-available inorganic nitrogen," James said.

"Our results suggest that this is not the case, and that you can develop healthy soils with high organic nitrogen contents without reducing plant-available nitrogen and by extension crop yields."

"Ways to increase the size of the soil N bank are identical to those seeking to increase soil carbon levels, as they are both part of the soil organic matter."

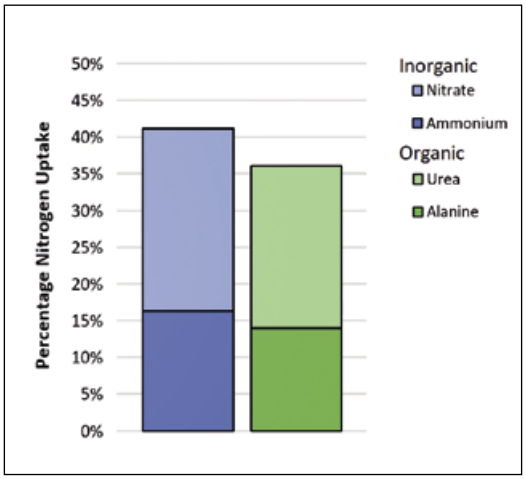

Figure 1. What percentage of the added nitrogen compounds was taken up by the plant after 180 minutes? The inorganic nitrogen pool is comprised of ammonium (NH_4^+) and nitrate (NO_3^-), while the dissolved organic nitrogen pool consists of urea (CON_2H_4) and an amino acid, alanine ($C_3H_7NO_2$). All nitrogen species were added concurrently.

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Resilient soil aids nitrogen uptake

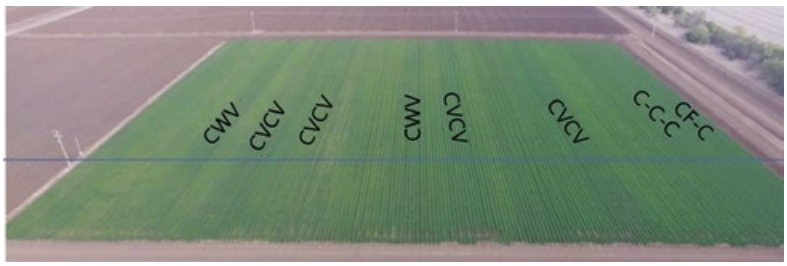
The results from long-term rotation trials by the late Dr Ian 'Rocky' Rochester show diverse rotations have a longer-term impact on soil health and resilience.

CSIRO Agriculture and Food scientists Ben Macdonald, Tim Weaver, Mark Farrell, Dio Antille, Kelly Gordon and Tony Nadelko have been building on Rocky's 19-year crop and nitrogen (N) rate field trial, which started in 1997 at the Australian Cotton Research Institute (ACRI). This trial has helped determine N fertilisation rates for the cotton industry and test the effect of rotations on nitrogen use efficiency (NUE).

Since 2007 field trial examined six crop rotations, continuous cotton (CCC), cotton-faba fallow (CF~C), cotton vetch fallow (CV~C), continuous cotton vetch (CVCVCV), cotton wheat fallow (CW~C) and cotton wheat vetch (CWV). Over the 10-year period, three fertiliser rates were always included in the field trial (0, 200, 360 kg/ha) design and the fertilised plots were re-randomised every two years, at the end of every rotation cycle. Field management practices include residue incorporation, no stubble burning and notably during the fallow, opportunistic plants were tolerated until field preparation.

The plant N uptake in the zero N fertiliser plots reflects the apparent soil N mineralisation. The soil on average supplied 162 kg N/ha every cotton season. This was not uniform across the crop rotation treatments (Figure 1) where apparent mineralisation rates varied from 0.83 to 1.51 kg N/ha/day.

Not all of the applied fertiliser was taken up by the plant (Figure 1). The unaccounted fertiliser N was either left in the soil or lost to denitrification and deep drainage. The fertiliser application did lift average yields (Figure 2) for all rotations but gains were greatest in the rotations that had lower apparent soil N mineralisation. Current researchers say these effects are still echoing through the field trial site. Since the end of the 2017 cotton season there has been no fertiliser applied to the field and no cotton grown. There has been winter wheat grown every year until this 2020 season. The on-going effect of the crop rotations on the winter wheat greenness is evident in Figure 3. The average



Winter wheat 2019, after rotation experiments.

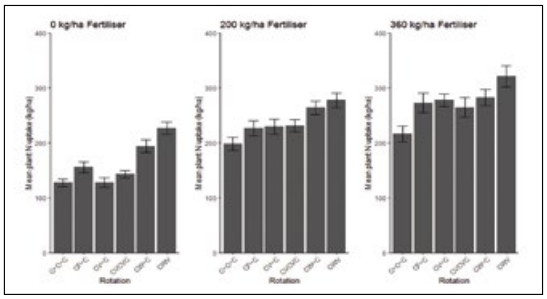


Figure 1. Average N uptake (kg/ha) between 2007-2017.

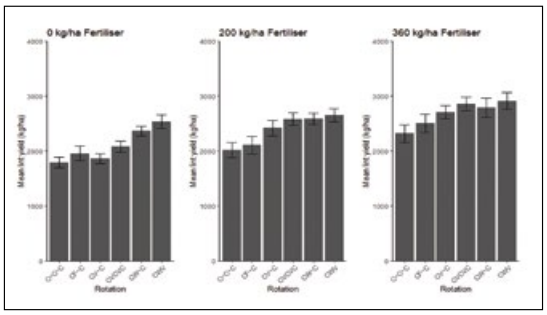


Figure 2. Average lint yield (kg/ha) between 2007-2017.

soil nitrogen mineralisation and yield data from the long-term trial indicate:

- Selection of appropriate crop rotations is important for sustained soil N mineralisation.
- Soils with greater soil N mineralisation had better average yields.
- Soils can supply large amounts of N to the cotton crop.

To maintain a healthy and productive soil, N fertilisation is required to replace N that is removed during harvest. Further, the N fertiliser is required to boost yield and generate biomass for incorporation into the soil. Rocky's experiment shows that diverse rotations have a longer-term impact on soil health and resilience. It is this resilience that enables the soil to deliver N to the plant via mineralisation," Ben said.

Tim agrees, saying N management is not only thinking about the seasonal application of bagged N but a longer-term plan that includes the management of soil organic N. This may be through the use of different rotations which include legumes and/or cover crops but it is important to make sure the N applied as fertiliser is the balance between N returned to soil as legume and that required by crop for maximum sustainable yield.

For more

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An aerial view of trial-plot picking at the two 2019–20 More Profit from Nitrogen trial paddocks at ACRI.

Enhancing nutrient use in cotton

Timing and application method of irrigation and nitrogen (N) fertiliser play a major role in how efficiently your crop is using N, and how much is being lost.

Researchers have quantified these links in the Enhancing nutrient use in cotton project led by NSW DPI's Graeme Schwenke and including NSW DPI's Jon Baird and Guna Nachimuthu, and CSIRO's Ben Macdonald. It is a project under the Australian Government Rural R&D for Profit's More Profit from Nitrogen program, led and co-funded by CRDC.

Two main questions were addressed: does the interaction of irrigation management and N fertiliser timing affect fertiliser N use efficiency (NUE = lint yield / N fertiliser applied) in cotton; and does the method of in-crop application affect NUE? Experiments began in 2016-17 at the Australian Cotton Research Institute (ACRI), along with on-farm trials near Moree, Boggabri and Narromine.

Work was also undertaken on phosphorus (P), with an initial focus on charting the decline in soil P stocks in long-term cotton paddocks of North West and Central West NSW. Interactive responses between N, P and irrigation strategies were later investigated in detail, as well as contrasting P fertiliser application strategies and application timing in cotton rotation systems.

To improve NUE requires either more yield from the same amount of N fertiliser, or the same yield from less applied N. Neither situation is possible where N fertiliser is applied in excess of that which the plant can utilise. The research found that the application of an additional 200 kg N/ha fertiliser (equivalent to industry average) above the calculated rate needed for the trial paddocks, gave no increase in lint yield and decreased NUE.

Where N rates are optimised for crop needs, NUE can be improved by reducing N losses to the environment. The experiments found that N loss in irrigation runoff water can be up to or exceeding 20 per cent of applied N, particularly during early-season irrigations (from pre-plant drilled N). Runoff N totals over the season were greatly reduced by having less than 70 per cent of the N applied pre-plant or by using a polymer-coated urea product which slowed the release of urea from the banded application.

In treatments where more than 50 per cent of the season's N fertiliser was applied in-crop, N runoff losses were no different between side-dressed and broadcast urea, but runoff was greater from water-run urea as dry conditions meant slow subbing into the beds and a higher proportion of water leaving the field laden with dissolved urea.

Water-run urea loss can be reduced by shutting off the injection of urea into the irrigation water when the water first reaches the tail drain – with no effect on plant growth. Water-running with either UAN (urea ammonium nitrate) or ammonia gave similar runoff loss results. However, a separate study into ammonia gas loss during water-run ammonia showed an additional 24 per cent of N was lost from the field as ammonia gas.

Irrigation timing strategy (the size of the soil water deficit used to trigger an irrigation) tended to have more impact on growth and yield than N rate or N timing strategies. Cotton grown with a smaller deficit trigger (50mm in 2016-17 and 2017-18, 60mm in 2018-19 and 2019-20) generally produced taller plants with greater biomass than those with a larger deficit trigger (70mm in 2016-17 and 2017-18, 90mm in 2018-19 and 2019-20).

However, greater vegetative growth only translated into greater lint yield in one of the four trial years (2017-18), where the addition of P fertiliser also boosted yields where N and irrigation were optimised. In the same season, a yield response to P fertiliser was also observed in a cotton-wheat-vetch rotation system in another field in ACRI, suggesting seasonal conditions and factors other than critical soil Colwell P was driving the P response.

Irrigation deficit treatment also affected soil N mineralisation rates in the top zero to 30 cm of the soil. Greater mineralisation was measured in treatments irrigated with lower deficit triggers (more frequent, smaller volume irrigations) compared to those with a higher soil water deficit (less frequent, larger volume irrigations). Across the plant bed-furrow system, soil mineralisation activity was found to be greatest in the plant line, with less N produced in the furrow soils. A future area of research would be the development of a system linking rapid in-crop soil N measurement with timely in-crop N management decisions.

For more

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Understanding the role of soil organic nitrogen

Ongoing research into cotton's nitrogen (N) uptake has emphasised the relatively minor contribution of fertiliser N to the total N taken up by the plant, which is often less than 30 per cent.

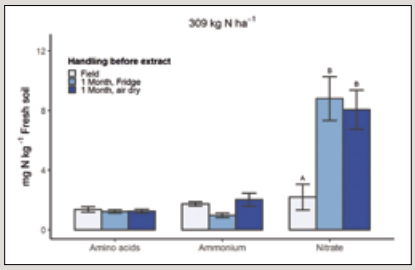

Figure 1. The effect of sample storage treatment on nitrogen species. Different letters indicate mean values are significantly different at a 95% probability level.

A project is underway to improve N management by determining cotton's N preference (nitrate, ammonium, dissolved organic N – DON) and how this can be managed in different growing regions. This work will help farmers better account for all N pools in their fertiliser decisions, increase productivity and nitrogen use efficiency (NUE), and therefore reduce environmental impacts.

Traditionally, it has been assumed that N is only available for plant uptake when in mineral form, that is, as ammonium and nitrate. Accordingly, the organic N pool (pre-mineralisation), has not been considered an important source of N.

Continued results from research in cotton demonstrate the importance of soil mineralisation to total plant N uptake. Recent research in other cropping systems has also highlighted that DON such as peptides and free amino acids may be directly accessible to plants.

In light of this, it is important to develop a better understanding of the role of organic N in cotton farming systems, and how this pool may be managed in such a way that NUE could be improved. This in particular because: assessments of N availability that focus on the nitrate pool may underestimate N availability; the type and application rate of inorganic fertilisers will likely affect the organic N pool, which in turn, could influence fertiliser NUE; and organic N is soluble and represents a significant proportion of leaching losses.

Work undertaken by CSIRO in collaboration with the University of Queensland and supported by CRDC aims to quantify the uptake of DON in different cotton varieties. Specifically, this research addresses the importance of the DON pool relative to nitrate and ammonium for cotton nutrition, the impact of soil type on uptake of DON relative to nitrate and ammonium, the influence of DON on NUE; and the influence of genetic variability (Bt and non-Bt varieties) on the relative uptakes of nitrate, ammonium and DON.

This project has also led to breakthroughs in how soil samples should be stored. Sample storage is often unavoidable, and inconsistencies in soil storage temperatures, moisture and duration could be confounding soil N measurements. Work is underway and includes field, glasshouse and laboratory-scale experiments, which also has broader implications for how to go about both research and agronomic soil testing.

N and soil water

Research is also investigating the relationship between soil N availability and soil water potential. By determining soil N fluxes and the soil water retention characteristics accurate estimates can be provided of nitrate$^-$, ammonia and DON as a function of soil water. Soil-specific functions can be employed to predict soil N supply between wetting and drying or irrigation cycles during the cropping season, and to better understand soil-specific interactions between soil water and pattern of N release.

Minimising the yield in

A conundrum for growers is overcoming yield variability within fields and across farms.

Sometimes, despite having the same management and weather conditions, nearby fields and areas within the same field can nonetheless vary considerably in yield. Researchers and crop managers all recognise this is due to a wide range of reasons, however, while soil constraints and variability may explain some yield variations, there is no framework to readily assess the core factors.

A project supported by CRDC is seeking to understand what causes yield gaps across various locations, and to also develop a framework for growers, consultants and regional extension specialists to diagnose key factors and assess their relative significance and contribution to yield variability.

Led by Dr Guna Nachimuthu of NSW DPI, two approaches are being used to understand the yield differences which include modelling, by combining freely available spatial data and on-farm datasets, and an in-field approach, comparing soil and crop management factors on yield of nearby fields on the same farm.

The modelling is coordinated by Sydney University's Patrick Filippi, and has led to the development of a prototype online tool to map soil constraints over depths. The soil constraint maps were found to have a strong relationship with cotton yield, helping to understand the causes of within-field yield variation. It is currently undergoing refinement before release to the industry. The modelling is also focused on identifying yield gaps within fields. The novel approach predicts the season-specific yield potential within fields, which can then be used to identify the size of yield gaps across fields and farms. These yield gap maps point to the constraining factors to yield when

yield variability to maximise cotton farming systems

Figure 1. Cotton lint yield influenced by previous rotation crop (the orange and yellow area in the middle of the yield map is the section of the paddock that missed wheat rotation).

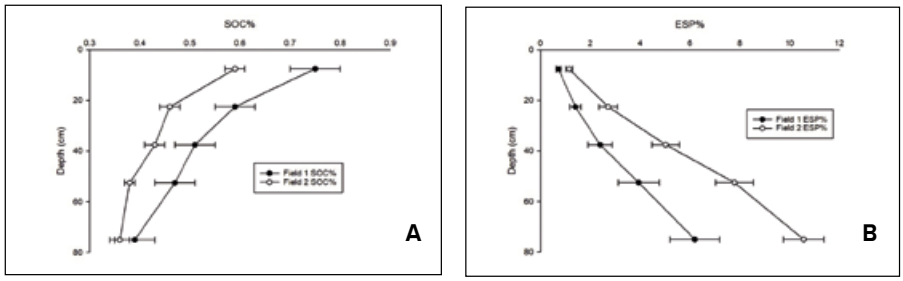

Figure 2. Paired paddock sites showing a significant difference in soil organic carbon and sodicity. (The average lint yield over five years for paddock 1 and 2 are 12.5 and 14.8 bales/ha respectively).

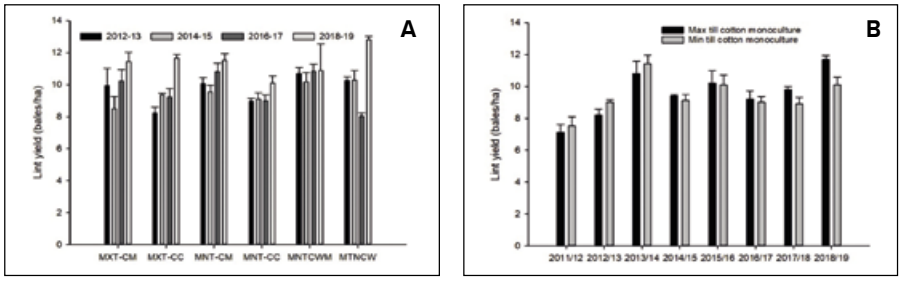

Figure 3. Effect of long term rotations on cotton lint yield (A-All treatments including rotations system only in those years with cotton crop: MXT- Maximum tillage, MNT-Minimum tillage, CM- cotton maize, CC-cotton monoculture, CWM-cotton wheat maize, CW- cotton wheat; B-Cotton monoculture systems).

compared to other datasets, such as soil maps and management information.

The in-field research on seven paired sites (14 fields) investigated the effect of soil and crop management data on yield, finding that both soil constraints and crop management factors cause yield differences which are limiting yield potential. Key initial results include:

- A section of a field that missed a wheat crop rotation (due to rain at planting) resulted in a significant yield penalty of up to four bales/ha (Figure 1). This reiterates results from long-term rotation trials at ACRI, the benefits of adopting a cropping system-level approach.
- Notable differences in a set of paired fields with yield differences were soil organic carbon and sodicity levels. The field with a five-year average of 12.5 bales/ha had significantly lower soil organic carbon and higher sodicity levels than the other field with 14.8 bales/ha (Figure 2), suggesting the role of soil organic carbon to improve the nutrient supply and/or structural stability of the soil.
- There was a weak correlation between soil profile N measurements (after planting) and yield measurements at coring sites across all fields, with N only accounting for three per cent of the variability in yield. N levels in the profile across several fields were well above the crop requirement suggesting a strong potential for optimisation of N use.
- A simulated field experiment on soil compaction at ACRI (NSW DPI and CSIRO) investigated the yield response to wheel traffic compaction imposed on either side of plant beds (compacted), one side of plant beds (semi-compacted) and no compaction (control). This trial received 230kg N/ha and adopted similar farm management except for compaction. The results suggested yield levels are directedly related to the level of wheel traffic. The lint yield of compacted, semi compacted, and control treatments were 2191, 2648 and 2778 kg/ha. The compacted treatment showed higher (canopy temperature) stress which was a function of lower crop water use caused by limited root access to sub-soil due to compaction.
- Yield data since 2011-12 where the yield potential of varieties used were similar, indicates the year to year yield variability (Figure 3) is more than the treatment differences suggesting the strong influence of weather factors on yield.

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Fundamentals for tropical cotton published

Growing cotton in tropical regions of Australia has hinged on integral research that aims to find the 'sweet spots' in promising, yet challenging climates. Success has been about finding the balance of avoiding the highest risks and capitalising on opportunities created by the tropic's unique climate of wet and dry seasons.

PAUL GRUNDY

Increased leaf size is a response to cloud, humidity and high night temperatures. Ordco agronomist Penny Goldsmith demonstrates leaf size in the Ord last year, which Paul says is hotter than the Burdekin 'and the leaves got even bigger!'

The foundation for current management practices for northern Australian cotton production that seeks to sow cotton during the wet season is largely based on research by QLD DAF's Dr Paul Grundy and CSIRO's Dr Stephen Yeates undertaken over five seasons in the Burdekin region of North Queensland. This study was recently published in the *Journal of Field Crops Research*.

"This work not only set up a basis for how to better grow cotton sown during the wet season in Australia's tropics, but has led to questions being asked about how summer crops in other regions might be better grown," says CRDC R&D Manager Susan Maas.

"The knowledge that was gained about how cotton interacted with the climate in the Burdekin, and in particular how cloudiness affected fruit set and yield potential of Bollgard varieties led to a fresh look at how cotton might be better grown in other areas, with Central Queensland being a good case in point.

"The Burdekin research has also been pivotal for supporting the industry expansion into Western Australia and the Northern Territory."

The researchers also developed novel research methods to consider how cotton might respond to the local environment.

Due to differences in how cotton crop growth responds to tropical conditions particularly during the wet season, traditional feasibility modelling around planting and yield implications proved to be unreliable.

"The approach Steve and Paul took to determine when a crop might be sown so that flowering, boll fill and picking occurred during periods of reduced climatic risk while at the same time maintaining the capacity to overcome periods of poor weather, was novel," Susan said.

"We had to determine both the potential magnitude and likely timing of climatic risks in these environments from a cotton plants perspective to then be able to identify the best crop production 'sweet spots'."

What the research found

Crop growth and the development of bolls is dependent on light intensity. A deficiency of sunlight due to cloudiness can often occur during the tropical wet season. The impact that solar radiation deficiency might have on cotton growth is not something most people think about as extended

PAUL GRUNDY

Typical days in monsoon regions.

cloudy periods are uncommon in Australia's southern cotton production regions. "The objective of our study was to evaluate both the impact that cloudiness might have on fruit shedding and canopy growth responses and determine how well a crop might recover and compensate when sunny weather returns," Paul said.

"To capture these impacts under field conditions, we used multiple planting dates over five seasons to expose crops to a range of cloudiness scenarios in the hope of measuring an effect.

"Over this period we were fortunate to achieve a cross-section of scenarios, with conditions ranging from mostly sunny through to crops exposed to cloudy weather for several weeks."

Reliance on mother nature to provide sunlight deficit treatments via cloudiness as opposed to a more traditional experimental methods such as the use artificial shade structures created some statistical challenges with no two seasons being the same. However, Paul and Steve were very much interested in the collective impact of cloud during the monsoon that often comes hand in hand with increased night temperatures, humidity and rainfall that may also alter crop response compared to a shade tent.

"Unsurprisingly, we were able to demonstrate that cloudiness during flowering was a primary causal factor for fruit abscission," Paul says.

"The timing of cloudiness in relation to the progression of flowering was important. Fruit losses during early flowering could be compensated for through the retention of bolls during later flowering provided sunny weather resumed.

"In contrast, cloudiness that continued or re-occurred during later flowering was particularly detrimental to yield compensation."

This relationship would seem simple enough, except both fruit abscission and monsoon conditions also altered other crop growth responses, with the most notable being more rapid canopy development and increased leaf size. Rapid canopy development by tropical crops can pose significant crop management challenges.

Excessively leafy canopies can self-shade the lower branches and exacerbate fruit shedding. The loss of fruit in turn enables even more rapid canopy expansion setting up a negative feedback loop that can result in rank, unproductive growth. At the same time, when sunny weather returns, compensation was maximised when the crop was poised for rapid canopy expansion enabling the production of new fruiting sites to replace lower canopy fruit losses.

The resulting canopy management balancing act poses significant challenges for crop managers who have limited control over irrigation and nutrition when regular rainfall is taking place. Mepiquat chloride application can keep canopy expansion in check, but its use during flowering requires a careful approach – if too much is applied and sunny weather returns, the ability of the crop to rapidly compensate can be constrained, and if too little is applied the canopy

may still become excessively rank.

To aid decision making for canopy management a model was devised for the status of the crop during the season that takes into account the number of nodes (the crop's time clock), crop height (the growth of the crop) and retention of lower canopy fruit (see NORpak Burdekin and North Queensland Coastal Dry Tropics publication). This approach is now being validated at a number of sites across northern Australia.

Interestingly, fibre quality during the five years of study was excellent, with many crops attracting a premium for length and strength. In combination with mild temperatures during the boll filling period, the shedding of bolls during cloudy weather was a factor that preserved fibre quality as fruit was not retained during periods that were unfavourable for photosynthesis thus conserving assimilates for growth. High fibre quality has been a regular characteristic for Bollgard crops grown across a range of sites in northern Australia for this reason.

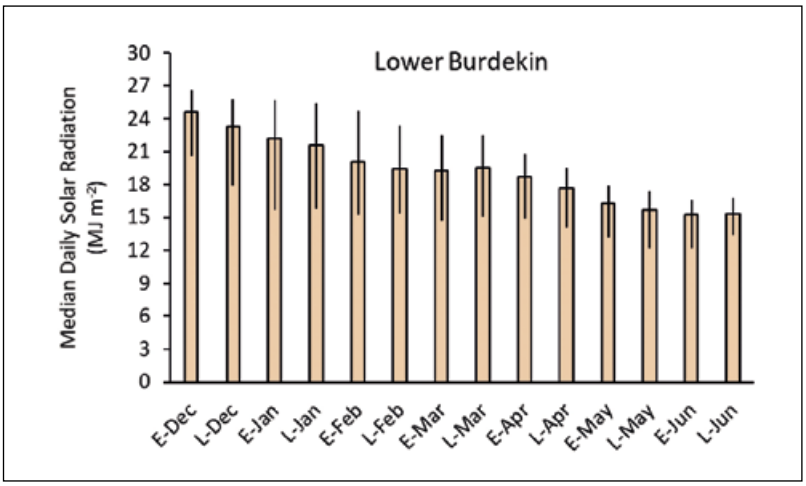
Retention and radiation

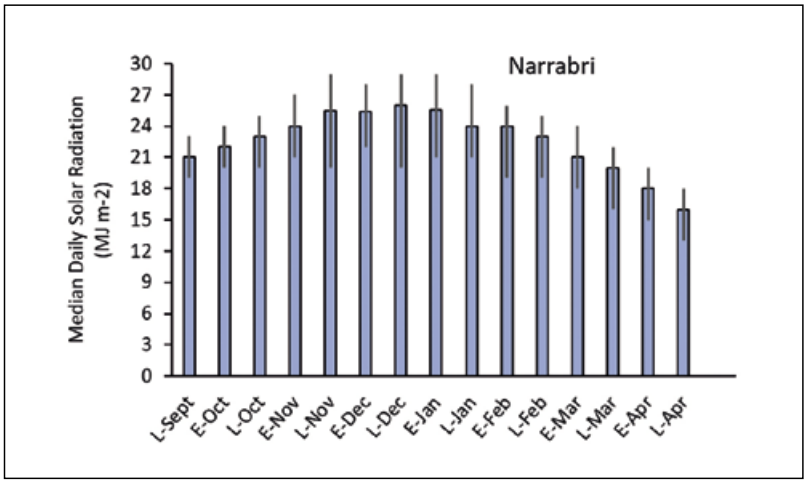
The study identified for the Burdekin climate that fruit retention was likely to be maximised with radiation at 24.2MJ m^{-2} d^{-1} representing a mostly cloudless day for this location during February and March. Weather records for the Burdekin indicate that median levels of daily radiation during late February to early April when flowering takes place range between 19.3-19.5 MJ m^{-2} d^{-1} which indicates that cotton production in the Burdekin will nearly always be affected to some extent by cloud induced fruit abscission, with less than 10 per cent of seasons being unaffected (Fig 1). In comparison solar radiation records for Narrabri between late December and late February spanning the usual period of crop flowering range from 24-26 MJ m^{-2} d^{-1} underscoring why cloudiness is rarely a constraint in this environment.

The boll survival relationships for radiation identified during the study provide a useful measure of the limitations posed by cloud for the Burdekin environment.

The specific values identified by this study cannot be directly extended to other tropical regions because differences in temperature and season length alter the opportunity for compensation and yield recovery. However the information can be used to benchmark potential cloudiness limitations of candidate production sites where weather records exist and identify likely sweet spots for sowing that best avoid cloudiness related risks that might beset flowering and boll fill. This has enabled sowing times that are most likely to maximise crop success to be identified for more recent production locations such as the Ord River in WA and Georgetown in North Queensland.

Fig 1. Shows the variability of median half monthly daily solar radiation calculated for 1950-2017 for the lower Burdekin and Narrabri growing seasons. The error bars show the range in 10% and 90% of seasons. Climate data from the Silo data base.





"Interestingly, fibre quality during the five years of study was excellent, with many crops attracting a premium for length and strength"

The boll survival relationships for radiation identified during the study provide a useful measure of the limitations posed by cloud for the Burdekin environment.

The specific values identified by this study cannot be directly extended to other tropical regions because differences in temperature and season length alter the opportunity for compensation and yield recovery. However the information can be used to benchmark potential cloudiness limitations of candidate production sites where weather records exist and identify likely sweet spots for sowing that best avoid cloudiness related risks that might beset flowering and boll fill. This has enabled sowing times that are most likely to maximise crop success to be identified for more recent production locations such as the Ord River in WA and Georgetown in North Queensland.

Building the foundations

Steve Yeates has spent the main proportion of his life undertaking research in the tropics. He says the North is not one homogenous place in terms of climate, soil or pests, yet the Burdekin work provided a basic foundation for cotton growing there. He says this was not by chance.

"Looking to apply the benefits of the research to a wider area was inherent in this research from the outset," Steve said.

"At the time we didn't know how much would be relevant, but we knew the work we were doing would have applications elsewhere, and allowed us to translate knowledge to management, then tweak management when crops were grown in new tropical regions.

"The Burdekin also showed us how selective we have to be when choosing the best growing locations."

Steve says the challenges posed by the North include the lack of uniformity in climate and soils.

"You can't look at North Queensland or tropical Australia as uniform, it's more diverse than all the other regions we grow cotton put together.

"What works at Katherine won't be the exactly the same for the Ord, Gulf or North Queensland."

Steve cites the growth and success of a growing industry in the Ord as validation of their approach.

Another major application of the Burdekin work was determining better planting dates for Central Queensland. While not a new growing area by any means, growing cotton there is challenging, as the region is susceptible to monsoonal influences that seemed to hit at the wrong time and variable weather that could "be like Moree one day and Katherine the next" Steve says.

Avoiding the vagaries of the monsoon was the goal in translating the Burdekin research into management in Central Queensland.

Central Queensland a major beneficiary

A better understanding of the impact of cloud on cotton crop response and how to mitigate climate risks from the Burdekin research provided fresh insights for cotton production in Central Queensland. The traditional sowing time at Emerald spanned mid-September to the end of October which meant flowering and boll fill occurred from December to February, a period afflicted by decreasing and increasingly variable solar radiation (due to cloudiness), hot nights and high chance of rainfall coinciding with boll opening and picking.

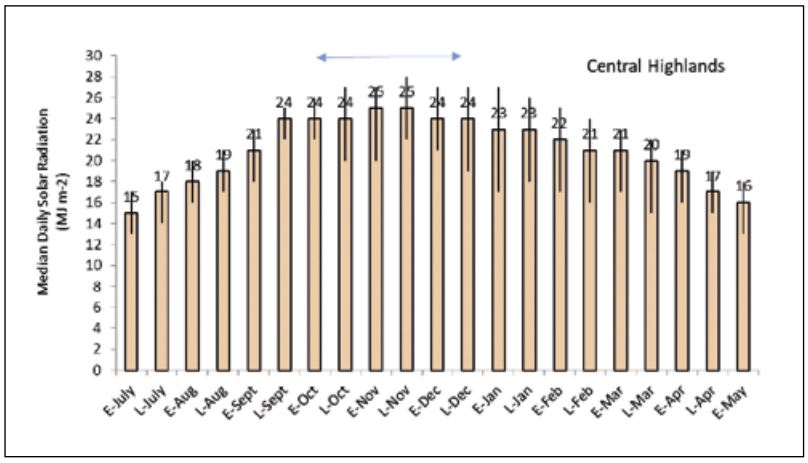


Fig 2. Shows the variability of median half monthly daily solar radiation calculated for 1950-2015 for Emerald. The error bars show the range in 10 per cent and 90 per cent of seasons. The arrow identifies the most optimal solar radiation period for flowering and boll fill. Climate data from Silo data base.

A detailed climatic analysis found that spring and early summer was the most optimal period for flowering, boll setting and opening as favourable temperatures combine with more intense, reliable radiation (Fig 2). To capture this period required late winter sowing. Crops sown in August proved successful, coinciding flowering and boll filling with better spring conditions that have delivered yield improvements of 15 to 25 per cent compared to crops planted at the traditional time. The risk of rainfall at picking remains but is 50 per cent less likely compared to mid-spring sowing.

New research is now underway to further capitalise on these gains by bringing forward sowing even earlier to late May/early June. The objective of this research is to increase the crop's exposure to spring-time conditions by commencing flowering during late September instead of late October and shift picking into late December/early January when the risk of rainfall is greatly reduced.

PAUL GRUNDY

Example of different growth habits. The tall crop was exposed to two to three weeks of cloudiness during late squaring and early flowering resulting in boll shedding. The crop then compensated by growing more upper branches and bolls which made it tall (it was empty underneath but you can't make fruit stick when sunlight is missing). The second photo is for a crop planted about 20 days later and it got the sunlight (that allowed the first crop to compensate) from the start of flowering. The result was minimal shedding and a much shorter plant. Both crops yielded around 11.3 bales so yield was virtually the same despite big differences in growth habit.

If crops are not negatively affected by the extended cool start, opportunity exists to further increase yield and largely avoid monsoonal rain at picking which is still a key production risk for the Central Highlands environment.

Longer season offers improved yield and quality

Steve Yeates and Paul Grundy's research has given Central Queensland's growers a range of options.

Steve and Paul's work in the Burdekin paved the way for their work in Emerald which has added flexibility to the system in the Dawson Valley, resulting in improved yield and quality in Bollgard 3. Their work was used to validate a longer planting window in the region, from August to December.

Consultant Damien Erbacher of Dawson Ag Consulting is based in Theodore and said the work has given them grounding in the benefits and pitfalls of early planted cotton in particular.

"Their research added scientific rigor to assumptions about earlier planting dates," Damien said.

"If we plant in the last week of August and first week of September, there are big advantages if we can manage the crop well, as it's on average boll filling in better conditions.

"Improved yield and quality is a no-brainer if you can get it right.

"It has taken us a few seasons to get it right, and I think given how variable our climate is, it is the long-term average we should be looking at: coming up with a system we can pull off nine seasons out of 10."

Damien says if planting early, everything has to be right: field and bed preparation, planting accuracy, along with irrigation need to be spot on to make it work, and potentially avoid issues like black root rot that come with planting in cooler conditions.

"If you have enough water to get a crop established early, it can just sit there, which happened last season with rain in January which brought the crop 'back to life'. This, followed by a warmer than average April, allowed the crop to be very successful.

"I think this is a better option than planting on rain in December, as the crop still needs time to establish, whereas an early-planted crop has its roots down and is better placed to take advantage of rain, light and heat.

"But there are potential downsides to longer seasons: disease, more insect pest generations to deal with.

"It is a complex balance we have to deal with."

For more

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PAUL GRUNDY

Picking early planting trials near Emerald.

QLD DAF Principal Research Scientist Dr Paul Grundy presents to growers and agronomists at a NACRA cotton field walk in Kununurra, in June 2019.

Fostering RD&E collaboration and leadership

NACRA, the Northern Australia Crop Research Alliance, has been supported by a CRDC Grassroots Grant to look at options for industry leadership and coordination of crop research priorities across Western Australia, Northern Territory and Queensland.

NACRA is an industry-owned crop research company based in the Ord District at Kununurra. NACRA has been successful in integrating industry investment in crop R&D with government and RDC funding. This has contributed to the current cotton research being undertaken in Kununurra and in other northern locations and helps identify and address the issues that will make the cotton industry successful in this part of the world.

NACRA Chair John Foss says a similar approach applied across northern Australia could work for growers and for research corporations.

"One size never fits all, so deciding what works best for growers in each state/territory/region is really important," he said.

"An organised voice to secure crop R&D investment for the north from levies paid and government grant rounds would mean more tailored research, driven by the knowledge and farm production outcomes of growers."

The CRDC Grassroots Grant is looking at how research priorities could be coordinated by a single industry-based group, leveraging additional resources to support industry-driven (and funded) crop R&D investment.

Some research priorities are necessarily local, some are regional, and some apply across the whole north. This project is looking at how that might work.

"With the cotton industry building in the Ord, the NT and parts of northern Queensland, working together is timely," John said.

"R&D corporations have their own means of identifying research priorities, and this process will recommend a mechanism for northern and tropical crop research requirements to be prioritised by growers and fed through to funding bodies.

"COVID-19 may have delayed the cross-border consultation on this process, but it hasn't stopped the priorities coming forward.

"With the cotton industry starting to move at a fast pace in Northern Australia, flexible, farmer-driven research and development, supported by quality extension, is essential.

"This project is looking at how that can be delivered effectively."

For more
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Ginning closer to a reality in the Ord

Plans are underway to build a cotton gin in Western Australia.

Currently, cotton grown in WA and the Northern Territory is trucked more than 3000km to Dalby or St George in South-West Queensland for processing. However, with trials and now commercial crops proving to be viable in Northern Australia, a gin is integral to the industry's expansion.

Ord River District Co-operative (ORDCO), Kimberley Agricultural Investment (KAI) and MG Corporation have announced a joint agreement has been reached to establish a gin in Kununurra. A Memorandum of Understanding was signed by the three parties in May which sets the framework for the proposed ownership and management structure of the gin. An Expression of Interest call was then made to other local farmers and industry stakeholders to join the project, with 13 additional interested parties indicating a willingness to explore the opportunity further.

ORDCO CEO David Cross said this allows for a co-owned, industry-led facility to be established. The next steps include the development of a comprehensive business case.

"Cotton production has been trialled extensively in the Ord River Irrigation Area over the past four years and the positive results of these trials have given local growers a level of confidence that a commercial cotton industry in the region is viable and sustainable," David said.

"The project partners are very pleased to receive initial support from the State of Western Australia and look forward to continuing a close working relationship to see this exciting and important project for Northern Australia come to fruition."

Sowing in the Ord region takes place between January and March, with picking during the favourable mid-year dry season conditions. After ginning, cotton seed will be retained locally as a valuable stockfeed for the Northern pastoral industry.

For more
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The fine cotton affair

There are two big 'Q's of cotton production – the *quantity* and *quality* of the crop that contribute to the gross return.

There are many factors over the duration of a season that contribute to each of these 'Q's – requiring an agronomic juggling act of management, timing and luck.

The past season has seen the scourge of low micronaire, caused by immature fibres, predominantly in the more southern growing regions of Australia. Growers across these valleys saw significant discounts of between $50 and $100 per bale due to low micronaire.

Micronaire (or 'mic' as it is commonly referred to by industry) is a measurement adopted by the cotton processing sector to define cotton fibre linear density or 'fineness'. Based upon the air resistance presented by the fibre being tested when subjected to set pressures, it is a function of both the linear density of the fibre, and its maturity.

While it is a standard measurement for the industry, sometimes confusingly, it no longer appears with units. The cotton trade however, presents these gradings in the following scales.

Cotton trade gradings	
≥ 5.3	G7
5.0 – 5.2	G6
3.5 – 4.9	G5
3.3 – 3.4	G4
3.0 – 3.2	G3
2.7 – 2.9	G2
2.5 – 2.6	G1
≤ 2.4	G0

The goal for a grower and their consultant is to deliver bales between the premium range of 3.8 to 4.5, but ideally not outside 3.5 to 4.9 (G5).

So, unlike a lot of other fibre parameters, micronaire has a 'Goldilocks' zone' where you neither want to be too high or too low.

Image 1

The Goldilocks' zone

A high micronaire fibre (4.5 and above) will produce coarse yarns with fewer fibres in its cross section. Lacking in tensile strength, the resultant yarn can be weak. Due to its coarseness, this cotton is used to produce our denims and course blends (for added strength).

Low micronaire cotton is prone to knots and makes the spinning and fabric production process slow (and frustrating). The finished product is often not perfect. While the resultant yarn is indeed finer, the knots (knows as neps) formed by tangling and knotting, do not allow for uniform dye uptake. Anyone who has ever tried to brush a toddler's hair in the morning will understand the problems that come with a fine fibre.

Micronaire is not just a southern issue – in previous seasons growers in northern and western regions have suffered equally disappointing discounts for high micronaire. Micronaire is a big issue for the Australian industry. By understanding how day degree accumulation affects cotton micronaire, growers and consultants can best manage their crop to the seasonal conditions experienced each year.

A major factor in determining micronaire is temperature during the mid and latter stages of boll fill. To this extent, some will argue that control of micronaire is beyond the scope of the grower and the consultant. The fact that not all crops in the southern regions were impacted by the problem last year would suggest otherwise. Good agronomic advice may not remove the issue, however it can reduce how much of the crop is affected and to what extent. So how can we as advisors help influence this final figure?

As micronaire is largely a function of boll maturity, this is our main control point. Managing the number of immature bolls at crop cutout is the key factor. Our southern growing valleys are limited by a major environmental factor when it comes to this issue – a shorter growing season with less hot days to finish off the crop.

This was the situation last season when we saw an extended period of mild weather and low degree days, when the crop was requiring heat to continue maturing. If this was the only factor that caused the problem, we would have seen a complete southern downgrade. It is important to ask then why was that not the case?

Obviously, some did things differently and avoided the low mic discounts at the end of the season. At pre-planting, this may have been changing to a variety like 714B3F when planting in the back half of the planting window.

Post planting however, there is also much the advisor can do, particularly in relation to decision making around timing of crop cut-out.

This lays the foundation for the harvesting of all the fruit which has set on the plant. Due consideration must be given regarding the last effective square on the plant. This is the time in the crop when management decisions must be made, which in turn relates to the last effective flower and harvestable boll.

A crop left to grow out too long may feature a high portion of fruit that isn't physiologically mature at defoliation time. CottASSIST data for Carrathool this year showed the average day degrees per day for May was 2.7, April 5.2 and March 7.2; late maturing bolls were visually observed in the crop to stall in their development. To put it into perspective a flower requires 750 day degrees to become an open mature boll.

The decay in day degrees at the back end of the growing season is marked. Image 1 and Image 2 are from a crop of 746B3F and 714B3F this year in the Carrathool region. Both figures show bolls that were tagged with the date in February when they became a flower, while the photos were taken when assessing the crops for defoliation at the very end of March. Both figures demonstrate a big difference in boll size and therefore maturity, for only two or three days difference in boll age. Timing of crop cutout is critical, and every day missed can add multiple days onto maturity of the crop at defoliation time.

Overall good management includes timely irrigation scheduling and nutrition supply (including carbohydrate availability) and control of insects when economically viable. For southern growers this will lead to an adequate production higher mic cotton in the middle and lower parts of the plant, that can then blend with the lower micronaire cotton on top of the plant. It is basic maths as the grower attempts to dilute late season bolls that have the potential to bring them a discount. Every season the numbers change.

Growers and consultants continue to strive for the highest yields and quality. Some years in the southern growing region there will be no opportunity to do this late season. Yield will be accumulated within the plant in line with the accumulation of adequate day degrees. Bolls that are grown later in the season will not be as heavy as those created early.

Like all things farming, the factors which will dominate crop production are going to be regionally and even farm specific. It is worthwhile as an industry to share our farming successes, but also reflect on what can be done differently in the future. This is not just a southern problem – this is about our industry's reputation. Just as importantly, it has the ability to put a few more dollars back into your clients' pockets.

CCA is a professional organisation for independent consultants and offers regular upskilling and technical information to its members based on the season and their needs. For membership information contact www.cropconsultants.com.au

Image 3 shows a 748B3F boll, again in the Carrathool region cut open on the 16 April. This boll was a flower on the 13 February and is only just physiologically mature in the middle of April, a time most would agree to be the back end for defoliation to begin. The boll has no jelly or unformed cotyledons in the seed, however the seed coating is only just starting to turn dark, a sure sign of maturity.
This particular paddock of 748B3F grew to be 110cm tall and after slow early season growth did not want to stop growing at cutout. 1.2L of Pix was applied to this part of the field as part of a variable rate application on the 17 January. The crop then received 2.5L of Pix on the 24 January and a further two litres of Pix on February 4. Aggressive pix management was required to keep crop maturity on track and achieve a final field yield of 11.7 bales per hectare. Out of the 651 bales classed only two bales were G4 micronaire (3.3-3.4). The indeterminate nature of varieties like 748B3F take timely management to induce cutout. Particularly in seasons like the one past, where cool weather delayed squaring, and the assimilate demand of the crop did not act to constrain late January growth.

Image 2

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MELANIE JENSON